A wireless antenna siting and related infrastructure plan for southern Wisconsin. no. 51 September 2006

[s.l.]: Southeastern Wisconsin Regional Planning Commission, September 2006

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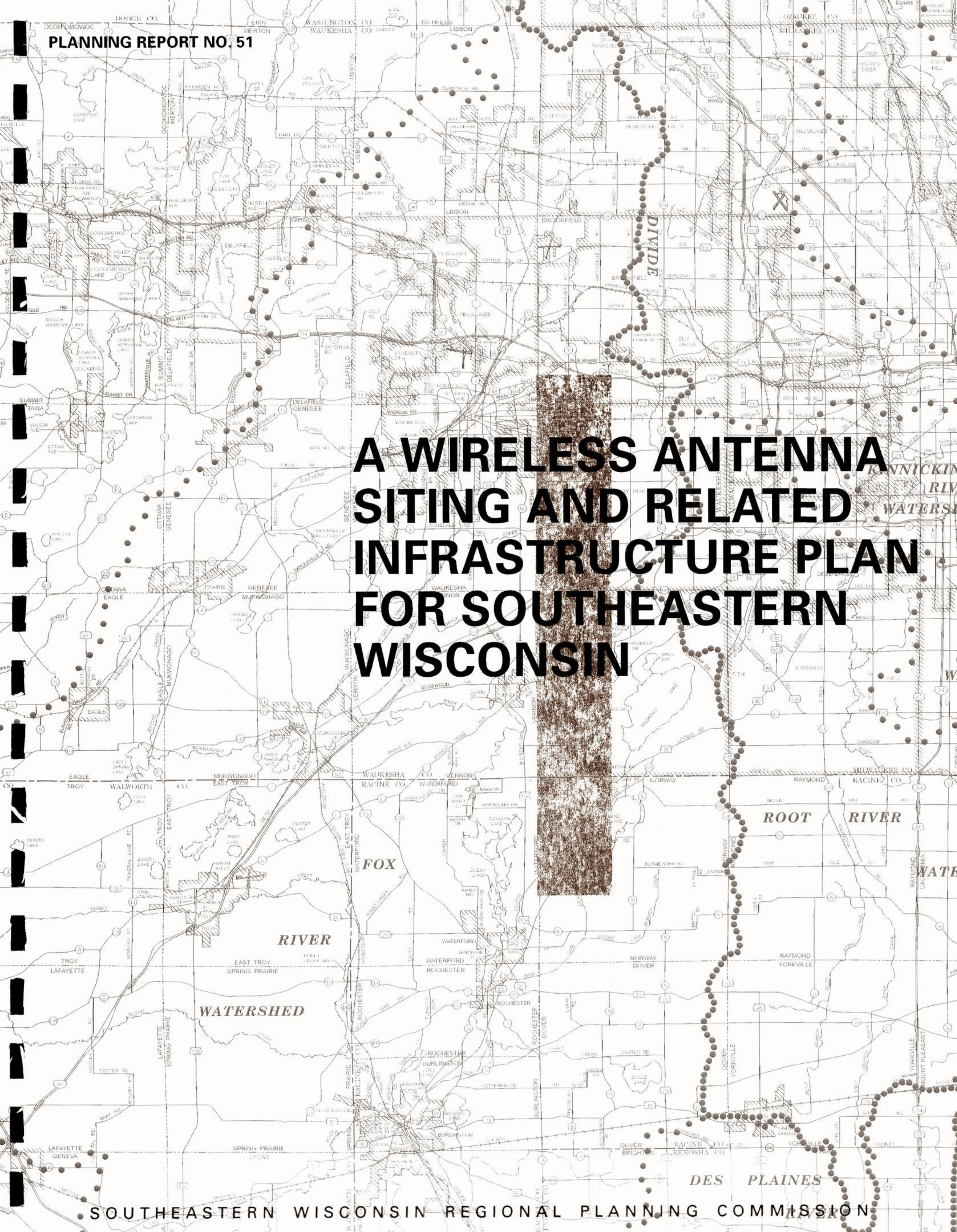
PLANNING REPORT NO. 51

A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN



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Special acknowledgement is due Ms. Lynn G. Heis, Secretary; Ms. Nancee A. Nejedlo, Principal Planning Draftsman; Mr. Donald P. Simon, Principal Planning Draftsman; and Mr. Jason W. Zehrung, Senior Telecommunications Planner, for their contributions to this report.

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Special acknowledgement is due the following former members of the Committee: Kenneth Brown, RF Engineer, Nextel Commmunications, Inc.; Brahim Gaddour, Director of Network Operations, Time Warner Telecom of Wisconsin; and Paul R. Schumacher, former Program Manager, TriCounty Business Partnerships.

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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Serving the Counties of: KENOSHA
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SUBJECT: Certification of Adoption of A Wireless Antenna Siting and Related Intrastructure Plan for Southeastern Wisconsin

TO: The Legislative Bodies of All the Local Units of Government within the Southeastern Wisconsin Region, Consisting of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha

This is to certify that at a regular meeting of the Southeastern Wisconsin Regional Planning Commission held at the Racine County Highway and Office Building, Yorkville, Wisconsin, on the 13th day of September 2006, the Commission, by unanimous vote of all Commissioners present, being 18 ayes and 0 nays, and by appropriate resolution, a copy of which is made a part hereof and is incorporated by reference to the same force and effect as if it had been specifically set forth herein in detail, did adopt a wireless antenna siting and related intrastructure plan for Southeastern Wisconsin as part of the master plan for the physical development of the Southeastern Wisconsin Region. Said plan is documented in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Intrastructure Plan for Southeastern Wisconsin*, published in September 2006, which is attached hereto and made a part hereof. Such action taken by the Commission is hereby recorded on and is a part of said plan, which plan is hereby transmitted to all concerned levels and agencies of government in the Southeastern Wisconsin Region for implementation.

IN TESTIMONY WHEREOF, I have hereunto set my hand and seal and cause the Seal of the Southeastern Wisconsin Regional Planning Commission to be hereto affixed.

Dated at the City of Pewaukee, Wisconsin, this 15th day of September 2006.

Thomas H. Buestrin, Chairman
Southeastern Wisconsin
Regional Planning Commission

ATTEST:

Philip C. Evenson

Philip C. Evenson, Deputy Secretary

RESOLUTION NO. 2006-19

RESOLUTION OF THE SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION ADOPTING A REGIONAL WIRELESS TELECOMMUNICATIONS PLAN FOR SOUTHEASTERN WISCONSIN, THE PLAN BEING A PART OF THE MASTER PLAN FOR THE PHYSICAL DEVELOPMENT OF THE REGION CONSISTING OF THE COUNTIES OF KENOSHA, MILWAUKEE, OZAUKEE, RACINE, WALWORTH, WASHINGTON, AND WAUKESHA IN THE STATE OF WISCONSIN

WHEREAS, under the guidance of the Advisory Committee on Regional Telecommunications Planning, the Commission staff has completed all planning studies necessary for the preparation of a regional wireless telecommunications plan, including the preparation of SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*, which report contains proposals, programs, and descriptive and explanatory matter intended by the Commission to form the regional wireless telecommunications plan and to constitute an integral part of the master plan for the physical development of the Region; and

WHEREAS, the Advisory Committee on Regional Telecommunications Planning completed its review of the regional wireless telecommunications plan at its meeting held on August 29, 2006, and recommended its adoption by the Commission; and

WHEREAS, under the provisions of Section 66.0309(9) of the Wisconsin Statutes, the Regional Planning Commission is authorized and empowered, as the work of making the whole master plan progresses, to adopt a resolution approving the regional wireless telecommunications plan for Southeastern Wisconsin as a part of the master plan;

NOW THEREFORE, BE IT HEREBY RESOLVED:

FIRST: That the regional wireless telecommunications plan, being a part of the master plan for the physical development of the Region and set forth in SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*, published in September 2006, shall be and the same hereby is in all respects ratified, approved, and officially adopted.

SECOND: That the said SEWRPC Planning Report No. 51, together with all maps, plats, charts, programs, and descriptive and explanatory matter contained therein, are hereby made a matter of public record, and the originals and true copies thereof shall be kept at all times at the offices of the Southeastern Wisconsin Regional Planning Commission, presently located in the City of Pewaukee, Waukesha County, and State of Wisconsin, or at any subsequent office that the Commission may occupy, for examination and study by whomsoever may desire to examine same.

THIRD: That a true, correct, and exact copy of this resolution and the aforereferenced planning report shall be forthwith distributed to each of the local legislative bodies of the government units within the Region entitled thereto and to such other bodies, agencies, or individuals as the law may require or as the Commission or its Executive Committee or its Executive Director in their discretion shall determine and direct.

<u>FOURTH</u>: That the regional wireless telecommunications plan for Southeastern Wisconsin, following the adoption of this resolution, shall become an element of the master plan for the entire Region, which master plan shall be made for the general purpose of guiding and accomplishing a coordinated, adjusted, and harmonious development of the entire Region and which will, in accordance with existing and future needs, best promote public health, safety, morals, order, convenience, prosperity, or the general welfare, as well as efficiency and economy in the process of development; and that the purpose and effect of the adoption of the master plan shall be solely to aid the Regional Planning Commission, the local governments and local government officials in the Region, the State government and State government officials, and the Federal government and Federal government officials in the performance of their functions and duties.

The foregoing resolution, upon motion duly made and seconded, was regularly adopted at the meeting of the Southeastern Wisconsin Regional Planning Commission held on the 13th day of September 2006, the vote being: Ayes 18; Nays 0.

Thomas H. Buestrin, Chairman

ATTEST:

Philip C. Evenson

Philip C. Evenson, Deputy Secretary

PLANNING REPORT
NUMBER 51

A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN

Prepared by the

Southeastern Wisconsin Regional Planning Commission
P.O. Box 1607
W239 N1812 Rockwood Drive
Waukesha, WI 53187-1607
www.sewrpc.org

September 2006

Inside Region $10.00
Outside Region $20.00

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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September 1, 2006

STATEMENT OF THE CHAIRMAN

The Regional Planning Commission in 2004 undertook a program intended to help develop a high level of telecommunications service within the Southeastern Wisconsin Region. The initiation of this program recognized the vital role of telecommunications in maintaining the economic competitiveness of the Region and of providing certain important social services. This report is the second in a series of three reports which present the findings and recommendations of this planning program.

The first report – SEWRPC Memorandum Report No. 164, published in September 2005 – described the importance and potential application of high capacity telecommunication services in meeting growing needs in such areas as public safety emergency response, freeway traffic management, home health care, and environmental monitoring. This report sets forth recommendations concerning the development of high capacity wireless telecommunication services within the Region. It recognizes that, like transportation planning, telecommunications planning relates to infrastructure networks. Such planning differs, however, from public infrastructure system planning in two important respects: one, the rapid pace of technological change in telecommunications; and two, the role of private carriers in plan implementation. A third report will integrate this wireless services plan with a wireline services plan.

This report, while including information on the existing wireless infrastructure within the Region and on the present performance of this infrastructure, focuses primarily on looking ahead to the latter part of this first decade of the 21st century when new open standards technology will be used to provide a level of wireless telecommunications services well beyond those currently provided. The coming transition to what is termed in the industry fourth generation — 4G — wireless technology holds significant promise for the delivery of cost-effective, high-capacity, broadband telecommunication services throughout the Region. The wireless infrastructure plan herein presented constitutes the Commission's initial recommendations for the deployment of 4G technology in the years ahead; recognizing, however, that the rapidly evolving nature of this technology likely will lead to plan adjustments and modifications as experience in deploying this technology is attained.

While the wireless telecommunications recommendations contained in this report hold promise for the development of community wireless WiFi networks now being pursued in many areas, perhaps the greatest potential lies in the deployment of the 4G technology to provide a platform for the creation over the entire seven-county Region of an integrated public safety emergency response telecommunications network, beginning with high speed data and video transmissions and, perhaps, evolving to voice transmissions as well. Toward this end, it is respectfully requested that the recommendations contained herein be carefully considered by public safety agencies serving the Region at the county and local levels of government, with counties taking the lead in bringing together all concerned parties. The Regional Planning Commission stands ready to help its constituent county and local governments achieve this important objective.

Very truly yours,

Thomas H. Buestrin
Chairman

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INTRODUCTION

INTRODUCTION

The Southeastern Wisconsin Regional Planning Commission is charged by law with the function and duty of "making and adopting a master plan for the physical development of the Region." The permissible scope and content of this plan, as outlined in the enabling legislation, extend to all phases of regional development, implicitly emphasizing, however, the preparation of spatial designs for the use of land and for supporting transportation, and other utility facilities, including telecommunications facilities.

The scope and complexity of areawide development problems prohibit the making and adopting of an entire comprehensive development plan at one time. The Commission has, therefore, determined to proceed with the preparation of individual plan elements which together can form the required comprehensive plan. Each element is intended to deal with an identified areawide developmental or environmental problem. The individual elements are coordinated by being related to an areawide land use plan. Thus, the land use plan comprises the most basic regional plan element, an element on which all other elements are based. The regional wireless antenna site and related infrastructure plan is also strongly linked to the regional land use and transportation plans based on the relationship between land use patterns, major transportation facilities, and telecommunications traffic generation.

Because regional telecommunications planning comprises an integral part of a broader regional planning program, an understanding of the need for, and objectives of, regional planning and the manner in which these needs are being met in southeastern Wisconsin is necessary for a full understanding of the telecommunications planning process and of its findings and recommendations as presented in this report. To that end, this chapter describes the need for, and status of, the regional planning effort within the Southeastern Wisconsin Region.

NEED FOR REGIONAL PLANNING

Regional planning may be defined as comprehensive planning for a geographic area larger than a county but smaller than a state, united by economic interest, geography, and common areawide developmental and environmental problems. The need for such planning has arisen from certain important social and economic changes which, while national phenomena, have had far-reaching impacts on the problems facing local government. These changes include growth and redistribution of population and attendant urban development; changes in agricultural and industrial productivity, income levels, and leisure time; generation of mass recreational needs and pursuits; intensive use and consumption of natural resources; development of private water supply and sewage disposal systems; development of extensive electric power and communications networks; and development of limited-access highways and mass automotive transportation. Through the effects of these changes, entire regions like Southeastern Wisconsin are being subjected to the widespread diffusion of urban development and are thereby becoming, large, mixed rural and urban socio-economic complexes.

This urban diffusion, in turn, creates serious and complex areawide developmental and environmental problems.

The areawide problems which necessitate a regional planning effort in Southeastern Wisconsin all have their source in the changes in population size, composition, and distribution and in the attendant urban diffusion occurring within the Region. These areawide problems include, among others: drainage and flooding; air and water pollution; increased demand for park and outdoor recreation facilities, sewerage and water supply facilities, and housing; traffic congestion; a growing demand for high speed, broadband telecommunications; and, underlying all of the foregoing problems, rapidly changing land use development. These problems are all truly regional in scope, transcending both the geographic boundaries and the fiscal capabilities of the local municipal units of government comprising the Region, and can be properly addressed only within the context of a continuing, cooperative, areawide, comprehensive regional planning effort.

THE REGIONAL PLANNING COMMISSION

The Southeastern Wisconsin Regional Planning Commission was created in August 1960, pursuant to the provisions of Section 66.0303 of the Wisconsin Statutes, to serve and assist the local, state, and federal units of government in solving areawide problems and in planning for the more orderly and more economic development of Southeastern Wisconsin. The Commission's role is entirely advisory, and participation by local units of government in its work is on a voluntary, cooperative basis. The Commission is composed of 21 citizen members, three from each county in the Region. One Commissioner from each county is appointed to the Commission by the county board, one by the Governor from a list certified to him by the county board, and one by the Governor on his own motion.

The powers, duties, and functions of the Commission and the qualifications of the Commissioners are carefully set forth in the enabling legislation. The Commission is authorized to employ a staff and to appoint advisory committees to assist it in the execution of its responsibilities. Basic funding to support Commission operations is provided by the member counties, with the budget apportioned among the seven counties on the basis of relative equalized property valuation. The Commission is authorized to request and accept aid in any form from all levels and agencies of government to accomplish its objectives, and is authorized to deal directly with the state and federal governments for this purpose. The organizational structure of the Commission and its relationship to the constituent units and agencies of government comprising or operating within the Region is shown in Figure 1.

THE REGIONAL PLANNING CONCEPT IN SOUTHEASTERN WISCONSIN

Regional planning, as conceived by the Commission, is not substitute for, but a supplement to, local, state, and federal planning. Its objective is to assist the various levels and units of government in finding cooperative solutions to areawide developmental and environmental problems which cannot be properly resolved within the framework of a single municipality or county. As such, regional planning has three principal functions:

1. Inventory: the collection, analysis, and dissemination of basic planning and engineering data on a uniform, areawide basis so that, in light of such data, the various levels and agencies of government and private investors operating within the Region can better make decisions concerning community development.

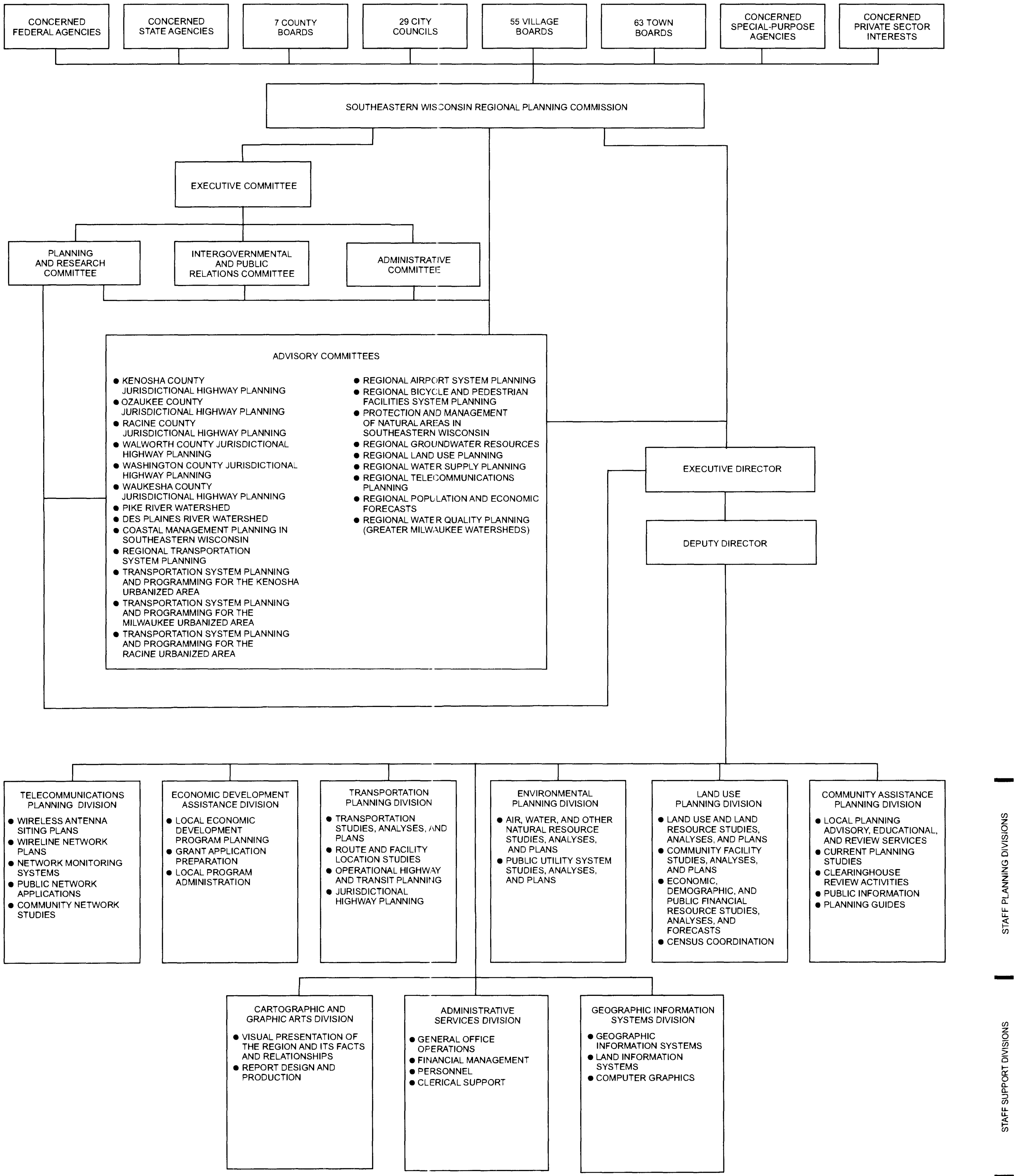
2. Plan Design: the preparation of a framework of long-range plans for the physical development of the Region, these plans being limited to functional elements having areawide significance.

3. Plan Implementation: promotion of plan implementation by providing a center to coordinate the planning and plan implementation activities of the various levels and agencies of government in the Region and by providing the introduction of information on areawide problems, recommended solutions to these problems, and alternatives thereto, as part of the existing decision-making process.

The work of the Commission, therefore, is seen as a continuing planning process providing outputs of value to the making of development decisions by public and private agencies and to the preparation of

Figure 1

SEWRPC ORGANIZATIONAL STRUCTURE: 2005



plans and plan implementation programs at the local, state, and federal levels. It emphasizes close cooperation between the governmental agencies and private enterprises responsible for the development and maintenance of land uses in the Region and for the design, construction, operation, and maintenance of the supporting public and private facilities. All Commission work programs are intended to be carried out within the context of a continuing overall planning program which provides for periodic re-evaluation of the plans produced and for the extension of planning information and advice necessary to convert the plans into action programs at the local, regional, state, and federal levels.

THE REGION

The Southeastern Wisconsin Planning Region, as shown on Map 1, is comprised of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties. Exclusive of Lake Michigan, these seven counties have a total of 2,689 square miles, or about 5 percent of the total land and inland water area of Wisconsin, and a total resident population of about 1.97 million people. About 36 percent of the population of the State lives in these seven counties, which contain three of the fifteen metropolitan statistical areas which are wholly or partially located in Wisconsin. The seven counties provide about 1.19 million jobs, or about 36 percent of the total employment of the State. The Region contains real property valued at about $145.4 billion as measured in equalized valuation, or about 37 percent of all of the tangible wealth of the State, as measured by such valuation. The Region contains 154 local units of government, exclusive of school and other special-purpose districts, and encompasses all or parts of 11 major watersheds.

Geographically the Region is located in a relatively good position with regard to continued growth and development. It is bounded on the east by Lake Michigan, which provides an ample supply of fresh water for both domestic and industrial use, and is an integral part of a major international transportation network. It is bounded on the south by the rapidly expanding northeastern Illinois metropolitan region and on the west and north by the fertile agricultural lands and desirable recreational areas of the rest of the State of Wisconsin. Many of the most important industrial areas and heaviest population concentrations in the Midwest lie within 250 miles of the Region, and over 27.3 million people reside within this radius.

COMMISSION WORK PROGRAMS TO DATE

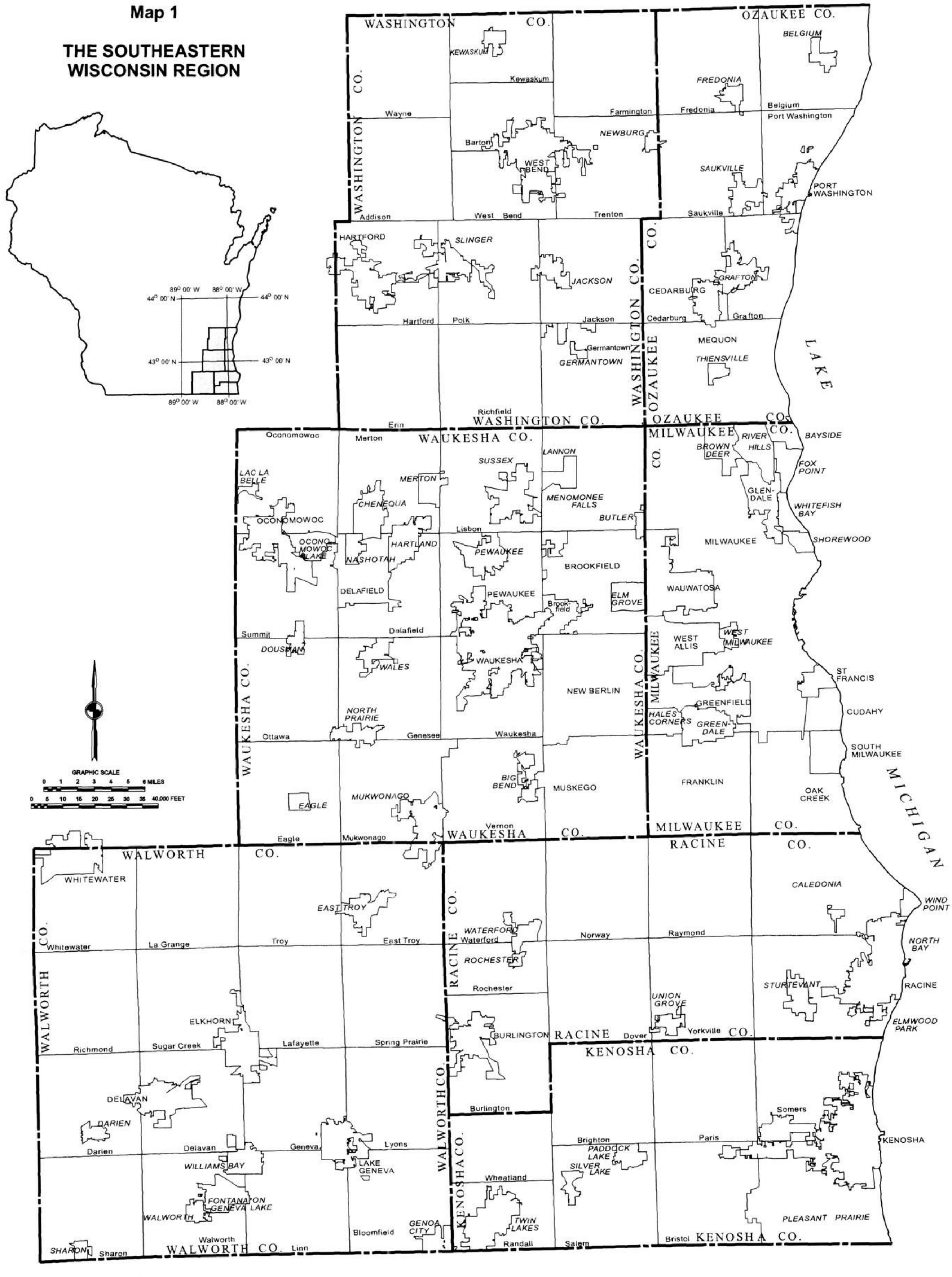
Since its creation in 1960, the Regional Planning Commission has diligently pursued its three basic functions of areawide inventory, plan design, and promotion of plan implementation through intergovernmental cooperation and coordination, although the relative emphasis placed upon these functions has changed somewhat over time. Initially, major emphasis in the Commission's work program was on the inventory function, with increasing attention being placed over the years on the plan design and on the intergovernmental coordination functions.

With respect to the inventory function, the Commission's planning program, as conducted since 1961, has resulted in the creation of a data bank containing in a readily usable form the basic planning and engineering information required for sound, areawide planning. The data assembled in the regional data bank include, among others, definitive data on streamflows; floodlands; surface and groundwater quality; woodlands, wetlands, and wildlife habitat; sites having scenic, scientific, cultural, and recreational value; soils; existing and proposed land uses; travel habits and patterns; transportation system capacity and utilization; existing and proposed utility service areas; and the demographic and economic base and structure of the Region. The data base also includes an extensive topographic and cadastral base mapping and horizontal and vertical survey control file. In wireless networks, the inventories include a comprehensive layout of antenna sites in the Region along with the areal coverage of these sites for the various wireless frequency bands and radio technologies.

Some of the data in the regional planning data bank have been assembled through the collation of data collected by other agencies. Data so assembled include data on highway and transit facility capacity, use, and service levels; transportation terminal facility capacity; automobile and truck availability; and population and economic activity levels. Much of the data in the regional data bank, however, have been assembled through original inventory efforts conducted by the Commission itself. Such inventory efforts have ranged from aerial photography, large-scale topographic and cadastral base mapping, and

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

control survey programs; through extensive land use, woodland, wetland, wildlife habitat, potential park site, and public utility system inventories; to massive travel inventory, detailed operational soil survey, and streamflow gaging and water quality monitoring efforts. Wireless inventory data sources used by the Commission include federal databases such as the Federal Communications Commission and Federal Aviation Administration; permit records of local units of government; and data from wireless service providers.

The regional planning data bank is supported by an extensive data conversion, filing, and retrieval capability which permits the basic data to be readily manipulated and tabulated by various geographic areas, ranging in size from the Region as a whole down through natural watersheds, counties, and minor civil divisions to planning analysis areas, census enumeration districts and tracts, traffic analysis zones, U.S. Public Land Survey sections and quarter-sections, and, for certain data, urban blocks and block faces. Of increasing importance in the regional planning data bank is the Commission's automated geographic information systems capability. A key regional map file consists of land use data which have been digitized, allowing for automated map reproduction and related data analysis functions. The Commission's planning data bank provides valuable points of departure for all Commission work efforts and is, moreover, available for use by the constituent agencies and units of government and the private sector.

With respect to the plan design function, the Commission has placed great emphasis upon the development of a comprehensive plan for the physical development of the Region in the belief that such a plan is essential if land use development is to be properly coordinated with development of supporting transportation, telecommunications, utility, and community facility systems; if the development of each of these individual functional systems is to be coordinated with the development of each of the others; and if serious and costly developmental and environmental problems are to be avoided and a safer, more healthful and attractive, as well as more efficient regional settlement pattern is to be achieved. Under the Commission's approach, the preparation, adoption, and use of the comprehensive plan are considered to be the primary objective of the planning process; and all planning and plan implementation efforts are related to the comprehensive plan.

Telecommunication networks have become a vital resource in the physical development of metropolitan regions. Business firms, local units of government, educational facilities, and individual households all depend on communications in the conduct of their daily lives and high speed—broadband—communications for data and video as well as voice communications is becoming an integral part of a modern society.

The comprehensive plan not only provides an official framework for coordinating and guiding growth and development within a multijurisdictional urbanizing region, but also provides a good conceptual basis for the application of systems engineering skills to the growing problems of such a region. The comprehensive regional plan also provides the essential framework for more detailed physical development planning at the county, community, and neighborhood levels.

As previously noted, because the scope and complexity of areawide development problems prohibit the preparation of an entire comprehensive plan at one time, the Commission has determined to proceed with the preparation of individual plan elements which together comprise the required comprehensive plan. By the end of 2003, the adopted regional plan consisted of 29 individual plan elements. Four of these elements are land use related: the regional land use plan, the regional housing plan, the regional library facilities and services plan, and the regional park and open space plan. Twelve of the plan elements relate to transportation. These consist of the regional transportation plan including highway and transit elements, the regional airport system plan, the transportation systems management plan, the elderly and handicapped transportation plan, the regional bicycle and pedestrian facilities plan, and detailed transit development plans for the Kenosha, Racine Waukesha, and West Bend urbanized areas and for Ozaukee, Washington, and Waukesha Counties. Eleven of the adopted plan elements fall within the broad functional area of environmental planning. These consist of the regional water quality management plan, the regional wastewater sludge management plan, the regional air quality attainment and maintenance plan, and comprehensive watershed development plans for the Des Plaines, Fox, Milwaukee, Menomonee, Kinnickinnic, Pike River, Root River, and Oak Creek watersheds. The final two plan elements consist of comprehensive community development plans for the Kenosha and Racine urbanized areas.

The telecommunications planning program is new to the Commission with the initial planning studies beginning in 2004. The program initiation was in recognition of the vital role of telecommunications in the regional economy. In form, it most closely resembles transportation planning, with both relating to infrastructure networks. It differs, however, in the rapid pace of technological change and the role of private carriers in plan implementation.

The Commission also carries on an active community assistance planning program, in which functional guidance and advice on planning problems are provided to local units of government and regional planning studies are interpreted locally so that the findings and recommendations of these studies may be incorporated into local development plans and plan implementation programs. Six local planning guides have been prepared under this program to provide information helpful in the preparation of local plans and plan implementation ordinances. The subjects of these guides are land subdivision control, official mapping, zoning, organization of local planning agencies, floodland and shoreland development, and the use of soils data in development planning and control. Telecommunications planning services will also be extended to local units of government as part of the Commission's community assistance program. Beyond the questions related to antenna siting, some communities may require assistance in assessing telecommunications service levels and needs.

TELECOMMUNICATIONS— DEFINITION AND IMPORTANCE

Telecommunication networks provide the infrastructure for information interchange in all advanced societies. Such networks are vital for the efficient production and distribution of goods and services in a modern economy. Telecommunication exchanges also serve to help weave the social and political fabric of modern day life. Recent and continuing advances in communications technology have allowed for information transfer at rates considered infeasible even a decade ago. Although originally developed for voice communication only, telecommunication networks now transmit data, video, and multimedia forms of information.

Varying rates of deployment of new communications technologies in different areas of the United States and in the rest of the world have produced one aspect of the so-called "digital divide,"[1] placing areas with outmoded telecommunication technologies at a competitive disadvantage in national and global commerce. Such disadvantaged areas are also prevented from introducing communications-based advances in fields such as telemedicine, public safety, education, environmental monitoring, and transportation that have major impacts on the quality of life. For all of the above reasons, telecommunications planning should be an important concern of elected and appointed public officials in a metropolitan region such as Southeastern Wisconsin.

One mode of telecommunications, terrestrial wireless communications, is advancing more rapidly than other modes such as traditional wireline and satellite wireless communications. Although the first commercial cellular wireless network did not become operable until 1983, wireless telephony is rapidly becoming the predominant form of local and long distance voice communication in the United States and elsewhere. Some countries in Europe and Asia, have higher rates of wireless telephone usage than does the United States. With the advent of the third generation (3G) of wireless communication technology, wireless is expected to become important in data and video as well as voice transmission.

Wireless communication requires above ground antenna structures and related infrastructure. In certain instances the location of these structures and associated support equipment may have impacts on land use and on perceived property values. These impacts and perceptions may be positive or negative

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[1]*The term "digital divide" is commonly used to refer to the differences between households, businesses and other organizations that, for whatever reasons, have access to personal computers and the Internet and those that do not. It can also be used to distinguish between areas that are underserved in that the areas do not have high speed data service available. Such underserved—or disadvantaged—areas may exist in urban, as well as rural areas.*

depending upon the site specific situations. The coming third generation of wireless telecommunications may be expected to require a larger number of antenna sites with smaller cellular coverage. This projected increase in antenna site requirements contributes to a need for areawide planning of the required future antenna site network. Site planning, if properly carried out in a cooperative manner by the public and private sector interests involved, can assist in avoiding the potential haphazard location of a multitude of future wireless antenna sites; maintain a harmonious relationship between private sector antenna site planning and county and local land use planning; and help to avoid needless conflicts over antenna structure siting and local land use development. Also in this respect, it is necessary to look beyond the current state of telecommunication networks and their supporting technologies, to the possibilities for the development of better wireless and wireline networks within Southeastern Wisconsin. Areawide plans must recognize the implications of new technologies, including fourth generation (4G) wireless technology, new versions of the Internet, and the anticipated blending of telecommunication networks into one operationally integrated but diverse multimedia system.

ADVISORY COMMITTEE

The long-established practice of the Commission has been to conduct major regional planning programs with the assistance of appropriately structured advisory committees. The membership of such committees was to be drawn, as appropriate, to include knowledgeable and concerned representatives of the constituent counties and municipalities; of concerned State and Federal agencies; of the academic community; and of concerned private businesses and industries. Accordingly, an Advisory Committee on Regional Telecommunications Planning was created by the Commission to guide the preparation of the recommended plans. The Committee consists of the following members:

Kurt W. Bauer, Chairman .... Executive Director Emeritus, SEWRPC
William R. Drew, Vice-Chairman .... SEWRPC Commissioner; and Executive Director, Milwaukee County Research Park
Roger Caron .... President, Racine Area Manufacturers and Commerce
Bob Chernow .... Chairman, Regional Telecommunications Commission
David L. DeAngelis .... Village Manager, Village of Elm Grove
Michael Falaschi .... President, Wisconsin Internet
Barry Gatz .... Network Supervisor, CenturyTel
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Rob N. Richardson .... Director, Racine County Information Systems
Steven L. Ritt .... Attorney at Law, Michael Best & Friedrich
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Special acknowledgement is due the following former members of the Committee: Kenneth Brown, RF Engineer, Nextel Communications, Inc.; Brahim Gaddour, Director of Network Operations, Time Warner Telecom of Wisconsin; and Paul R. Schumacher, former Program Manager, TriCounty Business Partnerships.

PROSPECTUS

On December 4, 2002 the Commission authorized the preparation of a Prospectus for a Regional Telecommunications Planning Program. During the following year the Commission staff, under the guidance of a predecessor Advisory Committee, prepared a prospectus for a regional telecommunications planning program. This prospectus described in some detail the need for, and the major work elements of such a planning program. In December 2003, the Commission approved the initiation of a Regional telecommunications planning program based on this prospectus. The prospectus envisions the regional telecommunication plan to be comprised of two elements: a wireless antenna siting and related infrastructure plan; and an overall telecommunications network plan. In addition, a technical report presenting the findings of an inventory of the existing regional telecommunications system and system performance; and a memorandum report on public enterprise networks.

NEED FOR REGIONAL TELECOMMUNICATIONS PLANNING

Based upon a careful examination of the historical background and of the current state of telecommunications facilities and services within the Region, the Advisory Committee that guided the preparation of the afore-referenced Prospectus concluded that seven factors contribute to the need for the conduct of a regional telecommunications planning program and the preparation of a regional telecommunications plan for Southeastern Wisconsin. These factors are:

1. <u>The lack of comprehensive information on the state of telecommunications facilities and services within the Region readily available to county and municipal officials, businessmen and industrialists, and concerned citizens</u>.

   In past years, comprehensive information on the Regional telecommunications infrastructure was available from the Public Service Commission of Wisconsin (PSC). The PSC no longer has any jurisdiction over the growth areas of the telecom infrastructure, i.e. the packet-switched wireline network and all wireless networks. Without such information, public planning of any kind is not possible.

   Quality of service information on telecommunication services within the Region is also lacking. Many users of data services are often unaware of the degraded nature of transmission rates provided in some parts of the Region. Remedies for the correction of service deficiencies often take extended time periods with increasing subscriber frustration. At the same time, information on levels of service is rarely publicized. A regional network monitoring system could assist significantly in identifying network deficiencies as well as publicizing service quality levels throughout the Region.

2. <u>The increasing need for advanced telecommunication facilities and services to support the economic development of the Region</u>.

   Currently, primary economic competitors of the Region include countries of East Asia—South Korea, Japan and increasingly China. Manufacturing jobs especially are moving from Southeastern Wisconsin to East Asia. East Asia is reported to be ahead of the United States and the Region in broadband telecom-communications services—both in terms of transmission speeds and in lower costs of these services. A regional telecommunications plan would assist Southeastern Wisconsin in recovering and maintaining its competitive position in the global economy by identifying the telecommunications infrastructure required to prosper in the current economic environment.

3. <u>The need to address the universal provision of adequate broadband telecommunication services within the Region</u>.

   A long term public approach to planning for the universal provision of broadband services within the Region is needed. Such an approach requires the evaluation of alternative network configurations and technologies to ascertain what is in the best socioeconomic interests of the people of Southeastern Wisconsin.

4. <u>The need to address differences in the provision of adequate telecommunication services in rural and other underserved areas of the Region</u>.

The governor in 2003 called for the provision of universal broadband communication services to all areas of Wisconsin as part of a needed economic development program. Creative network design innovations are required to make such universal coverage cost-effective in rural and disadvantaged areas in a more effective manner. Such innovations can be evaluated as part of a regional telecommunications planning process.

5. The need to develop special purpose public telecommunication networks within the Region for applications such as telemedicine, public safety, transportation, environmental monitoring, and education.

   Some of the greatest benefits of advanced telecommunications technology can result from the development of special public networks in areas such as emergency telemedicine, home health care telemedicine, air and water pollution monitoring, transportation system management, and education.

   Many of these public network applications are regional in scope and planning for such would be enhanced by a regional telecommunication planning program.

6. The need to assist local units of government in telecommunication network development.

   Wisconsin municipalities have authority to provide telecommunications services, and court decisions have upheld this authority. Over 25 municipalities have been certified by the Wisconsin Public Service Commission to provide competitive telecommunications services. The Village of Jackson, within the Southeastern Wisconsin Region, is creating a broad-band telecommunication utility to provide telecommunication facilities and services within the Village. Municipalities choosing this route could significantly benefit from planning assistance at the regional level. All municipalities within the Region will, however, require planning assistance with respect to telecommunication issues, particularly as related to future wireless and broadband communications services. In this respect, it should be noted that Section 66.0295(2)(d) of the *Wisconsin Statutes* requires that local comprehensive plans specifically address telecommunications facilities as an integral part of the utilities and community facilities element of such plans.

7. The need to develop a well-conceived antenna siting and related infrastructure plan for wireless communications in the Region.

   The emerging major role of all forms of mobile and fixed wireless communications in future broadband services highlights the importance of a regional antenna siting and related infrastructure planning effort. Particularly important will be consideration of new radio and free space optical bands beyond VHF and UHF (3GHz) in the SHF (Super High Frequency), EHF (Extremely High Frequency) and near infrared—free space optical—regions. These higher frequency bands are synonymous with broad-band capability and offer a potentially powerful and low cost alternative for the local loop—a potential key to resolution of the "last mile" connection problem. The antenna siting plan would also provide the structure for orderly expansion of wireless communications services in the Region.

   While long-term trends emphasize the move to higher frequencies for broadband capability, short-term considerations for interoperable communications in public safety agencies (police, fire, and emergency medical services) restrict local governments to lower band spectrum for voice communications. For example, both 150 MHz and 800 MHz are popular public safety bands in Wisconsin. Until at least 3G based voice over internet protocol services are widely available, there is little choice but to remain at lower frequencies for interoperable public safety voice communications. Realistically, only the advent of public sector 4G networks will allow for a universal public safety transformation to broadband frequencies.

SEWRPC TECHNICAL STUDY DESIGN MEMORANDUM NO. 3 WIRELESS ANTENNA SITE AND RELATED INFRASTRUCTURE DESIGN

In 2004, a series of six technical study design memoranda were prepared to further define the content of the Regional Telecommunications Planning Program. One of these design memoranda, No. 3, described the system design sequence to be followed in the creation of the wireless infrastructure plan element.

Particular attention in the memorandum was focused on the optimization of antenna site location within the Region with the objective of encouraging co-location of antenna on supporting structures, and minimizing the number of single user antenna sites while providing full coverage of high quality service throughout the Region.

The memorandum described a mathematical programming model to be developed to assist in this process of antenna site location optimization.

PLAN DESIGN YEAR

The wireless antenna siting and related infrastructure plan for the Southeastern Wisconsin Region is to have a plan design year 2015. This design year was selected to correspond with the year 2015 stage of a set of new land use and transportation system plans being prepared for the Region. These plans are to have a design year 2035 with appropriate ten year stagings. The plan design year of 2015 was also selected to provide a long-range, as opposed to a short-range, basis for the planning effort. Because of the rapidly changing economic, technological, regulatory, and market conditions concerned, private sector telecommunications planning efforts tend to be relatively short range, a five year time horizon often being used. A longer time horizon—10 years—was selected for the antenna siting and related infrastructure planning effort in order to permit the planning to reflect probable new technologies, including fourth generation (4G) wireless technology, and new versions of the Internet. The designation of a design year is not intended to preclude the earlier introduction of 4G technology, but only to specify the latest date by which such technology should be in use within the Region.

SCHEME OF PRESENTATION

The findings and recommendations of the wireless antenna site and related infrastructure planning program are documented in this report. Following this introduction, Chapter II sets forth the principles and concepts underlying the wireless infrastructure plan and outlines the major steps in the planning process. Chapter III presents the objectives of the wireless planning program and the standards by which alternative plans will be judged. Chapter IV documents the demographic, economic land use and transportation system inventory findings—the background conditions for the antenna siting plan. Chapter V documents the findings of the wireless telecommunication infrastructure inventory required for the planning effort. This chapter will also describe the network monitoring system being established to collect performance data on the regional wireless networks over time. In Chapter VI, aggregate and spatial forecasts of demand for wireless telecommunications services will be presented with spatial demands based on future land use forecasts and plans. The end products of these forecasts use areal call generation data by land use and unit density. A modal split between wireless and wireline traffic will also be estimated and applied to telecom demand. Two forms of plan design will be presented in Chapter VII–one for second/third (2G, 3G) generation wireless and one for fourth generation (4G) wireless. The 2G/3G plan will be a forecast/plan with projection of existing trends linked with a rational antenna siting plan. The 4G plan will be a true futures plan moving beyond current infrastructures and trends to a vision of wireless communications in years 2010 and beyond. Chapter VIII concludes with a summary of the findings and recommendations of the antennae siting and related infrastructure planning effort.

Chapter II

BASIC PRINCIPLES AND CONCEPTS

INTRODUCTION

In the preparation of a regional wireless antenna siting and infrastructure plan, the Regional Planning Commission followed a systematic planning approach that combined traditional regional planning procedures with well established radio frequency system engineering procedures. This chapter describes the approach followed by the Commission in preparing the wireless antenna siting and infrastructure plan. More specifically, the chapter details the major elements of the wireless network planning process and how radio frequency system engineering was integrated into the regional planning process. Definitions are provided for the various wireless technologies, both fixed and mobile, together with the descriptive parameters that characterize the applications of these technologies.

BASIC PRINCIPLES UNDERLYING THE REGIONAL PLANNING PROCESS

The planning process applied in the regional telecommunications planning effort is based on four basic principles. These are:

1. Telecommunications planning must be regional in scope. The need for and demand in telecommunication services develops over the entire urban region without regard to corporate limit lines. Thus, telecommunications planning cannot be accomplished successfully within the confines of a single municipality or a single county if that municipality or county is a part of a larger urban complex. The regional telecommunications system, which is comprised of wireless and wireline facilities and attendant services, must form an interoperable system over the entire region, a system which can adequately serve the developing telecommunication needs of the developing region.

2. Telecommunications planning must be conducted concurrently with and cannot be separated from land use planning. The land use pattern determines the amount and spatial distribution of the need and demand for telecommunication services; and for wireless communications, local use development has a major impact on radio propagation patterns.

3. Telecommunications planning must be comprehensive, considering in an integrated manner access, distribution and core networks using various wireless and wireline technologies for multiple service applications and media.

4. Private sector companies are significant providers of telecommunications services within the Region. These private sector companies independently prepare plans for the development of their networks; independently develop their own levels of service; and independently provide competitive services. Meaningful public telecommunication planning effort must recognize the existence of these private sector planning efforts; and pursue the public planning effort in close cooperation with the private providers, actively involving these providers in the public planning process.

PLANNING PROCESS

The planning process used consisted of the following sequential work elements:

1. Formulation of Objectives and Standards
   A set of wireless telecommunications facility and service objectives and standards were formulated. These objectives and standards emphasize the provision of areawide, low-cost, fixed and mobile broadband telecommunications facilities and services. The objectives are supported by a set of standards that provide quantifiable measures of availability, response time, throughput, and accuracy, the parameters that define the performance of a communications system that will meet the agreed upon objectives.

2. Conduct of Facilities and Services Inventory
   A sound planning process must be based upon factual data about the existing state of the system being planned. Such data are provided by an inventory function that for the wireless antenna siting and infrastructure planning process includes the collation and collection of definitive information on the location of existing antenna sites and related infrastructure and on the technical specifications of the attendant antennas and supporting structures. The inventory data are then used as inputs to radio propagation models that determine the capacity and coverage of the existing sites located throughout the Region. A second dimension to the inventory relates to network performance. A network monitoring system has been established at the Commission offices that provides a means for measuring the quality of the existing wireless network services. A central server computer located at the Commission offices scans remote site transceivers—cell phones—located at various changing locations throughout the Region. The data collected from these scans is used to compile data on the quality of service within the Region.

   In order to be comprehensive, the inventory, in addition to modeling antenna sites providing commercial service, also includes antenna sites that provide public support services. This class of sites, which includes paging and microwave point-to-point link antenna sites, also may have resource value as future co-location sites for advanced wireless communications systems.

3. Analyses and Forecasts
   Spatial forecasts of potential subscribers and the attendant call generation characteristics are based upon the year 2000 existing land use inventory and future land use plans prepared and maintained by the Commission. The basic areal unit of analysis is the U.S. Public Land Survey section, and approximately one square mile area.

4. Plan Design
   Plan designs are generated based on selected technologies and available antenna sites. The technologies determine the range and performance characteristics of communications from each antenna site. The aggregate collection of antenna sites and their composite coverage, capacity and quality of service determine the overall performance of the system. Two types of plan design are contemplated in the current program. The first will be a rationalization and optimization of current trends in wireless second (2G) and third (3G) generation communications technologies and services. The second, will represent a completely new—beyond 3G—wireless network configuration that will reach beyond currently deployed capabilities and trends based on those capabilities to provide a system with the enhanced performance necessary to support the economic development and quality of life challenges of the coming decade as defined by the objectives and standards.

5. Plan Test and Evaluation
   A number of means exist for plan test and evaluation. The most commonly used is system simulation in which a dynamic model of the network is used to simulate the performance of the existing system—or of alternative planned systems—on a computer. Such simulation can take place at varying levels of detail from high level evaluations of system capacity based on statistical estimates of subscriber usage, to detailed investigations of network packet transmissions. Interest at the regional system planning level emphasizes models that view a

network as a service provider. The objective of a modeling effort is to determine the system coverage and capacity and the level of service possible at various traffic loadings.

Small-scale experimental verifications of wireless network plans are also possible. Such experiment may be necessary to validate some assumptions made in simulation modeling.

6. Plan Selection And Implementation
Following public informational meetings and hearings on alternative wireless network plans, one of the alternative plans, or some composite version of these plans, will be adopted to help guide the short and long-range development of the regional telecommunications infrastructure within Southeastern Wisconsin. In presenting the alternative plans for public informational meetings and hearings, strong emphasis will be placed on the performance standards characterizing each alternative plan and how these standards relate to the capital investment and operating costs implicit in implementing each plan. Since one of the alternative plans will always represent a no-plan projection of current trends, these performance standards data will play a critical role in plan selection and adoption.

INVOLVED TECHNOLOGIES

Although the above description of the planning process delineates the basic work elements of regional telecommunications planning, it does not define the various technologies and provider networks that will establish the scope of the planning program. This section describes these technologies and networks as well as the frequency bands involved in wireless planning in Southeastern Wisconsin.

Mobile Wireless Networks

The major antenna site users—owners or renters—in Southeastern Wisconsin are the mobile cellular/Personal Communication System (PCS) service providers such as Cingular, Nextel, Sprint and Verizon. Based on the Federal Communications Commission (FCC) database, there are 376 antenna sites serving 393 cellular/PCS antennas in the Region. These sites are a resource not only for their present applications in second generation (2G, 2.5G) networks, but also as a resource for co-location of 3G and 4G networks.

The emphasis for wireless 2G, 2.5G and 3G infrastructure planning will be on a regional set of antenna sites that will provide adequate coverage, capacity, and quality of service for the Region as such coverage, capacity and quality of service are defined by objectives and standards set forth in this report. Second generation networks are already in place. Planning issues will relate mostly to coverage and quality of service. Third generation networks are just coming on the scene in Southeastern Wisconsin. Primary planning decisions here relate to planned coverage of the various service providers and their selection of antenna sites.

Fourth generation (4G) wireless infrastructure planning will proceed with significantly different objectives and procedures. The primary objective of the 4G plan is to present an imaginative, big broadband (20-100 megabits/second) fixed and mobile wireless plan for the Region that provides universal, region-wide coverage at affordable costs to all citizens of the Region. Current mobile cellular networks operate in the 800-900 MHz frequency bands. PCS networks utilize the 1900 MHz band. Although 3G networks will continue to operate in these same bands, 4G systems will move to higher frequencies such as the 5.2-5.9 GHz range.

Fixed Wireless Networks

Fixed wireless networks in the Region are currently small in size as compared to their mobile cellular/PCS counterparts. They are, however, expected to expand rapidly in the next few years, particularly with the advent of WiMAX technology. Most fixed wireless systems are now managed by Internet Service Providers (ISPs). Because they operate in higher frequency ranges (2.4 GHz or 5.7 GHz), their radius of coverage is limited to about 3 miles from each base station. Since they serve subscribers at fixed locations, there is no need to provide wide coverage, but instead they locate in areas with higher population densities to enhance their revenue potential. Most fixed wireless operators deploy proprietary systems such as the Motorola Canopy System. They tend to serve local areas mostly within a single county. In the future, however, it is expected that larger scale fixed wireless networks will be deployed by larger service providers offering a region-wide broadband service alternative. The advent of WiMAX (IEEE 802.16) technology is expected to lead to a merger of fixed and mobile communications networks all based on Internet operation. Although wireless communcations networks, fixed and mobile, are now generally confined to frequencies below 6 GHz, future systems, particularly mesh network systems, are expected to employ higher frequencies up to and including the 60 GHz band because of the faster transmission rates possible at these frequencies. Although shorter in range coverage and subject to strong atmospheric alternation, these frequency bands will play a role in multihop mesh network configurations. In some deployments, even free space near infrared optical links can expand performance capabilities.

SUMMARY

Regional planning for wireless antenna siting and related infrastructure development combines traditional planning procedures with the methodology of radio frequency systems engineering. A six-step process is followed: beginning with the formulation of objectives and standards, and a determination of the current state of the system in terms of both infrastructure and performance. These two initial steps are followed by the preparation of forecasts of probable future demand for services which establishes the requirements for network coverage and capacity. Alternative plans meeting these requirements are then prepared, tested, and evaluated. The plan test involves computer simulation modeling that permits the evaluation of each alternative plan in terms of ability to meet the objectives and standards. The best plan is then selected for adoption and implementation. Implementation takes place in the form of guidance to private wireless service providers and regulatory agencies concerned; or directly through public sector applications. The regional wireless antenna siting planning process encompasses both fixed and mobile wireless in both their present second (2G) and (3G) generations and fourth generation (4G) technology that merges fixed and wireless telecommunication into one Internet based infrastructure.

Chapter III

OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

Planning is a rational process for formulating and meeting objectives. Therefore, the formulation of objectives is an essential task which must be undertaken before a comprehensive plan can be prepared and evaluated. Objectives guide the preparation of plans and, when converted to specific measures of plan effectiveness, termed standards, provide the structure for evaluating how well the plan meets planning objectives. Because planning objectives provide this basis for plan preparation and evaluation, the formulation of objectives is a particularly important step in the planning process.

Accordingly, a set of recommended objectives with supporting principles and standards was formulated as a part of the wireless antenna study and related infrastructure planning effort. The associated standards perform an important function in plan design since they provide the basis for relating the objectives to alternative plan configurations.

It is important to note that the objectives, principles, and standards presented herein are intended to serve as a basis for determining desired alternative and recommended wireless antenna and related infrastructure. The standards, particularly, must be applied with judgment in the more detailed public and private planning and engineering studies which will be needed during plan implementation. The objectives, principles, and standards formulated herein relate only to the wireless portion of the comprehensive regional telecommunications plan to be prepared by the Regional Planning Commission. The comprehensive plan will include both wireless and wireline elements relating to core as well as access networks. Despite these differences in focus, the objectives, principles, and standards presented herein will also apply to the comprehensive plan. Additional objectives, principles, and standards may be expected, however, to apply to the wireline and core networks of the comprehensive plan.

It is also important to note that the objectives, principles, and standards presented herein were formulated within the context of other objectives, principles, and standards previously adopted by the Regional Planning Commission. These other objectives, principles, and standards relate to socioeconomic, land use, transportation, and sewerage system development within the Region and to environmental protection and enhancement. As such, the telecommunications system development objecttives, principles, and standards are intended to support these other regional development objectives, principles, and standards.

DEFINITIONS

The terms "objective," "principle," "standard," "plan," "policy," and "program" are subject to a range of interpretations. To clarify their meanings, the Regional Planning Commission has defined these terms as they are used within the context of this planning process as follows:

1. Objective: A goal or end toward the attainment of which plans and policies are directed.

2. Principle: A fundamental, generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: A criterion used as a basis of comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: A design which seeks to achieve agreed-upon objectives.

5. Policy: A rule or course of action used to ensure plan implementation.

6. Program: A coordinated series of policies and actions to carry out a plan.

Although this chapter deals with only the first four of these terms, an understanding of their interrelationship and the concepts they represent is essential to the following discussion of objectives, principles, and standards.

To be useful in planning, objectives must be logical and clearly stated. The consideration of objectives for plan design and evaluation is facilitated by complementing each objective with one or more quantifiable standards. These standards are, in turn, directly related to a planning principle which supports the objective. The objectives relate primarily to the provision of universal wireless broadband telecommunications services within the Region, and to the desired performance of the system, its availability, and the overall quality of service. Each objective, together with its supporting principle and standards, is given in the following section. The following objectives, principles and standard, or standards are intended to be used in the formulation and evaluation of alternate wireless antenna siting and related infrastructure plans and in the preparation of a recommended plan that will provide 4G wireless telecommunication services within the Region.

In considering the objectives and supporting standards set forth in this Chapter, it should be recognized that those objectives and supporting standards are intended to be applied at the system planning level, and that the effect of individual facilities on each other, or on the system as a whole, requires the application of mathematical models to quantitatively test alternative systems, thereby permitting adjustment of the subsequent configuration of the system concerned to meet the existing and forecast demand. It should also be recognized that an overall analysis of each alternative system plan considered must be made on the basis of cost. Such an analysis may show that the attainment of one or more of the standards is beyond economic practicality, and that the standard or standards concerned cannot be achieved and must be either reduced or eliminated. It should also be recognized that it is unlikely that any one plan proposal will meet all of the standards fully; and the extent to which each standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan considered to achieve the specific objectives which the given standard or standards compliment. It should be further recognized that certain objectives and standards inherently may be in conflict, requiring resolution through compromise; and that meaningful alternative plan evaluation can only take place through comprehensive assessment of each alternative plan considered against all of the objectives and standards. The selected plan will thus represent a compromise with respect to meeting conflicting objectives supporting standards. Finally, it should be recognized that the standards must be judiciously applied to areas which are already partially or fully served in order to avoid any unreasonable extensive reconstruction programs. Given the important role of the private sector in providing telecommunications facilities and services within the Region, and given the concern of these providers about the continued freedom to operate independently in a competitive market, it is important to note that the following objectives, principles, and standards are not intended to have any regulatory implications, but are intended for use solely in plan preparation and evaluation.

OBJECTIVES, PRINCIPLES, AND STANDARDS

Objective No. 1—Broadband Wireless Telecommunications Performance

A level of broadband wireless communications performance that is competitive in a global economy and supports cost effective enhancements of public sector services.

Principle

High quality telecommunication services are vital to the expeditious conduct of national and international business and industrial transactions, and to prompt responses to emergencies. To be competitive in a global economy, the Region requires advanced, low cost broadband telecommunications services, some of which can be provided by wireless telecommunications technology. The services should have a level of availability and continuity which facilitate business and industrial transactions, but which also ensure prompt responses to emergencies.

Standards

- Broadband wireless services should provide a transmission rate in the range of 20 to 200 megabits per second.[1]
- Broadband wireless communication networks should be available 99.9 percent of the time.[2]
- Wireless voice service should be provided at a minimum MOS Standard Value of 4.0.[3]
- Wireless data and video service should be provided at a maximum Uncorrected Bit Error Rate of 15 bits per million bits transmitted.[4]
- Wireless data and video service shall be provided at a maximum packet loss of 10 percent.[5]

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[1]*The generally accepted range for both IEEE 802.16a, d and 4G wireless networks is 20 to 100 megabits per second. The high end target value was raised to meet the needs of high definition television on demand.*

[2]*While wireline telephone service has a general availability standard of 99.999 percent (equivalent to a total of 3 minutes down time per year), wireless service availability has not yet reached this level. The standard of 99.9 percent (equivalent to a total of 8.6 hours of down time per year) is believed to represent an achievable goal by the plan target year 2015.*

[3]*Mean Opinion Score, (MOS) was originally defined based upon a subjective evaluation of voice quality by a group of listeners. It is now objectively defined as an ITU-T P.800 specification, and is determined from a standard formula based upon signal to noise ratio (SNR), line delays, and other factors. The value ranges from 1.0 to 5.0, corresponding to lowest and highest levels of voice quality satisfaction.*

[4]*This error rate was based on the low end of current wireless communications experience.*

[5]*This packet loss percentage was based on the low end of current wireless communications experience.*

Objective No. 2—Universal Wireless Broadband Telecommunications Services

The provision of broadband wireless telecommunication services to all geographic areas of the Region.

Principle

Residents and organizations of the Region, regardless of geographic location, should be offered an equal access to broadband telecommunications services in order to promote the social and economic welfare of the Region.

Standards

- Broadband wireless network coverage should be provided in all geographic areas of the Region and should be available to all residences, businesses, industries, and organizations of the Region.
- In determining wireless network geographic coverage based on radio propagation modeling, the received power standard at the remote should be -80dBmW.
- In determining wireless network geographic coverage based on radio propagation modeing, the signal time/location variability standard should be set at 90 percent.

Objective No. 3—Redundancy

The provision of alternative transmission paths through the individual providers of telecommunication networks so as to minimize network congestion, reduce susceptibility to radio interference, and provide high immunity to catastrophic failure.

Principle

Robust and reliable networks are required in a communications dependent economy and society and in emergency situations.

Standard

- Redundancy is measured based on the average number of alternative transmission paths between users in a network. Desirably, the ratio of the average number of alternative transmission paths to the total number of links in the network should be at least 20 percent.[6]

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[6] *This standard value was based on partial mesh paths in a full mesh topology where the number of links L=N(N-1))/2; and N=number of nodes in network.*

Objective No. 4—Antenna Site Number Optimization
The number of wireless antenna site locations within the Region should be optimized.

Principle
Optimization of the number of antenna sites within a planning area is consistent with minimization of infrastructure investment costs, with the provision of redundancy in the service of each individual provider, and with promotion of environmental protection and the pursuit of a high aesthetic quality in the land and cityscape.

Standard

- The number of antenna sites should be the smallest number that provide universal coverage and quality of service within the Region.

Objective No. 5—Serve Most Demanding Application
Telecommunications systems should be designed to serve the most demanding expected system application, thereby permitting all applications to be accommodated.

Principle
The planned telecommunication system should not preclude needed applications of the system.

Standard

- The planned network bandwidth should be the broadest possible with projected technologies within the planning period; approximately 200 megabits per second.

Objective No. 6—Network Infrastructure Cost Minimization
Achieve the provision of wireless telecommunication networks which are both economical and efficient, meeting all other objectives at the lowest cost possible.

Principle
Minimization of capital and operating costs conserves limited public and private capital resources. Any undue investment in telecommunication facilities and services must occur at the expense of other public and private investment; therefore, total telecommunication costs should be minimized for the desired level of service.

Standard

- The sum total of telecommunication system capital investment and operating costs should be minimized.

- Full use should be made of existing facilities and such facilities should be supplemented only with additional major facilities as necessary to serve the anticipated demand for the desired level of services.

Objective No. 7—Antenna Site Aesthetics and Safety
A high aesthetic quality and safe design in the telecommunication antennae and supporting structures and equipment with proper visual relation to land and cityscape.

Principle
Beauty and safety in the physical environment are conducive to the physical health and well-being of people; and as major features of the land and cityscape, telecommunication facilities have an important impact on the aesthetic quality of the total environment. In order to ensure public safety, careful attention must always be given to structural design principles and practices, including careful conformance to existing regulatory codes.

Standards

- Telecommunication facilities should be located to avoid the destruction of visually pleasing buildings, structures, and natural features, and to avoid interference with visitors to such features.

- Co-location on existing antenna sites is preferred over new antenna support structure deployment.

- Antenna locations on existing buildings, or other existing structures are preferred over new antenna tower construction.

- Antenna structures should be designed, constructed and maintained to insure a safe environment.

- Antenna support structure heights should be minimized consistent, however, with maximizing the potential for antenna co-location, and with providing a potential for height extension and capacity expansion.

Objective No. 8—Preference For Use In Public Safety Emergencies

A broadband wireless communication network that assures capacity for, and provides preference to police, fire, emergency medical, and homeland security agencies for use in times of public emergencies.

Principle

The potential for interagency communication by police, fire, emergency medical, and homeland security agencies in times of public emergencies—such as national disasters including flooding and wind, snow and sleet storms, and freezing rain, and in times of culturally related disasters such as fire, explosions, nuclear electric power generation plant failures, and terrorist attack, must be protected and preserved.

Standard

Public safety related multi-media traffic should be assigned the highest priority based on network port designation and assignment.

UNIVERSAL BROADBAND SERVICE AND AFFORDABILITY

The Commission Advisory Committee recognized the need to define universal broadband telecommunications service in terms of affordability as well as geographic coverage. The Committee could not, however, agree on the percentage of gross monthly household income which should as a maximum be allocated to broadband telecommunication service. The Committee concluded that the issue of affordability needs to be addressed by the Congress and the President at the national level and that adoption of an affordability standard by the Commission should await action at the national level.

APPLICATION—SPECIFIC REQUIREMENTS

The wireless communications performance standard of 20 to 200 megabits per second specified above is ultimately justified based on network applications. The term broadband is often confusing to many as a measure of data transmission rate since it is measured in Hertz (cycles per second). Data transfer rate, however, is measured in bits per second or more typically in megabits (millions of bits) per second. The term broadband derives from the radio frequency spectral bandwidth licensed to a particular service provider or unlicensed to the general public. This bandwidth is measured in Hertz or in the broadband range megahertz (millions of cycles per second) or gigahertz (billions of cycles per second). High data transfer rates require wide or broadband widths. The ratio of data transfer rate to bandwidth expressed in percentage is spectral efficiency. With 100 percent spectral efficiency, 100 megahertz of bandwidth allows for a data transfer rate of 100 megabits per second.

Wide bandwidths and fast data transfer rates are important only as they relate to applications. DSL and cable broadband are often sold to consumers based on faster downloads of Web pages many of which contain images and video. The objectives and standards for this wireless infrastructure plan must also consider other potential public sector and private sector applications that create the need for broadband telecommunication networks.

The dominant underlying media in all advanced broadband applications is video. A brief summary of the bandwidth requirements of the three predominant media reveals the sharp differences in media bandwidth requirements:

1. Voice—64 kilobits per second

2. Data—1 megabit per second

3. Video—5 to 200 megabits per second

Even though many applications require a mix of media to be effective, video bandwidth needs are so much larger that they predominate in multimedia bandwidth specifications. Video band width requirements are a function of: format resolution, frame rate, modulation methods, and compression technology.

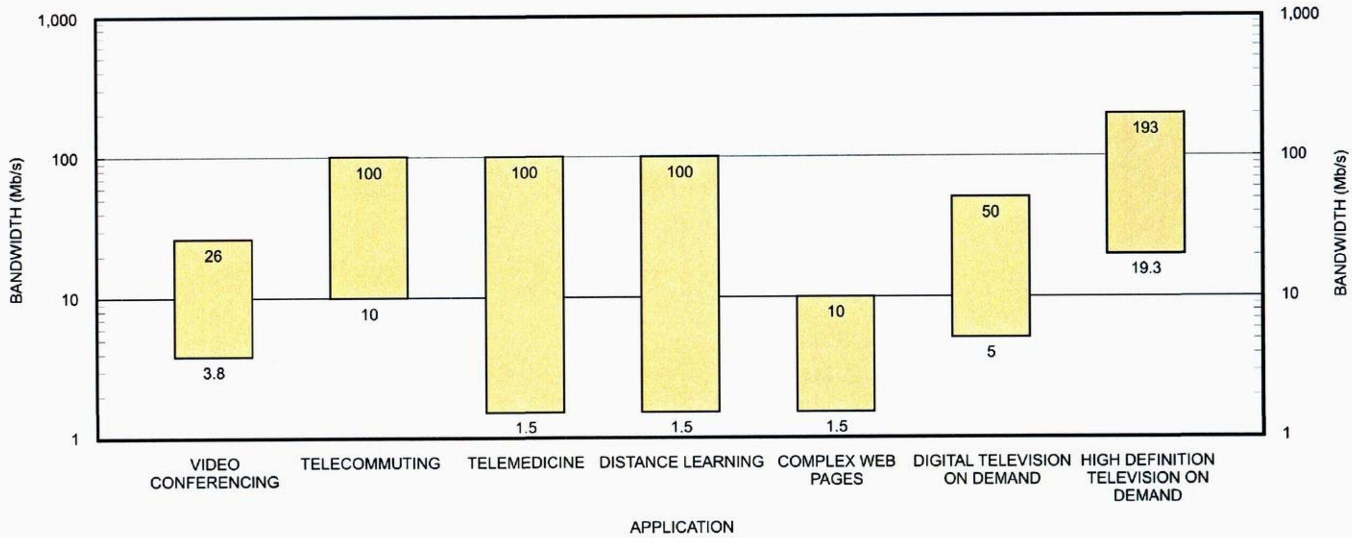
For one form of video communications, video conferencing, a range of bandwidth requirements based on international standard H.393 are:

1. VCR Quality Resolution: 352 x 288 pixels—3.8 megabits per second

2. TV Quality Resolution: 740 x 480 pixels—13.4 megabits per second

Figure 2

VIDEO APPLICATIONS SPEED MATRIX



Source: SEWRPC.

Video teleconferencing plays a key role in many public and private applications of broadband including areas such as telecommuting, home healthcare, and distance learning. It, therefore, represents a key capability in terms of broadband performance. It may, in fact, be the primary application for public sector, business and professional uses of the system.

In the consumer domain, television in both its standard and high definition formats is the equivalent driving force for major broadband capabilities. To accommodate 10 channels of high definition digital television on demand, a network with a bandwidth of about 193 megabits per second will be required. Such an Internet based capacity would allow potential users to purchase televised entertainment services from any content provider serving the Internet.

These two primary examples are given to illustrate the need for a "big broadband" communications capability. It is not possible, or appropriate, to review all potential broadband applications. To indicate the future scope of broadband communications, however, a display of a number of applications and the attendant bandwidth needs are shown in Figure 2.

Chapter IV

INVENTORY FINDINGS–BACKGROUND CONDITIONS

INTRODUCTION

Reliable planning data are essential for the formulation of workable development plans. Consequently, an inventory of existing conditions is the first step in the planning process. The crucial nature of factual information in the planning process should be evident, since no reliable forecasts can be made or alternative courses of action evaluated without knowledge of the current state of the system being planned. The necessary inventory not only provides data describing the existing conditions, but also provide a basis for identifying existing and potential problems in the planning area and opportunities for development. The inventory data are also crucial to the forecasting of future facility and service needs, formulating alternative plans, and evaluating such plans.

Information regarding existing conditions and historic trends with respect to the demographic and economic base, to certain elements of the natural environment, and to certain elements of the man-made environment of the planning area provides a sound foundation for undertaking the telecommunications planning process. The Regional Planning Commission has developed an extensive database pertaining to these and other aspects of the Southeastern Wisconsin Region, updating that database periodically. A major inventory update effort was carried out by the Regional Planning Commission in the early 2000s in support of the preparation of new land use and transportation system plans and other elements of the comprehensive plan for the Region. This section presents a summary of the results of that inventory update pertaining to the population, economy, land use pattern, natural and agricultural resource base, and the transportation system within the Region.

DEMOGRAPHIC AND ECONOMIC BASE

Population[1]

Historic Trends and Distribution Among Counties

The total resident population of the Region stood at 1,931,200 in 2000, compared to 1,810,400 in 1990. The increase of 120,800 persons, or 7 percent, in the regional population during the 1990's is substantially greater than the increase experienced during the 1970s (8,700 persons) and 1980s (45,600 persons)—but less than the increases of 333,000 persons and 182,500 persons experienced during the 1950s and 1960s, respectively (see Table 1).

In relative terms, the Region's population grew at a somewhat slower rate than the population of the State and of the United States during the 1990's. As a result, the regional share of the State population,

[1]*The Regional Planning Commission conducted a detailed inventory and analysis of the regional population in 2004 following the release of the 2000 Federal census. The findings are presented in detail in SEWRPC Technical Report No. 11 (4th Edition),* The Population of Southeastern Wisconsin, *dated July 2004.*

Table 1

POPULATION TRENDS IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1950-2000

Year	Region			Wisconsin			United States			Regional Population as a Percent of:	
	Population	Change from Preceding Year		Population	Change from Preceding Year		Population	Change from Preceding Year			
		Number	Percent		Number	Percent		Number	Percent	Wisconsin	United States
1950	1,240,618	- -	- -	3,434,575	- -	- -	151,325,798	- -	- -	36.1	0.82
1960	1,573,614	332,996	26.8	3,951,777	517,202	15.1	179,323,175	27,997,377	18.5	39.8	0.88
1970	1,756,083	182,469	11.6	4,417,821	466,044	11.8	203,302,031	23,978,856	13.4	39.7	0.86
1980	1,764,796	8,713	0.5	4,705,642	287,821	6.5	226,504,825	23,202,794	11.4	37.5	0.78
1990	1,810,364	45,568	2.6	4,891,769	186,127	4.0	249,632,692	23,127,867	10.2	37.0	0.73
2000	1,931,165	120,801	6.7	5,363,675	471,906	9.6	281,421,906	31,789,214	12.7	36.0	0.69

Source: U.S. Bureau of the Census and SEWRPC.

decreased slightly, from 37 percent to 36 percent while the regional share of the national population also declined. As indicated in Table 1, the regional share of the State and national populations has been gradually decreasing since 1960.

During the 1990s, six of the constituent counties of the Region experienced significant population growth, while Milwaukee County lost population. Waukesha County experienced the greatest gain in population during the 1990s, increasing by 56,100 persons. Kenosha, Ozaukee, Racine, Walworth, and Washington Counties gained between 9,400 and 22,200 persons each. Milwaukee County lost 19,100 persons.

The past decade saw further change in the relative distribution of the population among the counties of the Region, continuing long-term trends in this respect (see Table 2 and Figure 3). Milwaukee County's share of the regional population decreased by about 4 percentage points during the 1990s, while the share of each of the other six counties increased. Over the past fifty years, the most notable change in the distribution has been the increase in Waukesha County's share, from 7 percent to 19 percent of the regional population, and the decrease in Milwaukee County's share, from 70 percent to 49 percent.

Components of Population Change

Population change can be attributed to natural increase and net migration. Natural increase is the balance between births and deaths in an area over a given period of time; it can be measured directly from historical records on the number of births and deaths for an area. Net migration is the balance between migration to and from an area over a given period of time; as a practical matter, net migration is often determined as a derived number, obtained by subtracting natural increase from total population change for the time period concerned.

Of the total population increase of 120,800 persons in the Region between 1990 and 2000, 116,900 can be attributed to natural increase; the balance to modest net in-migration—about 3,900 persons. The level of natural increase in the Region has been relatively stable since the 1970s, averaging about 119,000 persons per decade (see Table 3 and Figure 4). This is significantly lower than the levels experienced during the 1950s and 1960s—which include much of the post-World War II baby-boom era—when natural increase in the Region reached very high levels of 224,500 and 202,400 persons, respectively.

As noted above, the Region experienced a modest net in-migration during the 1990s—the first decade since the 1950s that the Region as a whole experienced positive net migration. The net in-migration of 3,900 persons for the Region during the 1990s followed three decades of net out-migration—out-migrations of 81,800 persons during the 1980s, 104,400 persons during the 1970s, and 19,900 persons during the 1960s.

An important aspect of net migration is the in-migration of persons to the Region from abroad. There was a significant movement of foreign-born persons into the Region during the 1990s. About 45,400 foreign-born persons in the Region in 2000 were reported by the U.S. Census Bureau to have entered the country between 1990 and 2000; this is significantly greater than the figures ranging from 12,300 to 18,300 reported in the 1970, 1980, and 1990 censuses. The increase in the foreign born

Table 2

POPULATION IN THE REGION BY COUNTY: 1950-2000

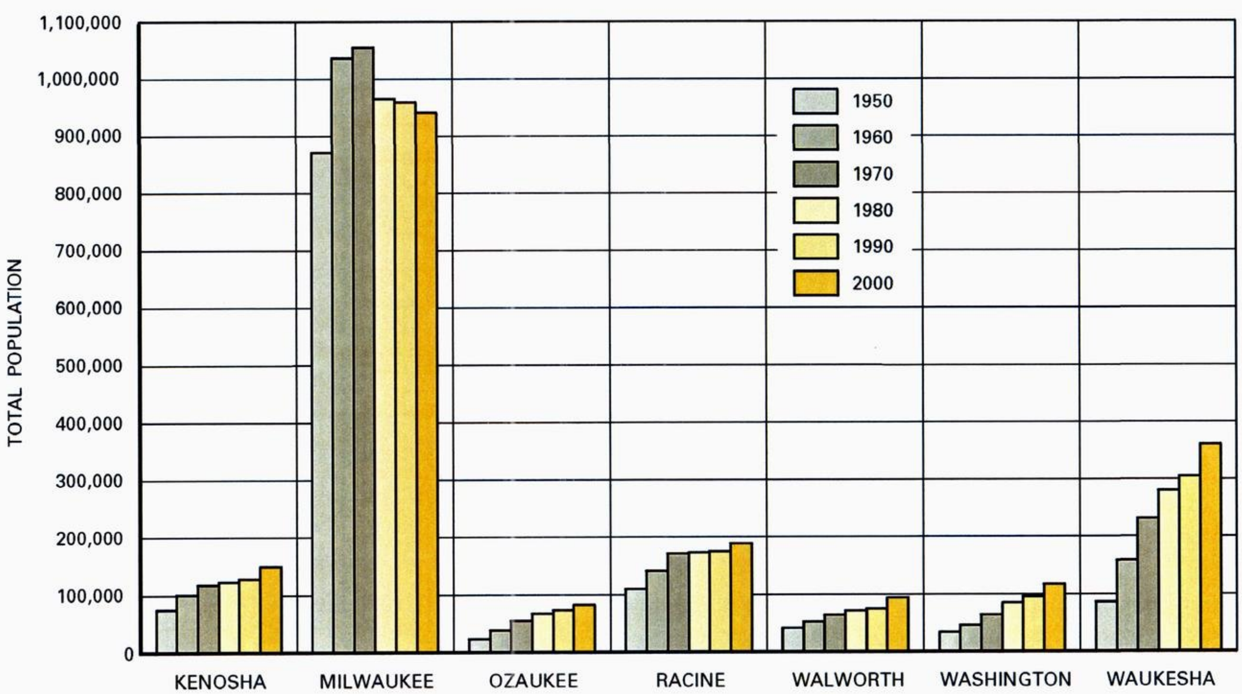
County	Total Population											
	1950		1960		1970		1980		1990		2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Kenosha	75,238	6.1	100,615	6.4	117,917	6.7	123,137	7.0	128,181	7.1	149,577	7.7
Milwaukee	871,047	70.2	1,036,041	65.8	1,054,249	60.1	964,988	54.7	959,275	53.0	940,164	48.7
Ozaukee	23,361	1.9	38,441	2.5	54,461	3.1	66,981	3.8	72,831	4.0	82,317	4.3
Racine	109,585	8.8	141,781	9.0	170,838	9.7	173,132	9.8	175,034	9.7	188,831	9.8
Walworth	41,584	3.4	52,368	3.3	63,444	3.6	71,507	4.0	75,000	4.1	92,013	4.7
Washington	33,902	2.7	46,119	2.9	63,839	3.6	84,848	4.8	95,328	5.3	117,496	6.1
Waukesha	85,901	6.9	158,249	10.1	231,335	13.2	280,203	15.9	304,715	16.8	360,767	18.7
Region	1,240,618	100.0	1,573,614	100.0	1,756,083	100.0	1,764,796	100.0	1,810,364	100.0	1,931,165	100.0

County	Population Change									
	1950-1960		1960-1970		1970-1980		1980-1990		1990-2000	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	25,377	33.7	17,302	17.2	5,220	4.4	5,044	4.1	21,396	16.7
Milwaukee	164,994	18.9	18,208	1.8	-89,261	-8.5	-5,713	-0.6	-19,111	-2.0
Ozaukee	15,080	64.6	16,020	41.7	12,520	23.0	5,850	8.7	9,486	13.0
Racine	32,196	29.4	29,057	20.5	2,294	1.3	1,902	1.1	13,797	7.9
Walworth	10,784	25.9	11,076	21.2	8,063	12.7	3,493	4.9	17,013	22.7
Washington	12,217	36.0	17,720	38.4	21,009	32.9	10,480	12.4	22,168	23.3
Waukesha	72,348	84.2	73,086	46.2	48,868	21.1	24,512	8.7	56,052	18.4
Region	332,996	26.8	182,469	11.6	8,713	0.5	45,568	2.6	120,801	6.7

Source: U.S. Bureau of the Census and SEWRPC.

Figure 3

POPULATION IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of the Census and SEWRPC.

Table 3

LEVELS OF POPULATION CHANGE, NATURAL INCREASE, AND NET MIGRATION FOR THE REGION BY COUNTY: 1950-2000

County	1950-1960			1960-1970			1970-1980		
	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration
Kenosha	25,377	13,931	11,446	17,302	15,125	2,177	5,220	7,746	-2,526
Milwaukee	164,994	150,141	14,853	18,208	122,192	-103,984	-89,261	60,105	-149,366
Ozaukee	15,080	5,926	9,154	16,020	6,090	9,930	12,520	4,798	7,722
Racine	32,196	21,473	10,723	29,057	20,441	8,616	2,294	12,842	-10,548
Walworth	10,784	5,733	5,051	11,076	4,685	6,391	8,063	2,451	5,612
Washington	12,217	7,501	4,716	17,720	8,122	9,598	21,009	7,163	13,846
Waukesha	72,348	19,746	52,602	73,086	25,699	47,387	48,868	18,011	30,857
Region	332,996	224,451	108,545	182,469	202,354	-19,885	8,713	113,116	-104,403

County	1980-1990			1990-2000		
	Population Change	Natural Increase	Net Migration	Population Change	Natural Increase	Net Migration
Kenosha	5,044	8,177	-3,133	21,396	9,365	12,031
Milwaukee	-5,713	69,529	-75,242	-19,111	64,145	-83,256
Ozaukee	5,850	5,141	709	9,486	3,916	5,570
Racine	1,902	13,720	-11,818	13,797	11,127	2,670
Walworth	3,493	2,939	554	17,013	2,592	14,421
Washington	10,480	7,756	2,724	22,168	7,159	15,009
Waukesha	24,512	20,068	4,444	56,052	18,582	37,470
Region	45,568	127,330	-81,762	120,801	116,886	3,915

Source: U.S. Bureau of the Census, Wisconsin Department of Health and Family Services, and SEWRPC.

population, including a significant Hispanic component, is an important aspect of the population migration pattern for the Region during the 1990s.

Households

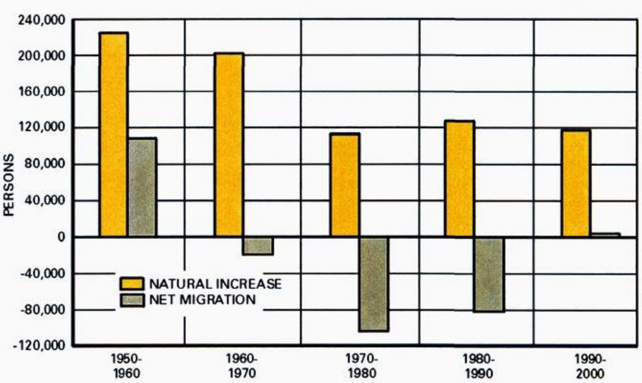
Historic Trends and Distribution Among Counties

In addition to resident population, the number of households, or occupied housing units, is of importance in telecommunications planning. Households directly influence the demand for urban land as well as the demand for transportation and other public facilities and services such as telecommunications facilities and services. By definition, a household includes all persons who occupy a housing unit—defined by the Census Bureau as a house, an apartment, a mobile home, a group of rooms, or a single-room that is occupied, or intended for occupancy, as a separate living quarter.

The number of households in the Region increased by 72,900 households, or 11 percent, from 676,100 households in 1990, to 749,000 households in 2000.

Figure 4

COMPONENTS OF POPULATION CHANGE IN THE REGION: 1950-2000



Source; U.S. Bureau of the Census, Wisconsin Department of Health and Family Services, and SEWRPC.

This follows increases of 48,200 households during the 1980s; 91,500 households during the 1970s; 70,600 households during the 1960s; and 111,400 households during the 1950s.

During the 1990s, all counties in the Region experienced increases in the number of households, led by Waukesha County, which gained 29,200 households, an increase of 28 percent. Milwaukee County gained 4,700 households—a 1 percent increase—during the 1990s, despite experiencing a decrease in total population. Changes in the distribution of households in the Region going back 50 years are indicated in Table 4 and Figure 5. These changes are similar to the distributional changes in the total population.

Household Size

In relative terms, the rate of growth in households in the Region during the 1990s, 10.8 percent, exceeded the rate of growth in the total population, 6.7 percent, as well as the rate of growth in the household population, 6.6 percent. Similar patterns were observed over each of the four previous decades. For the past 50 years overall, the number of households in the Region increased by 111 percent, while the total population increased by 56 percent and the household population increased by 58 percent. These differential growth rates between households and population are reflected in a declining average household size in the Region.

For the Region as a whole, the average household size—calculated as the household population divided by the number of households—was 2.52 persons in 2000 (see Table 5). During the 1990s, the average household size in the Region decreased by about 0.10 person per household, or about 4 percent, from the 1990 figure of 2.62 persons. The decrease in household size during the 1990s represents a continuation of a long-term trend in declining average household size for the Region over the past 50 years. A particularly large decrease in the average household size for the Region occurred between 1970 and 1980. Each of the seven counties in the Region has experienced a similar long-term trend of declining household size, traceable back to the 1970 or prior censuses. The decline in household size is related in part to changing household types in the Region. Single-person households and other non-family households have increased at a much faster rate than family households in the Region over the past three decades.

Employment[2]

Historic Trends and Distribution Among Counties

Information regarding the number and type of employment opportunities, or jobs, in an area is an important measure of the size and structure of the area's economy. Employment data presented in this section pertain to both wage and salary employment and the self-employed, and include both full-time and part-time jobs.

Total employment in the Region stood at 1,222,800 jobs in 2000, compared to 1,062,600 jobs in 1990. The increase of 160,200 jobs during the 1990s compares to 114,400 during the 1980s; 163,300 during the 1970s; 111,900 during the 1960s; and 99,500 during the 1950s (see Table 6).

In relative terms, employment in the Region grew at a somewhat slower rate than both the State and the Nation during the 1990s. As a result, the Region's share of total State employment decreased from about 38 percent to about 36 percent, with the regional share of national employment also showing a slight decrease.

Historically, employment levels, both nationally and within the Region, tend to fluctuate in the short-term, rising and falling in accordance with business cycles. The long period of nearly uninterrupted job growth between 1983 and 2000 is unusual in this respect. Nationally and within the Region, total employment increased each year during that time, with the exception of a slight decrease in 1991. The extended period of employment growth in the Region ended after 2000, with total employment in the Region decreasing each year between 2000 and 2003. Estimated total employment in the Region stood at 1,179,000 jobs in 2003, about 4 percent below the 2000 level.

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[2] *The Regional Planning Commission conducted a detailed inventory and analysis of the regional economy in 2004. The findings are presented in detail in SEWRPC Technical Report No. 10 (4th Edition),* The Economy of Southeastern Wisconsin, *dated July 2004.*

Table 4

HOUSEHOLDS IN THE REGION BY COUNTY: 1950-2000

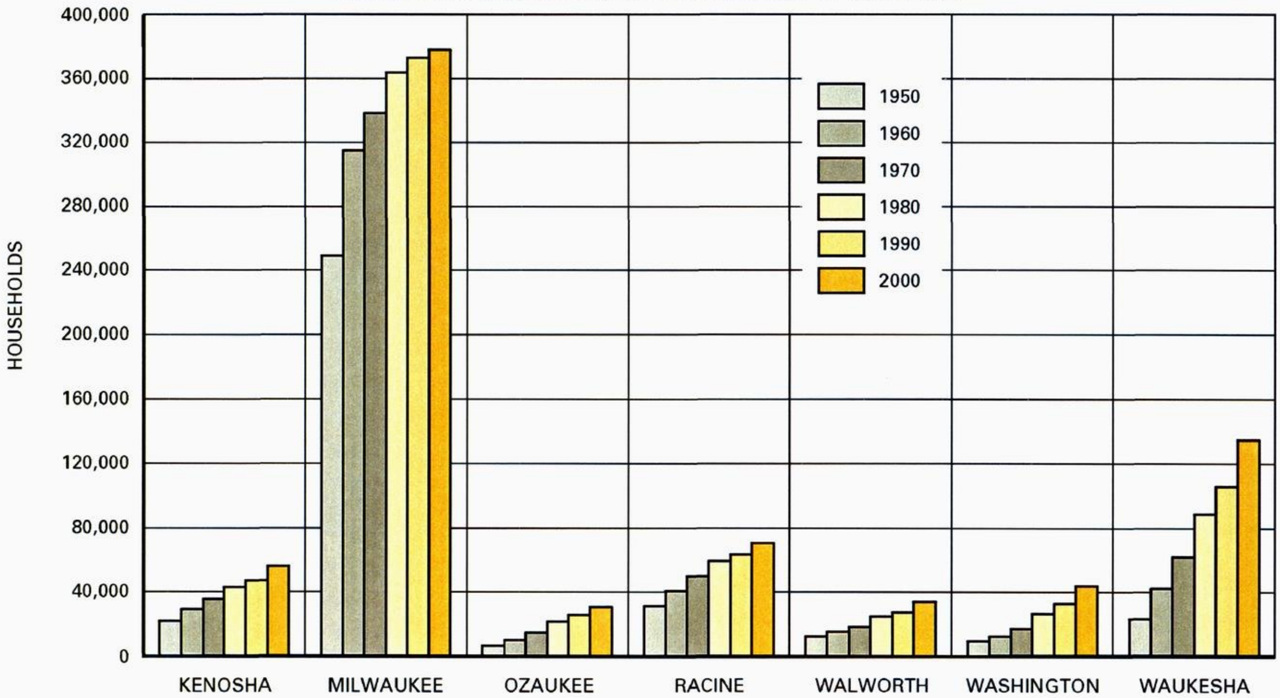
County	Total Households											
	1950		1960		1970		1980		1990		2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Kenosha	21,958	6.2	29,545	6.4	35,468	6.6	43,064	6.9	47,029	6.9	56,057	7.5
Milwaukee	249,232	70.3	314,875	67.6	338,605	63.1	363,653	57.9	373,048	55.2	377,729	50.4
Ozaukee	6,591	1.9	10,417	2.2	14,753	2.8	21,763	3.5	25,707	3.8	30,857	4.1
Racine	31,399	8.8	40,736	8.7	49,796	9.3	59,418	9.5	63,736	9.4	70,819	9.5
Walworth	12,369	3.5	15,414	3.3	18,544	3.5	24,789	3.9	27,620	4.1	34,505	4.6
Washington	9,396	2.7	12,532	2.7	17,385	3.2	26,716	4.2	32,977	4.9	43,843	5.8
Waukesha	23,599	6.6	42,394	9.1	61,935	11.5	88,552	14.1	105,990	15.7	135,229	18.1
Region	354,544	100.0	465,913	100.0	536,486	100.0	627,955	100.0	676,107	100.0	749,039	100.0

County	Household Change									
	1950-1960		1960-1970		1970-1980		1980-1990		1990-2000	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	7,587	34.6	5,923	20.0	7,596	21.4	3,965	9.2	9,028	19.2
Milwaukee	65,643	26.3	23,730	7.5	25,048	7.4	9,395	2.6	4,681	1.3
Ozaukee	3,826	58.0	4,336	41.6	7,010	47.5	3,944	18.1	5,150	20.0
Racine	9,337	29.7	9,060	22.2	9,622	19.3	4,318	7.3	7,083	11.1
Walworth	3,045	24.6	3,130	20.3	6,245	33.7	2,831	11.4	6,885	24.9
Washington	3,136	33.4	4,853	38.7	9,331	53.7	6,261	23.4	10,866	32.9
Waukesha	18,795	79.6	19,541	46.1	26,617	43.0	17,438	19.7	29,239	27.6
Region	111,369	31.4	70,573	15.1	91,469	17.0	48,152	7.7	72,932	10.8

Source: U.S. Bureau of the Census and SEWRPC.

Figure 5

HOUSEHOLDS IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of the Census and SEWRPC.

Table 5

AVERAGE HOUSEHOLD SIZE IN THE REGION BY COUNTY: 1950-2000

County	Average Persons per Household					
	1950	1960	1970	1980	1990	2000
Kenosha	3.36	3.36	3.26	2.80	2.67	2.60
Milwaukee	3.34	3.21	3.04	2.59	2.50	2.43
Ozaukee	3.51	3.65	3.66	3.04	2.79	2.61
Racine	3.37	3.39	3.35	2.86	2.70	2.59
Walworth	3.25	3.28	3.16	2.74	2.60	2.57
Washington	3.55	3.64	3.63	3.14	2.86	2.65
Waukesha	3.51	3.66	3.66	3.11	2.83	2.63
Region	3.36	3.30	3.20	2.75	2.62	2.52

Source: U.S. Bureau of the Census and SEWRPC.

Table 6

EMPLOYMENT IN THE REGION, WISCONSIN, AND THE UNITED STATES: 1950-2000

Year	Region			Wisconsin			United States			Regional Employment as a percent of:	
	Jobs	Change from Preceding Year		Jobs	Change from Preceding Year		Jobs	Change from Preceding Year			
		Number	Percent		Number	Percent		Number	Percent	Wisconsin	United States
1950	573,500	- -	- -	1,413,400	- -	- -	61,701,200	- -	- -	40.6	0.93
1960	673,000	99,500	17.3	1,659,400	246,000	17.4	72,057,000	10,355,800	16.8	40.6	0.93
1970	784,900	111,900	16.6	1,929,100	269,700	16.3	88,049,600	15,992,600	22.2	40.7	0.89
1980	948,200	163,300	20.8	2,429,800	500,700	26.0	111,730,200	23,680,600	26.9	39.0	0.85
1990	1,062,600	114,400	12.1	2,810,400	380,600	15.7	136,708,900	24,978,700	22.4	37.8	0.78
2000	1,222,800	160,200	15.1	3,421,800	611,400	21.8	165,209,800	28,500,900	20.8	35.7	0.74

NOTE: Excludes military employment.

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Information on current and historic employment levels is presented by county in (Table 7 and Figure 6). Each county in the Region experienced an increase in employment between 1990 and 2000. With an increase of 81,100 jobs, Waukesha County accounted for just over half of the total increase in the regional employment during the 1990s. Among the other six counties, the growth in employment during the 1990s ranged from 4,800 jobs in Racine County to 16,500 jobs in Kenosha County.

Between 1990 and 2000, Milwaukee and Racine Counties decreased in their share of total regional employment while the share of each of the other five counties increased. Over the past five decades, Milwaukee County has experienced a substantial decrease in its share of regional employment; Waukesha County has experienced a substantial increase; and Ozaukee, Walworth, and Washington Counties have experienced gradual increases. In Kenosha and Racine Counties, the share of total regional employment in 2000 was about the same as in 1950, with some fluctuations occurring over the intervening decades.

Substantial job growth has also occurred in the counties located immediately south of the Region. Employment in Lake and McHenry Counties (Illinois), combined increased by about 146,800 jobs during the 1990s. By 2000 total employment in Lake and McHenry Counties combined stood at 505,200 jobs. A significant number of Kenosha and Walworth County residents find employment in Northeastern Illinois.

Table 7

EMPLOYMENT IN THE REGION BY COUNTY: 1950-2000

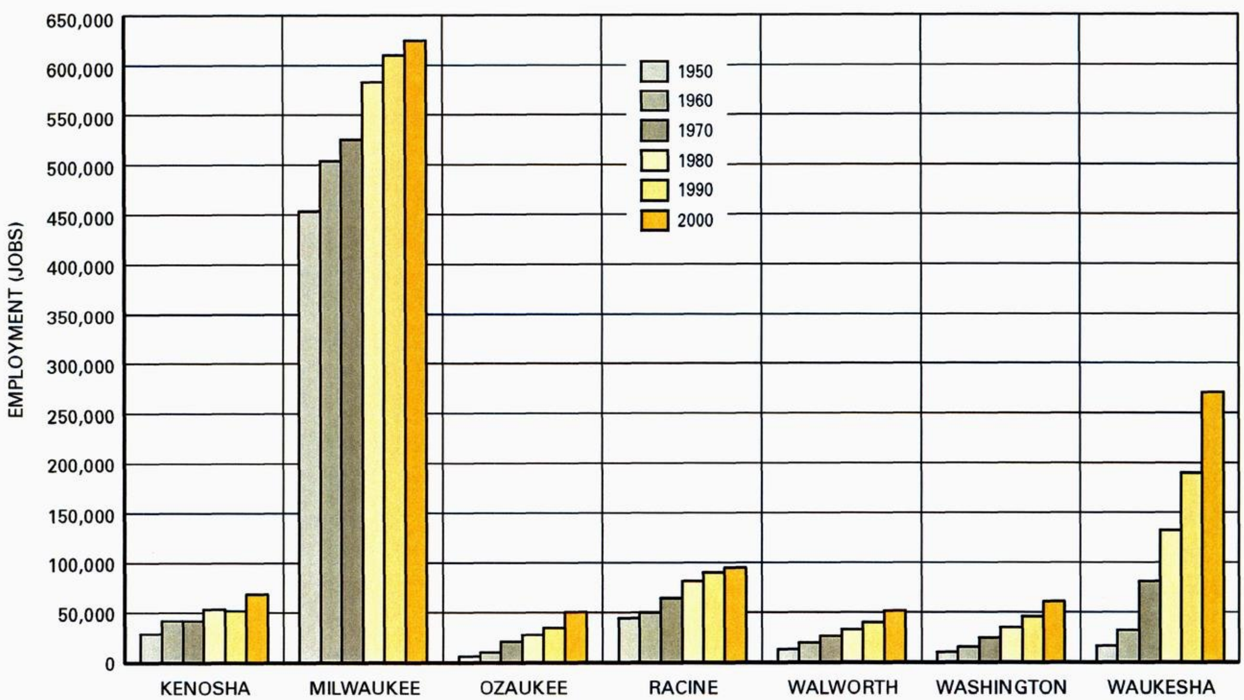
County	Total Employment (Jobs)											
	1950		1960		1970		1980		1990		2000	
	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Kenosha	29,100	5.1	42,200	6.3	42,100	5.4	54,100	5.7	52,200	4.9	68,700	5.6
Milwaukee	453,500	79.1	503,300	74.8	525,200	66.9	583,200	61.5	609,800	57.4	624,600	51.1
Ozaukee	6,600	1.0	10,200	1.5	21,300	2.7	28,200	3.0	35,300	3.3	50,800	4.2
Racine	44,500	7.8	49,900	7.4	64,600	8.2	81,200	8.6	89,600	8.4	94,400	7.7
Walworth	13,200	2.3	19,600	2.9	26,400	3.4	33,500	3.5	39,900	3.8	51,800	4.2
Washington	10,200	1.8	15,200	2.3	24,300	3.1	35,200	3.7	46,100	4.3	61,700	5.0
Waukesha	16,400	2.9	32,600	4.8	81,000	10.3	132,800	14.0	189,700	17.9	270,800	22.2
Region	573,500	100.0	673,000	100.0	784,900	100.0	948,200	100.0	1,062,600	100.0	1,222,800	100.0

County	Employment Change									
	1950-1960		1960-1970		1970-1980		1980-1990		1990-2000	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Kenosha	13,100	45.0	-100	-0.2	12,000	28.5	-1,900	-3.5	16,500	31.6
Milwaukee	49,800	11.0	21,900	4.4	58,000	11.0	26,600	4.6	14,800	2.4
Ozaukee	3,600	54.5	11,100	108.8	6,900	32.4	7,100	25.2	15,500	43.9
Racine	5,400	12.1	14,700	29.5	16,600	25.7	8,400	10.3	4,800	5.4
Walworth	6,400	48.5	6,800	34.7	7,100	26.9	6,400	19.1	11,900	29.8
Washington	5,000	49.0	9,100	59.9	10,900	44.9	10,900	31.0	15,600	33.8
Waukesha	16,200	98.8	48,400	148.5	51,800	64.0	56,900	42.8	81,100	42.8
Region	99,500	17.3	111,900	16.6	163,300	20.8	114,400	12.1	160,200	15.1

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Figure 6

EMPLOYMENT IN THE REGION BY COUNTY: 1950-2000



Source: U.S. Bureau of Economic Analysis and SEWRPC.

Table 8

EMPLOYMENT BY GENERAL INDUSTRY GROUP IN THE REGION: 1970-2000

	Employment								Percent Change in Employment			
	1970		1980		1990		2000					
General Industry Group	Jobs	Percent of Total	Jobs	Percent of Total	Jobs	Percent of Total	Jobs	Percent of Total	1970-1980	1980-1990	1990-2000	1970-2000
Agriculture	12,000	1.5	10,000	1.0	7,200	0.7	6,000	0.5	-16.7	-28.0	-16.7	-50.0
Construction	32,400	4.1	33,900	3.6	45,100	4.2	53,800	4.4	4.6	33.0	19.3	66.0
Manufacturing	254,400	32.4	264,200	27.9	223,500	21.0	224,300	18.3	3.9	-15.4	0.4	-11.8
Transportation, Communication, and Utilities	38,500	4.9	42,200	4.4	46,300	4.4	54,800	4.5	9.6	9.7	18.4	42.3
Wholesale Trade	37,200	4.7	46,200	4.9	55,300	5.2	64,400	5.3	24.2	19.7	16.5	73.1
Retail Trade	133,900	17.1	153,900	16.2	185,400	17.4	193,700	15.8	14.9	20.5	4.5	44.7
Finance, Insurance, and Real Estate	47,600	6.1	75,600	8.0	81,800	7.7	93,700	7.7	58.8	8.2	14.5	96.8
Services	141,800	18.1	216,700	22.8	304,700	28.7	406,000	33.2	52.8	40.6	33.2	186.3
Government and Government Enterprises[a]	84,400	10.8	101,100	10.7	106,200	10.0	114,400	9.3	19.8	5.0	7.7	35.5
Other[b]	2,700	0.3	4,400	0.5	7,100	0.7	11,700	1.0	63.0	61.4	64.8	333.3
Total	784,900	100.0	948,200	100.0	1,062,600	100.0	1,222,800	100.0	20.8	12.1	15.1	55.8

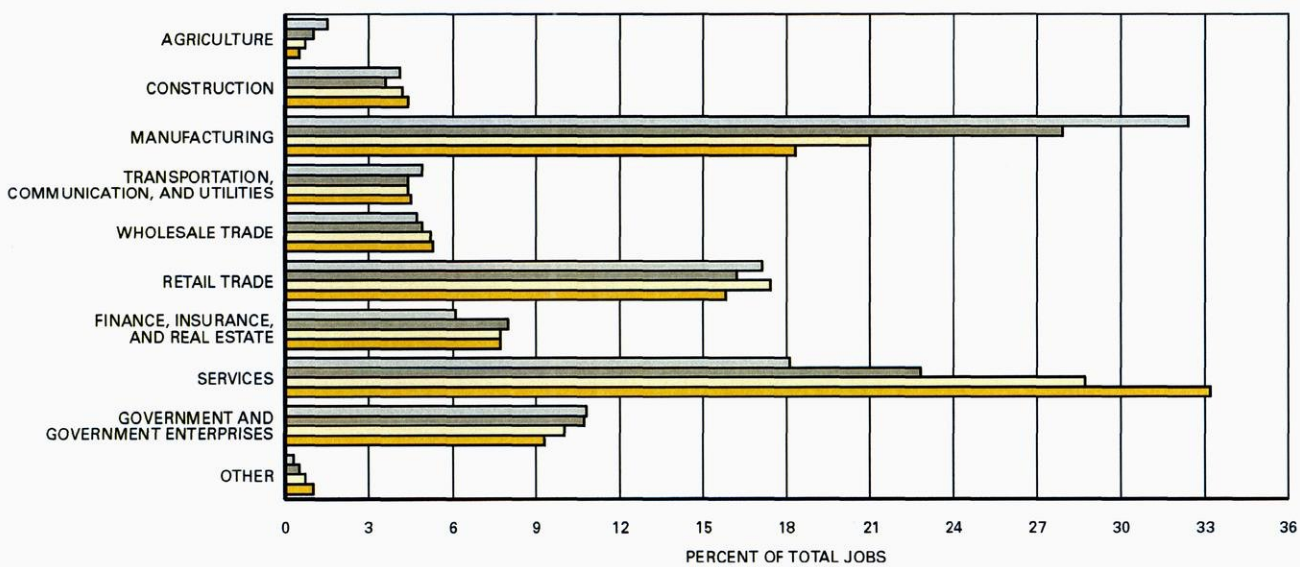
[a] *Includes all nonmilitary government agencies and enterprises.*

[b] *Includes agricultural services, forestry, commercial fishing, mining, and unclassified jobs.*

Source: U.S. Bureau of Economic Analysis and SEWRPC.

Figure 7

PERCENT DISTRIBUTION OF EMPLOYMENT BY GENERAL INDUSTRY GROUP IN THE REGION: 1970, 1980, 1990, AND 2000



Source: U.S. Bureau of Economic Analysis and SEWRPC.

Employment by Industry

Information regarding employment by industry group provides insight into the structure of the regional economy and changes in that structure over time. As indicated in Table 8 and Figure 7, the services sector made up the largest proportion of regional employment in 2000, accounting for 33 percent of total employment. This was followed by manufacturing and retail trade, with 18 percent and 16 percent of total regional employment, respectively. Together, these three sectors accounted for roughly two-thirds of regional employment in 2000.

The 1990s saw a continuation of a shift in the regional economy from a manufacturing to a service orientation. Manufacturing employment in the Region was virtually unchanged during the 1990s, following a 15 percent decrease during the 1980s, and a modest 4 percent increase during the 1970s. Conversely, service-related employment increased substantially during each of the past three decades—by 33 percent during the 1990s, 41 percent during the 1980s, and 53 percent during 1970s. Due to these differential growth rates, the proportion of manufacturing jobs relative to total jobs in the Region decreased from 32 percent in 1970 to 18 percent in 2000, while service-related employment increased from 18 percent in 1970 to 33 percent in 2000. In comparison to the manufacturing and services industry groups, other major industry groups—such as wholesale trade, retail trade, government, and finance, insurance and real estate—have been relatively stable in terms of their share of total employment in the Region over the last three decades.

The State of Wisconsin and the United States have experienced a similar shift from manufacturing to service-related employment. However, the trend in manufacturing employment for the State overall has been more robust than for the Region. Manufacturing employment in the State increased by 24 percent between 1970 and 2000; the Region's manufacturing employment decreased by 12 percent during this time. While historically the Region exceeded the State in the proportion of manufacturing jobs relative to total jobs, by 2000 the Region and State had about the same proportion of jobs in manufacturing—just over 18 percent. In comparison, manufacturing jobs comprised about 12 percent of all jobs in the Nation in 2000.

LAND USE

The Commission relies on two types of inventories and analyses in order to monitor urban growth and development in the Region—an urban growth ring analysis and a land use inventory. The urban growth ring analysis delineates the outer limits of concentrations of urban development and depicts the urbanization of the Region over the past 150 years. When related to urban population levels, the urban growth ring analysis provides a good basis for calculating urban population and household densities. By contrast, the Commission land use inventory is a more detailed inventory that places all land and water areas of the Region into one of 66 discrete land use categories, providing a basis for analyzing specific urban and nonurban land uses. Both the urban growth ring analysis and the land use inventory for the Region have been updated to the year 2000 under the continuing regional planning program.

Urban Growth Ring Analysis

The urban growth ring analysis illustrates the historical pattern of urban settlement, growth, and development of the Region since 1850 for selected points in time. Areas identified as urban under this time series analysis include areas of the Region where residential structures or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of residential, commercial, industrial, governmental, institutional, or other urban land uses. In addition, the identified urban areas encompass certain open space lands such as urban parks and small areas being preserved for resource conservation purposes within the urban areas.[3]

As part of the urban growth ring analysis, urban growth for the years prior to 1940 was identified using a variety of sources, including the records of local historical societies; land subdivision plat records; farm plat maps; U.S. Geological Survey topographic maps; and Wisconsin Geological and Natural History Survey records. Urban growth for

[3] *As part of the urban growth ring analysis, urban areas are defined as concentrations of residential, commercial, industrial, governmental, or institutional buildings or structures, along with their associated yards, parking, and service areas, having a combined area of five acres or more. In the case of residential uses, such areas must include at least 10 structures—over a maximum distance of one-half mile—located along a linear feature, such as a roadway or lakeshore, or at least 10 structures located in a relatively compact group within a residential subdivision. Urban land uses which do not meet these criteria because they lack the concentration of buildings or structures—such as cemeteries, airports, public parks, golf courses—are identified as urban where such uses are surrounded on at least three sides by urban land uses that do meet the aforereferenced criteria.*

the years 1940, 1950, 1963, 1970, 1980, 1990, and 2000 was identified using aerial photographs. Because of limitations inherent in the source materials, information presented for the years prior to 1940 represents the extent of urban development at approximately those points in time, whereas the information presented for later years can be considered precisely representative of those respective points in time.

The urban growth ring analysis, updated through 2000, is presented graphically on Map 2. In 1850, the urban portion of the Region was concentrated primarily in the larger urban centers located at Burlington, Kenosha, Milwaukee, Racine, Waukesha, and West Bend, along with many smaller settlements throughout the Region. Over the 100-year period from 1850 to 1950, urban development in the Region occurred in a pattern resembling concentric rings around existing urban centers, resulting in a relatively compact regional settlement pattern. After 1950, there was a significant change in the pattern and rate of urban development in the Region. While substantial amounts of development continued to occur adjacent to established urban centers, considerable development also occurred in isolated enclaves in outlying areas of the Region. Map 2 indicates a continuation of this trend during the 1990s, with significant amounts of development occurring adjacent to existing urban centers, and with considerable development continuing to occur in scattered fashion in outlying areas.

The urban growth ring analysis, in conjunction with the Federal censuses, provides a basis for calculating urban population and household densities in the Region and changes in density over time. Table 9 relates the urban area identified by the urban growth ring analysis with the urban population and households, going back to 1940.[4] In Table 9, the "urban population" is the total population of the Region excluding the rural farm population, as reported by the U.S. Bureau of the Census; similarly, "urban households" as reported in that table consist of all households other than rural farm households.[5]

As indicated in Table 9, the population density of the urban portion of the Region—as identified by the urban growth ring analysis—decreased significantly, from 10,700 persons per square mile in 1940 to about 5,100 persons per square mile in 1970, 3,900 persons per square mile in 1980, and 3,500 persons per square mile in 1990. During the 1990s, the urban population density decreased slightly—to about 3,300 persons per square mile in 2000. The long-term decrease in the urban population density is due in part to a trend toward lower density residential development. The decrease is also attributable, in part, to significant increases in the number of jobs—jobs having increased at a faster rate than population since 1960—and the attendant increase in commercial and industrial development in the Region. Part of the decrease in the urban population density also relates to the fact that the number of persons per household—the household being the basic unit of demand for residential development—has decreased by 25 percent since 1950.

A different density trend for the Region emerges when urban density is calculated based upon households rather than population (see Figure 8). Since 1963, the relative decrease in urban household density has been much lower than the decrease in urban population density. Between 1963 and 2000, the urban household density decreased by 23 percent, compared to a 43 percent decrease in the urban population density.

Land Use Inventory

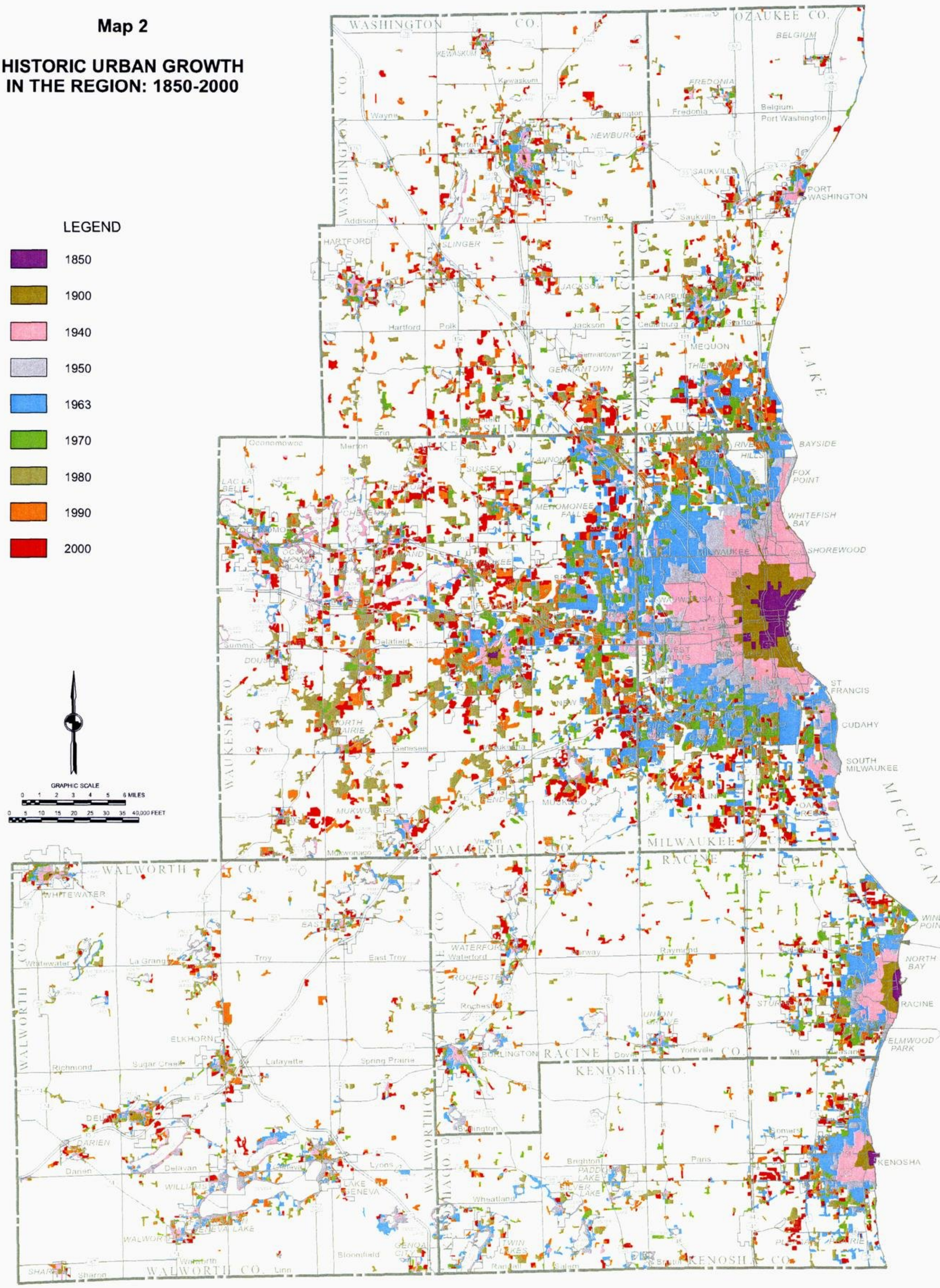
The Commission land use inventory is intended to serve as a relatively precise record of land use for the entire area of the Region at selected points in time. The land use classification system used in the inventory consists of nine major categories which are divisible into 66 sub-categories, making the

[4] *The urban growth ring analysis areas presented in Table 9 were developed using computerized map area measuring software. The area measurements presented in Table 9 differ slightly from the corresponding area measurement reported in the previous regional land use plan report, SEWRPC Planning Report No. 45, those measurements having been based on a combination of manual and computer measurement techniques.*

[5] *The Commission uses this method of approximating the population and households within the urban areas identified in the urban growth ring analysis in the absence of actual population and household counts for these areas. This method may include certain nonfarm residents living outside the identified urban areas in the estimate of the urban population and households for the Region, and, as a result, may overstate somewhat the actual urban population and household densities.*

Map 2

HISTORIC URBAN GROWTH IN THE REGION: 1850-2000



Source: SEWRPC.

Table 9

URBAN POPULATION DENSITY AND URBAN HOUSEHOLD DENSITY IN THE REGION: 1940-2000

Year	Urban Area[a] (square miles)	Urban Population: Persons[b]	Urban Population: Density (persons per urban square mile)	Urban Households: Households[c]	Urban Households: Density (households per urban square mile)
1940	93	991,535	10,662	272,077	2,926
1950	146	1,179,084	8,076	338,572	2,319
1963	282	1,634,200	5,795	470,856	1,670
1970	338	1,728,666	5,114	529,404	1,566
1980	444	1,749,238	3,940	623,441	1,404
1990	509	1,800,751	3,538	672,896	1,322
2000	579	1,923,674	3,322	746,500	1,289

[a] *Based upon the Regional Planning Commission urban growth ring analysis.*

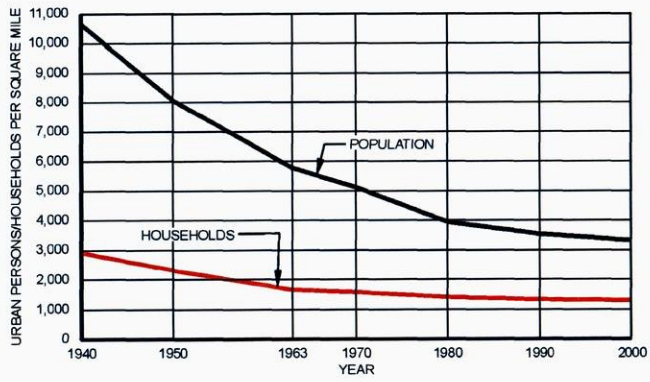
[b] *Total population, excluding rural farm population, as reported in the Federal Census; 1963 is Commission estimate.*

[c] *Total households, excluding rural farm households, as reported in the Federal Census; 1963 is Commission estimate.*

Source: U.S. Bureau of the Census and SEWRPC.

Figure 8

URBAN POPULATION AND HOUSEHOLD DENSITY IN THE REGION: 1940-2000



Source: U.S. Bureau of the Census and SEWRPC.

inventory suitable for both land use and transportation planning, adaptable to stormwater drainage, public utility, and community facility planning, and compatible with other land use classification systems. Aerial photographs serve as the primary basis for identifying existing land use, augmented by field surveys as appropriate. The most recent regional land use inventory was carried out based upon aerial photography taken in spring of 2000. The results of that inventory are summarized on Map 3 and Table 10.

Existing Land Use: 2000

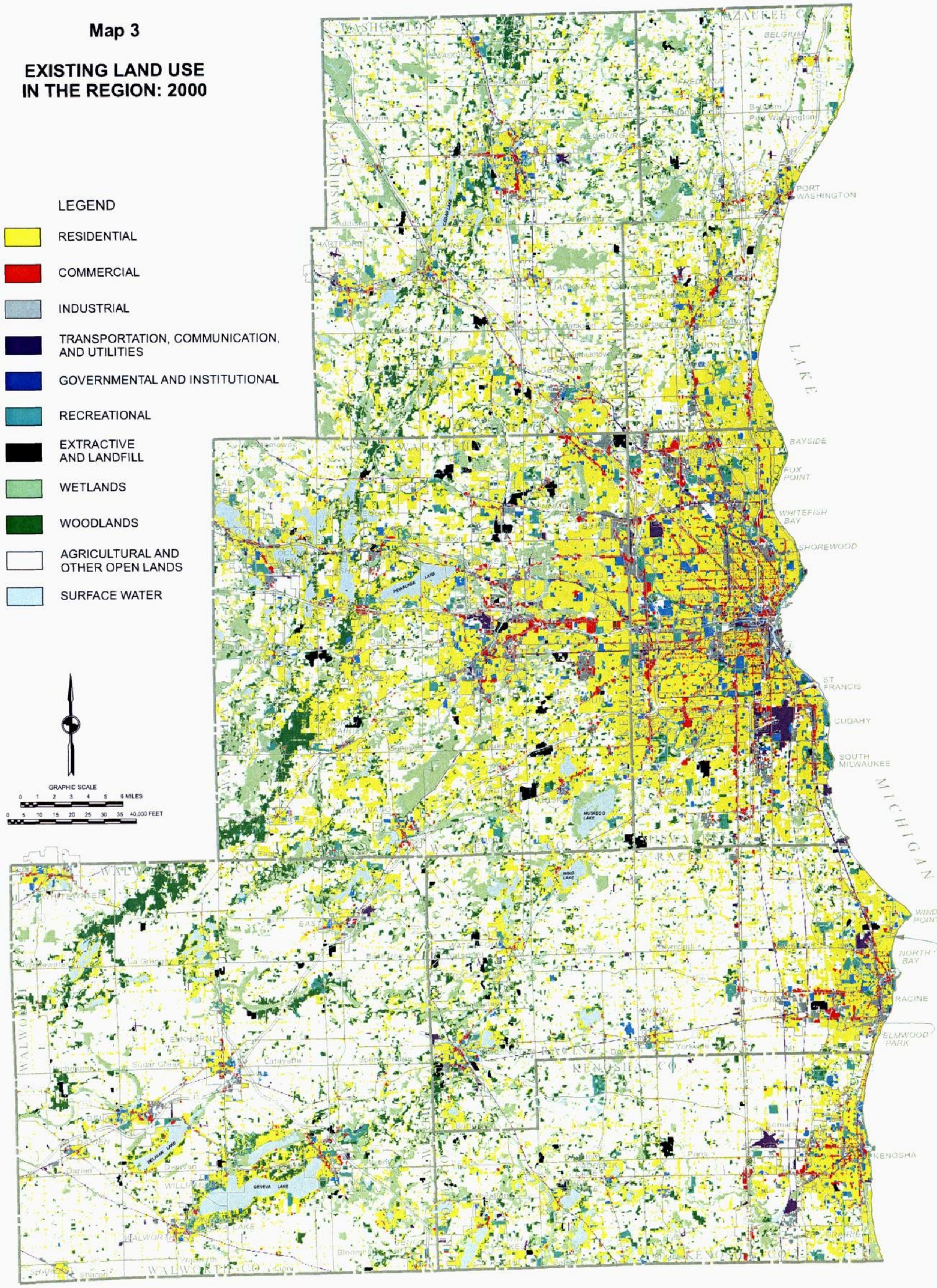
Areas considered "urban" under the land use inventory include areas identified as being in residential, commercial, industrial, transportation-communication-utility, governmental-institutional, or intensive recreational uses, along with "unused" urban lands.[6] In 2000, urban land uses as identified in the regional land use inventory encompassed about 761 square miles, or 28 percent of the total area of the Region. Residential land comprised the largest urban land use category, encompassing about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the Region.[7] In combination, commercial and industrial lands encompassed about 63 square miles, or about 8 percent of all urban land and about 2 percent of the Region overall. Land used for governmental and institutional purposes encompassed 34 square miles, or 4 percent of all urban land and 1 percent of the Region overall. Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. Land devoted to transportation, communication and utility uses—including areas used for streets and highways, railways, airports, and utility and communication facilities—totaled 201 square miles, or 26 percent of all urban land and 8 percent of the Region overall. Unused urban lands encompassed 51 square miles, or 7 percent of all urban land and 2 percent of the overall area of the Region (see Table 10).

[6] *Unused urban lands consist of open lands, other than wetlands and woodlands, which are located within urban areas but which were not developed for a particular use at the time of the land use inventory. Among the lands included in this category are lands where development was underway but not completed at the time of the inventory, and once-developed lands which have been cleared of development.*

[7] *As identified in the regional land use inventory, the residential land use category encompasses all residential land, including rural residential development, defined as residential development at a density of no more than one dwelling unit per five acres. It is envisioned that, utilizing property boundary information in a digital format, future regional land use inventories will specifically identify the location and extent of rural residential development, enabling the separate reporting of urban and rural residential land.*

Map 3

EXISTING LAND USE IN THE REGION: 2000



Source: SEWRPC.

Table 10

EXISTING LAND USE IN THE SOUTHEASTERN WISCONSIN REGION: 2000

Land Use Category[a]	Square Miles	Percent of Urban/ Nonurban	Percent of Total
Urban			
Residential	362.1	47.6	13.5
Commercial	30.3	4.0	1.1
Industrial	32.9	4.3	1.2
Transportation, Communication, and Utilities	200.9	26.4	7.5
Governmental	33.7	4.4	1.2
Recreational	50.4	6.6	1.9
Unused Urban Land	50.9	6.7	1.9
Subtotal Urban	761.2	100.0	28.3
Nonurban			
Natural Areas			
Surface Water	77.4	4.0	2.9
Wetlands	275.7	14.3	10.2
Woodlands	182.7	9.5	6.8
Subtotal Natural Areas	535.8	27.8	19.9
Agricultural	1,259.4	65.3	46.8
Unused Rural and Other Open Land	133.5	6.9	5.0
Subtotal Nonurban	1,928.7	100.0	71.7
Total	2,689.9	- -	100.0

[a]*Off-street parking is included with the associated land use.*

Source: SEWRPC.

Areas considered "nonurban" under the land use inventory include agricultural lands, wetlands, woodlands, surface water, extractive and landfill sites, and "unused" rural lands.[8] In 2000, nonurban lands as identified in the regional land use inventory encompassed about 1,929 square miles, or 72 percent of the total area of the Region. Agricultural land constituted the largest nonurban land use category, encompassing 1,259 square miles, representing about 65 percent of all nonurban land and about 47 percent of the overall area of the Region. Wetlands, woodlands, and surface water together encompassed 536 square miles, representing about 28 percent of all nonurban land and 20 percent of the Region overall. All other nonurban lands, including extractive, landfill, and unused rural lands, encompassed 134 square miles, representing about 7 percent of all nonurban land and 5 percent of the overall area of the Region.

The results of the year 2000 regional land use inventory are presented along with the results of prior land use inventories for the Region in Table 11. Table 11 indicates a significant increase in urban land uses in the Region between 1990 and 2000. As noted above, the year 2000 land use inventory indicates that urban land uses encompassed about 761 square miles in the Region in 2000. This compares to the figure of 637 square miles indicated by the 1990 land use inventory. It is estimated that about 15 square miles—or 12 percent

[8] *Unused rural lands consist of open lands, other than wetlands and woodlands, which are located within rural areas but which were not in agricultural, pasture, or related use at the time of the land use inventory.*

Table 11

LAND USE IN THE SOUTHEASTERN WISCONSIN REGION AS REPORTED IN THE YEAR 2000 AND PRIOR REGIONAL LAND USE INVENTORIES

Land Use Category[a]	Existing Land Use in Square Miles				
	1963	1970	1980	1990	2000
Urban					
Residential	180.0	210.8	269.1	300.4	362.1
Commercial	11.5	14.8	19.3	24.7	30.3
Industrial	13.5	17.3	22.0	26.1	32.9
Transportation, Communication, and Utilities	134.9	150.0	166.1	171.8	200.9
Governmental	21.8	27.2	30.0	30.8	33.7
Recreational	26.0	33.1	39.3	42.3	50.4
Unused Urban Land	54.5	51.0	45.0	40.5	50.9
Subtotal Urban	442.2	504.2	590.8	636.6	761.2
Nonurban					
Natural Areas					
Surface Water	71.6	74.0	76.2	76.9	77.4
Wetlands	274.3	270.3	266.6	268.7	275.7
Woodlands	186.8	184.3	181.9	185.9	182.7
Subtotal Natural Areas	532.7	528.6	524.7	531.5	535.8
Agricultural	1,637.1	1,564.7	1,475.4	1,395.4	1,259.4
Unused Rural and Other Open Land	77.2	91.6	98.4	126.0	133.5
Subtotal Nonurban	2,247.0	2,184.9	2,098.5	2,052.9	1,928.7
Total	2,689.2	2,689.1	2,689.3	2,689.5	2,689.9

[a] *Off-street parking is included with the associated land use.*

NOTE: As part of the regional land use inventory for the year 2000, the delineation of existing land use was referenced to real property boundary information not available for prior inventories. This change increases the precision of the land use inventory and makes it more useable to public agencies and private interests throughout the Region. As a result of the change, however, year 2000 land use inventory data are not strictly comparable with data from the 1990 and prior inventories. At the county and regional level, the most significant effect of the change is to increase the transportation, communication, and utilities category—the result of the use of actual street and highway rights-of-way as part of the 2000 land use inventory, as opposed to the use of narrower estimated rights-of-way in prior inventories. This treatment of streets and highways generally diminishes the area of adjacent land uses traversed by those streets and highways in the 2000 land use inventory relative to prior inventories. Changes in total area may be due to this procedural change or to actual changes in the Lake Michigan shoreline.

Source: SEWRPC.

of the increase of 125 square miles in urban land indicated by the 1990 and 2000 inventories—is attributable to the referencing of land use delineations to real property boundaries in the 2000 inventory, particularly to the adjustment of estimated street rights-of-way to match actual rights-of-way. Thus, the actual increase in urban land uses in the Region during the 1990s, discounting the effect of procedural changes in the land use inventory, may be estimated at about 110 square miles, or 17 percent. This compares to increases of 46 square miles, or 8 percent, during the 1980s, and 87 square miles, or 17 percent, during the 1970s.

Environmental Corridors

One of the most important tasks completed under the regional planning program for Southeastern Wisconsin has been the identification and delineation of areas of the Region in which concentrations of the best remaining elements of the natural resource base occur. It was recognized that preservation of such areas is important to both the maintenance of the overall environmental quality of the Region and to the continued provision of amenities required to maintain a high quality of life for the resident population.

Under the regional planning program, seven elements of the natural resource base have been considered essential to the maintenance of the ecological balance, natural beauty, and overall quality of life in Southeastern Wisconsin: 1) lakes, rivers, and streams, and their associated shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and 7) rugged terrain and high-relief topography. In addition, there are certain other features which, although not part of the natural resource base per se, are closely related to, or centered upon, that base and are a determining factor in identifying and delineating areas with recreational, aesthetic, ecological, and cultural value. These five additional elements are: 1) existing park and open space sites; 2) potential park and open space sites; 3) historic sites; 4) scenic areas and vistas; and 5) natural areas and critical species habitat sites.

The delineation of these 12 natural resource and natural resource-related elements on maps results, in most areas of the Region, in an essentially linear pattern of relatively narrow, elongated areas which have been termed "environmental corridors" by the Regional Planning Commission.[9] Primary environmental corridors include a variety of the aforementioned important natural resource and resource-related elements and are at least 400 acres in size, two miles in length, and 200 feet in width. Secondary environmental corridors generally connect with the primary environmental corridors and are at least 100 acres in size and one mile in length. In addition, smaller concentrations of natural resource base elements that are separated physically from the environmental corridors by intensive urban or agricultural land uses have also been identified. These areas, which are at least five acres in size, are referred to as isolated natural resource areas.

The preservation of environmental corridors and isolated natural resource areas in essentially natural, open uses yields many benefits, including recharge and discharge of groundwater; maintenance of surface and groundwater quality; attenuation of flood flows and stages; maintenance of base flows of streams and watercourses; reduction of soil erosion; abatement of air and noise pollution; provision of wildlife habitat; protection of plant and animal diversity; protection of rare and endangered species; maintenance of scenic beauty; and provision of opportunities for recreational, educational, and scientific pursuits. Conversely, since these areas are generally poorly suited for urban development, their preservation can help avoid serious and costly developmental problems.

Primary Environmental Corridors

As shown on Map 4, the primary environmental corridors in the Region are primarily located along major stream valleys, around major lakes, and along the Kettle Moraine. These primary environmental corridors contain almost all of the best remaining woodlands, wetlands, and wildlife habitat areas in the Region, and represent a composite of the best remaining elements of the natural resource base. The protection of the primary environmental corridors from additional intrusion by incompatible land uses, degradation, and destruction is one of the key objectives of the adopted regional land use plan.

As indicated in Table 12, primary environmental corridors encompassed about 462 square miles, or about 17 percent of the total area of the Region, in 2000. As indicated in Table 13, there was a small net increase of 0.7 square mile, or 0.2 percent, in primary environmental corridor lands in the Region between 1990 and 2000. The change in area is the net result of increases in primary environmental corridor lands in certain areas of the Region and decreases in other areas. Decreases in primary environmental corridor lands occur, for the most part, as a result of conversion to urban or agricultural use. Increases may occur as a result of managed restoration efforts (e.g., wetland, woodland, or prairie restoration) and as a result of situations where lands, such as farmed floodplains or wetlands, are simply allowed to revert to a more natural condition.

Secondary Environmental Corridors

As further shown on Map 4, secondary environmental corridors are generally located along the small perennial and intermittent streams within the Region. Secondary environmental corridors also contain a variety of resource elements, often remnant resources from primary environmental corridors which have been developed for intensive urban or agricultural purposes.

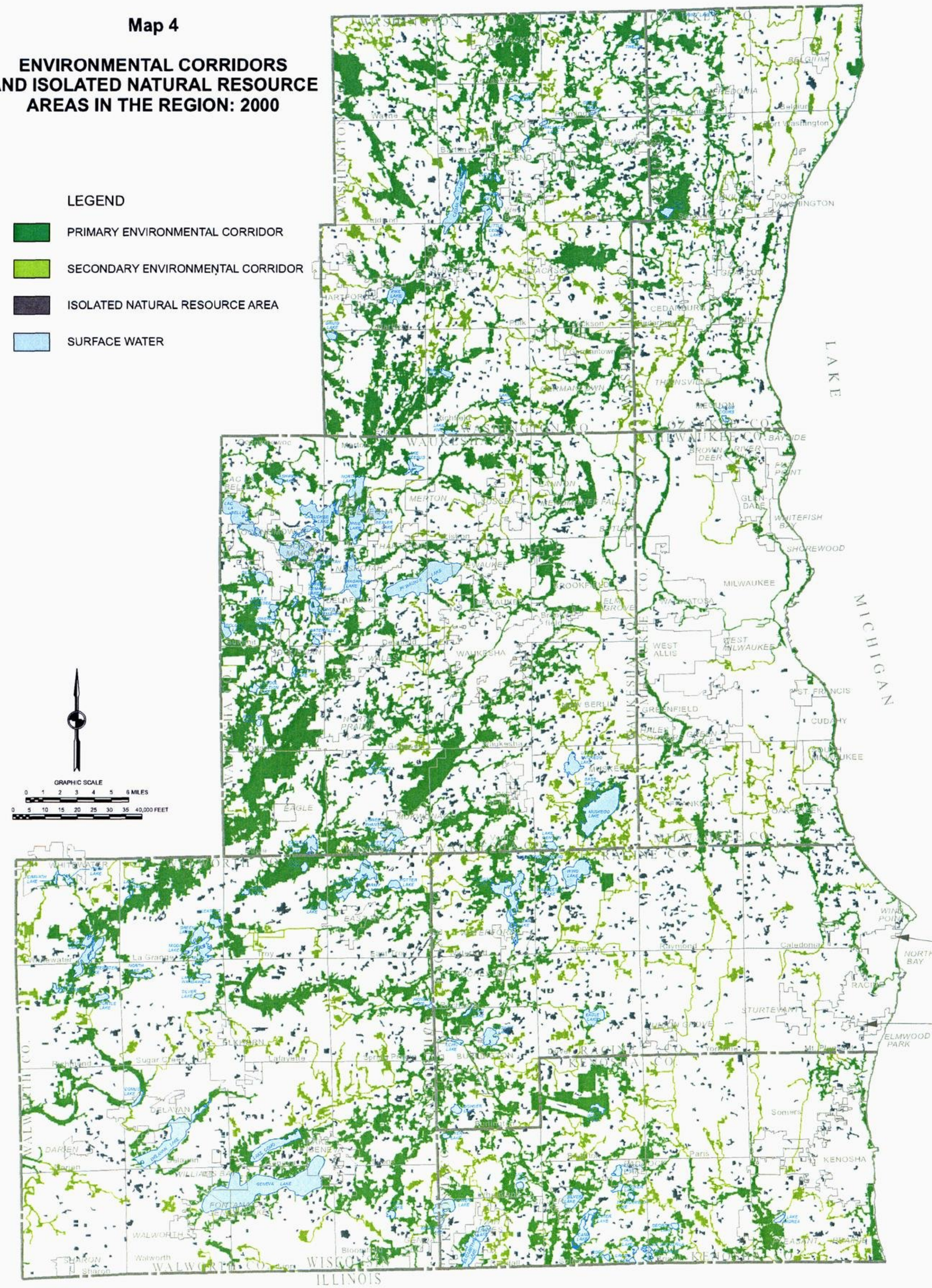
Secondary environmental corridors facilitate surface-water drainage, maintain pockets of natural resource features, and provide corridors for the movement of wildlife, as well as for the movement and dispersal of seeds for a variety of plant species.

In 2000, secondary environmental corridors encompassed about 75 square miles, or about 3 percent of the total area of the Region. There was a small net increase of 0.2 square mile, or 0.3 percent, in secondary environmental corridor lands in the Region between 1990 and 2000—also the result of increases in secondary environmental corridor lands in certain areas of the Region and decreases in other areas.

[9] *A detailed description of the process of delineating environmental corridors in Southeastern Wisconsin is presented in the March 1981 issue (Volume 4, No. 2) of the* SEWRPC Technical Record.

Map 4

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION: 2000



Source: SEWRPC.

Table 12

ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION BY COUNTY: 2000

County	Primary Environmental Corridors		Secondary Environmental Corridors		Isolated Natural Resource Areas		Total Environmental Corridors and Isolated Natural Resource Areas	
	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region	Square Miles	Percent of County/ Region
Kenosha	43.8	15.7	10.0	3.6	6.0	2.2	59.8	21.5
Milwaukee	14.5	6.0	5.2	2.1	3.3	1.4	23.0	9.5
Ozaukee	32.2	13.7	7.6	3.2	5.6	2.4	45.4	19.3
Racine	35.5	10.4	10.8	3.2	12.0	3.5	58.3	17.1
Walworth	99.2	17.2	14.6	2.5	12.9	2.3	126.7	22.0
Washington	94.2	21.6	15.4	3.6	10.1	2.3	119.7	27.5
Waukesha	142.8	24.6	11.2	1.9	13.0	2.3	167.0	28.8
Region	462.2	17.2	74.8	2.8	62.9	2.3	599.9	22.3

Source: *SEWRPC.*

Table 13

CHANGE IN ENVIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS IN THE REGION: 1990-2000

Resource Feature	Existing 1990 (square miles)	Change: 1990-2000				Existing 2000 (square miles)
		Gains (square miles)	Losses (square miles)	Net Change		
				Square miles	Percent	
Primary Environmental Corridors	461.5	5.5	4.8	0.7	0.2	462.2
Secondary Environmental Corridors	74.6	1.9	1.7	0.2	0.3	74.8
Isolated Natural Resource Areas	63.3	3.0	3.4	-0.4	-0.6	62.9
Total Environmental Corridors and Isolated Natural Resource Areas	599.4	10.4	9.9	0.5	0.1	599.9

Source: *SEWRPC.*

Isolated Natural Resource Areas

In addition to the primary and secondary environmental corridors, other smaller pockets of wetlands, woodlands, surface water, or wildlife habitat exist within the Region. These pockets are isolated from the environmental corridors by urban development or agricultural use, and although separated from the environmental corridor network, these isolated natural resource areas have significant value. They may provide the only available wildlife habitat in an area, usually provide good locations for local parks, and lend unique aesthetic character and natural diversity to an area.

Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or about 2 percent of the total area of the Region, in 2000. There was a small net decrease of 0.4 square mile, or 0.6 percent, in isolated natural resource areas in the Region between 1990 and 2000.

AGRICULTURAL RESOURCE BASE

Agricultural land in the Region has decreased significantly over the past four decades. It is estimated that lands devoted to agricultural use decreased by 22 percent between 1963 and 2000, including a decrease of about 8 percent during the 1990s.[10] Despite this decrease, a large portion of the total area of the Region remains in agricultural use, and agriculture remains an important component of the regional economy.

Based upon the Commission's regional land use inventory, about 1,259 square miles, or 47 percent of the total area of the Region, were in agricultural use

[10] *These estimates are based upon the Commission's regional land use inventories and discount the effect of the procedural shifts made as part of the year 2000 inventory, described earlier in this chapter.*

in 2000. It should be noted that this figure includes lands actually used for agriculture—primarily cultivated lands and lands used for pasture—and excludes the wetland and woodland portions of existing farm units.

Map 5 shows the extent of agricultural land in the Region as identified in the year 2000 regional land use inventory and further identifies those areas which are covered by highly productive soils—comprised of soils in agricultural capability Class I and Class II, as classified by the U.S. Natural Resources Conservation Service. Agricultural lands covered by Class I and Class II soils encompassed about 945 square miles, or 75 percent of all agricultural land in the Region, in 2000. The adopted regional land use plan recommends the preservation of Class I and Class II soils insofar as practicable.

TRANSPORTATION FACILITIES AND SERVICES

Arterial Street and Highway System

The arterial streets and highways are defined as streets and highways that are previously intended to provide a high degree of traffic service, carrying relatively high volumes of traffic at relatively high operating speeds. The arterial street system may be divided into freeway facilities and nonfreeway, or standard arterial, streets and highways. A freeway is a special type of arterial providing the highest degree of mobility and the most limited degree of access. A freeway is defined as a directionally divided arterial highway with full control of marginal access and grade separation at all intersecting streets and highways. Standard arterial streets and highways may be directionally divided or undivided, with at-grade intersections, and partial or full control of marginal access to abutting property. Table 14 provides information on the mileage of arterials in the Region in 2001. Data on the existing and historic mileage of collector and land access streets and of the total street and highway system within the Region are also provided. Land access streets are primarily intended to provide access to abutting properties. Collector streets are intended primarily as connectors between the arterial and land access street systems. Streets and highways may also be classified according to jurisdiction. Jurisdictional classification establishes which level of government—State, county, or local—has responsibility for the design, construction, maintenance, and operation of each segment of the total street and highway system. Table 15 presents the distribution of existing arterial highway mileage within the Region in 2001 by State, county, and local jurisdictional classification. Map 6 shows the arterial street and highway system as it existed within the Region in 2001, by freeway and standard facility and by jurisdictional classification.

The location and configuration of the State Trunk Highway system, consisting of both freeway and nonfreeway facilities, has particular significance for telecommunications system planning. In order to provide public safety these facilities require good wireless telecommunications services.

Arterial Street and Highway System Traffic Volume

The average weekday traffic volume on each segment of the arterial street and highway system within the Region in 2001 is graphically displayed on Map 7. The magnitude of arterial street and highway traffic volume can also be measured in terms of total arterial system average weekday vehicle-miles of travel. About 40.0 million vehicle-miles of travel occurred on the arterial street and highway system within the Region on an average weekday in 2001. Freeways, which comprise about eight percent of the total arterial street mileage, carried 37.2 percent of the total arterial vehicle miles of travel which took place within the Region on an average weekday in 2001.

Public Transit

Public transportation may be divided into service provided for the general public and service provided to special population groups. Examples of special group public transportation include yellow school bus service operated by area school districts, and fixed-route bus and paratransit van service provided by counties or municipalities for the elderly and disabled. Service to special population groups is considered only implicitly in the public transportation planning process, with the exception of paratransit operated within urban fixed-route transit service areas to meet the transportation needs of those persons who because of mental or physical disability are unable to use conventional transit service. Such service is required to be provided within fixed-route urban transit service areas under the Federal Americans with Disabilities act of 1990, and the needed configurations of such service is explicitly considered by the Commission in regional transportation system planning.

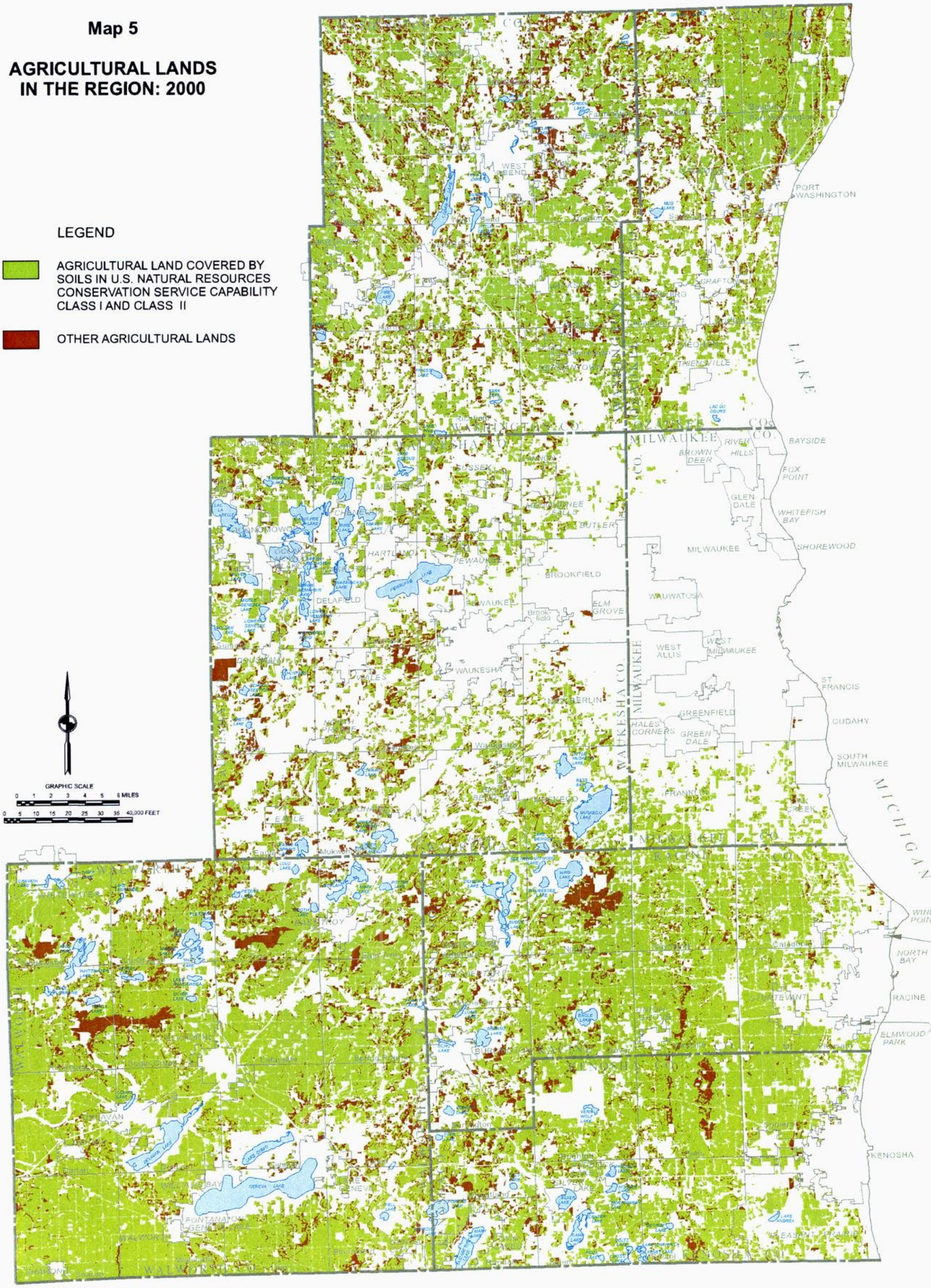
Map 5

AGRICULTURAL LANDS IN THE REGION: 2000

LEGEND

AGRICULTURAL LAND COVERED BY SOILS IN U.S. NATURAL RESOURCES CONSERVATION SERVICE CAPABILITY CLASS I AND CLASS II

OTHER AGRICULTURAL LANDS



Source: SEWRPC.

Table 14

DISTRIBUTION OF TOTAL ARTERIAL STREET AND HIGHWAY SYSTEM MILEAGE AND VEHICLE MILES OF TRAVEL (VMT) WITHIN THE REGION BY COUNTY: 2001

County	Total Miles	Freeway System Miles	Nonfreeway System Miles
Kenosha	317.6	12.0	305.6
Milwaukee	781.8	67.8	714.0
Ozaukee	250.7	26.2	224.5
Racine	352.6	12.0	340.6
Walworth	436.6	48.9	387.7
Washington	406.5	42.8	363.7
Waukesha	746.0	60.0	686.0
Region	3,291.8	269.7	3,022.1

County	Total VMT in Thousands	Freeway System		Nonfreeway System	
		VMT in Thousands	Percent	VMT in Thousands	Percent
Kenosha	3,119.0	806	25.8	2,313	74.2
Milwaukee	16,666.0	6,895	41.4	9,771	58.6
Ozaukee	2,235.0	949	42.5	1,286	57.5
Racine	3,374.0	865	25.6	2,509	74.4
Walworth	2,338.0	763	32.6	1,575	67.4
Washington	3,091.0	1,369	44.3	1,722	55.7
Waukesha	9,160.0	3,237	35.3	5,923	64.7
Region	39,983.0	14,884	37.2	25,099	62.8

Source: SEWRPC.

Table 15

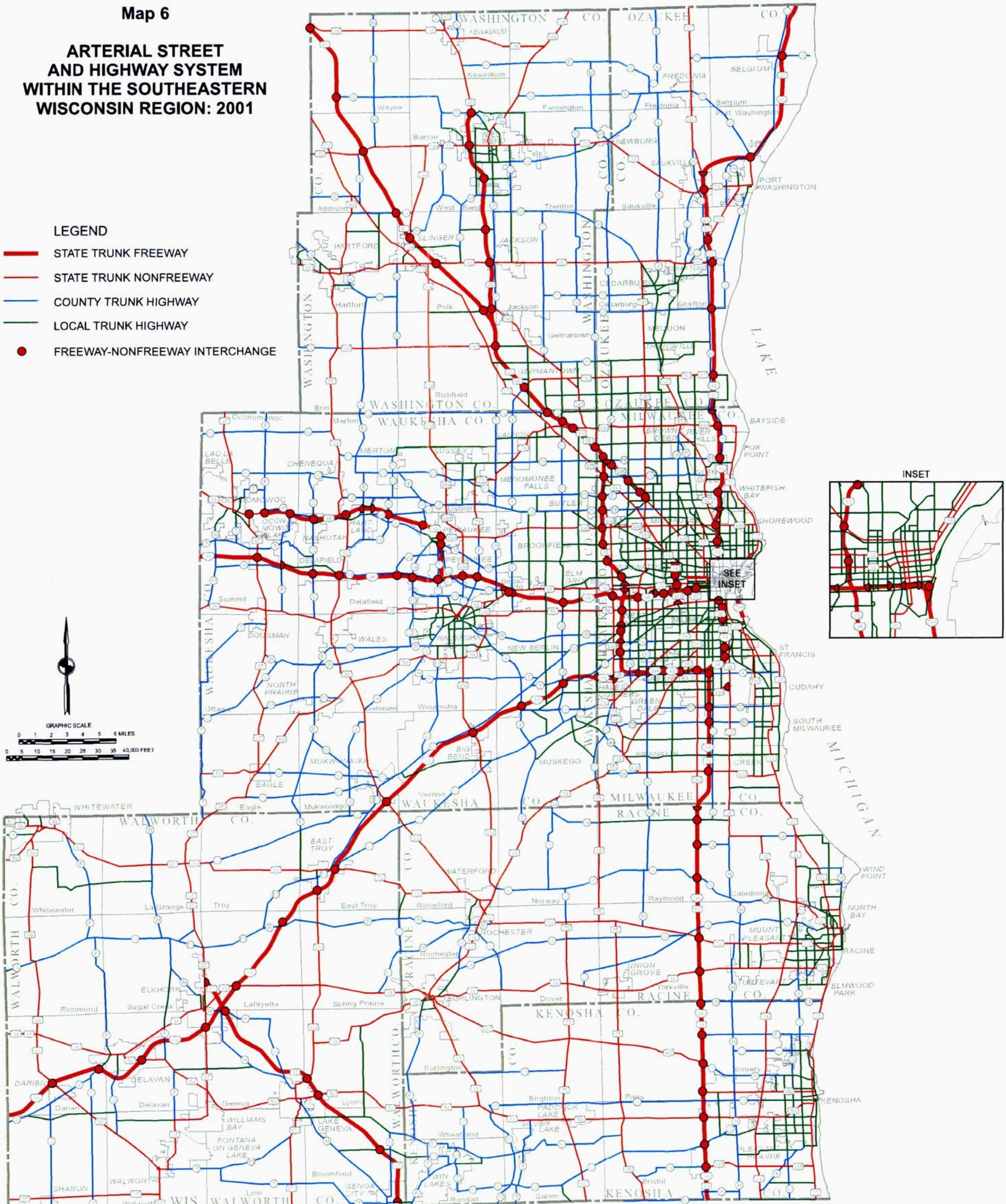
DISTRIBUTION OF EXISTING ARTERIAL STREET AND HIGHWAY MILEAGE WITHIN THE REGION BY COUNTY AND JURISDICTIONAL CLASSIFICATION: 2001

County	State			County		Local		Total	
	Trunk Highways (miles)	Connecting Streets (miles)	Percent of Total	Miles	Percent of Total	Miles	Percent of Total	Miles	Percent of Total
Kenosha	107.4	10.1	37.0	140.8	44.3	59.3	18.7	317.6	100.0
Milwaukee	175.3	87.3	33.6	87.7	11.2	431.5	55.2	781.8	100.0
Ozaukee	67.9	11.1	31.5	109.0	43.5	62.7	25.0	250.7	100.0
Racine	140.5	21.2	45.9	118.9	33.7	72.0	20.4	352.6	100.0
Walworth	193.0	18.4	48.4	168.9	38.7	56.3	12.9	436.6	100.0
Washington	173.3	14.4	46.2	149.8	36.9	69.0	16.9	406.5	100.0
Waukesha	220.5	18.4	32.0	351.7	47.1	155.4	20.9	746.0	100.0
Region	1,077.9	180.9	38.3	1,126.8	34.2	906.2	27.5	3,291.8	100.0

Source: Wisconsin Department of Transportation and SEWRPC.

Map 6

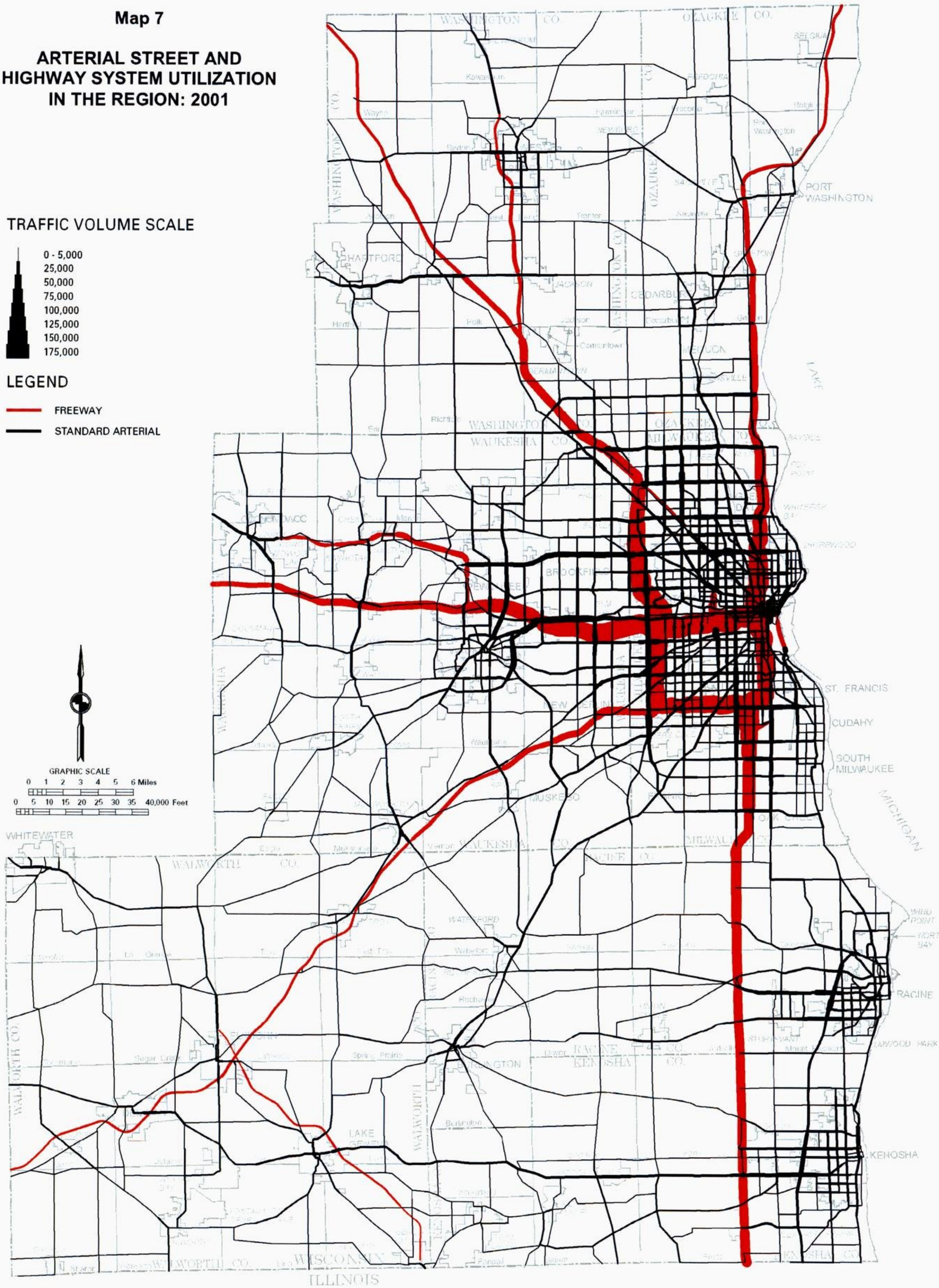
ARTERIAL STREET AND HIGHWAY SYSTEM WITHIN THE SOUTHEASTERN WISCONSIN REGION: 2001



Source: SEWRPC.

Map 7

ARTERIAL STREET AND HIGHWAY SYSTEM UTILIZATION IN THE REGION: 2001



Source: SEWRPC.

Public transit service to the general public may further be divided into three categories: intercity, urban, and rural. Intercity or interregional public transportation provides services across regional boundaries and includes Amtrak railway passenger service, interregional bus service, and commercial air travel. Rural—and small urban community—public transportation provides service in and between small urban communities and rural areas, and may provide connections to urban areas. Urban public transportation, commonly referred to as public transit, provide service within and between the large urban areas of the Region. Public transit is essential in any metropolitan area to meet the travel needs of persons unable to use personal automobile transportation; to provide an alternative mode of travel, particularly in heavily traveled corridors within and between urban areas and in densely developed urban communities and activity centers; and to provide choice in transportation modes as an enhancement of quality of life and to support and enhance the regional economy.

Urban public transit may be further divided into rapid express, and local levels of service. Rapid transit is intended to facilitate relatively fast and convenient transportation along heavily traveled corridors and between major activity centers and high- and medium-density urban centers and communities within the Region. Rapid transit has relatively high average operating speeds and relatively low accessibility, with station spacing one to three miles or more apart.

Rapid transit service can be provided by commuter, heavy, or light rail operating over exclusive, grade-separated rights-of-way or by motor buses operating over exclusive, grade-separated busways. Rapid transit can also be provided by motor buses operating in mixed traffic on freeways and by light rail operating over exclusive, though not fully grade-separated, rights-of-way.

Express transit service is provided over arterial streets and highways or on exclusive rights-of-way with stops generally one-quarter to two miles apart at intersecting transit routes, intersecting arterial streets, and major traffic generators. Express transit services trips of moderate length can be provided by motor bus or by light rail operating in mixed traffic on shared right-of-way, in reserved street lanes, or on exclusive rights-of-way. Express transit service provides a greater degree of accessibility at somewhat slower operating speeds than rapid transit and may provide "feeder" service to the rapid transit system.

Local transit service is characterized by a high degree of accessibility and low operating speeds. Local service is provided over arterial and collector streets with stops generally one-eighth to one-quarter miles apart. Such service can be provided by motor bus, electric trolleybus, or streetcar. Local transit service can also be provided on a demand-responsive basis, such as with automobiles or vans operating as a shared-ride taxi.

The extent of rapid and express fixed route transit service within the Region in 2001 is shown on Map 8.

Rural and Small Urban Community Demand-Responsive Transit Service

As shown on Map 9 demand-responsive rural public transit in the form of publicly operated shared-ride taxicab service was also provided in the Region in 2001. Shared-ride taxicab service was provided by the City of Port Washington Transport Taxi Service in Ozaukee County, and the Hartford City Taxi Service and City of West Bend Taxi Service in Washington County. These three systems served local travel in and immediately adjacent to the sponsoring municipality. In addition, both Ozaukee and Washington Counties provided shared-ride taxicab service on a countywide basis. The two county taxi systems principally served travel in the small urban communities and rural areas in each county and between the rural areas and all communities. The Ozaukee and Washington County taxi system did serve some communities located within the Milwaukee urban area including the communities of Germantown in Washington County and Mequon, Cedarburg and Grafton in Ozaukee County. These county taxi systems, however, do not serve trips that could be made on municipal systems in each county—Port Washington in Ozaukee

Map 8

RAPID AND EXPRESS FIXED-ROUTE PUBLIC TRANSIT SERVICE IN THE REGION: 2001

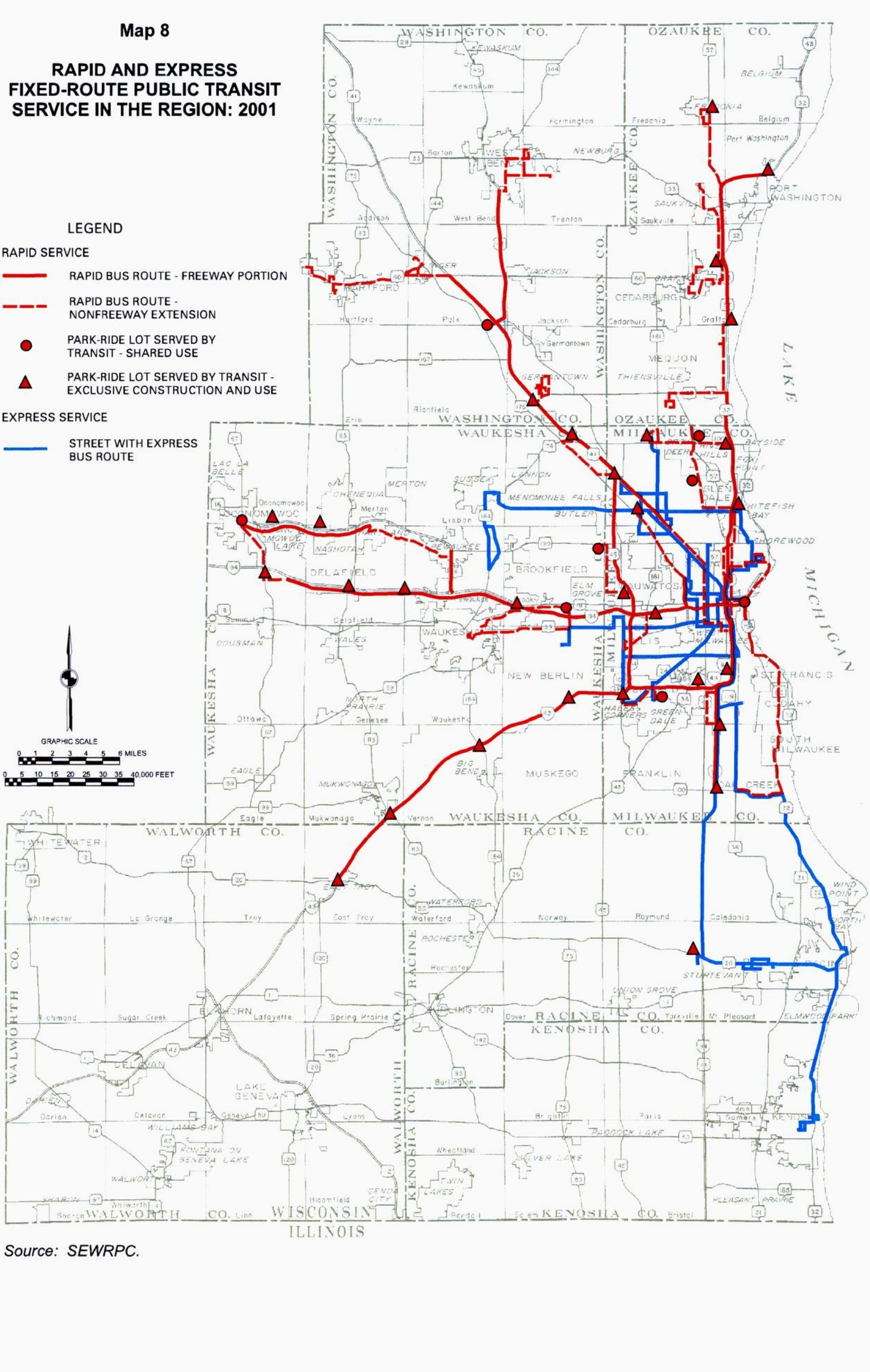
LEGEND

RAPID SERVICE

- RAPID BUS ROUTE - FREEWAY PORTION
- RAPID BUS ROUTE - NONFREEWAY EXTENSION
- PARK-RIDE LOT SERVED BY TRANSIT - SHARED USE
- PARK-RIDE LOT SERVED BY TRANSIT - EXCLUSIVE CONSTRUCTION AND USE

EXPRESS SERVICE

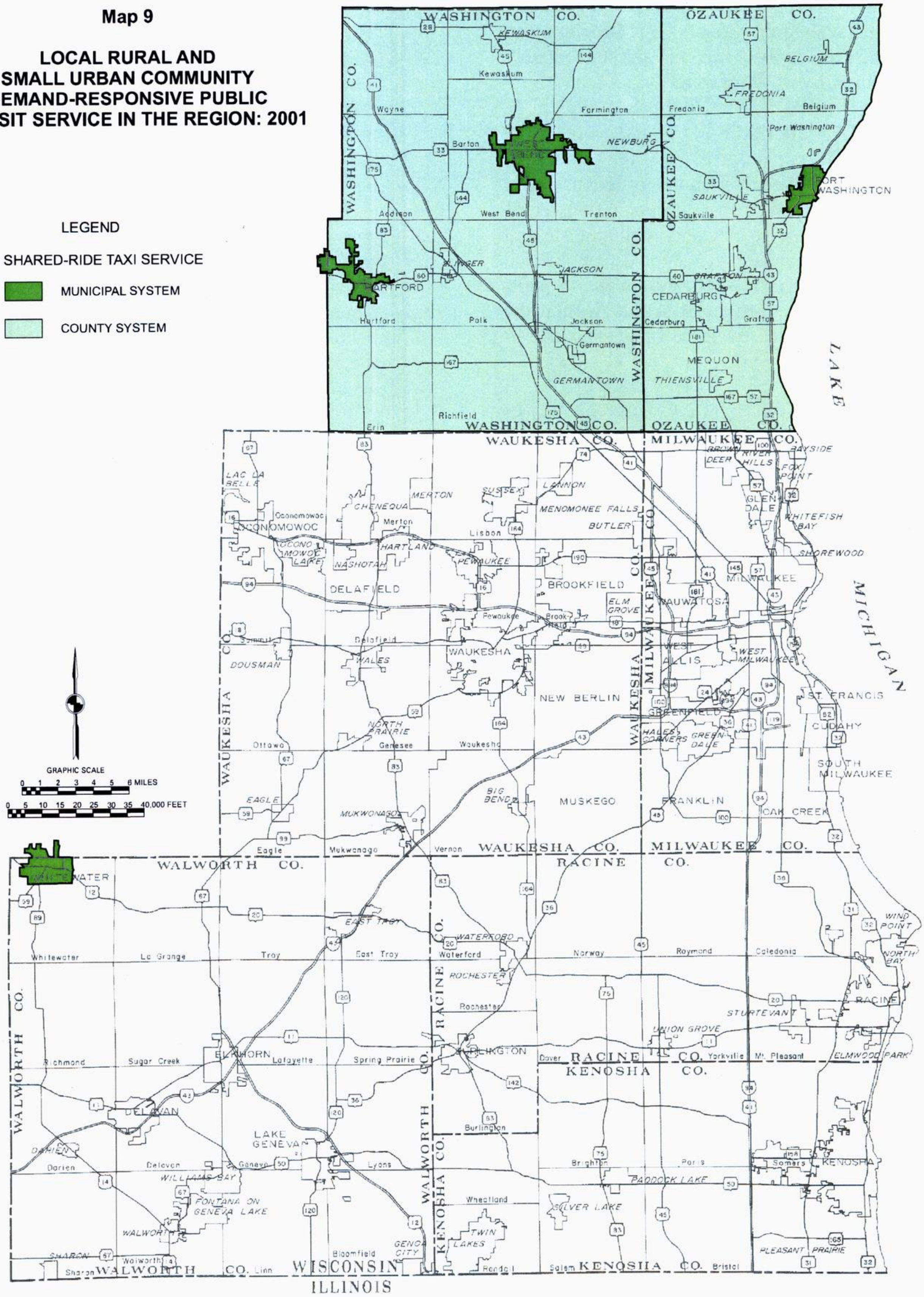
- STREET WITH EXPRESS BUS ROUTE



Source: SEWRPC.

Map 9

LOCAL RURAL AND SMALL URBAN COMMUNITY DEMAND-RESPONSIVE PUBLIC TRANSIT SERVICE IN THE REGION: 2001



Source: SEWRPC.

County and Hartford and West Bend in Washington County. Public shared-ride taxicab service was also provided in Walworth County by Browns Cab Service which served local travel in and immediately adjacent to the City of Whitewater.

PARK-RIDE FACILITIES

Park-ride facilities enable more efficient travel within southeastern Wisconsin through transfer of mode between private vehicle and public transit, and between single occupant or solo driver private vehicles and carpools. In 2001, there were 46 park-ride lots serving intra-regional travel within the Region, with 37 served by rapid or express transit bus service.

As already noted in 2001, rapid or express transit bus service was provided to 37 park-ride lots within the Region, as shown on Map 10. These intermodal parking facilities provided 6,120 parking spaces.

Also as already noted, in 2001, there were 9 park-ride lots not served by transit located within the Region containing 390 parking spaces as shown on Map 10. Most of these parking spaces, about 50 percent, were located within Waukesha County, with about another 29 percent within Washington County, and the remaining 21 percent in Walworth County.

SUMMARY

Reliable planning data are essential for the formulation of workable development plans. The critical nature and factual information in the planning process should be evident, since no reliable forecast can be made or alternate course of action formulated without the nature of the current state of the system being planned. Information regarding existing conditions and historical trends with respect to the demographic and economic base to certain elements of the natural environment, and to certain elements of the man made environment of the planning area is essential to the telecommunications planning process. This chapter presents a summary of the results of Commission inventories pertaining to the population, economy, land use pattern, natural and agricultural resource base and the transportation system within the Region. Inventory findings pertinent to telecommunications planning include the following:

Demographic and Economic Base

- The population of the Region increased by 120,800 persons, or 7 percent, from 1,810,400 persons in 1990 to 1,931,200 persons in 2000. Of the total population increase of 120,800 persons during the 1990s, 116,900 can be attributed to natural increase; the balance can be attributed to a modest net in-migration—about 3,900 persons—into the Region. The past decade saw a continuation of the long-term trend to decentralization of urban development within the Region. Milwaukee County's share of the total regional population decreased by about 4 percentage points during the 1990s, while the share of each of the other six counties increased.

- The number of households, or occupied housing units, in the Region increased by 72,900, from 676,100 in 1990 to 749,000 households in 2000. In relative terms, the rate of growth in households, 11 percent, exceeded the rate of growth in total population, 7 percent. Similar patterns have been observed over each of the four previous decades. The differential growth rates in households and population are reflected in a declining average household size. During the 1990s, the average household size in the Region decreased by about 4 percent, from 2.62 persons in 1990 to 2.52 persons in 2000.

- Total employment in the Region increased by 160,200 jobs, or 15 percent, from 1,062,600 in 1990 to 1,222,800 jobs in 2000. Employment levels, both nationally and within the Region, tend to fluctuate in the short-term, rising and falling in accordance with business cycles. The long period of nearly uninterrupted job growth between 1980 and 2000 is unusual in this respect. Nationally and within the Region, total employment increased each year during that time, with the exception of a slight decrease in 1991.

- Each county in the Region experienced an increase in employment during the 1990s. Between 1990 and 2000, reflective of the trend to decentralization of urban development within the Region. Milwaukee and Racine

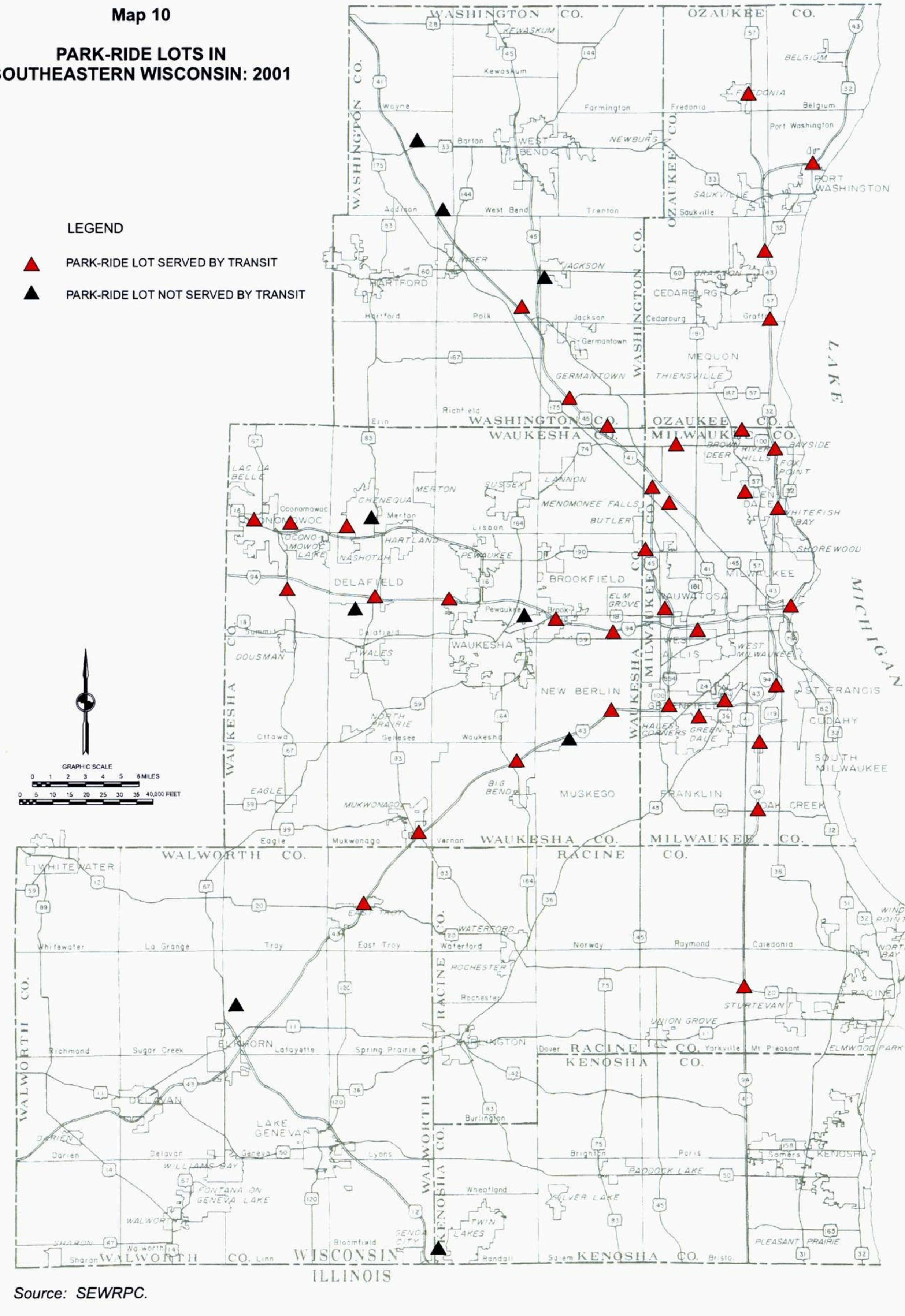
Map 10

PARK-RIDE LOTS IN SOUTHEASTERN WISCONSIN: 2001

LEGEND

▲ PARK-RIDE LOT SERVED BY TRANSIT

▲ PARK-RIDE LOT NOT SERVED BY TRANSIT



Source: SEWRPC.

Counties decreased in their relative share of total regional employment while the share of each of the other five counties increased.

- The 1990s saw a continuation of a shift in the regional economy from a manufacturing to a service orientation. Manufacturing employment in the Region was virtually unchanged during the 1990s, following a 15 percent decrease during the 1980s, and a modest 4 percent increase during the 1970s. Conversely, service-related employment increased substantially during each of the past three decades—by 33 percent during the 1990s, 41 percent during the 1980s, and 53 percent during 1970s. Due to these differential growth rates, the proportion of manufacturing jobs relative to total jobs in the Region decreased from 32 percent in 1970 to 18 percent in 2000, while service-related employment increased from 18 percent in 1970 to 33 percent in 2000.

Land Use

- Urban land uses encompassed about 761 square miles, or 28 percent of the total area of the Region, in 2000. Residential land comprised the largest urban land use category, encompassing about 362 square miles, or about 48 percent of all urban land and about 14 percent of the overall area of the Region. In combination, commercial and industrial lands encompassed about 63 square miles, or about 8 percent of all urban land and about 2 percent of the Region overall. Land used for governmental and institutional purposes encompassed 34 square miles, or 4 percent of all urban land and 1 percent of the Region overall. Land devoted to intensive recreational uses encompassed about 50 square miles, or 7 percent of all urban land and 2 percent of the Region overall. Land devoted to transportation, communication, and utility uses—including areas used for streets and highways, railways, airports, and utility and communication facilities—totaled 201 square miles, or 26 percent of all urban land and 8 percent of the Region overall. Unused urban lands encompassed 51 square miles, or 7 percent of all urban land and 2 percent of the overall area of the Region.

- Areas considered "nonurban" under the land use inventory include agricultural lands, wetlands, woodlands, surface water, extractive and landfill sites, and unused rural lands. In 2000, nonurban lands as identified in the regional land use inventory encompassed about 1,929 square miles, or 72 percent of the total area of the Region. Agricultural land constituted the largest nonurban land use category, encompassing 1,259 square miles, representing about 65 percent of all nonurban land and about 47 percent of the overall area of the Region. Wetlands, woodlands, and surface water together encompassed 536 square miles, representing about 28 percent of all nonurban land and 20 percent of the Region overall. All other nonurban lands, including extractive, landfill, and unused rural lands, encompassed 134 square miles, representing about 7 percent of all nonurban land and 5 percent of the overall area of the Region.

- Commission inventories indicate a continued significant increase in urban land uses within the Region. Urban land uses increased by about 110 square miles from 1990 to 2000, or by about 17 percent.

- The population density of the urban portion of the Region has continued to decrease from 10,700 persons per square mile in 1940 to about 5,100 persons per square mile in 1970, 3,900 persons per square mile in 1980, and 3,500 persons per square mile in 2000. During the 1990s, the urban population density continued to decrease, but at a slower rate, to about 3,300 persons per square mile in 2000. A different density trend for the Region emerges when urban density is calculated based upon households rather than population. Since 1963, the relative decrease in urban household density has been much lower than the decrease in urban population density. Between 1963 and 2000, the urban household density decreased by 23 percent, compared to a 43 percent decrease in the urban population density.

- The most important elements of the natural resource base and features closely related to that base—including wetlands, woodlands, prairies, wildlife habitat, major lakes and streams and associated shorelands and floodlands, and historic, scenic, and recreational sites—when combined result in essentially elongated patterns referred to by the Commission as "environmental corridors." "Primary" environmental corridors, which are the longest and widest type of environmental corridor, are generally located along major stream valleys, around major lakes, and along the Kettle Moraine; they encompassed 462 square miles, or 17 percent of the total area of the Region, in 2000. "Secondary" environmental corridors are generally located along small perennial and intermittent streams; they encompassed 75 square miles, or 3 percent of the Region, in 2000. In addition to the environmental corridors, "isolated natural resource areas," consisting of small pockets of natural resource base elements separated physically from the environmental corridor network, have been identified. Widely scattered throughout the Region, isolated natural resource areas encompassed about 63 square miles, or 2 percent of the Region, in 2000.

- Agricultural land in the Region has decreased significantly over the past four decades. It is estimated that lands devoted to agricultural use decreased by 22 percent between 1963 and 2000, including a decrease of about 8 percent during the 1990s. Despite this decrease, a large portion of the total area of the Region remains in agricultural use, and agriculture remains an important component of the regional economy. About 1,259 square miles, or 47 percent of the total area of the Region, were in agricultural use in 2000. Of this total, about 945 square miles, or 75 percent, were covered by highly productive soils—agricultural capability Class I and Class II soils, as identified by the U.S. Natural Resources Conservation Service.

- As of 2001, there were approximately 11,937 miles of streets and highways—land-access, collector, and arterial—within the Region. Only 28 percent, or 3,292 miles, of the street and highway system were arterials with the principal function of moving traffic. The miles of arterials within the Region have increased from 3,188 in 1963 to 3,292 miles in 2001, an increase of 100 miles or 3 percent. The freeway system in 2001 of 270 miles accounted for 8 percent of the total arterial street and highway system and 2 percent of the total street and highway system yet carried over 37 percent of the arterial vehicle miles of travel on an average weekday, with the Region.

- The extent of fixed route public transit service in southeastern Wisconsin significantly increased from 1991 to 2001 from 63,300 vehicle-miles of service on an average weekday to 79,600 vehicle-miles of service, an increase of 26 percent. The extent of fixed route service provided in 2001 was also 24 percent greater than that provided in 1972 and only 6 percent less than that provided in 1963. Demand-responsive transit service in the Region also significantly increased from 1991 to 2001, from 1,800 vehicle-miles of service on an average weekday to 7,700 vehicle-miles of service. However, since 2001, the extent of fixed route transit service has significantly declined by about 10 percent to 71,900 vehicle-miles of service on an average weekday due to the economic downturn following September 11, 2001, reduced Federal funds, and State and local budget problems.

- The number of park-ride lots enabling the transfer of mode between private vehicles and public transit and from solo driver private vehicles to carpools has increased from 8 in 1972, to 37 in 1991, and to 46 in 2001. Of the 46 park-ride lots in 2001, 37 were provided with transit service. On an average weekday in 2001, about 38 percent of the approximately 6,500 spaces at the 46 park-ride lots were estimated to be in use.

The background inventory data presented in this Chapter is of both direct and indirect use in the wireless telecommunications planning process. Population and household estimates and forecasts in regional aggregate form and distributed by existing and proposed land use patterns will provide the basis for voice, data, and video traffic demand analyses. National traffic data from the Federal Communications Commission and the U.S. Bureau of Census will be allocated to the Region based on the regional share of the national population. These estimates will be verified and cross-correlated with data on state, regional, or industry levels so as to obtain the best estimate of current traffic and the framework for design year forecasts. The data to be allocated include: the number of subscribers, the average number of daily calls for each subscriber, and the average length of each call. From such data, it is possible to estimate existing and to forecast call generation for subregional areas down to the U.S. Public Land Survey system section. Most of the national call data relate to voice calls, but information on wireless data traffic is also becoming available. Wireless video traffic data, however, have not been available long enough to be meaningful. Employment data are also useful in forecasting wireless traffic from work locations. National traffic data can be allocated to the Region based on the regional share of national employment. Voice and data traffic by subregional area can be estimated and forecast based on regional employment and land use data. Land use data can also be used to differentiate as to whether population, employment, or a combination of both, should be used to determine traffic generation rates in a particular subarea of the planning Region. Areas designated as environmental corridors are generally excluded from consideration as potential antenna site locations.

A special aspect of wireless traffic generation relates to calls made during travel. Recent statistics released by the National Highway Traffic Safety Administration indicate that at any given time about eight percent of automobile drivers are using cell phones. Therefore, data on arterial street and highway traffic volumes provides an important resource for estimating and forecasting wireless traffic in the Region. Vehicular traffic volumes segregated by street and highway segments will be an important input for wireless traffic level forecasts.

All of the above uses of background data relate to the demand side of telecommunications systems. On the supply side, relating to network infrastructure design, population density or more precisely household density is an important variable to be considered in the choice of communications technology. In geographic areas with low household densities, wireless infrastructures may be more cost effective for broadband communications than wireline systems. High household density areas favor use of fiber optic cable networks.

Overall, the background data on population, households, employment, land use and transportation traffic patterns facilitates wireless network design, permitting alternative designs to be developed that can meet existing and probable future needs during the life of the network infrastructure.

Chapter V

WIRELESS TELECOMMUNICATIONS INFRASTRUCTURE INVENTORY FINDINGS

INTRODUCTION

Reliable planning data are essential for the formulation of workable development plans. Consequently, an inventory of existing conditions is the first step in the planning process. The crucial nature of factual information in the planning process should be evident, since no reliable forecasts can be made or alternative courses of action evaluated without knowledge of the current state of the system being planned. The necessary inventory not only provides data describing the existing conditions, but also provide a basis for identifying existing and potential problems in the planning area and opportunities for development. The inventory data are also crucial to the forecasting of future facility and service needs, formulating alternative plans, and evaluating such plans.

Chapter IV presented data on the existing demography and economy; the existing land use pattern; and the existing transportation system of the planning area. These factors provide the setting for the telecommunication facilities and services of an area, and affect the configuration of the demand upon those facilities and services, and the configuration of the facilities and services themselves. The sound development of a telecommunications facilities and services plan must also consider: telecommunications technologies currently employed within the Region; emerging technologies that may displace these current technologies; the planimetry and hypsometry of the Region that has a major impact on the deployment of wireless communications systems displayed as Canopy data; and the existing telecommunications infrastructure within the Region. The performance of that existing infrastructure must also be monitored. The results of the monitoring is reported in a later chapter. The regulatory environment must also be inventoried. The results of this inventory will also be provided in a separate chapter.

Infrastructure inventories in wireless networks relate primarily to antenna sites, their transmission interconnection to core networks and the coverage areas of these sites. Wireless performance inventories are based on standard measurements of availability, throughput, response time and accuracy.

The wireless antenna site inventory has limitations related to the accuracy of the data sources necessarily used in its compilation. The FCC database has recognized deficiencies in the form of both inaccurate data pertaining to the base transceiver stations locations and characteristics, and in the form of the omission of stations especially with respect for PCS networks in the 1900 MHz range. Data acquired from local units of government is generally reliable for geographic positional and structural data, but often is not current on provider designations and lacks information on antenna configuration and power. Overcoming these shortcomings in the last analysis requires the cooperation of each wireless service provider. As of the date of this report one wireless service provider—Sprint—has provided the Commission with a complete set of antenna site data for the Region. A second provider—Nextel—has provided the Commission with geographic positional data.

INFRASTRUCTURE INVENTORY DATA SOURCES

Comprehensive and accurate wireless telecommunications infrastructure inventories are a rare commodity. Although national data bases on antenna sites have been compiled by the (FCC) Federal Communications Commission and Federal Aviation Administration (FAA), these data bases tend to be inaccurate and incomplete. Neither agency has attempted a comprehensive antenna site compilation, so that an accurate antenna site inventory requires collation of data from at least four major sources: the FAA database is primarily concerned with the location and height of antenna structures, data more conveniently and often more accurately collated from the other databases used. Therefore, the FAA database, although obtained, was not used in the compilation of the inventories.

1. FCC Database
   This data base provided a good starting point for an inventory of antennae sites for traditional cellular networks in the 800 to 900 MHz range; but is a poor source of data for personal communication system (PCS) wireless networks in the 1900 MHz range.

2. Mobiledia Website
   This data base provided information of fair quality relating to PCS networks.

3. Local Units of Government
   The county and municipal units of government within the Region constitute a good confirmation source for antennae site locations providing cellular and PCS service, and the only independent source of data for fixed wireless antenna sites.

4. Network Operators
   The network operators comprised the final confirmation source for all four classes of wireless networks and a critical check on the coverage element of the inventory.

Using all four of the above sources, the Commission compiled a comprehensive inventory for regional antenna sites. Geographic and technical data for each site then provide the foundation for radio propagation studies to determine the radio coverage of individual sites and the overall radio coverage of the Region.

The antenna site inventory was focused on those sites related to wireless service providers and public agencies that furnish telecommunication services to the general public or to county and local units of government. Other antenna sites serve a wide range of commercial and public uses. Such sites may be classified as follows:

1. Mobile cellular and PCS antennae serving cellular phone networks; cellular in the 800 to 900 MHz band; and PCS in the 1900 MHz band.

2. Fixed wireless antennae serving broadband internet service providers (ISPs), antennae operating in the unlicensed 2.4 GHz and 5.2-5.9 GHz bands.

3. Land mobile wireless antennae, including antennae serving multi-agency, multijurisdictional 800 trunk networks operating under 800 MHz range; and antennae serving other police, fire, emergency medical service and public works networks.

4. Paging antenna sites

5. Microwave antenna sites

Excluded from the inventory were private commercial and broadcast auxiliary land mobile networks; amateur radio service antennae; commercial radio and restricted radio telephone (FRC) antennae; and general mobile radio service (GMRS) antennae. These types of networks were excluded because they do not provide communication services to the public or to local units of government.

Of the inventoried sites, only the first three classes listed above were inventoried for site coverage and capacity. Site data for paging and microwave point-to-point links were collected only to provide a comprehensive inventory of antenna sites and structures that may be utilized in future wireless antenna site planning. For those sites of direct planning interest, the mobile cellular-PCS class dominates in terms of both number and regional impact, but each category was covered in the Regional telecommunications infrastructure inventory.

MOBILE CELLULAR/PCS INFRASTRUCTURE INVENTORY

The mobile cellular infrastructure inventory describes the antenna sites and related supporting infrastructure of the three 800 to 900 MHz band wireless service providers in Southeastern Wisconsin: Nextel Communications; Cingular Communications; and U.S. Cellular. Together, these providers account for 300 antenna sites in the Region according to the FCC database. Because of co-located antennas, the number of base transceiver stations will be more than the number of antenna sites. A base transceiver station consists of an omnidirectional antenna, or a set of directional antennas, interconnected to a transceiver with supporting power source and accessory equipment located at an antenna site. An antenna site is a parcel of land with a located tower, or other elevated structure, capable of accommodating a base transceiver station. Classified by provider, the number of base transceiver stations were recorded as follows: 1) Nextel Communications–104; 2) U.S. Cellular–146 3) Cingular Communications–50.

The FCC database does not provide comprehensive information on PCS antenna sites. Such information is, however, available from the local units of government as described below:

For each antenna site, the following data were collected and tabulated:

1. Name of Service Provider

2. Type of structure

3. Sole locator or co-locator

4. Geographic Coordinates
   - latitude and longitude

   - State plane coordinates

   - U.S. Public Land Survey System Section, Township and Range

   - street address

5. Antenna Height

   - above ground (feet)

6. Antenna Sectors

   - number, if applicable

7. Antenna Power
   a. in watts

8. Antenna Frequency

   a. in megahertz (MHz)

   b. or in gigahertz (GHz)

9. Antenna Pattern

   - if available

10. Zoning, Conditional Use Permit and Lease Data[1]

Wireless Infrastructure Inventory
As previously noted, antenna site data were collected in the following categories:

1. Mobile cellular and PCS networks;

2. Fixed wireless networks; and

3. Land mobile public networks

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[1]*The information on zoning, conditional use permit and lease data were collected at this time in the interest of efficiency. In collecting this information, the Commission is looking ahead to the possible preparation of a Commission local planning guide on the siting of wireless antenna structure and related facilities within the Region. In addition, information concerning the conditions placed by county and local municipalities on antenna structure locations and designs is of material interest to the Commission's constituents, counties and municipalities as are data concerning fees and lease arrangements and payments.*

The inventory data collected in these three categories include:

1. Positional data in the form of latitude and longitude, state plane coordinates, U.S. Public based Survey System Section, Township and Range, and street address;
2. Type of Structure;
3. Technical data including to the extent available antenna height, type, power and frequency.

The findings of only the first two inventory categories are herein presented. Inventory data were also collected on paging antenna sites and point-to-point microwave antenna sites as potential sites for future wireless network deployments.

The inventory findings are presented herein by county.

KENOSHA COUNTY

Antenna site data for Kenosha County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases
   a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22
   b. For Nextel Communications, Inc.–Land Mobile–Commercial
2. Local governmental databases, included data provided by the following local units of government in Kenosha County: City of Kenosha–24 sites; Village of Genoa City–0 sites; Village of Paddock Lake–5 sites; Village of Pleasant Prairie–14 sites; Village of Silver Lake–0 sites; Village of Twin Lakes–5 sites; Town of Brighton–6 sites; Town of Bristol–7 sites; Town of Paris–6 sites; Town of Randall–4 sites; and Town of Salem–5 sites; Town of Somers–14 sites; and Town of Wheatland–4 sites. There are a total of 94 sites within Kenosha County.

Antenna and Antenna Site Inventory–Cellular/PCS

The cellular/PCS antenna site inventory findings for Kenosha County are summarized in Tables 16 through 21 reproduced on pages 59 through 64, one for each wireless service provider as follows: Table 16–Cingular Wireless–16 antenna sites, Table 17–Nextel Communications–13 antenna sites, Table 18–Sprint PCS–18 antenna sites, Table 19–T-Mobile–11 antenna sites, Table 20–U.S. Cellular–21 antenna sites, and Table 21–Verizon Wireless–15 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 11 through 16. Map 17 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 16, 17, and 20 representing the cellular (800–900 MHz) service providers, are based on compilation and reconciliation of data from the FCC and local government data bases. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired from the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 18, 19, and 21 representing the PCS service providers were compiled almost entirely from local governmental data bases since PCS sites were largely absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of their sites.

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all, fixed

Table 16

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 11)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
K1	42-32-20	88-12-32	201,588	2,482,752	T. 1 N., R. 19 E. Sec. 14	9240 328th Ave. Town of Randall	150.88	S	140.82	891.51
K2	42-33-03	88-16-50	205,534	2,463,350	T. 1 N., R. 19 E. Sec. 17	37800 87th St. Town of Randall	190.24	S	N/A	1945
K3	42-34-17	88-05-38	214,117	2,513,469	T. 1 N., R. 20 E. Sec. 2	6969 236th Ave. Village of Paddock Lake	98.4	S	140.82	891.51
K4	42-34-53	88-08-48	217,441	2,499,174	T. 1 N., R. 20 E. Sec. 4	27811 60th St. Town of Salem	265.68	S	140.82	891.51
K5	42-33-37	88-02-28	210,398	2,527,777	T. 1 N., R. 21 E. Sec. 8	19460 81st St. Town of Bristol	193.52	S	N/A	1945
K6	42-33-34	87-57-38	210,615	2,549,483	T. 1 N., R. 21 E. Sec. 12	2028 128th Ave. Town of Bristol	141.04	S	N/A	1945
K7	42-32-13.7	87-59-07	202,326	2,543,020	T. 1 N., R. 21 E. Sec. 23	14901 Wilmot Rd. Town of Bristol	150.88	S	140.82	891.51
K8	42-32-40.3	87-53-22.3	205,655	2,568,751	T. 1 N., R. 22 E. Sec. 15	8851 Green Bay Rd. Village of Pleasant Prairie	280.76	S	140.82	891.51
K9	42-30-01	87-57-02	189,123	2,552,706	T. 1 N., R. 22 E. Sec. 31	WisDOT Weigh Station IH 94 and CTH ML, Village of Pleasant Prairie	98.4	S	140.51	891.51
K10	42-32-35	87-49-28	205,570	2,586,299	T. 1 N., R. 23 E. Sec. 18	8961 Sheridan Rd. City of Kenosha	78.72	S	140.82	891.51
K11	42-36-00	88-16-00	223,527	2,466,720	T. 2 N., R. 19 E. Sec. 29	3403 392nd Ave. Town of Wheatland	229.6	S	N/A	1945
K12	42-38-12	88-04-37	238,007	2,517,484	T. 2 N., R. 20 E. Sec. 13	1271 224th Ave. Town of Brighton	200.08	S	N/A	1945
K13	42-37-30	88-00-15	234,216	2,537,164	T. 2 N., R. 21 E. Sec. 22	16105 Burlington Rd. Town of Paris	141.04	S	N/A	1945
K14	42-39-28	87-50-12	247,282	2,581,922	T. 2 N., R. 22 E. Sec. 1	7th St. Town of Somers	190.24	S	N/A	1945
K15	42-39-03	87-55-52	244,107	2,556,587	T. 2 N., R. 22 E. Sec. 8	900 100th Ave. Town of Somers	278.8	S	N/A	1945
K16	42-37-30	87-49-41	235,400	2,584,549	T. 2 N., R. 23 E. Sec. 18	1815 Birch Rd. Town of Somers	98.4	S	140.82	891.51

[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*
[b]*Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market may be expected to decline. To adapt to the shift to broadband communications, many ISPs have offered some form

Table 17

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 12)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
K17	42-33-03	88-16-50	205,534	2,463,350	T. 1 N., R. 19 E. Sec. 17	37800 87th St. Town of Randall	200.08	O	62	851.6625
K18	42-32-19	88-11-23	201,599	2,487,919	T. 1 N., R. 19 E. Sec. 24	31315 93rd St. Town of Randall	180.4	O	N/A	851.6625
K19	42-34-17	88-05-37	214,119	2,513,544	T. 1 N., R. 20 E. Sec. 2	6969 236th Ave. Village of Paddock Lake	226.32	O	N/A	851.6625
K20	42-33-34	87-57-38	210,615	2,549,483	T. 1 N., R. 21 E. Sec. 12	2028 128th Ave. Town of Bristol	134.48	O	250	851.6625
K21	42-34-41	87-50-34	218,194	2,581,030	T. 1 N., R. 22 E. Sec. 1	6203 28th Ave. City of Kenosha	65.6	O	250	851.6625
K22	42-34-32	87-54-00	216,889	2,565,645	T. 1 N., R. 22 E. Sec. 4	6509 77th Ave. City of Kenosha	150.88	O	N/A	851.6625
K23	42-33-38.52	87-53-16.13	192,811	2,569,539	T. 1 N., R. 22 E. Sec. 27	11513 Green Bay Rd. Village of Pleasant Prairie	459.2	O	N/A	851.6625
K24	42-31-18	87-49-18	197,797	2,587,251	T. 1 N., R. 23 E. Sec. 30	10415 Sheridan Rd. Village of Pleasant Prairie	150.88	O	N/A	851.6625
K25	42-38-12	88-04-37	238,007	2,517,484	T. 2 N., R. 20 E. Sec. 13	1271 224th Ave. Town of Brighton	98.4	O	N/A	851.6625
K26	42-36-24	87-57-33	227,829	2,549,436	T. 2 N., R. 21 E. Sec. 25	12508 38th St. Town of Paris	75.44	O	500	851.6625
K27	42-39-03.1	87-55-51.3	244,119	2,556,639	T. 2 N., R. 22 E. Sec. 8	1000 100th Ave. Town of Somers	321.44	O	100	865.8375
K28	42-37-01.1	87-52-28.3	232,153	2,572,120	T. 2 N., R. 22 E. Sec. 23	HWY 31 off Becker Rd. Town of Somers	308.32	O	37	865.6625
K29	42-37-30	87-49-41	235,400	2,584,549	T. 2 N., R. 23 E. Sec. 18	1815 Birch Rd. Town of Somers	78.72	O	N/A	851.6625

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local governmental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed wireless industry. For this reason, inventory data collection efforts were concentrated on those companies of demonstrated stability and longevity. There are currently two known fixed wireless service providers operating in Kenosha County. The antenna site data for these providers are listed in Table 57 and shown on Map 59.

Table 18

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 13)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
K30	42-31-40	88-16-08	197,198	2,466,668	T. 1 N., R. 19 E. Sec. 20	920 Lance Dr. Village of Twin Lakes	252.56	O	N/A	1970
K31	42-34-17	88-05-37	214,119	2,513,544	T. 1 N., R. 20 E. Sec. 2	6969 236th Ave. Village of Paddock Lake	249.28	O	N/A	1970
K32	42-34-11	87-57-38	214,359	2,549,391	T. 1 N., R. 21 E. Sec.1	75th St. City of Kenosha	88.56	O	N/A	1970
K33	42-34-41	87-50-34	218,194	2,581,030	T. 1 N., R. 22 E. Sec. 1	6203 28th Ave. City of Kenosha	78.72	O	N/A	1970
K34	42-34-22	87-51-19	216,184	2,577,714	T. 1 N., R. 22 E. Sec. 2	6724 39th Ave. City of Kenosha	68.88	O	N/A	1970
K35	42-33-28.49	87-55-7.48	210,335	2,560,758	T. 1 N., R. 22 E. Sec. 8	9201 Wilmot Rd. Village of Pleasant Prairie	134.48	O	N/A	1970
K36	42-33-54	87-52-29	213,216	2,572,550	T. 1 N., R. 22 E. Sec. 11	75th St. City of Kenosha	104.96	O	N/A	1970
K37	42-31-25	87-52-32	198,131	2,572,710	T. 1 N., R. 22 E. Sec. 22	10300 57th Ave. Village of Pleasant Prairie	131.2	O	N/A	1970
K38	42-30-12.12	87-57-01.01	190,251	2,552,752	T. 1 N., R. 22 E. Sec. 31	12001 120th Ave. Village of Pleasant Prairie	111.52	O	N/A	1970
K39	42-32-35	87-49-28	205,570	2,586,299	T. 1 N., R. 23 E. Sec. 18	8961 Sheridan Rd City of Kenosha	88.56	O	N/A	1970
K40	42-36-00	88-16-00	223,527	2,466,720	T. 2 N., R. 19 E. Sec. 29	3403 392nd Ave. Town of Wheatland	249.28	O	N/A	1970
K41	42-38-46	87-58-18	242,119	2,545,722	T. 2 N., R. 21 E. Sec. 12	843 136th Ave. Town of Paris	150.88	O	N/A	1970
K42	42-37-47	87-52-32	236,791	2,571,725	T. 2 N., R. 22 E. Sec. 15	1533 Green Bay Rd. Town of Somers	150.88	O	N/A	1970
K43	42-37-31	87-53-41	235,041	2,566,609	T. 2 N., R. 22 E. Sec. 15	7150 18th St. Town of Somers	118.08	O	N/A	1970
K44	42-36-17	87-50-45	227,888	2,579,957	T. 2 N., R. 22 E. Sec. 25	3520 30th Ave. City of Kenosha	88.56	O	N/A	1970
K45	42-35-49	87-50-43	225,058	2,580,179	T. 2 N., R. 22 E. Sec. 25	4311 30th Ave. City of Kenosha	137.76	O	N/A	1970
K46	42-35-44	87-53-09	224,273	2,569,275	T. 2 N., R. 22 E. Sec. 34	46th St. City of Kenosha	118.08	O	N/A	1970
K47	42-35-02	87-49-07	220,488	2,587,482	T. 2 N., R. 23 E. Sec. 31	625 57th St. City of Kenosha	111.52	O	N/A	1970

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

Inventory Findings–Geographic Coverage
Originally, it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain

Table 19

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 14)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
K48	42-31-40	88-16-08	197,198	2,466,668	T. 1 N., R. 19 E. Sec. 20	920 Lance Dr. Village of Twin Lakes	219.76	O	N/A	1990
K49	42-34-17	88-05-37	214,119	2,513,544	T. 1 N., R. 20 E. Sec. 2	6969 236th Ave. Village of Paddock Lake	200.08	O	N/A	1990
K50	42-34-11	87-57-38	214,359	2,549,391	T. 1 N., R. 21 E. Sec. 1	75TH St. City of Kenosha	111.52	O	N/A	1990
K51	42-34-30	87-51-01	217,028	2,579,040	T. 1 N., R. 22 E. Sec. 1	3303 66th St. City of Kenosha	98.4	O	N/A	1990
K52	42-33-03	87-53-32	207,935	2,567,967	T. 1 N., R. 22 E. Sec. 15	8600 Green Bay Rd. Village of Pleasant Prairie	180.4	O	N/A	1990
K53	42-31-38.82	87-51-13.24	199,680	2,578,570	T. 1 N., R. 22 E. Sec. 23	9915 39th Ave. Village of Pleasant Prairie	121.36	O	N/A	1990
K54	42-39-03	87-55-52	244,107	2,556,587	T. 2 N., R. 22 E. Sec. 8	900 100th Ave. Town of Somers	246	O	N/A	1990
K55	42-37-01	87-52-27	232,145	2,572,217	T. 2 N., R. 22 E. Sec. 23	23rd St. Town of Somers	98.4	O	N/A	1990
K56	42-35-44	87-53-09	224,273	2,569,275	T. 2 N., R. 22 E. Sec. 34	46th St. City of Kenosha	88.56	O	N/A	1990
K57	42-37-30	87-49-41	235,400	2,584,549	T. 2 N., R. 23 E. Sec. 18	1815 Birch Rd. Town of Somers	121.36	O	N/A	1990
K58	42-35-02	87-49-07	220,488	2,587,482	T. 2 N., R. 23 E. Sec. 31	625 57th St. City of Kenosha	114.8	O	N/A	1990

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that such radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission staff in such coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be prepared only for the networks of cooperating service providers and documented in a separate report. The infrastructure inventory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the

Table 20

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 15)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
K59	42-34-50	88-13-13	216,705	2,479,359	T. 1 N., R. 19 E. Sec. 2	33807 Geneva Rd. Town of Wheatland	180.4	S	100	890.01
K60	42-31-40	88-16-08	197,198	2,466,668	T. 1 N., R. 19 E. Sec. 20	920 Lance Dr. Village of Twin Lakes	180.4	S	140.82	890.01
K61	42-31-55.1	88-15-07.3	198,821	2,471,180	T. 1 N., R. 19 E. Sec. 21	236 E. Main St. Village of Twin Lakes	115.128	O	28	890.01
K62	42-32-00	88-04-46	200,340	2,517,678	T. 1 N., R. 20 E. Sec. 24	23100 98th St. Town of Salem	121.36	S	140.82	890.01
K63	42-31-13	88-05-54	195,466	2,512,696	T. 1 N., R. 20 E. Sec. 26	23913 Wilmot Rd. Town of Salem	59.04	S	10	890.01
K64	42-31-14	88-10-44	195,083	2,490,982	T. 1 N., R. 20 E. Sec. 30	10720 Fox River Rd. Town of Salem	150.88	S	75	890.01
K65	42-33-37	88-02-28	210,398	2,527,777	T. 1 N., R. 21 E. Sec. 8	19460 81st St. Town of Bristol	177.12	S	140.82	890.01
K66	42-32-15.56	87-59-58.36	202,421	2,539,171	T. 1 N., R. 21 E. Sec.22	14401 Wilmot Rd. Town of Bristol	150.88	O	N/A	890.01
K67	42-32-14.1	87-59-07.3	202,366	2,542,997	T. 1 N., R. 21 E. Sec. 23	14401 Wilmot Rd. Town of Bristol	149.896	S	90	890.01
K68	42-34-41	87-50-34	218,194	2,581,030	T. 1 N., R. 22 E. Sec. 1	6203 28th Ave. City of Kenosha	99.056	O	100	890.01
K69	42-33-03	87-53-32	207,935	2,567,967	T. 1 N., R. 22 E. Sec. 15	8600 Green Bay Rd. Village of Pleasant Prairie	249.28	O	100	890.01
K70	42-31-38.82	87-51-13.24	199,680	2,578,570	T. 1 N., R. 23 E. Sec. 23	9915 39th Ave. Village of Pleasant Prairie	98.4	O	140.82	890.01
K71	42-31-10.03	87-56-51.42	196,129	2,553,326	T. 1 N., R. 23 E. Sec. 30	11800 108th St. Village of Pleasant Prairie	88.888	S	140.82	890.01
K72	42-30-57	87-49-22	195,664	2,587,007	T. 1 N., R. 23 E. Sec. 30	Sheridan Rd. Village of Pleasant Prairie	65.6	O	15	890.01
K73	42-38-12	88-04-37	238,007	2,517,484	T. 2 N., R. 20 E. Sec. 13	1271 224th Ave. Town of Brighton	141.04	S	N/A	890.01
K74	42-35-26	88-05-29	221,116	2,513,982	T. 2 N., R. 20 E. Sec. 35	4320 232nd Ave. Town of Brighton	164	O	50	890.01
K75	42-39-07	87-57-22	244,346	2,549,854	T. 2 N., R. 21 E. Sec. 12	12209 7th St. Town of Paris	141.04	S	100	890.01
K76	42-35-23	87-58-00	221,606	2,547,568	T. 2 N., R. 21 E. Sec. 36	4815 128th Ave. Town of Paris	98.4	S	N/A	890.01
K77	42-37-01.1	87-52-28.3	232,153	2,572,120	T. 2 N., R. 22 E. Sec. 23	2380 47th Ave. City of Kenosha	299.792	S	75	890.01
K78	42-35-04	87-51-41	220,392	2,575,959	T. 2 N., R. 22 E. Sec. 35	5619 44th Ave. City of Kenosha	78.72	O	N/A	890.01
K79	42-36-37	87-49-28	230,062	2,585,661	T. 2 N., R. 23 E. Sec. 19	3000 Sheridan Rd. City of Kenosha	98.4	O	140.82	890.01

[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b]*Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

Table 21

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS-WIRELESS ANTENNAS IN KENOSHA COUNTY, WISCONSIN: 2005

Site Number (See Map 16)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
K80	42-34-50	88-13-13	216,705	2,479,359	T. 1 N., R. 19 E. Sec. 2	33807 Geneva Rd. Town of Wheatland	164	S	N/A	929.1125
K81	42-31-40	88-16-08	197,198	2,466,668	T. 1 N., R. 19 E. Sec. 20	920 Lance Dr. Village of Twin Lakes	200.08	S	N/A	929.1125
K82	42-34-17	88-05-38	214,117	2,513,469	T. 1 N., R. 20 E. Sec. 2	6969 236th Ave. Village of Paddock Lake	180.4	S	N/A	929.1125
K83	42-31-14	88-10-44	195,083	2,490,982	T. 1 N., R. 20 E. Sec. 30	10720 Fox River Rd. Town of Salem	98.4	S	N/A	929.1125
K84	42-34-11	87-57-38	214,365	2,549,369	T. 1 N., R. 21 E. Sec. 1	75th St. City of Kenosha	101.7	O	N/A	929.1125
K85	42-34-41	87-50-34	218,200	2,581,009	T. 1 N., R. 22 E. Sec. 1	6203 28th Ave. City of Kenosha	N/A	O	N/A	929.1125
K86	42-31-25	87-52-32	198,131	2,572,710	T. 1 N., R. 22 E. Sec. 22	10300 57th Ave. Village of Pleasant Prairie	72.16	S	N/A	929.1125
K87	42-32-35	87-49-28	205,577	2,586,279	T. 1 N., R. 23 E. Sec. 18	8961 Sheridan Rd. City of Kenosha	105	O	N/A	929.1125
K88	42-38-26	88-06-42	239,210	2,508,110	T. 2 N., R. 20 E. Sec. 15	25000 Burlington Rd. Town of Brighton	167.28	S	N/A	929.1125
K89	42-36-09	88-09-40	225,047	2,495,115	T. 2 N., R. 20 E. Sec. 29	3930 288th Ave. Town of Brighton	180.4	S	N/A	929.1125
K90	42-37-19	87-58-03	233,347	2,547,035	T. 2 N., R. 22 E. Sec. 02	12908 Burlington Rd. Town of Paris	124.7	O	N/A	929.1125
K91	42-40-06	87-51-37	250,970	2,575,453	T. 2 N., R. 21 E. Sec. 24	4211 1st. St. Town of Somers	88.6	S	N/A	929.1125
K92	42-39-03.1	87-55-50.3	244,121	2,556,714	T. 2 N., R. 22 E. Sec. 8	BTC Tower Town of Somers	98.4	S	N/A	929.1125
K93	42-38-21	87-54-02	240,068	2,564,891	T. 2 N., R. 22 E. Sec. 16	12th St. Town of Somers	147.6	S	N/A	929.1125
K94	42-37-24	87-50-27	234,710	2,581,106	T. 2 N., R. 22 E. Sec. 24	18th St. City of Kenosha	98.4	O	N/A	929.1125

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.

[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.

[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Kenosha County and local municipalities of Kenosha County, Wisconsin and SEWRPC.

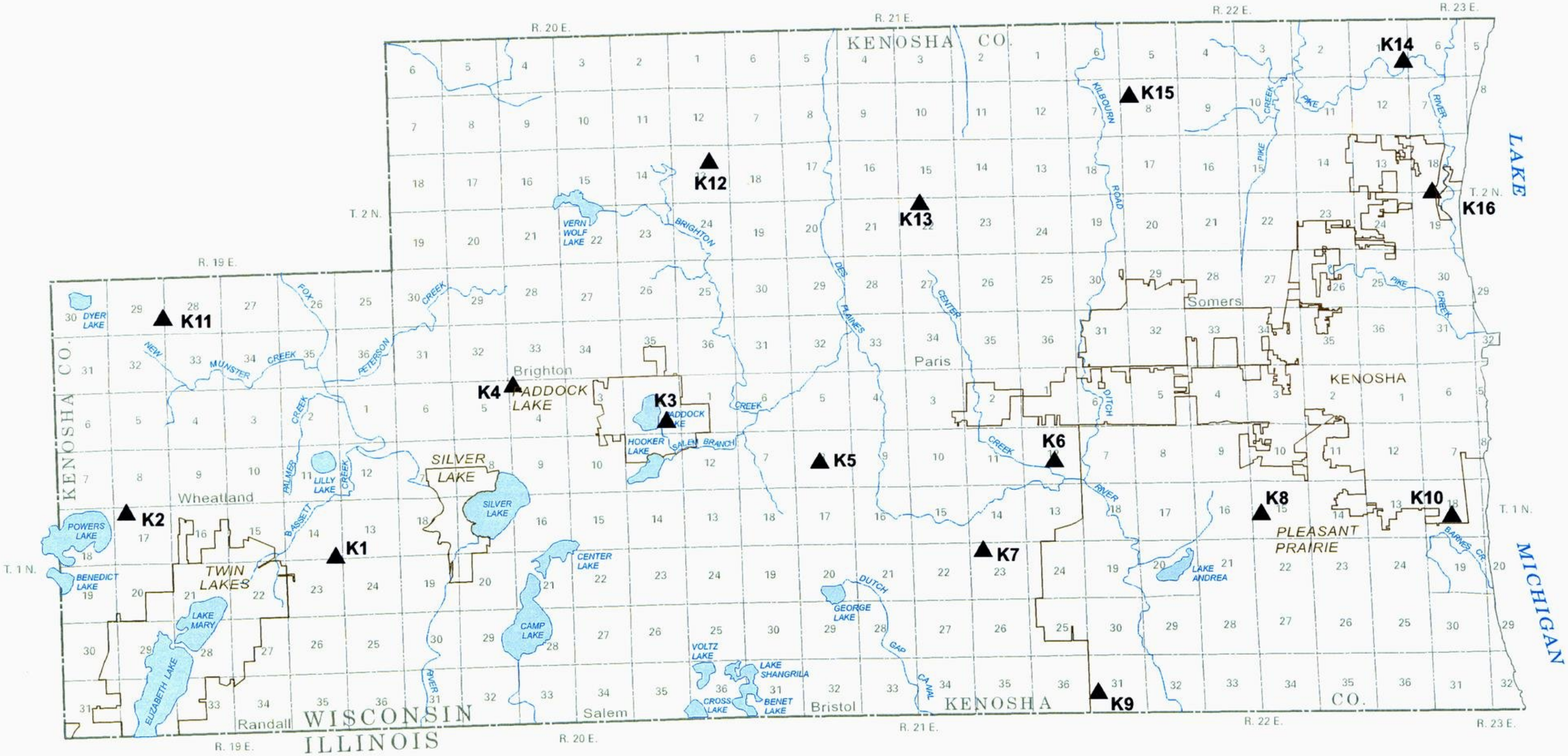
Commission regional wireless network monitoring system which recorded performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 94 base transceiver stations on 60 cellular–PCS mobile wireless antenna sites within Kenosha County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the

Map 11

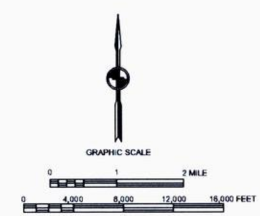
ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (16)

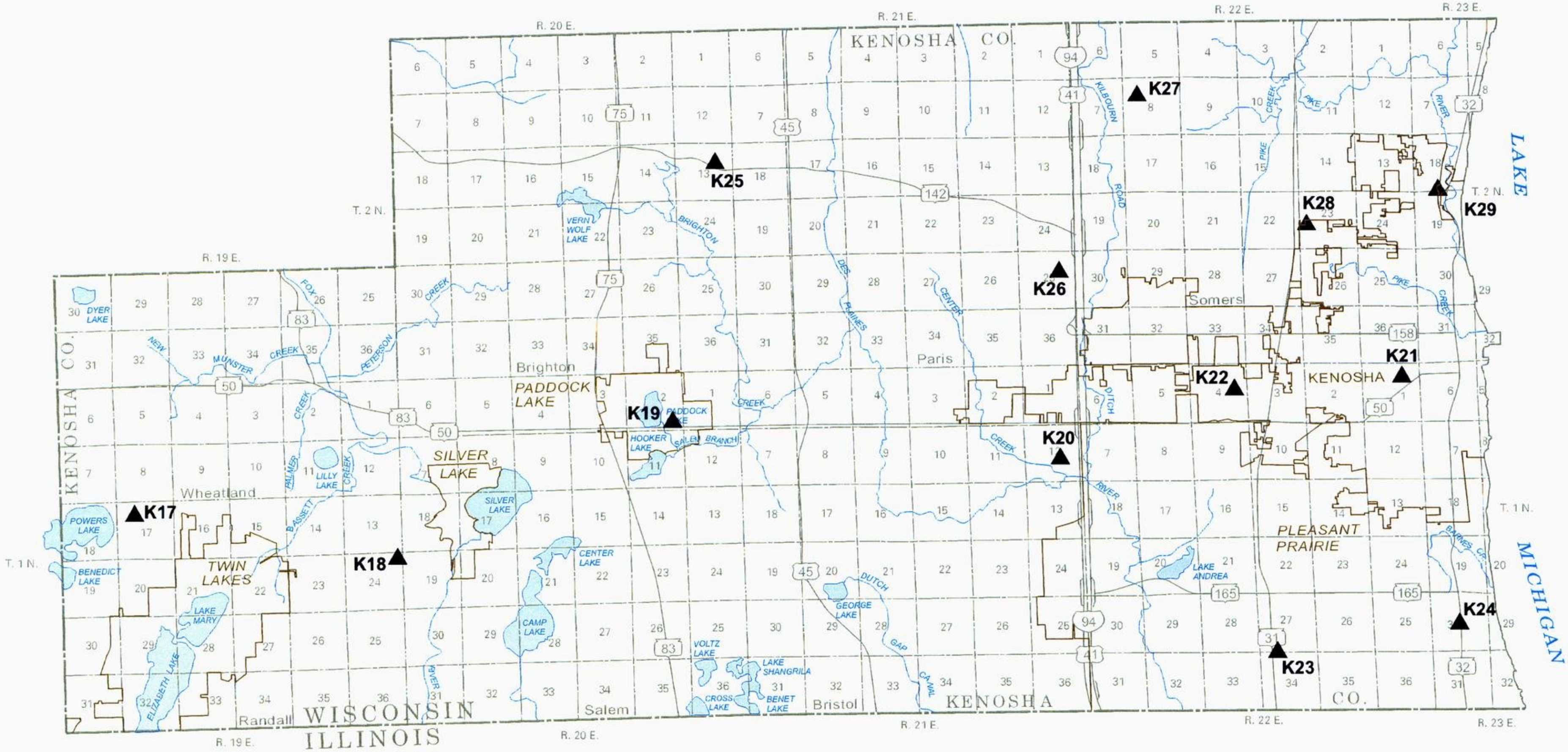
K5 IDENTIFICATION NUMBER (SEE TABLE 16)



Source: SEWRPC.

Map 12

ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (13)

K21 IDENTIFICATION NUMBER (SEE TABLE 17)

GRAPHIC SCALE

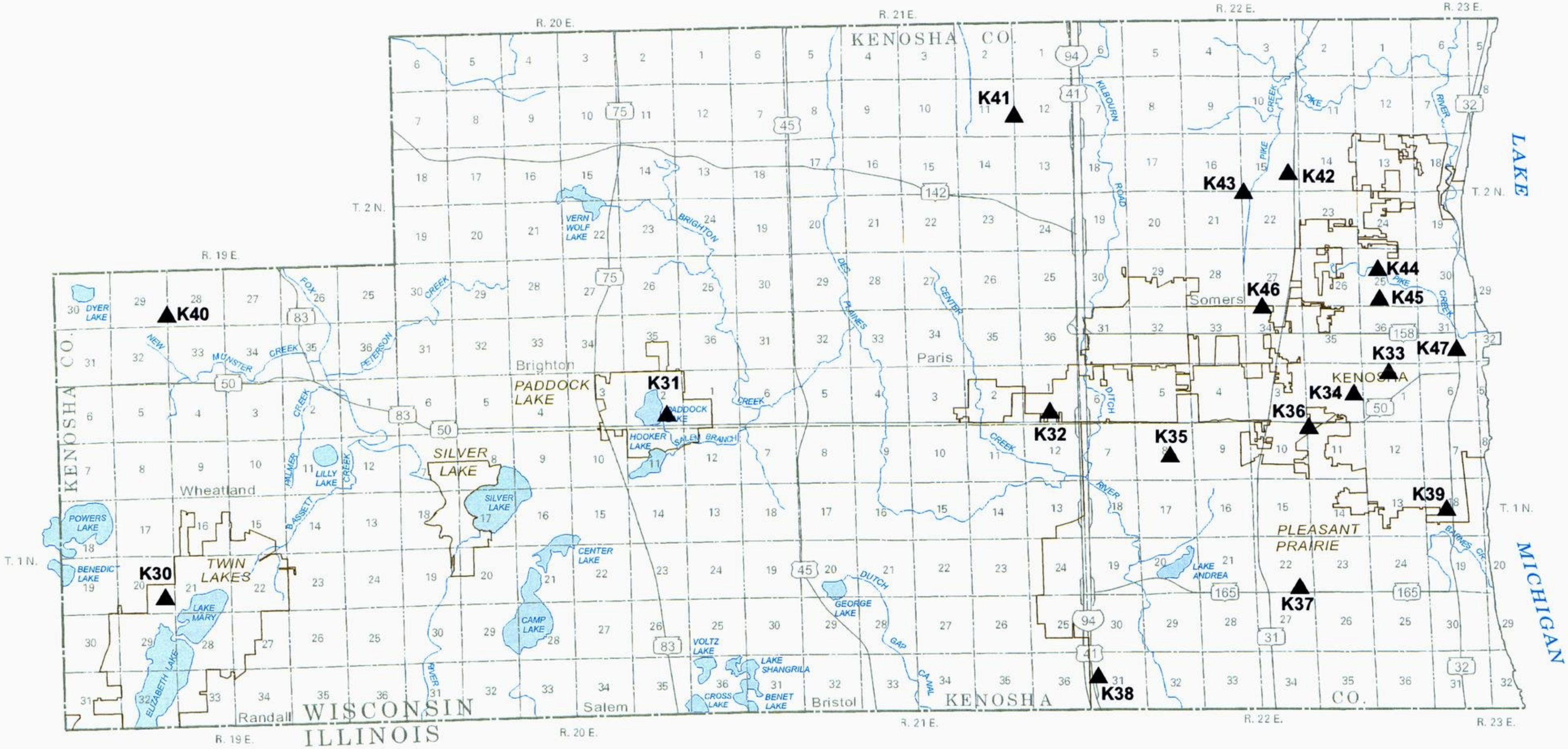
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 13

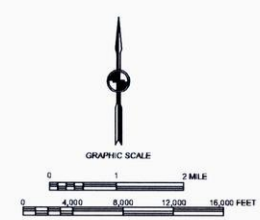
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (18)

K31 IDENTIFICATION NUMBER (SEE TABLE 18)



GRAPHIC SCALE

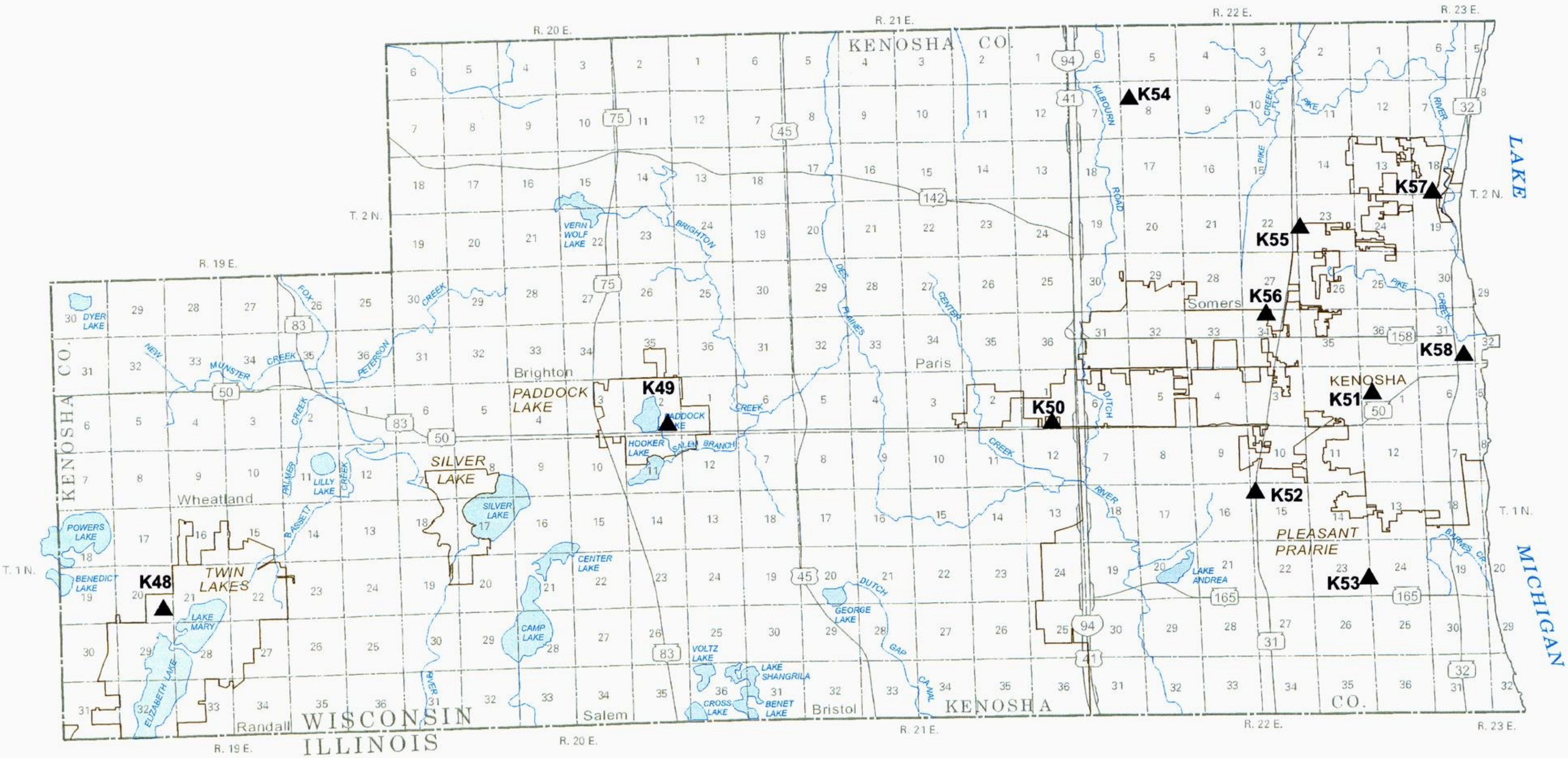
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 14

ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

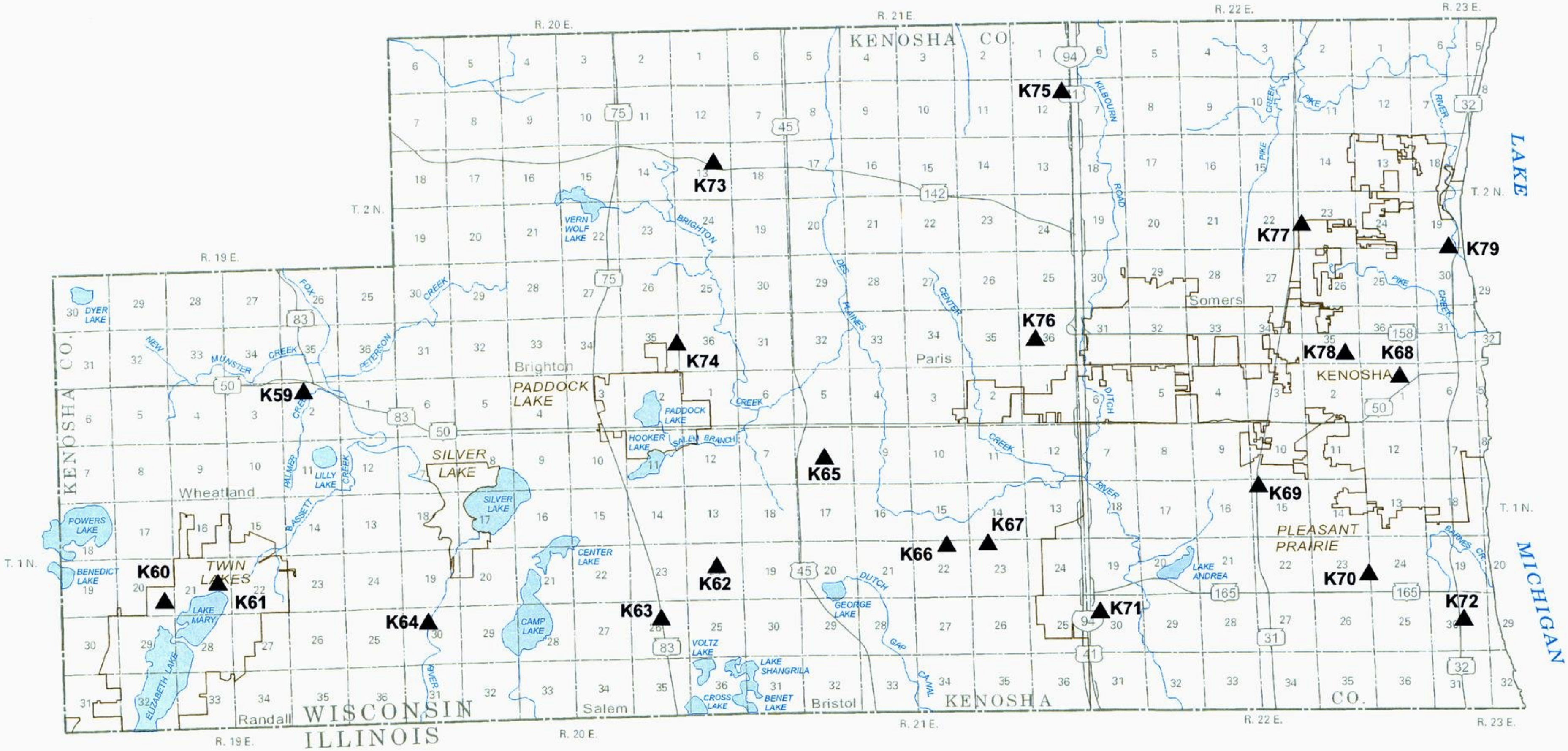
▲ ANTENNA SITE (11)

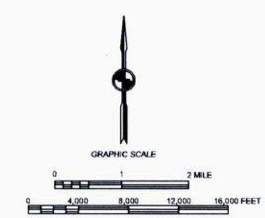
K51 IDENTIFICATION NUMBER (SEE TABLE 19)

Source: SEWRPC.

Map 15

ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005





LEGEND

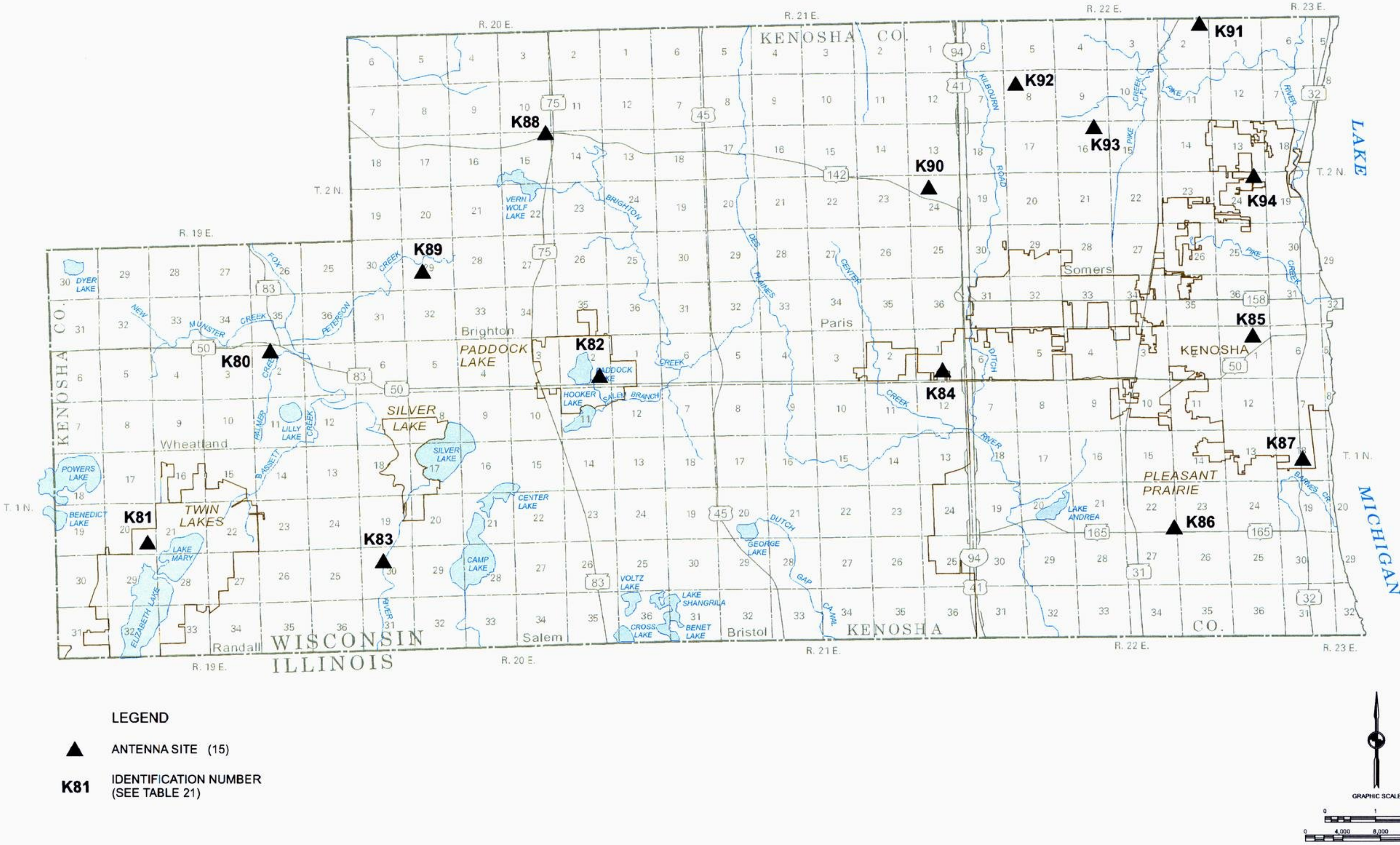
▲ ANTENNA SITE (21)

K61 IDENTIFICATION NUMBER (SEE TABLE 20)

Source: SEWRPC.

Map 16

ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

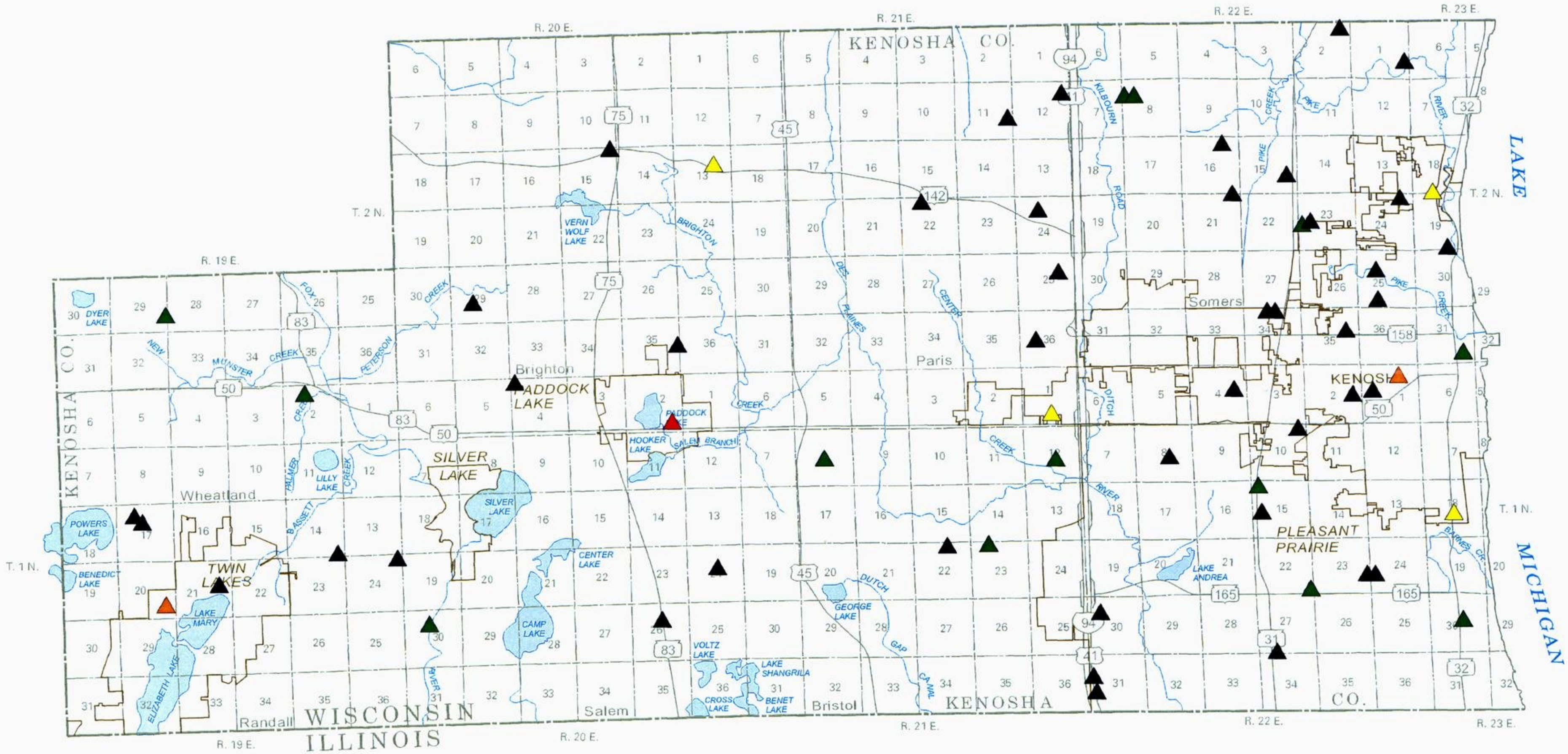
▲ ANTENNA SITE (15)

K81 IDENTIFICATION NUMBER (SEE TABLE 21)

Source: SEWRPC.

Map 17

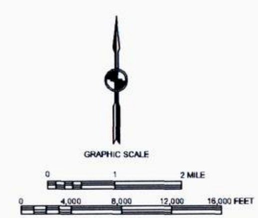
ANTENNA SITE LOCATIONS IN KENOSHA COUNTY, WISCONSIN: 2005



LEGEND

▲	1 ANTENNA SITE	(43)
▲	2 ANTENNA SITES	(13)
▲	3 ANTENNA SITES	(4)
▲	4 ANTENNA SITES	(2)
▲	5 ANTENNA SITES	(1)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAYBE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.



Source: SEWRPC.

County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

MILWAUKEE COUNTY

Antenna site data for Milwaukee County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases

    a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22

    b. For Nextel Communications, Inc.–Land Mobile–Commercial

2. Local governmental databases included data provided by the following local units of government in Milwaukee County: City of Cudahy–6 sites; City of Franklin–11 sites; City of Glendale–7 sites; City of Greenfield–19 sites; City of Milwaukee–129 sites; City of Oak Creek–14 sites; City of St Francis–5 sites; City of South Milwaukee–4 sites; City of Wauwatosa–27 sites; City of West Allis–19 sites; Village of Bayside–5 sites; Village of Brown Deer–5 Sites; Village of Fox Point–1 site; Village of Greendale–5 sites; Village of Hales Corners–1 site; Village of River Hills–4 sites; Village of Shorewood–2 sites; Village of West Milwaukee–4 sites; and Village of Whitefish Bay–7 sites. There are a total of 275 sites within Milwaukee County.

Antenna and Antenna Site Inventory–Cellular/PCS

The cellular/PCS antenna site inventory findings for Milwaukee County are summarized in Tables 22 through 27 reproduced on pages 73 through 86, one for each wireless service provider as follows: Table 22–Cingular Wireless–54 antenna sites, Table 23–Nextel Communications–41 antenna sites, Table 24–Sprint PCS–77 antenna sites, Table 25–T-Mobile–39 antenna sites Table 26–U.S. Cellular–38 antenna sites, and Table 27–Verizon Wireless–26 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 18 though 23. Map 24 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 22, 23, and 26 representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired from the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 24, 25, and 27 representing the PCS service providers were compiled almost entirely from local governmental databases since PCS sites were largely absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local govern-

Table 22

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 18)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M1	42-54-04	88-01-32	334,687	2,529,004	T. 5 N., R. 21 E. Sec. 16	8909 W. Drexel Ave. City of Franklin	200.0	S	550	N/A
M2	42-54-29	87-55-41	337,851	2,555,059	T. 5 N., R. 22 E. Sec. 8	7525 S. 10th St. City of Oak Creek	98.4	O	N/A	N/A
M3	42-54-05	87-51-05	335,942	2,575,655	T. 5 N., R. 22 E. Sec. 12	2900 5th Ave. City of South Milwaukee	78.7	O	N/A	N/A
M4	42-51-25	87-55-34	319,424	2,556,043	T. 5 N., R. 22 E. Sec. 32	809 W. Oakwood Rd. City of Oak Creek	128.0	O	N/A	N/A
M5	42-51-21	87-50-42	319,389	2,577,796	T. 5 N., R. 22 E. Sec. 36	E. Oakwood Rd City of Oak Creek	180.5	O	N/A	N/A
M6	43-00-36	87-59-42	374,556	2,536,234	T. 6 N., R. 21 E. Sec. 3	6623 W. Greenfield Ave. City of West Allis	108.3	O	N/A	N/A
M7	43-00-28	88-03-21	373,361	2,519,987	T. 6 N., R. 21 E. Sec. 6	11515 W. Rogers St. City of West Allis	88.6	O	N/A	N/A
M8	43-00-07	88-02-21	371,340	2,524,494	T. 6 N., R. 21 E. Sec. 8	10201 W. Lincoln Ave. City of West Allis	65.6	O	N/A	N/A
M9	42-59-20	87-59-03	366,934	2,539,318	T. 6 N., R. 21 E. Sec. 11	5600 W. Oklahoma Ave. City of Milwaukee	180.5	O	N/A	N/A
M10	42-58-08	88-01-03	359,433	2,530,574	T. 6 N., R. 21 E. Sec. 21	4142 S. 84th St. City of Greenfield	121.4	S	N/A	N/A
M11	42-57-39	87-58-50	356,736	2,540,531	T. 6 N., R. 21 E. Sec. 23	5300 Layton Ave. City of Greenfield	150.9	S	N/A	N/A
M12	42-56-54	88-00-31	352,000	2,533,132	T. 6 N., R. 21 E. Sec. 28	5301 S. 76th St. Village of Greendale	75.5	S	N/A	N/A
M13	42-57-10	88-02-28	353,414	2,524,394	T. 6 N., R. 21 E. Sec. 29	5050 S. 104th St City of Greenfield	131.2	S	N/A	N/A
M14	42-57-31	88-02-53	355,495	2,522,486	T. 6 N., R. 21 E. Sec. 30	4737 S. 108th St. City of Greenfield	105.0	S	N/A	N/A
M15	42-65-16	88-00-13	248,186	2,534,562	T. 6 N., R. 21 E. Sec. 34	7100 Euston St. Village of Greendale	128.0	O	N/A	N/A
M16	43-00-09	87-55-05	372,328	2,556,878	T. 6 N., R. 22 E. Sec. 8	2325 S. Howell Ave. City of Milwaukee	52.5	O	N/A	N/A
M17	45-58-35	87-52-43	363,081	2,567,668	T. 6 N., R. 22 E. Sec. 15	3719 S. Kinnickinnic Ave. City of St. Francis	105.0	O	N/A	N/A
M18	42-58-19	87-55-12	361,182	2,556,635	T. 6 N., R. 22 E. Sec. 20	4001 S. 6th St. City of Milwaukee	68.9	O	N/A	N/A
M19	42-58-06.6	87-51-25.2	360,354	2,573,524	T. 6 N., R. 22 E. Sec. 23	4168 S. Packard Ave. City of St. Francis	154.9	S	140.82	891.51
M20	42-57-19	87-51-41	355,507	2,572,473	T. 6 N., R. 22 E. Sec. 26	3555 E. Pabst Ave. City of Cudahy	88.6	S	N/A	N/A
M21	42-56-24	87-51-43.6	349,936	2,572,422	T. 6 N., R. 22 E. Sec. 35	5555 S. Packard Ave. City of Cudahy	101.0	S	140.82	891.51
M22	43-05-27	87-57-17	404,269	2,546,283	T. 7 N, R 21 E. Sec. 1	3341 W. Hopkins St. City of Milwaukee	98.4	O	N/A	N/A
M23	43-05-38	88-00-29	405,033	2,532,014	T. 7 N., R. 21 E. Sec. 4	7677 W. Appleton Ave. City of Milwaukee	75.5	O	N/A	N/A
M24	43-06-10	88-03-41	407,940	2,517,696	T. 7 N., R. 21 E. Sec. 6	N. 119th St. and W. Hampton Ave. City of Wauwatosa	118.1	O	N/A	N/A

Table 22 (continued)

Site Number (See Map 18)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M25	43-05-00	88-01-21	401,100	2,526,248	T. 7 N., R. 21 E. Sec. 9	8814 W. Lisbon Ave City of Milwaukee	68.9	O	N/A	N/A
M26	43-04-38	87-59-36	399,060	2,536,091	T. 7 N., R. 21 E. Sec. 10	6400 W. Burleigh St. City of Milwaukee	131.2	O	N/A	N/A
M27	43-05-31	87-58-47	404,511	2,539,596	T. 7 N., R. 21 E. Sec. 2	5301 W. Fond du Lac Ave. City of Milwaukee	75.5	O	N/A	N/A
M28	43-05-24	87-58-46	403,804	2,539,688	T. 7 N., R. 21 E. Sec. 11	4051 N. 53rd St. City of Milwaukee	98.4	O	N/A	N/A
M29	43-04-38	87-57-12	399,319	2,546,775	T. 7 N, R. 21 E. Sec. 12	3204 N. 32nd St. City of Milwaukee	98.4	O	N/A	N/A
M30	43-03-41	88-00-22	393,209	2,532,816	T. 7 N., R. 21 E. Sec. 15	7500 W. North Ave. City of Wauwatosa	59.1	O	N/A	N/A
M31	43-03-40	88-02-54	392,840	2,521,537	T. 7 N., R. 21 E. Sec. 18	2323 N. Mayfair Rd. City of Wauwatosa	108.3	O	N/A	N/A
M32	43-02-45	88-01-32	387,417	2,527,755	T. 7 N., R. 21 E. Sec. 21	8948 Watertown Plank Rd. City of Wauwatosa	177.2	O	N/A	N/A
M33	43-02-49	87-59-04	388,085	2,538,732	T. 7 N., R. 21 E. Sec. 23	Hawley Rd. City of Milwaukee	88.6	O	N/A	N/A
M34	43-02-26	88-01-52	385,459	2,526,316	T. 7 N., R. 21 E. Sec. 29	9401 W. Wisconsin Ave. City of Wauwatosa	16.4	O	N/A	N/A
M35	43-01-29	88-03-31	379,517	2,519,100	T. 7 N., R. 21 E. Sec. 31	561 S. Curtis Rd. City of West Allis	150.9	O	N/a	N/a
M36	43-01-22	87-57-59	379,397	2,543,772	T. 7 N., R. 21 E. Sec. 36	4213 W. National Ave. Village of West Milwaukee	88.6	S	N/A	N/A
M37	43-05-38	87-55-20	405,597	2.554,933	T. 7 N., R. 22 E. Sec. 5	Green Bay Ave. City of Milwaukee	98.4	O	N/A	N/A
M38	43-05-17	87-54-12	403,598	2,560,031	T. 7 N., R. 22 E. Sec. 9	E. Capitol Dr and Holton St. City of Milwaukee	180.5	O	N/A	N/A
M39	43-04-33.5	87-52-52	399,346	2,566,077	T. 7 N., R. 22 E. Sec. 10	3210 N. Maryland City of Milwaukee	111.9	S	140.82	891.51
M40	43-04-20	87-51-56	398,086	2,570,267	T. 7 N., R. 22 E. Sec. 14	3000 N. Lincoln Memorial Dr. City of Milwaukee	69.0	O	N/A	N/A
M41	43-03-02	87-56-35	389,671	2,549,760	T. 7 N., R. 22 E. Sec. 19	1535 N 24th St. City of Milwaukee	98.4	O	N/A	N/A
M42	43-11-31	87-58-23	440,990	2,540,491	T. 8 N., R. 21 E. Sec. 2	County Line Rd. at Brown Deer Tr. Village of Brown Deer	66.6	O	NA	N/A
M43	43-10-54	87-58-12	437,265	2,541,397	T. 8 N., R. 21 E. Sec. 2	4800 W. Green Brook Dr. Village of Brown Deer	128.0	O	N/A	N/A
M44	43-10-46	88-02-48	435,967	2,520,973	T. 8 N., R. 21 E. Sec. 6	107th St. and N. Granville Rd. City of Milwaukee	121.4	O	N/A	N/A
M45	43-09-03	88-00-27	425,790	2,521,666	T. 8 N., R. 21 E. Sec. 16	7825 W. Good Hope Rd. City of Milwaukee	75.5	O	N/A	N/A
M46	43-08-47	88-03-29	423,852	2,518,216	T. 8 N., R. 21 E. Sec. 19	7111 N. 115th St. City of Milwaukee	105.0	O	N/A	N/A
M47	43-08-46	87-56-50	424,459	2,547,789	T. 8 N., R. 21 E. Sec. 24	Range Line Rd. City of Glendale	85.3	O	N/A	N/A
M48	43-07-26	88-02-09	415,792	2,524,338	T. 8 N., R. 21 E. Sec. 29	5827 N. 99th St. City of Milwaukee	128.0	O	N/A	N/A
M49	43-06-54	88-03-23	412,425	2,518,928	T. 8 N., R. 21 E. Sec. 30	5401 N. Lovers Lane Rd. City of Milwaukee	75.5	O	N/A	N/A
M50	43-10-44	87-55-03	436.698	2,555,420	T. 8 N., R. 22 E. Sec. 8	877 Glenco Pl. Village of Bayside	N/A	O	N/A	N/A
M51	43-09-23	87-54-59	428,407	2,555,922	T. 8 N., R. 22 E. Sec. 17	7650 N. Pheasant La. Village of River Hills	78.7	S	N/A	N/A

Table 22 (continued)

Site Number (See Map 18)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M52	43-07-54	87-54-42	419,432	2,557,407	T. 8 N., R. 22 E. Sec. 29	6321 N. Lydell Ave. Village of Whitefish Bay	78.7	O	N/A	N/A
M53	43-07-47	87-56-26	418,531	2,549,715	T. 8 N., R. 22 E. Sec. 26	Camden Rd. City of Glendale	131.2	O	N/A	N/A
M54	43-06-35	87-53-44	411,544	2,561,909	T. 8 N., R. 22 E. Sec. 33	1200 E. Fairmont St. Village of Whitefish Bay	118.0	O	140.82	891.51

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

mental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed, wireless industry. For this reason, inventory data collection efforts will be concentrated on those companies of demonstrated stability and longevity. There is currently one known fixed wireless service provider operating in Milwaukee County. The antenna site data for this provider is listed in Table 57 and shown on Map 59.

Inventory Findings–Geographic Coverage

As already noted, originally, it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be provided only for the cooperating service providers in a separate report. The infrastructure inventory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

Table 23

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 19)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M55	42-55-07	87-59-05	341,325	2,539,788	T. 5 N., R. 21 E. Sec. 2	5510 W. Rawson Ave. City of Franklin	102.0	O	10	855.6875
M56	42-54-04	88-01-32	334,687	2,529,004	T. 5 N., R. 21 E. Sec. 9	8909 W. Drexel Ave. City of Franklin	144.4	S	40	855.8125
M57	42-50-57	87-57-20	316,214	2,548,219	T. 5 N., R. 21 E. Sec. 36	3131 W. Elm Rd. City of Franklin	120.1	O	125	859.8375
M58	42-54-50.8	87-55-27.3	340,083	2,556,023	T. 5 N., R. 22 E. Sec. 8	7200 S. 10th St. City of Oak Creek	96.8	O	125	855.8125
M59	42-54-02	87-51-05	335,639	2,575,663	T. 5 N., R. 22 E. Sec. 12	2990 5th Ave. City of South Milwaukee	180.5	O	125	865.6125
M60	42-51-20.1	87-50-41.3	319,299	2,577,850	T. 5 N., R. 22 E. Sec. 36	4311 E. Oakwood City of Oak Creek	495.4	O	75	855.3125
M61	43-00-17.1	87-57-47.3	372,850	2,544,801	T. 6 N., R. 21 E. Sec. 1	3830 W. Grant St. City of West Milwaukee	269.0	O	160	865.7375
M62	43-00-35	87-59-40	374,459	2,536,386	T. 6 N., R. 21 E. Sec. 3	1745-1817 S. 66th St. City of West Allis	88.6	O	62	860.2875
M63	43-00-58.1	87-59-24.3	376,825	2,537,496	T. 6 N., R. 21 E. Sec. 3	1421 S. 62nd St. City of Milwaukee	36.1	O	120	865.2375
M64	43-00-58	88-02-03	376,534	2,525,709	T. 6 N., R 21 E. Sec. 5	9721 W. Greenfield Ave. City of West Allis	28.9	O	62	860.2875
M65	43-00-28	88-03-21	373,361	2,519,987	T. 6 N., R. 21 E. Sec. 6	11515 W. Rogers St. City of West Allis	121.4	O	N/A	N/A
M66	42-59-15.1	88-01-40.3	366,159	2,527,642	T. 6 N., R. 21 E. Sec. 17	3151 S. 92nd St. City of Milwaukee	197.0	O	100	865.8625
M67	42-57-39	87-58-50	356,736	2,540,531	T. 6 N., R. 21 E. Sec. 23	5300 W. Layton Ave. City of Greenfield	190.0	S	N/A	N/A
M68	42-58-20.1	87-57-04.3	361,087	2,548,286	T. 6 N., R. 21 E. Sec. 13	2900 W. Howard City of Milwaukee	161.0	O	62	860.5375
M69	42-57-46	87-58-04	357,527	2,543,933	T. 6 N., R. 21 E. Sec. 24	4267 W. Loomis Rd. City of Greenfield	85.3	S	N/A	N/A
M70	42-57-26	88-00-32	355,238	2,532,980	T. 6 N., R. 21 E. Sec. 28	4811 S. 76th St. City of Greenfield	66.0	S	10	855.6875
M71	43-00-19	87-54-54	373,361	2,557,670	T. 6 N., R. 22 E. Sec. 5	2156 S. 4th St. City of Milwaukee	65.9	O	10	857.3625
M72	42-59-42.1	87-55-14.3	369,588	2,556,255	T. 6 N., R. 22 E. Sec. 8	707-721 W. Cleveland Ave. City of Milwaukee	85.3	O	200	864.3625
M73	42-58-35	87-52-43	363,081	2,567,668	T. 6 N., R. 22 E. Sec. 15	3719 S. Kinnickinnic Ave. City of St. Francis	95.1	S	125	855.6375
M74	42-57-38.1	87-55-22.3	357,024	2,555,973	T. 6 N., R. 22 E. Sec. 20	830 W. Layton Ave. City of Milwaukee	121.4	O	31	860.2875
M75	42-55-51	87-50-57	346,685	2,575,974	T. 6 N., R. 22 E. Sec. 36	6260 S. Lake Dr. City of Cudahy	124.0	O	250	860.2875
M76	43-05-25	87-57-58.3	403,992	2,543,224	T. 7 N., R. 21 E. Sec. 1	4222 W. Capitol Dr. City of Milwaukee	141.1	O	5	860.2875
M77	43-05-25	88-03-50	403,371	2,517,135	T. 7 N., R. 21 E. Sec. 6	4100 N. 124th St. City of Wauwatosa	147.6	S	67	860.1375
M78	43-03-41	88-00-22	393,209	2,535,816	T. 7 N., R. 21 E. Sec. 15	7500 W. North Ave. City of Wauwatosa	N/A	O	N/A	N/A
M79	43-03-30	87-58-36	392,285	2,540,710	T. 7 N., R. 21 E. Sec. 14	2325 N. 50th St. City of Milwaukee	65.0	O	62	860.2875
M80	43-03-07	87-57-07.3	390,118	2,547,350	T. 7 N., R. 21 E. Sec. 24	3012 W. Galena St. City of Milwaukee	141.1	O	92	854.0875

Table 23 (continued)

Site Number (See Map 19)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M81	43-01-53	88-00-59	382,212	2,530,330	T. 7 N., R. 21 E. Sec. 28	108 Glenview Ave. City of Wauwatosa	165.0	O	30	857.3625
M82	43-05-18	87-54-15.3	403,693	2,559,874	T. 7 N., R. 22 E. Sec. 9	3950 Holton St. City of Milwaukee	255.9	O	100	865.9125
M83	43-03-35	87-55-48	393,097	2,553,166	T. 7 N., R. 22 E. Sec. 19	1361 W. North Ave. City of Milwaukee	109.9	O	62	857.3625
M84	43-03-06	87-54-43.3	390,282	2,558,041	T. 7 N., R. 22 E. Sec. 20	1610 N. 2nd St. City of Milwaukee	288.7	O	250	858.9125
M85	43-03-20	87-53-26	391,843	2,563,743	T. 7 N., R. 22 E. Sec. 21	1717 E. Kane Pl. City of Milwaukee	100.1	O	30	857.3625
M86	43-02-24	87-54-12	386,090	2,560,471	T. 7 N., R. 22 E. Sec. 28	733 N. Van Buren St. City of Milwaukee	132.9	O	10	855.9125
M87	43-02-01	87-54-20.3	383,746	2,559,913	T. 7 N., R. 22 E. Sec. 28	The Phoenix Building City of Milwaukee	108.3	O	25	857.3625
M88	43-02-19	87-54-32.3	385,546	2,558,977	T. 7 N., R. 22 E. Sec. 29	205 E. Wisconsin Ave. City of Milwaukee	68.9	O	5	855.9125
M89	43-02-19	87-55-11	385,474	2,556,104	T. 7 N., R. 22 E. Sec. 29	606 W. Wisconsin Ave. City of Milwaukee	275.6	O	115	852.2375
M90	43-02-17	87-56-02	385,177	2,552,322	T. 7 N., R. 22 E. Sec. 30	620 N. 17th St. City of Milwaukee	67.9	O	10	855.9125
M91	43-09-18	87-58-56.3	427,469	2,538,351	T. 8 N., R. 21 E. Sec. 14	5748 W. Clinton Ave. City of Milwaukee	249.4	O	62	857.3625
M92	43-09-05	88-03-06	425,713	2,519,878	T. 8 N., R. 21 E. Sec. 18	11270 W. Park Place City of Milwaukee	165.0	O	10	860.2875
M93	43-06-34	88-00-00	410,757	2,534,029	T. 8 N., R. 21 E. Sec. 19	7138 W. Fond du Lac Ave. City of Milwaukee	78.7	O	N/A	N/A
M94	43-10-55	87-54-23	437,786	2,558,356	T. 8 N., R. 22 E. Sec. 5	9075 N. Regent Rd. Village of Bayside	N/A	O	N/A	N/A
M95	43-07-54	87-54-42	419,432	2,557,407	T. 8 N., R. 22 E. Sec. 29	6321 N. Lydell Ave. Village of Whitefish Bay	153.0	O	62	855.9125

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the Commission wireless network monitoring system which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Table 24

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 20)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M96	42-55-07.32	87-59-04.92	341,358	2,539,793	T. 5 N., R. 21 E. Sec. 2	City of Franklin	120.1	S	55.19	1931.25
M97	42-55-44.4	88-03-03.24	344,689	2,521,977	T. 5 N., R. 21 E. Sec. 6	City of Franklin	117.0	S	57.19	1931.25
M98	42-53-26.88	88-02-11.4	330,861	2,526,161	T. 5 N., R. 21 E. Sec. 17	City of Franklin	120.0	S	55.19	1931.25
M99	42-51-03.96	87-57-28.8	316,902	2,547,547	T. 5 N., R. 21 E. Sec. 36	City of Franklin	80.0	S	55.19	1931.25
M100	42-55-25.32	87-56-53.88	343,417	2,549,496	T. 5 N., R. 22 E. Sec. 6	City of Oak Creek	65.0	S	57.19	1932.5
M101	42-54-27.72	87-54-46.8	337,822	2,559,094	T. 5 N., R. 22 E. Sec. 8	City of Oak Creek	100.0	S	55.19	1932.5
M102	42-54-42.48	87-51-46.08	339,657	2,572,501	T. 5 N., R. 22 E. Sec. 11	City of South Milwaukee	95.0	S	55.19	1931.5
M103	42-52-36.12	87-54-17.28	326,583	2,261,547	T. 5 N., R. 22 E. Sec. 21	City of Oak Creek	90.0	S	58.04	1932.5
M104	42-51-21.24	87-50-42.72	319,412	2,577,741	T. 5 N., R. 22 E. Sec. 36	City of Oak Creek	75.0	S	55.19	1931.25
M105	43-00-35.64	87-59-40.92	374,522	2,536,316	T. 6 N., R. 21 E. Sec. 3	City of West Allis	80.0	S	57.04	1932.5
M106	43-00-28.44	88-03-21.96	373,404	2,519,915	T. 6 N., R. 21 E. Sec. 6	City of West Allis	115.0	S	55.19	1932.5
M107	42-59-15.36	87-57-53.64	366,590	2,544,483	T. 6 N., R. 21 E. Sec. 13	City of Milwaukee	64.0	S	56.54	1932.5
M108	42-58-41.88	87-59-23.64	363,039	2,537,877	T. 6 N., R. 21 E. Sec. 15	City of Milwaukee	60.0	S	54.19	1932.5
M109	42-59-15.36	88-01-40.8	366,184	2,527,604	T. 6 N., R. 21 E. Sec. 17	City of Milwaukee	80.0	S	55.19	1932.5
M110	42-57-45	87-57-57.6	357,438	2,544,412	T. 6 N., R. 21 E. Sec. 24	City of Greenfield	100.0	S	55.19	1932.5
M111	42-57-01.44	87-58-57.72	352,920	2,540,049	T. 6 N., R. 21 E. Sec. 26	City of Greenfield	70.0	S	59.04	1931.25
M112	42-57-26.28	88-00-32.76	355,265	2,532,923	T. 6 N., R. 21 E. Sec. 28	City of Greenfield	79.0	S	55.19	1932.5
M113	43-00-45.72	87-55-30.36	375,997	2,554,901	T. 6 N., R. 22 E. Sec. 5	City of Milwaukee	96.0	S	54.69	1935
M114	42-59-42.36	87-55-13.8	369,616	2,556,292	T. 6 N., R. 22 E. Sec. 8	City of Milwaukee	70.0	S	55.19	1932.5
M115	42-58-58.08	87-53-26.88	365,334	2,564,348	T. 6 N., R. 22 E. Sec. 16	City of Milwaukee	60.0	S	55.19	1932.5
M116	42-58-50.52	87-56-28.32	364,232	2,550,884	T. 6 N., R. 22 E. Sec. 18	City of Milwaukee	90.0	S	59.09	1932.5
M117	42-58-14.88	87-55-25.32	360,741	2,555,656	T. 6 N., R. 22 E. Sec. 20	City of Milwaukee	70.0	S	57.19	1932.5
M118	42-57-19.8	87-51-41.4	355,587	2,572,441	T. 6 N., R. 22 E. Sec. 26	City of Cudahy	85.0	S	55.19	1932.5
M119	42-57-20.88	87-55-30	355,267	2,555,444	T. 6 N., R. 22 E. Sec. 29	City of Milwaukee	80.0	S	55.19	1932.5

Table 24 (continued)

Site Number (See Map 20)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M120	42-57-18.72	87-54-38.16	355,145	2,559,303	T. 6 N., R. 22 E. Sec. 29	City of Milwaukee	70.0	S	58.69	1932.5
M121	42-55-57.72	87-53-12.48	347,108	2,565,881	T. 6 N., R. 22 E. Sec. 34	City of Milwaukee	80.0	S	57.09	1932.5
M122	43-05-48.84	87-59-04.92	406,285	2,538,224	T. 7 N., R. 21 E. Sec. 2	City of Milwaukee	50.0	S	56.54	1932.5
M123	43-05-44.16	88-00-32.76	405,655	2,531,720	T. 7 N., R. 21 E. Sec. 4	City of Milwaukee	70.0	S	55.79	1932.5
M124	43-05-09.24	88-03-42.12	401,789	2,517,756	T. 7 N., R. 21 E. Sec. 7	City of Wauwatosa	80.0	S	55.19	1932.5
M125	43-05-18.24	88-01-27.84	402,934	2,527,697	T. 7 N., R. 21 E. Sec. 9	City of Milwaukee	51.0	S	59.09	1932.5
M126	43-04-45.84	88-00-15.48	399,783	2,533,143	T. 7 N., R. 21 E. Sec. 10	City of Milwaukee	65.0	S	55.19	1932.5
M127	43-05-22.56	87-57-57.6	403,746	2,543,282	T. 7 N., R. 21 E. Sec. 12	City of Milwaukee	95.0	S	55.19	1935
M128	43-04-16.32	87-57-12.6	397,124	2,546,785	T. 7 N., R. 21 E. Sec. 13	City of Milwaukee	70.0	S	55.19	1932.5
M129	43-03-46.08	87-57-11.88	394,065	2,546,913	T. 7 N., R. 21 E. Sec. 13	City of Milwaukee	70.0	S	58.04	1932.5
M130	43-04-26.76	87-58-33.96	398,033	2,540,722	T. 7 N., R. 21 E. Sec. 14	City of Milwaukee	80.0	S	56.04	1932.5
M131	43-03-40.68	87-58-35.76	393,366	2,540,701	T. 7 N., R. 21 E. Sec. 14	City of Milwaukee	50.0	S	54.54	1932.5
M132	43-03-39.96	88-00-22.68	393,102	2,532,768	T. 7 N., R. 21 E. Sec. 15	City of Wauwatosa	61.2	S	54.59	1932.5
M133	43-03-37.08	88-02-54.96	392,543	2,521,473	T. 7 N., R. 21 E. Sec. 18	City of Wauwatosa	84.0	S	56.39	1932.5
M134	43-03-05.04	88-00-19.8	389,573	2,533,066	T. 7 N., R. 21 E. Sec. 22	City of Wauwatosa	47.0	S	55.69	1932.5
M135	43-02-48.84	87-59-05.28	388,067	2,538,637	T. 7 N., R. 21 E. Sec. 23	City of Milwaukee	80.0	S	57.09	1932.5
M136	43-01-53.76	87-57-48.96	382,630	2,544,439	T. 7 N., R. 21 E. Sec. 25	City of Milwaukee	70.0	S	56.19	1932.5
M137	43-01-53.4	88-00-59.76	382,252	2,530,273	T. 7 N., R. 21 E. Sec. 28	City of Wauwatosa	100.0	S	55.19	1932.5
M138	43-02-16	88-02-25.44	303,595	2,523,876	T. 7 N., R. 21 E. Sec. 29	City of Wauwatosa	110.0	S	59.09	1932.5
M139	43-01-12.36	87-57-58.68	378,422	2,543,819	T. 7 N., R. 21 E. Sec. 36	Village of West Milwaukee	90.0	S	57.09	1932.5
M140	43-05-45.6	87-54-15.12	406,487	2,559,727	T. 7 N., R. 22 E. Sec. 4	City of Milwaukee	120.2	S	59.04	1932.5
M141	43-05-09.24	87-55-30.72	402,667	2,554,211	T. 7 N., R. 22 E. Sec. 8	City of Milwaukee	50.0	S	54.69	1932.5
M142	43-04-43.68	87-55-05.52	400,127	2,556,145	T. 7 N., R. 22 E. Sec. 8	City of Milwaukee	76.0	S	54.54	1932.5
M143	43-05-18.24	87-53-07.44	403,845	2,564,817	T. 7 N., R. 22 E. Sec. 10	Village of Shorewood	96.0	S	57.19	1933.75

Table 24 (continued)

Site Number (See Map 20)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M144	43-04-33.24	87-52-53.4	399,317	2,565,974	T. 7 N., R. 22 E. Sec. 10	City of Milwaukee	110.0	S	59.09	1933.75
M145	43-03-58.32	87-52-43.68	395,801	2,566,785	T. 7 N., R. 22 E. Sec. 15	City of Milwaukee	70.0	S	55.19	1933.75
M146	43-04-01.92	87-54-29.88	395,966	2,558,895	T. 7 N., R. 22 E. Sec. 17	City of Milwaukee	80.0	S	56.04	1935
M147	43-03-35.28	87-55-46.56	393,128	2,553,272	T. 7 N., R. 22 E. Sec. 19	City of Milwaukee	60.0	S	54.69	1932.5
M148	43-03-02.88	87-56-35.88	389,758	2,549,693	T. 7 N., R. 22 E. Sec. 19	City of Milwaukee	90.0	S	56.54	1933.75
M149	43-02-54.24	87-55-24.6	389,015	2,555,005	T. 7 N., R. 22 E. Sec. 20	City of Milwaukee	50.0	S	55.19	1932.5
M150	43-03-18.36	87-53-21.48	391,686	2,564,082	T. 7 N., R. 22 E. Sec. 21	City of Milwaukee	76.0	S	59.09	1932.5
M151	43-02-55.32	87-53-45.24	389,309	2,562,378	T. 7 N., R. 22 E. Sec. 21	City of Milwaukee	70.0	S	57.19	1933.75
M152	43-02-20.4	87-54-22.68	385,705	2,559,687	T. 7 N., R. 22 E. Sec. 28	City of Milwaukee	70.0	S	57.19	1932.5
M153	43-01-57.72	87-54-13.32	383,427	2,560,440	T. 7 N., R. 22 E. Sec. 28	City of Milwaukee	68.8	S	58.69	1932.5
M154	43-02-25.08	87-54-50.76	386,127	2,557,591	T. 7 N., R. 22 E. Sec. 29	City of Milwaukee	80.0	S	55.19	1933.75
M155	43-02-18.6	87-55-27.48	385,403	2,554,881	T. 7 N., R. 22 E. Sec. 29	City of Milwaukee	50.0	S	55.19	1933.75
M156	43-02-31.56	87-56-22.92	386,612	2,550,733	T. 7 N., R. 22 E. Sec. 30	City of Milwaukee	70.0	S	59.04	1933.75
M157	43-01-28.2	87-56-23.64	380,199	2,550,838	T. 7 N., R. 22 E. Sec. 31	City of Milwaukee	60.0	S	58.09	1932.5
M158	43-01-33.6	87-54-46.8	380,924	2,558,015	T. 7 N., R. 22 E. Sec. 32	City of Milwaukee	50.0	S	55.19	1932.5
M159	43-10-42.24	87-58-01.56	436,094	2,542,199	T. 8 N., R. 21 E. Sec. 2	Village of Brown Deer	80.0	S	55.19	1932.5
M160	43-11-12.48	88-00-32.04	438,885	2,530,980	T. 8 N., R. 21 E. Sec. 4	City of Milwaukee	80.0	S	55.19	1932.5
M161	43-09-21.96	87-57-52.56	427,985	2,543,064	T. 8 N., R. 21 E. Sec. 13	City of Milwaukee	80.0	S	54.69	1932.5
M162	43-09-22.32	88-00-54.36	427,697	2,529,592	T. 8 N., R. 21 E. Sec. 16	City of Milwaukee	118.1	S	54.69	1932.5
M163	43-08-47.76	88-03-29.52	423,928	2,518,176	T. 8 N., R. 21 E. Sec. 19	City of Milwaukee	100.0	S	54.19	1932.5
M164	43-08-13.92	88-00-27	420,822	2,531,785	T. 8 N., R. 21 E. Sec. 21	City of Milwaukee	56.0	S	59.09	1932.5
M165	43-07-56.64	87-58-03	419,331	2,542,501	T. 8 N., R. 21 E. Sec. 26	City of Milwaukee	85.0	S	55.19	1932.5
M166	43-07-35.76	88-01-46.56	416,820	2,525,979	T. 8 N., R. 21 E. Sec. 29	City of Milwaukee	100.0	S	59.09	1932.5
M167	43-06-55.8	88-01-0.84	412,856	2,529,465	T. 8 N., R. 21 E. Sec. 33	City of Milwaukee	100.0	S	55.19	1933.75

Table 24 (continued)

Site Number (See Map 20)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M168	43-06-54	87-57-53.64	413,008	2,543,350	T. 8 N., R. 21 E. Sec. 36	City of Milwaukee	70.0	S	59.09	1932.5
M169	43-10-44.4	87-55-03.36	436,638	2,555,393	T. 8 N., R. 22 E. Sec. 5	Village of Bayside	103.0	S	57.19	1931.25
M170	43-09-23.4	87-54-59.76	428,447	2,555,865	T. 8 N., R. 22 E. Sec. 17	Village of River Hills	80.0	S	57.19	1931.25
M171	43-07-54.84	87-54-42.84	419,515	2,557,343	T. 8 N., R. 22 E. Sec. 28	Village of Whitefish Bay	80.0	S	56.09	1932.5
M172	43-07-01.92	87-55-49.44	414,036	2,552,539	T. 8 N., R. 22 E. Sec. 31	City of Glendale	115.0	S	56.79	1933.75

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 275 base transceiver stations on 187 cellular–PCS mobile wireless antenna sites within Milwaukee County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

OZAUKEE COUNTY

Antenna site data for Ozaukee County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases
   a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22
   b. For Nextel Communications, Inc.–Land Mobile–Commercial
2. Local governmental databases included data provided by the following local units of government in Ozaukee County: City of Cedarburg–4 sites; City of Mequon–29 sites; City of Port Washington–8 sites; Village of Bay Side-0 sites; Village of Belguim–4 sites; Village of Fredonia–2 sites; Village of Grafton–5 sites; Village of Newburg–0 sites; Village of Saukville–1 site; Village of Thiensville–1 site; Town of Belgium–0 sites; Town of Cedarburg–2 sites; Town of Fredonia-1 site; Town of Grafton–5 sites; Town of Port Washington–3 sites; and Town of Saukville–2 sites. There are a total of 67 sites within Ozaukee County.

Table 25

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 21)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M173	42-54-04	87-51-41	334,688	2,529,004	T. 5 N., R. 21 E. Sec. 16	8909 W. Drexel Ave. City of Franklin	131.2	S	43	N/A
M174	42-51-21	87-50-42	319,389	2,577,796	T. 5 N., R. 22 E. Sec. 36	E. Oakwood Rd. City of Oak Creek	180.5	O	N/A	N/A
M175	43-00-32	88-01-05	374,004	2,530,080	T. 6 N., R. 21 E. Sec. 4	1981 S. 84th and 8435 W. National Ave. City of West Allis	91.9	O	N/A	N/A
M176	43-00-58	88-02-02	376,535	2,525,784	T. 6 N., R. 21 E. Sec. 5	9721 W. Greenfield Ave. City of West Allis	32.8	O	N/A	N/A
M177	43-00-28	88-03-21	373,361	2,519,987	T. 6 N., R. 21 E. Sec. 6	11515 W. Rogers St. City of West Allis	111.6	O	N/A	N/A
M178	42-59-20	87-59-03	366,934	2,539,318	T. 6 N., R. 21 E. Sec. 11	5600 W. Oklahoma Ave. City of Milwaukee	78.7	O	N/A	N/A
M179	42-57-46	87-58-02	357,531	2,544,082	T. 6 N., R. 21 E. Sec. 24	4205 W. Loomis Rd. City of Greenfield	82.0	S	N/A	N/A
M180	42-57-26	88-00-32	355,238	2,532,980	T. 6 N., R. 21 E. Sec. 28	4811 S. 76th St. City of Greenfield	72.2	S	N/A	N/A
M181	42-56-16	88-00-13	348,186	2,534,562	T. 6 N., R. 21 E. Sec. 34	7100 Euston St. Village of Greendale	128.0	S	N/A	N/A
M182	42-55-58	87-57-06	346,702	2,548,513	T. 6 N., R. 21 E. Sec. 36	6133 S. 27th St. City of Greenfield	98.4	S	N/A	N/A
M183	43-00-47	87-56-35	376,008	2,550,097	T. 6 N., R. 22 E. Sec. 6	1639 S. 23rd St. City of Milwaukee	69.0	O	N/A	N/A
M184	42-58-35	87-52-43	363,081	2,567,668	T. 6 N., R. 22 E. Sec. 15	3719 S. Kinnickinnic Ave. City of St. Francis	114.8	S	N/A	N/A
M185	42-57-19	87-51-41	355,507	2,572,473	T. 6 N., R. 22 E. Sec. 26	3555 E. Pabst Ave. City of Cudahy	114.8	S	N/A	N/A
M186	43-05-27	87-57-17	404,269	2,546,283	T. 7 N., R. 21 E. Sec. 1	3341 W. Hopkins St. City of Milwaukee	98.4	O	N/A	N/A
M187	43-05-31	87-58-47	404,512	2,539,597	T. 7 N., R. 21 E. Sec. 2	5301 W. Fond du Lac Ave. City of Milwaukee	75.5	O	N/A	N/A
M188	43-05-25	88-03-50	403,371	2,517,135	T. 7 N., R. 21 E. Sec. 6	4100 N. 124th St. City of Wauwatosa	147.6	S	N/A	N/A
M189	43-05-00	88-01-21	401,100	2,528,248	T. 7 N., R. 21 E. Sec. 9	8814 W. Lisbon Ave. City of Milwaukee	69.0	O	N/A	N/A
M190	43-04-38	87-59-36	399,060	2,536,091	T. 7 N., R. 21 E. Sec. 10	6400 W. Burleigh St. City of Milwaukee	131.2	O	N/A	N/A
M191	43-03-41	88-00-22	393,209	2,532,816	T. 7 N., R. 21 E. Sec. 15	7500 W. North Ave. City of Wauwatosa	N/A	O	N/A	N/A
M192	43-03-36	88-02-55	392,434	2,521,473	T. 7 N., R. 21 E. Sec. 18	2303 N. Mayfair Rd. City of Wauwatosa	N/A	O	N/A	N/A
M193	43-02-50	88-00-13	388,063	2,533,608	T. 7 N., R. 21 E. Sec. 27	1155 N. 73rd St. City of Wauwatosa	N/A	O	N/A	N/A
M194	43-02-49	87-59-04	388,085	2,538,732	T. 7 N., R. 21 E. Sec. 23	Hawley Rd. City of Milwaukee	88.6	O	N/A	N/A
M195	43-01-53	88-00-59	382,213	2,530,330	T. 7 N., R. 21 E. Sec. 28	108 Glenview Ave. City of Wauwatosa	N/A	O	N/A	N/A
M196	43-01-49	88-03-23	381,556	2,519,647	T. 7 N., R. 21 E. Sec. 31	306 S. 116th St. City of West Allis	150.9	O	N/A	N/A
M197	43-05-38	87-55-20	405,597	2,554,933	T. 7 N., R. 22 E. Sec. 5	Green Bay Ave. City of Milwaukee	98.4	O	N/A	N/A

Table 25 (continued)

Site Number (See Map 21)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M198	43-05-17	87-54-12	403,598	2,560,031	T. 7 N., R. 22 E. Sec. 9	E. Capitol Dr. and Holton Ave. City of Milwaukee	180.5	O	N/A	N/A
M199	43-02-24	87-54-30	386,056	2,559,135	T. 7 N., R. 22 E. Sec. 29	841 N. Broadway City of Milwaukee	78.7	O	N/A	N/A
M200	43-02-41	87-54-55	387,730	2,557,236	T. 7 N., R. 22 E. Sec. 29	N. 4th St. and Highland Blvd. City of Milwaukee	98.4	O	N/A	N/A
M201	43-10-42	87-58-01	436,070	2,542,241	T. 8 N., R. 21 E. Sec. 2	8945 N. Deerbrook Tr. Village of Brown Deer	111.5	O	N/A	N/A
M202	43-10-18	88-02-22	433,178	2,522,965	T. 8 N., R. 21 E. Sec. 8	8463 N. Granville Rd. City of Milwaukee	180.5	O	N/A	N/A
M203	43-09-03	88-00-27	425,790	2,531,666	T. 8 N., R. 21 E. Sec. 16	7824 W. Good Hope Rd. City of Milwaukee	75.5	O	N/A	N/A
M204	43-08-47	88-03-29	423,852	2,518,216	T. 8 N., R. 21 E. Sec. 19	7111 N. 115th St. City of Milwaukee	105.0	O	N/A	N/A
M205	43-08-46	87-56-50	424,459	2,547,789	T. 8 N., R. 21 E. Sec. 24	Range Line Rd. City of Glendale	85.3	O	N/A	N/A
M206	43-07-29	88-03-57	415,909	2,516,324	T. 8 N., R. 21 E. Sec. 30	5701 N. 124th St. City of Milwaukee	114.8	O	N/A	N/A
M207	43-06-34	88-00-00	410,757	2,534,029	T. 8 N., R. 21 E. Sec. 34	7138 W. Fond du Lac Ave. City of Milwaukee	78.7	O	N/A	N/A
M208	43-09-22	87-54-59	428,307	2,555,925	T. 8 N., R. 22 E. Sec. 8	7650 Pheasant La. Village of River Hills	105.0	O	N/A	N/A
M209	43-10-26	87-54-55	434,791	2,556,059	T. 8 N., R. 22 E. Sec. 17	8615 N. Port Washington Rd. Village of Fox Point	131.2	S	N/A	N/A
M210	43-07-54	87-54-42	419,432	2,557,407	T. 8 N., R. 22 E. Sec. 29	6321 N. Lydell Ave. Village of Whitefish Bay	N/A	O	N/A	N/A
M211	43-07-33	87-55-54	417,173	2,552,122	T. 8 N., R. 22 E. Sec. 30	Florist St./Glen Park St. City of Glendale	59.1	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

Antenna and Antenna Site Inventory–Cellular/PCS

The cellular/PCS antenna site inventory findings for Ozaukee County are summarized in a Tables 28 through 33 reproduced on pages 95 through 100, one for each wireless service provider as follows: Table 28–Cingular Wireless–16 antenna sites, Table 29–Nextel Communications–7 antenna sites, Table 30–Sprint PCS–12 antenna sites, Table 31–T-Mobile–7 antenna sites, Table 32–U.S. Cellular–13 antenna sites, Table 33–Verizon Wireless–12 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 25 through 30. Map 31 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

Table 26

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 22)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M212	42 54 04	88-01-32	334,687	2,529,004	T. 5 N., R. 21 E. Sec. 16	8909 W. Drexel Ave. City of Franklin	98.4	S	100	N/A
M213	42-54-48	87-51-25	340,226	2,574,055	T. 5 N., R. 22 E. Sec. 11	800 Manitoba Ave. City of South Milwaukee	98.4	O	N/A	N/A
M214	42-52-35	87-52-54	326,626	2,567,776	T. 5 N., R. 22 E. Sec. 22	9210 S. Pennsylvania Ave. City of Oak Creek	118.1	O	500	900
M215	43-00-55	88-00-57	376,346	2,530,618	T. 6 N., R. 21 E. Sec. 4	1501 S. 83rd St. City of West Allis	69.0	O	N/A	N/A
M216	43-00-58	88-02-02	376,535	2,525,784	T. 6 N., R. 21 E. Sec. 5	9721 W. Greenfield Ave. City of West Allis	32.8	O	N/A	N/A
M217	42-59-51	88-02-41	369,686	2,523,046	T. 6 N., R. 21 E. Sec. 8	10607 Arthur Ave. City of West Allis	95.1	O	N/A	N/A
M218	42-59-44	88-00-53	369,167	2,531,087	T. 6 N., R. 21 E. Sec. 9	8214 W. Cleveland Ave. City of West Allis	98.4	O	N/A	N/A
M219	42-59-20	87-59-03	366,934	2,539,318	T. 6 N., R. 21 E. Sec. 11	5600 W. Oklahoma Ave. City of Milwaukee	69.0	O	N/A	N/A
M220	43-00-10	87-57-04	372,210	2,548,035	T. 6 N., R. 21 E. Sec. 12	2975 W. Lincoln Ave. City of Milwaukee	59.0	O	N/A	N/A
M221	42-58-50	88-02-18	363,552	2,524,900	T. 6 N., R. 21 E. Sec. 17	10050 W. Beloit Rd. City of Greenfield	49.2	O	N/A	N/A
M222	42-57-46	87-58-04	357,528	2,543,933	T. 6 N., R. 21 E. Sec. 24	4267 W. Loomis Rd. City of Greenfield	78.7	S	N/A	N/A
M223	42-57-26	88-00-32	355,238	2,532,980	T. 6 N., R. 21 E. Sec. 28	4811 S. 76th St. City of Greenfield	65.6	S	N/A	N/A
M224	42-56-27	88-03-46	348,926	2,518,697	T. 6 N., R. 21 E. Sec. 31	5635A S. New Berlin Rd. Village of Hales Corners	98.4	S	N/A	N/A
M225	42-56-16	88-00-13	348,186	2,534,562	T. 6 N., R. 21 E. Sec. 34	7100 Euston St. Village of Greendale	82.0	O	100	885
M226	42-56-00	87-56-58	346,919	2,549,103	T. 6 N., R. 21 E. Sec. 36	6133 S. 27th St. City of Greenfield	121.4	S	N/A	885
M227	43-00-47	87-56-35	376,008	2,550,097	T. 6 N., R. 22 E. Sec. 6	1639 S. 23rd St. City of Milwaukee	69.0	O	N/A	N/A
M228	42-58-03	87-52-24	359,878	2,569,163	T. 6 N., R. 22 E. Sec. 22	4235 S. Nicholson Ave. City of St. Francis	78.7	S	N/A	N/A
M229	43-05-24	87-57-57	403,893	2,543,323	T. 7 N., R. 21 E. Sec. 12	W. Capitol Dr. and Sherman Blvd. City of Milwaukee	75.5	O	N/A	N/A
M230	43-04-22	88-03-22	397,043	2,519,361	T. 7 N., R. 21 E. Sec. 18	3015 N. 114th St. City of Wauwatosa	N/A	O	100	885
M231	43-03-40	88-02-54	392,841	2,521,538	T. 7 N., R. 21 E. Sec. 18	2323 N. Mayfair Rd. City of Wauwatosa	N/A	O	500	960
M232	43-03-46	88-00-40	393,683	2,531,468	T. 7 N., R. 21 E. Sec. 16	2445 Wauwatosa Ave. City of Wauwatosa	98.4	O	N/A	N/A
M233	43-02-45	88-01-32	387,417	2,527,755	T. 7 N., R. 21 E. Sec. 21	8948 Watertown Plank Rd. City of Wauwatosa	75.5	O	400	900
M234	43-03-06	88-00-28	389,656	2,532,455	T. 7 N., R. 21 E. Sec. 21	1529 Wauwatosa Ave. City of Wauwatosa	N/A	O	N/A	N/A
M235	43-02-48	87-58-44	388,020	2,540,219	T. 7 N., R. 21 E. Sec. 23	5225 W. Vliet St. City of Milwaukee	150.9	O	N/A	N/A

Table 26 (continued)

Site Number (See Map 22)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M236	43-01-59	87-57-17	383,218	2,546,799	T. 7 N., R. 21 E. Sec. 25	222 N. 33rd. St. City of Milwaukee	72.4	O	N/A	N/A
M237	43-01-53	88-00-59	382,213	2,530,330	T. 7 N., R. 21 E. Sec. 28	108 Glenview Ave. City of Wauwatosa	N/A	O	100	885
M238	43-01-31	88-02-15	379,853	2,524,739	T. 7 N., R. 21 E. Sec. 32	10001 W. Bluemound Rd. City of Milwaukee	75.5	O	N/A	N/A
M239	43-04-20	87-51-56	398,086	2,570,267	T. 7 N., R. 22 E. Sec. 14	3000 N. Lincoln Memorial Dr. City of Milwaukee	68.9	O	N/A	N/A
M240	43-03-35	87-52-35	393,457	2,567,489	T. 7 N., R. 22 E. Sec. 22	2275 W. Lincoln Memorial Dr. City of Milwaukee	49.2	O	N/A	N/A
M241	43-10-46	88-02-48	435,967	2,520,973	T. 8 N., R. 21 E. Sec. 6	N. 107th St. and N. Granville Rd. City of Milwaukee	121.4	O	N/A	N/A
M242	43-09-21	87-57-52	427,889	2,543,108	T. 8 N., R. 21 E. Sec. 14	4920 W. Calumet Rd. Village of Brown Deer	75.5	N/A	N/A	N/A
M243	43-09-22	88-00-54	427,665	2,529,620	T. 8 N., R. 21 E. Sec. 16	8530 W. Calumet Rd. City of Milwaukee	121.4	O	N/A	N/A
M244	43-08-46	88-03-28	423,752	2,518,293	T. 8 N., R. 21 E. Sec. 19	7007 N. 115th St. City of Milwaukee	101.7	O	N/A	N/A
M245	43-06-34	88-00-00	410,757	2,534,029	T. 8 N., R. 21 E. Sec. 34	7138 W. Fond du Lac Ave. City of Milwaukee	78.7	O	N/A	N/A
M246	43-10-55	87-54-23	438,826	2,598,351	T. 8 N., R. 22 E. Sec. 5	9075 N. Regent Rd. Village of Bayside	150.9	O	N/A	N/A
M247	43-09-23	87-54-59	428,408	2,555,922	T. 8 N., R. 22 E. Sec. 17	7650 N. Pheasant La. Village of River Hills	98.4	S	N/A	N/A
M248	43-07-54	87-54-42	419,432	2,557,407	T. 8 N., R. 22 E. Sec. 29	6321 N. Lydell Ave. Village of Whitefish Bay	N/A	O	N/A	N/A
M249	43-06-43	87-55-13	412,188	2,555,288	T. 8 N., R. 22 E. Sec. 32	Ironwood Ave. City of Glendale	98.4	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

The data presented in Tables 28, 29 and 33 representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired from the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 30, 31, and 32 representing the PCS service providers were compiled almost entirely from local governmental databases since PCS sites were largely

Table 27

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS ANTENNAS IN MILWAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 23)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M250	42-54-04	88-01-32	334,687	2,529,005	T. 5 N., R. 21 E. Sec. 16	8909 W. Drexel Ave. City of Franklin	193.6	S	N/A	N/A
M251	42-53-16	87-54-38	330,580	2,559,931	T. 5 N., R. 22 E. Sec. 16	8640 S. Howell Ave. City of Oak Creek	128.0	O	N/A	N/A
M252	42-51-21	87-50-42	319,389	2,577,796	T. 5 N., R. 22 E. Sec. 36	E. Oakwood Rd. City of Oak Creek	180.5	O	N/A	N/A
M253	42-52-12	87-56-27	323,901	2,551,978	T. 5 N., R. 21 E. Sec. 30	9600 S. 20th St. City of Oak Creek	118.1	O	N/A	N/A
M254	43-00-28	88-03-21	373,361	2,519,987	T. 6 N., R. 21 E. Sec. 6	11515 W. Rogers St. City of West Allis	89.4	O	N/A	N/A
M255	42-59-44	88-00-53	368,648	2,508,798	T. 6 N., R. 21 E. Sec. 9	8214 W. Cleveland Ave. City of West Allis	108.3	O	N/A	N/A
M256	42-59-20	87-59-03	366,934	2,539,318	T. 6 N., R. 21 E. Sec. 11	5600 W. Oklahoma Ave. City of Milwaukee	78.7	O	N/A	N/A
M257	42-58-17	88-04-00	360,035	2,517,397	T. 6 N., R. 21 E. Sec. 19	8787 W. Waterford Ave. City of Greenfield	170.6	O	N/A	N/A
M258	42-57-53	87-57-54	358,253	2,544,659	T. 6 N., R. 21 E. Sec. 24	4001 W. Loomis Rd. City of Greenfield	121.4	S	N/A	N/A
M259	42-56-16	88-00-13	348,186	2,534,562	T. 6 N., R. 21 E. Sec. 34	7100 Euston St. Village of Greendale	91.9	O	N/A	N/A
M260	43-00-25	87-56-09	373,829	2,552,083	T. 6 N., R. 22 E. Sec. 6	1800 W. Becher St. City of Milwaukee	78.7	O	N/A	N/A
M261	42-57-19	87-51-41	355,507	2,572,473	T. 6 N., R. 22 E. Sec. 26	3555 E. Pabst Ave. City of Cudahy	95.1	S	N/A	N/A
M262	43-05-00	88-01-21	401,100	2,528,248	T. 7 N., R. 21 E. Sec. 9	8814 W. Lisbon Ave. City of Milwaukee	68.9	O	N/A	N/A
M263	43-03-41	88-00-22	393,209	2,532,816	T. 7 N., R. 21 E. Sec. 16	7500 W. North Ave. City of Wauwatosa	N/A	O	N/A	N/A
M264	43-02-49	87-59-04	388,085	2,538,732	T. 7 N., R. 21 E. Sec. 23	Hawley Rd. City of Milwaukee	88.6	O	N/A	N/A
M265	43-01-59	87-57-17	383,218	2,546,799	T. 7 N., R. 21 E. Sec. 25	222 N. 33rd St. City of Milwaukee	72.2	O	N/A	N/A
M266	43-02-06	88-02-25	383,377	2,523,913	T. 7 N., R. 21 E. Sec. 29	10200 W. Bluemound Rd. City of Wauwatosa	108.3	O	N/A	N/A
M267	43-01-22	87-57-59	379,397	2,543,772	T. 7 N., R. 22 E. Sec. 36	4213 W. National Ave. Village of West Milwaukee	78.7	S	N/A	N/A
M268	43-05-16	87-53-07	403,619	2,564,855	T. 7 N., R. 22 E. Sec. 10	3909 N. Murray Ave. Village of Shorewood	124.7	O	N/A	N/A
M269	43-04-20	87-51-56	398,086	2,570,267	T. 7 N., R. 22 E. Sec. 14	3000 N. Lincoln Memorial Dr. City of Milwaukee	68.9	O	N/A	N/A
M270	43-03-18	87-55-08	391,451	2,556,177	T. 7 N., R. 22 E. Sec. 20	1901 N. 6th St. City of Milwaukee	68.9	O	N/A	N/A
M271	43-10-46	88-02-48	435,967	2,520,973	T. 8 N., R. 21 E. Sec. 6	107th St. and N. Granville Rd. City of Milwaukee	121.4	O	N/A	N/A
M272	43-08-46	88-03-28	423,752	2,518,292	T. 8 N., R. 21 E. Sec. 19	7007 N. 115th St. City of Milwaukee	150.9	O	N/A	N/A
M273	43-10-44	87-55-03	436,598	2,555,421	T. 8 N., R. 22 E. Sec. 5	877 Glenco Pl. Village of Bayside	N/A	O	N/A	N/A

Table 27 (continued)

Site Number (See Map 23)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
M274	43-07-54	87-54-42	419,432	2,557,407	T. 8 N., R. 22 E. Sec. 29	6321 N. Lydell Ave. Village of Whitefish Bay	N/A	O	N/A	N/A
M275	43-07-02	87-55-49	414,045	2,552,571	T. 8 N., R. 22 E. Sec. 31	Green Bay Ave. City of Glendale	150.9	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Milwaukee County and local municipalities of Milwaukee County, Wisconsin and SEWRPC.

absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Antenna Site Inventory–Fixed Wireless Service Providers

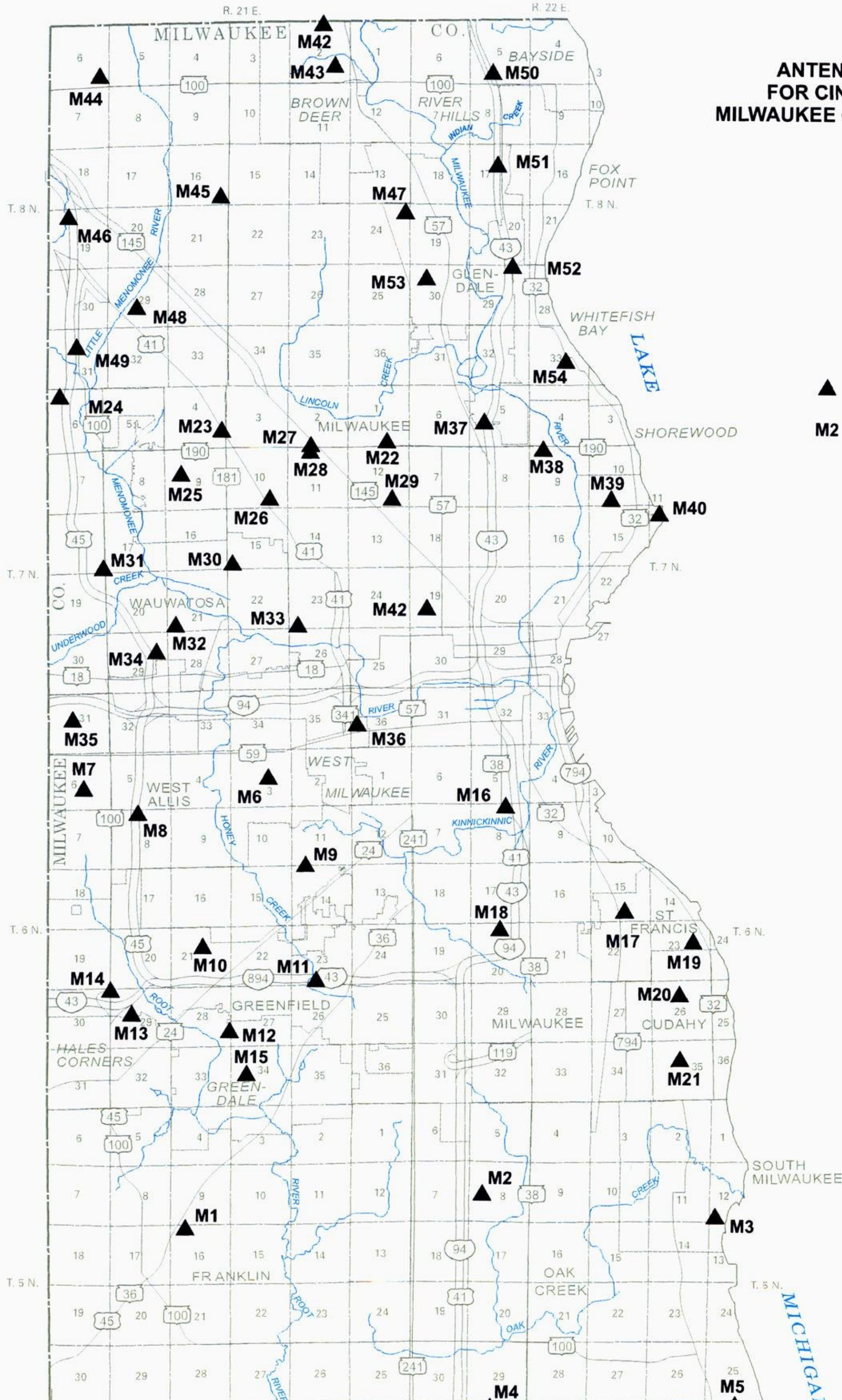
In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Inventory Findings – Geographic Coverage

As already noted, originally, it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be provided only for the cooperating service providers in

Map 18

ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (54)

M2 IDENTIFICATION NUMBER (SEE TABLE 22)

GRAPHIC SCALE

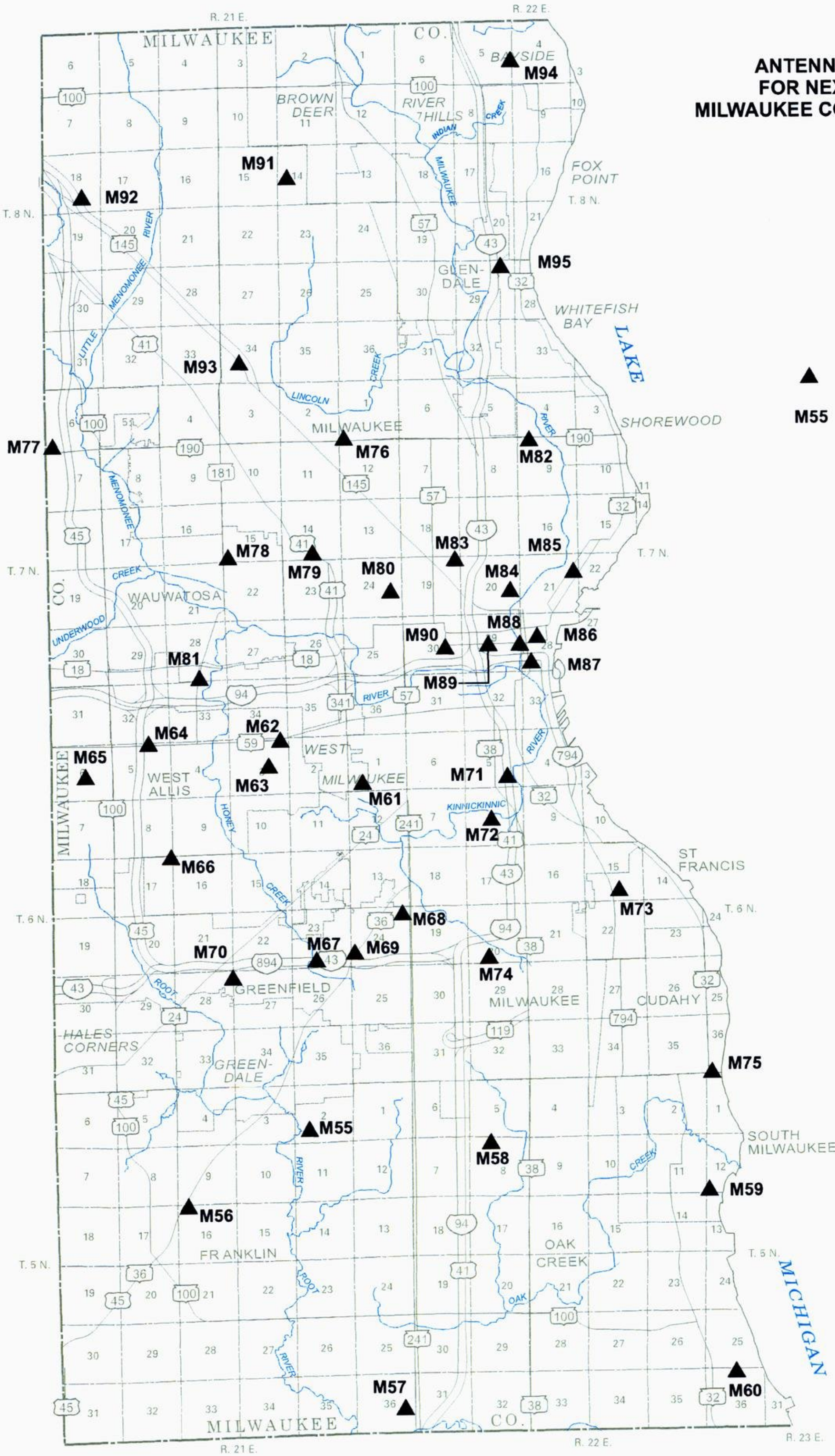
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 19

ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (41)

M55 IDENTIFICATION NUMBER (SEE TABLE 23)

GRAPHIC SCALE

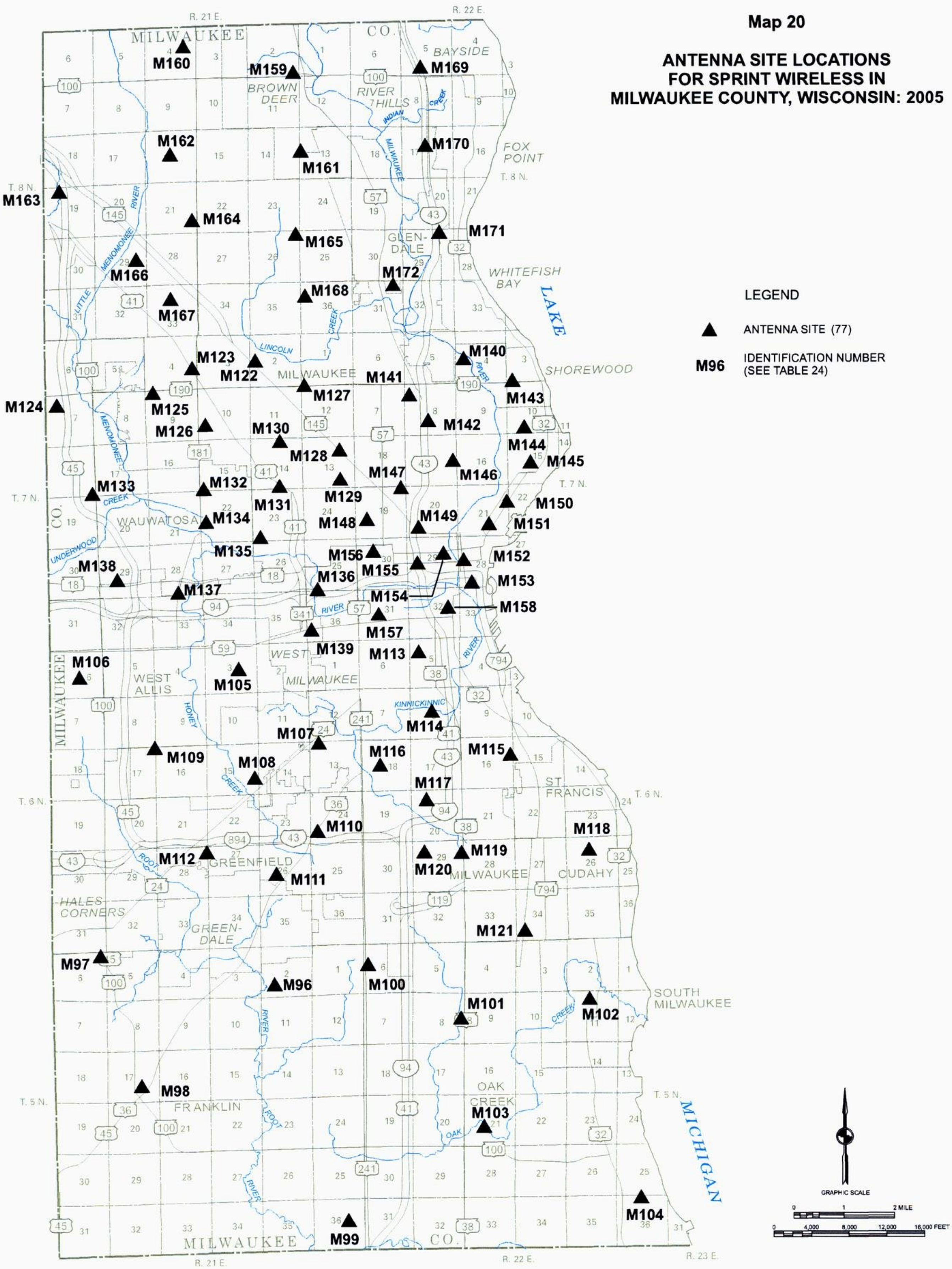
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 20

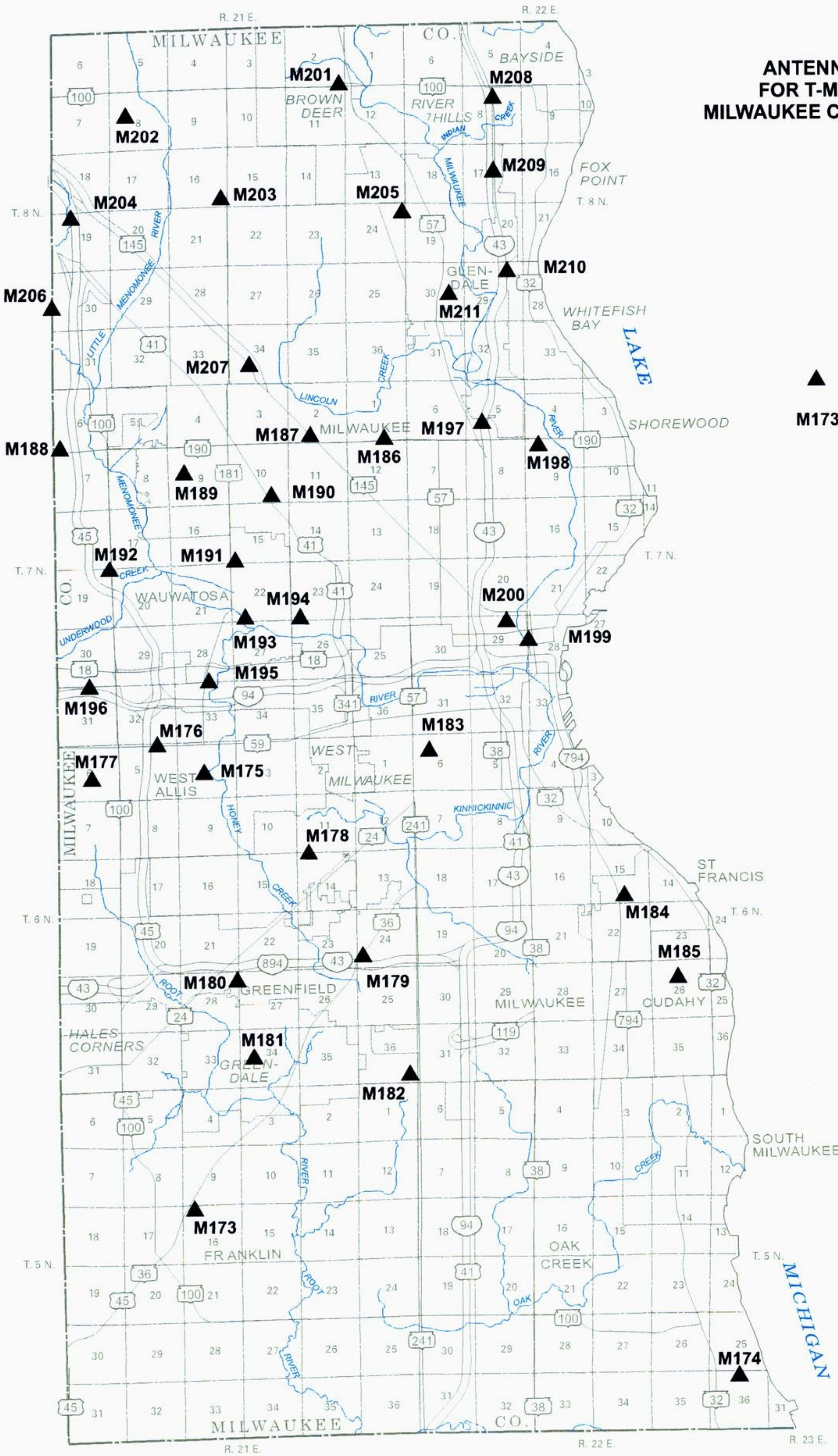
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 21

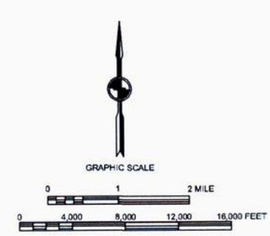
ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (39)

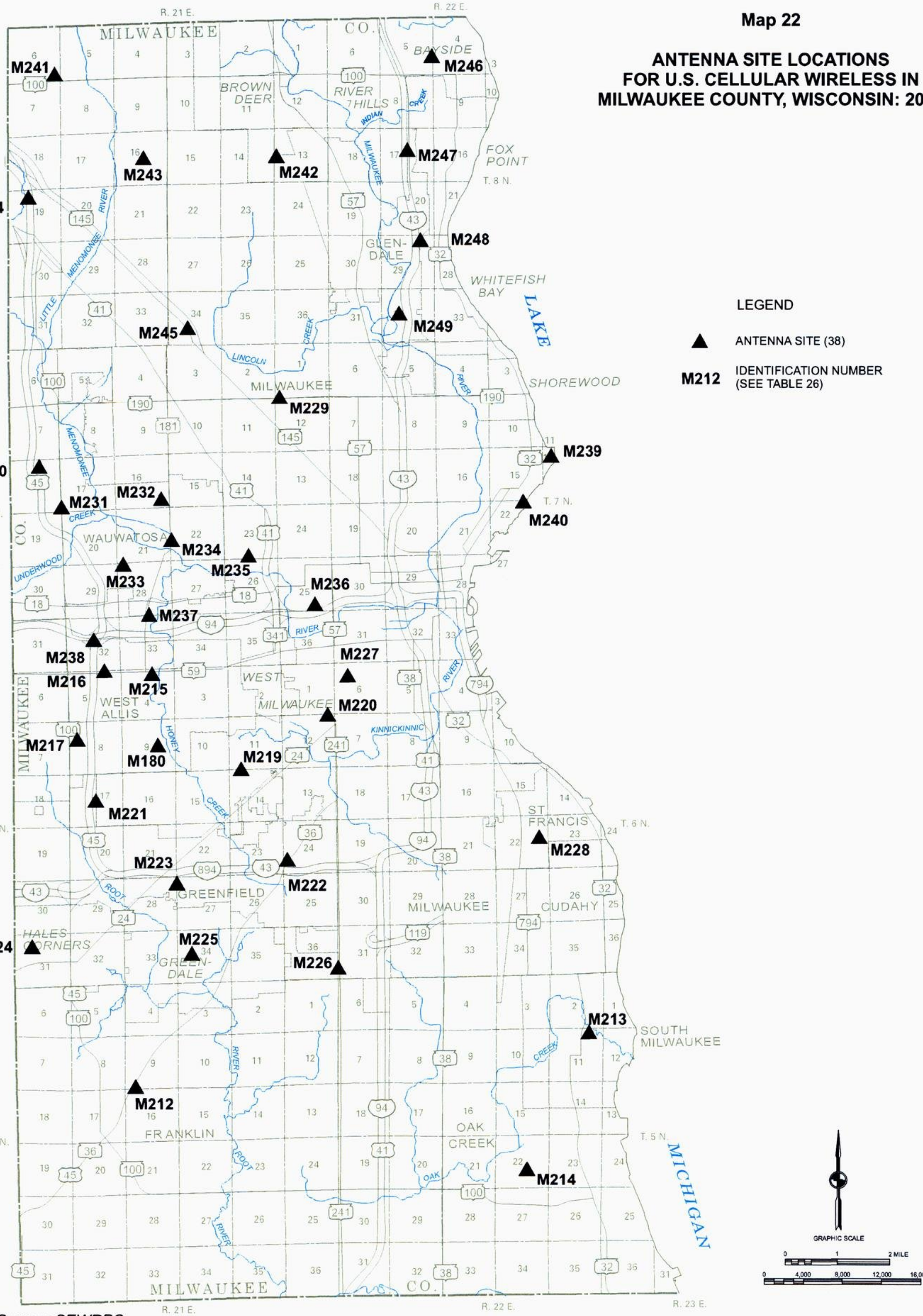
M173 IDENTIFICATION NUMBER (SEE TABLE 25)



Source: SEWRPC.

Map 22

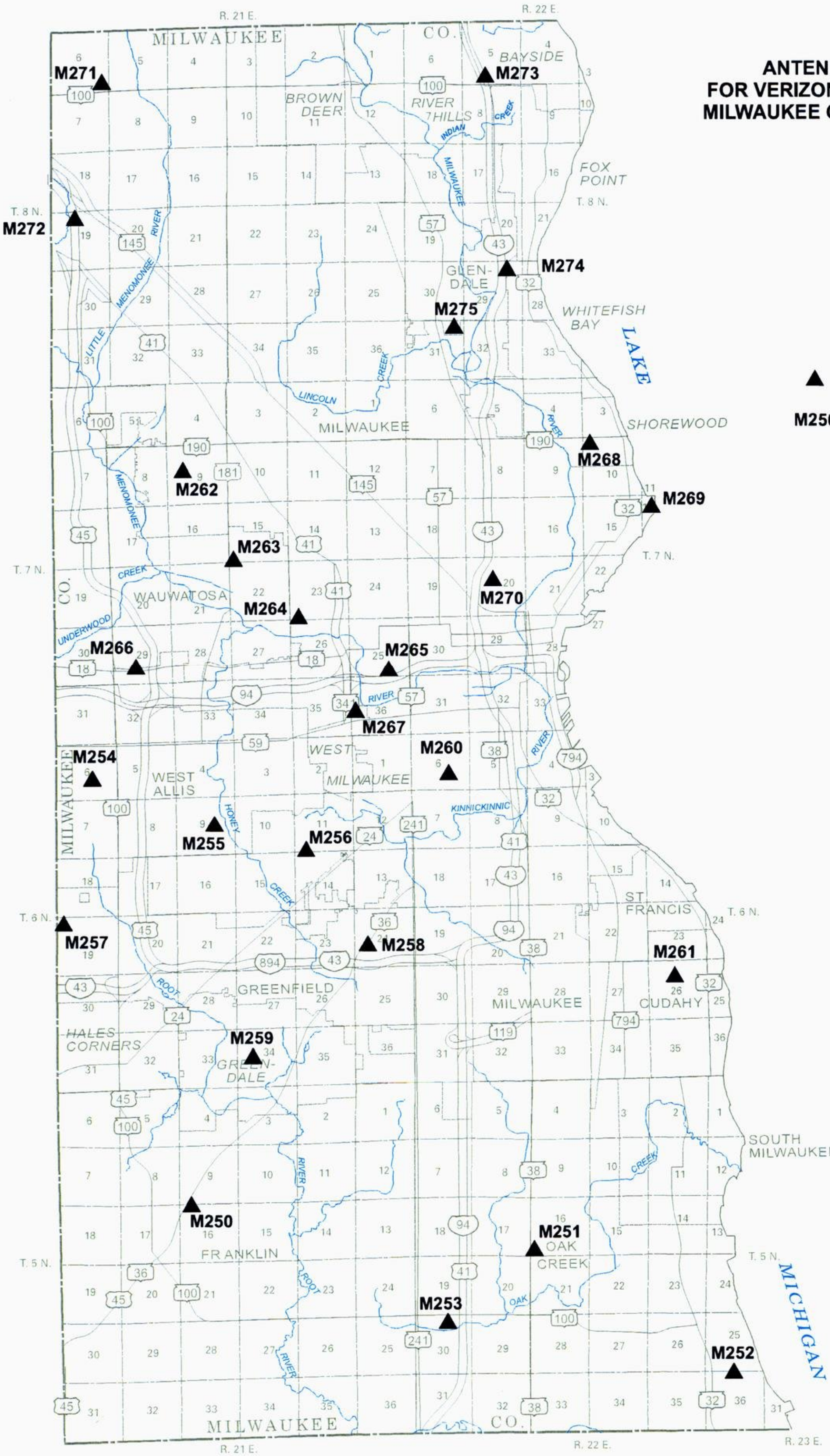
ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 23

ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS-WIRELESS IN MILWAUKEE COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (26)

M250 IDENTIFICATION NUMBER (SEE TABLE 27)

GRAPHIC SCALE

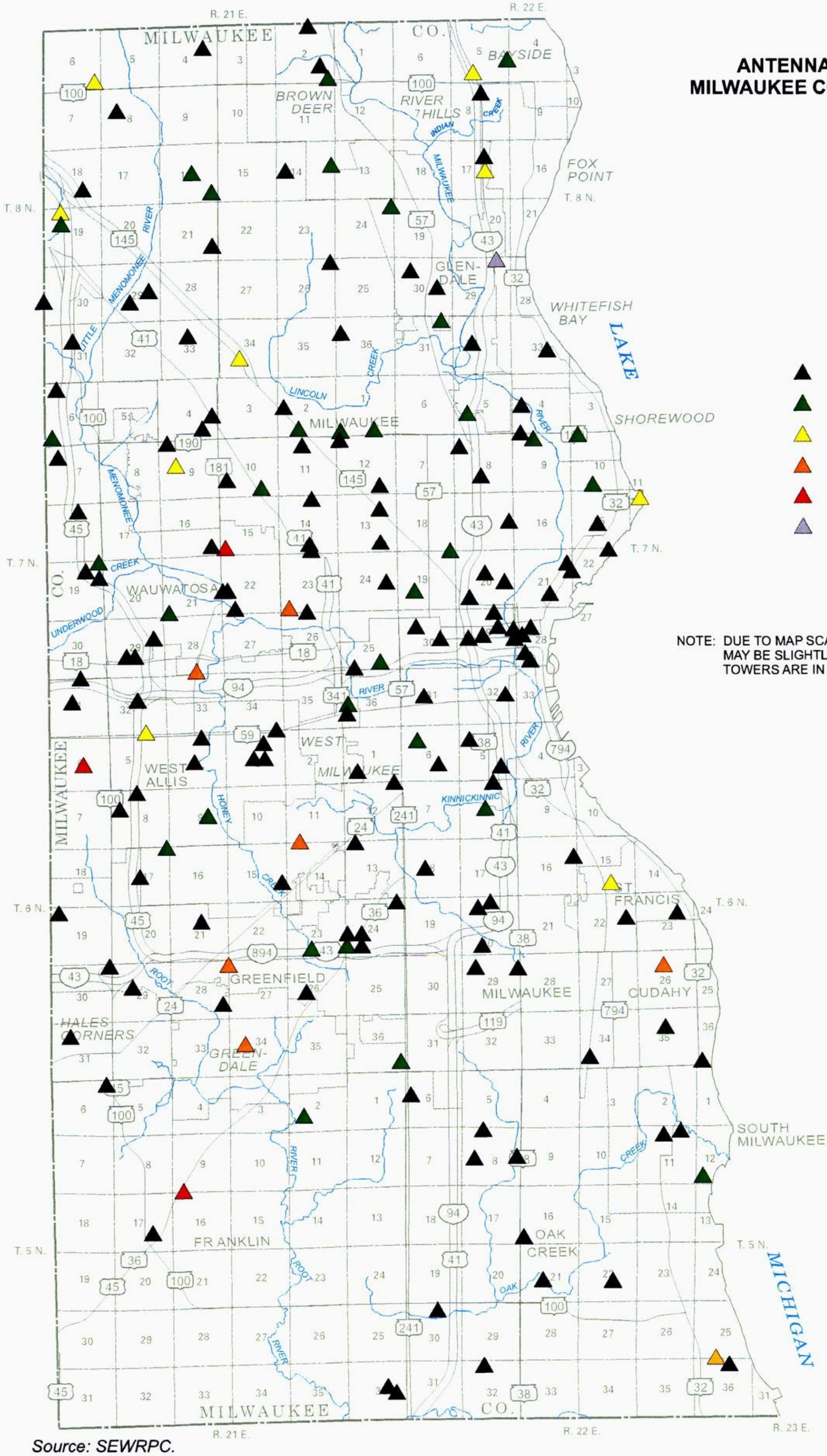
0 1 2 MILE

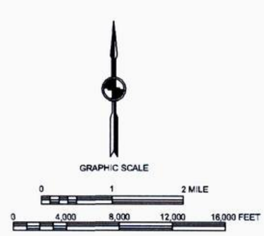
0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 24

ANTENNA SITE LOCATIONS IN MILWAUKEE COUNTY, WISCONSIN: 2005





LEGEND

▲ (black)	1 ANTENNA SITE	(135)
▲ (green)	2 ANTENNA SITES	(32)
▲ (yellow)	3 ANTENNA SITES	(9)
▲ (orange)	4 ANTENNA SITES	(7)
▲ (red)	5 ANTENNA SITES	(3)
▲ (purple)	6 ANTENNA SITES	(1)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAY BE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.

Source: SEWRPC.

Table 28

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN OZAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 25)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
O1	43-15-07	87-58-03	462,887	2,541,439	T. 9 N., R. 21 E. Sec. 11	Adjacent to 4508 W. Highland Rd. City of Mequon	128.0	O	N/A	N/A
O2	43-14-36	87-59-12	495,626	2,536,410	T. 9 N., R. 21 E. Sec.15	601 N. Main St. Village of Thiensville	105.0	O	N/A	N/A
O3	43-13-21	87-59-18	452,024	2,536,149	T. 9 N., R. 21 E. Sec. 22	11300 N. Buntrock Rd. City of Mequon	111.6	S	N/A	N/A
O4	43-12-51	87-56-41	448,977	2,535,876	T. 9 N., R. 21 E. Sec. 25	3100 W. Country Club Rd. City of Mequon	98.43	S	140.82	891.51
O5	43-12-37	88-01-40	447,320	2,525,744	T. 9 N., R. 21 E. Sec. 29	9415 W. Donges Bay Rd. City of Mequon	121.4	S	N/A	N/A
O6	43-13-56	87-15-19	455,998	2,553,774	T. 9 N., R. 22 E. Sec. 20	11800 N. Port Washington Rd. City of Mequon	212.4	S	75.00	N/A
O7	43-12-28	87-55-19	447,094	2,553,973	T. 9 N., R. 22 E. Sec. 20	10448 N. Port Washington Rd. City of Mequon	212.4	S	N/A	N/A
O8	43-20-40.6	87-57-04.2	496,757	2,544,983	T. 10 N., R. 21 E. Sec. 12	1717 Shady La. Town of Grafton	149.9	S	140.82	891.51
O9	43-17-35	87-59-23	477,721	2,535,183	T. 10 N., R. 21 E. Sec. 34	N49 W6411 Western Ave. City of Cedarburg	150.9	S	N/A	891.51
O10	43-17-37	87-58-03	478,069	2,541,069	T. 10 N., R. 21 E. Sec. 35	4433 Lakefield Rd. Town of Grafton	N/A	O	N/A	N/A
O11	43-18-59	87-55-48	486,613	2,550,843	T. 10 N., R. 22 E. Sec.19	Dakota Dr. Village of Grafton	N/A	O	N/A	N/A
O12	43-16-53	87-55-11	473,929	2,553,896	T. 10 N., R. 22 E. Sec. 32	Town of Grafton	N/A	O	N/A	N/A
O13	43-26-36	87-51-17.3	533,372	2,569,682	T. 11 N., R. 22 E. Sec. 3	1374 Lake Dr. Town of Port Washington	282.2	S	140.82	891.51
O14	43-24-38	87-52-38	521,276	2,564,011	T. 11 N., R. 22 E. Sec. 21	500 Thomas Dr. City of Port Washington	91.9	O	N/A	N/A
O15	43-23-26	87-52-15	514,032	2,565,918	T. 11 N., R. 22 E. Sec. 28	412 N. Wisconsin St. City of Port Washington	98.4	S	N/A	891.51
O16	43-29-47	87-50-26	552,801	2,572,942	T. 12 N., R. 22 E. Sec. 22	274 Lindale St. Village of Belgium	134.5	O	N/A	N/A

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC.

a separate planning report. The infrastructure inventory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the

Table 29

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN OZAUKEEE COUNTY, WISCONSIN: 2005

Site Number (See Map 26)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
O17	43-14-56	87-58-49	461,689	2,538,086	T. 9 N., R. 21 E. Sec. 14	5555 W. Highland Rd. City of Mequon	177.2	O	N/A	860.7875
O18	43-13-56	87-55-19	455,998	2,553,774	T. 9 N., R. 22 E. Sec. 20	11800 N. Port Washington Rd. City of Mequon	88.6	O	N/A	860.7875
O19	43-19-18	87-56-16	488,484	2,548,750	T. 10 N., R. 22 E. Sec. 19	1980 Washington Ave. Village of Grafton	124.7	O	N/A	860.7875
O20	43-17-35	87-59-23	477,721	2,535,183	T. 10 N., R. 21 E. Sec. 34	N49 W6411 Western Ave. City of Cedarburg	124.7	O	N/A	860.7875
O21	43-24-38	87-52-38	521,276	2,564,035	T. 11 N., R. 22 E. Sec. 21	500 Thomas Dr. City of Port Washington	91.9	O	N/A	860.7875
O22	43-22-35	87-52-56	508,833	2,564,573	T. 11 N., R. 22 E. Sec. 32	700 Sunset Rd. City of Port Washington	269.0	O	N/A	860.7875
O23	43-27-36	87-56-50	538,827	2,544,997	T. 12 N., R. 21 E. Sec. 35	616 Tower Dr. Village of Fredonia	150.9	O	N/A	860.7875

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC.

Commission wireless network monitoring system which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 67 base transceiver stations on 41 cellular–PCS mobile wireless antenna sites within Ozaukee County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

RACINE COUNTY

Antenna site data for Racine County were compiled from the same Federal sources previously cited for Kenosha County.

1. Federal Communications Commission (FCC) databases

    a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22

    b. For Nextel Communications, Inc.–Land Mobile–Commercial

Table 30

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN OZAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 27)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
O24	43-15-31.32	87-59-04.56	465,236	2,536,849	T. 9 N., R. 21 E. Sec. 11	6333 W. Bonniwell Rd. City of Mequon	80.0	S	N/A	1931.25
O25	43-13-21.72	87-59-19.32	452,092	2,536,073	T. 9 N., R. 21 E. Sec. 22	11300 N. Buntrock Rd. City of Mequon	120.0	S	N/A	1931.25
O26	43-15-15.84	87-54-51.12	464,130	2,555,636	T. 9 N., R. 22 E. Sec. 8	12800 N. Lakeshore Dr. City of Mequon	60.0	S	N/A	1931.25
O27	43-12-28.44	87-55-19.56	447,135	2,553,954	T. 9 N., R. 22 E. Sec. 29	10448 N. Port Washington Rd. City of Mequon	80.0	S	N/A	1931.25
O28	43-18-29.16	87-57-49.32	483,371	2,541,975	T. 10 N., R. 21 E. Sec. 25	1st Ave. and Falls Rd. Village of Grafton	82.0	S	N/A	1932.50
O29	43-17-50.28	88-01-24.24	479,054	2,526,183	T. 10 N., R. 21 E. Sec. 28	610 Horns Corners Rd. Town of Cedarburg	130.0	S	N/A	1931.25
O30	43-25-12	87-59-39.12	523,948	2,532,879	T. 11 N., R. 21 E. Sec. 16	3856 Lakeland Dr. Town of Saukville	80.0	S	N/A	1931.25
O31	43-26-36.60	87-51-16.56	533,434	2,569,735	T. 11 N., R. 22 E. Sec. 3	1374 Lake Dr. Town of Port Washington	90.0	S	N/A	1932.50
O32	43-23-26.52	87-52-15.24	514,084	2,565,899	T. 11 N., R. 22 E. Sec. 28	412 N. Wisconsin Ave. City of Port Washington	80.0	S	N/A	1931.25
O33	43-23-20.76	87-54-13.68	513,280	2,557,172	T. 11 N., R. 22 E. Sec. 30	2364 W. Grand Ave. City of Port Washington	123.0	S	N/A	1931.25
O34	43-27-36	87-56-49.56	538,828	2,545,030	T. 12 N., R. 21 E. Sec. 35	616 Tower Dr. Village of Fredonia	30.49	S	N/A	1931.25
O35	43-30-11.88	87-51-11.52	555,233	2,569,546	T. 12 N., R. 22 E. Sec. 15	Commerce St. Village of Belgium	120.1	S	N/A	1931.25

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC.

2. Local governmental data bases included data provided by the following 19 local units of government in Racine County: City of Burlington–4 sites; City of Racine–26 sites; Village of Caledonia–24 sites; Village of Elmwood Park–0 sites; Village of Mt. Pleasant–5 sites; Village of North Bay–0 sites; Village of Rochester–0 sites; Village of Sturtevant–2 sites; Village of Union Grove–2 sites; Village of Waterford–0 sites; Village of Wind Point–0 sites; Town of Burlington–6 sites; Town of Dover–5 sites; Town of Norway–5 sites; Town of Raymond–12 sites; Town of Rochester–6 sites; Town of Waterford–5 sites; Town of Yorkville–12 sites. There are a total of 114 sites within Racine County.

Table 31

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN OZAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 28)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
O36	43-14-11	88-00-48	456,923	2,529,391	T. 9 N., R. 21 E. Sec. 16	8320 W. Freistadt Rd. City of Mequon	111.6	S	N/A	1970
O37	43-12-51	87-59-36	448,953	2,534,913	T. 9 N., R. 21 E. Sec. 27	NW of Eastwood Ct. City of Mequon	164.1	S	N/A	1970
O38	43-13-56	87-55-19	455,998	2,553,774	T. 9 N., R. 22 E. Sec. 20	11800 N. Port Washington Rd. City of Mequon	111.6	S	N/A	1970
O39	43-12-28	87-55-19	447,092	2,553,996	T. 9 N., R. 22 E. Sec. 29	10448 N. Port Washington Rd. City of Mequon	88.6	S	N/A	1970
O40	43-21-26	87-55-27	501,529	2,552,049	T. 10 N., R. 22 E. Sec. 5	IH 43 and 2200 N. Ulao Parkway Town of Grafton	98.4	S	N/A	1970
O41	43-31-14	87-56-10	560,965	2,547,400	T. 12 N., R. 21 E. Sec. 12	NE corner of STH 57 and Hickory Grove Rd. Town of Fredonia	265.8	S	N/A	1970
O42	43-29-47	87-50-26	552,801	2,572,942	T. 12 N., R. 22 E. Sec. 22	274 Lindale St. Village of Belgium	134.5	S	N/A	1970

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.
[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.
[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC.

Antenna Site Inventory – Cellular/PCS

The cellular/PCS antenna site inventory findings for Racine County are summarized in Tables 34 through 39 reproduced on pages 108 through 115 one for each wireless service provider as follows: Table 34–Cingular Wireless–25 antenna sites, Table 35–Nextel Communications–13 antenna sites, Table 36–Sprint PCS–17 antenna sites, Table 37–T-Mobile–10 antenna sites, Table 38–U.S. Cellular–27 antenna sites, Table 39–Verizon Wireless–22 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 32 through 37. Map 38 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 34, 35, and 38, representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired the FCC data bases since these types of data were mostly absent from local governmental files. Tables 36, 37, and 39 representing the PCS service providers were compiled almost entirely from local governmental databases since PCS sites were largely absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Table 32

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN OZAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 29)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
O43	43-14-56	87-58-49	461,689	2,538,086	T. 9 N., R. 21 E. Sec. 14	5555 Highland Rd. City of Mequon	167.3	S	N/A	1950
O44	43-13-41	88-03-20	453,621	2,518,213	T. 9 N., R. 21 E. Sec. 19	11550 N. Wausaukee Rd. City of Mequon	78.7	S	N/A	1950
O45	43-12-51	87-59-36	448,953	2,534,913	T. 9 N., R. 21 E. Sec. 27	NW of Eastwood Ct. City of Mequon	114.8	S	N/A	1950
O46	43-12-37	88-01-40	447,320	2,525,744	T. 9 N., R. 21 E. Sec. 29	9415 W. Donges Bay Rd. City of Mequon	88.6	S	N/A	1950
O47	43-13-56	87-55-19	455,998	2,553,774	T. 9 N., R. 22 E. Sec. 20	11800 N. Port Washington Rd. City of Mequon	78.7	S	N/A	1950
O48	43-12-28	87-55-19	447,092	2,553,996	T. 9 N., R. 22 E. Sec. 29	10448 N. Port Washington Rd. City of Mequon	98.4	S	N/A	1950
O49	43-17-35	87-59-23	477,721	2,535,183	T. 10 N., R. 21 E. Sec. 34	N49 W6411 Western Ave. City of Cedarburg	154.2	S	N/A	1950
O50	43-19-18	87-56-16	488,484	2,548,750	T. 10 N., R. 22 E. Sec. 19	1980 Washington Ave. Village of Grafton	65.6	S	N/A	1950
O51	43-26-42	88-01-45	532,837	2,523,376	T. 11 N., R. 21 E. Sec. 06	3311 Highview Rd. Town of Saukville	170.6	S	N/A	1950
O52	43-23-30	87-57-19	513,876	2,543,469	T 11 N., R. 21 E. Sec. 26	Debra Wood Blvd. Village of Saukville	150.9	S	N/A	1950
O53	43-24-21	87-53-46	519,429	2,559,061	T. 11 N., R. 22 E. Sec. 20	3508 CTH K Town of Port Washington	150.9	S	N/A	1950
O54	43-23-26	87-52-15	514,032	2,565,918	T. 11 N., R. 22 E. Sec. 28	412 N. Wisconsin St. City of Port Washington	98.4	S	N/A	1950
O55	43-29-33	87-50-10	551,415	2,574,181	T. 12 N., R. 22 E. Sec. 23	480 S. Royal Ave. Village of Belgium	141.1	S	N/A	1950

[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*
[b]*Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the

Table 33

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS-WIRELESS ANTENNAS IN OZAUKEE COUNTY, WISCONSIN: 2005

Site Number (See Map 30)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey					
	Latitude	Longitude	North	East	Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
O56	43-15-07	87-58-03	462,887	2,541,439	T. 9 N., R. 21 E. Sec. 11	Adjacent to 4508 W. Highland Rd. City of Mequon	114.8	S	N/A	1975
O57	43-14-11	88-00-48	456,923	2,529,391	T. 9 N., R. 21 E. Sec. 16	8320 W. Freistadt Rd. City of Mequon	121.4	S	N/A	1975
O58	43-13-41	88-03-20	453,621	2,518,213	T. 9 N., R. 21 E. Sec. 19	11550 N. Wausaukee Rd. City of Mequon	95.1	S	N/A	1975
O59	43-13-24	87-57-16	452,545	2,545,195	T. 9 N., R. 21 E. Sec. 24	11313 N. Riverland Rd. City of Mequon	68.9	S	N/A	1975
O60	43-12-31	87-58-49	447,013	2,538,442	T. 9 N., R. 21 E. Sec. 26	Adjacent to 5616 W. Donges Bay Rd. City of Mequon	101.7	S	N/A	1975
O61	43-13-56	87-55-19	455,998	2,553,774	T. 9 N., R. 22 E. Sec. 20	11800 N. Port Washington Rd. City of Mequon	98.3	S	N/A	1975
O62	43-12-28	87-55-19	447,092	2,553,996	T. 9 N., R. 22 E. Sec. 29	10448 N. Port Washington Rd. City of Mequon	111.6	S	N/A	1975
O63	43-21-56	88-00-40	504,002	2,528,860	T. 10 N., R. 21 E. Sec. 4	8817 Cedar Sauk Rd. Town of Cedarburg	150.9	S	N/A	1975
O64	43-17-35	87-59-23	477,721	2,535,183	T. 10 N., R. 21 E. Sec. 34	N49 W6411 Western Ave. City of Cedarburg	134.5	S	N/A	1975
O65	43-19-10	87-56-15	487,677	2,548,820	T. 10 N., R. 22 E. Sec. 19	1981 Washington Ave. Village of Grafton	150.9	S	N/A	N/A
O66	43-16-50	87-55-05	473,635	2,554,371	T. 10 N., R. 22 E. Sec. 32	1054 Pioneer Rd. Town of Grafton	98.4	S	N/A	1975
O67	43-23-20	87-54-13	513,205	2,557,200	T. 11 N., R. 22 E. Sec. 30	2364 W. Grand Ave. City of Port Washington	121.4	O	N/A	N/A

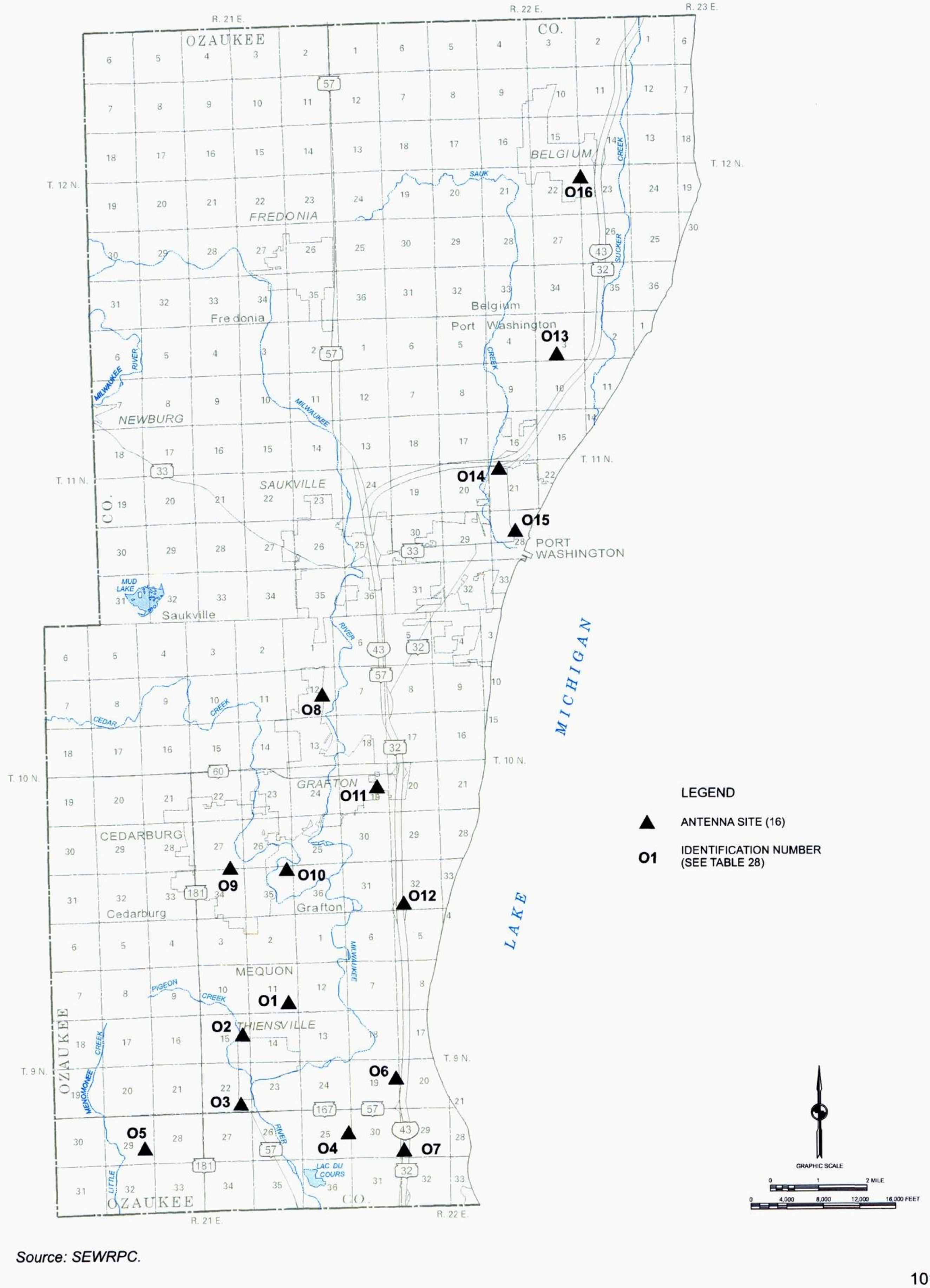
[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*
[b]*Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Ozaukee County and local municipalities of Ozaukee County, Wisconsin and SEWRPC.

growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Map 25

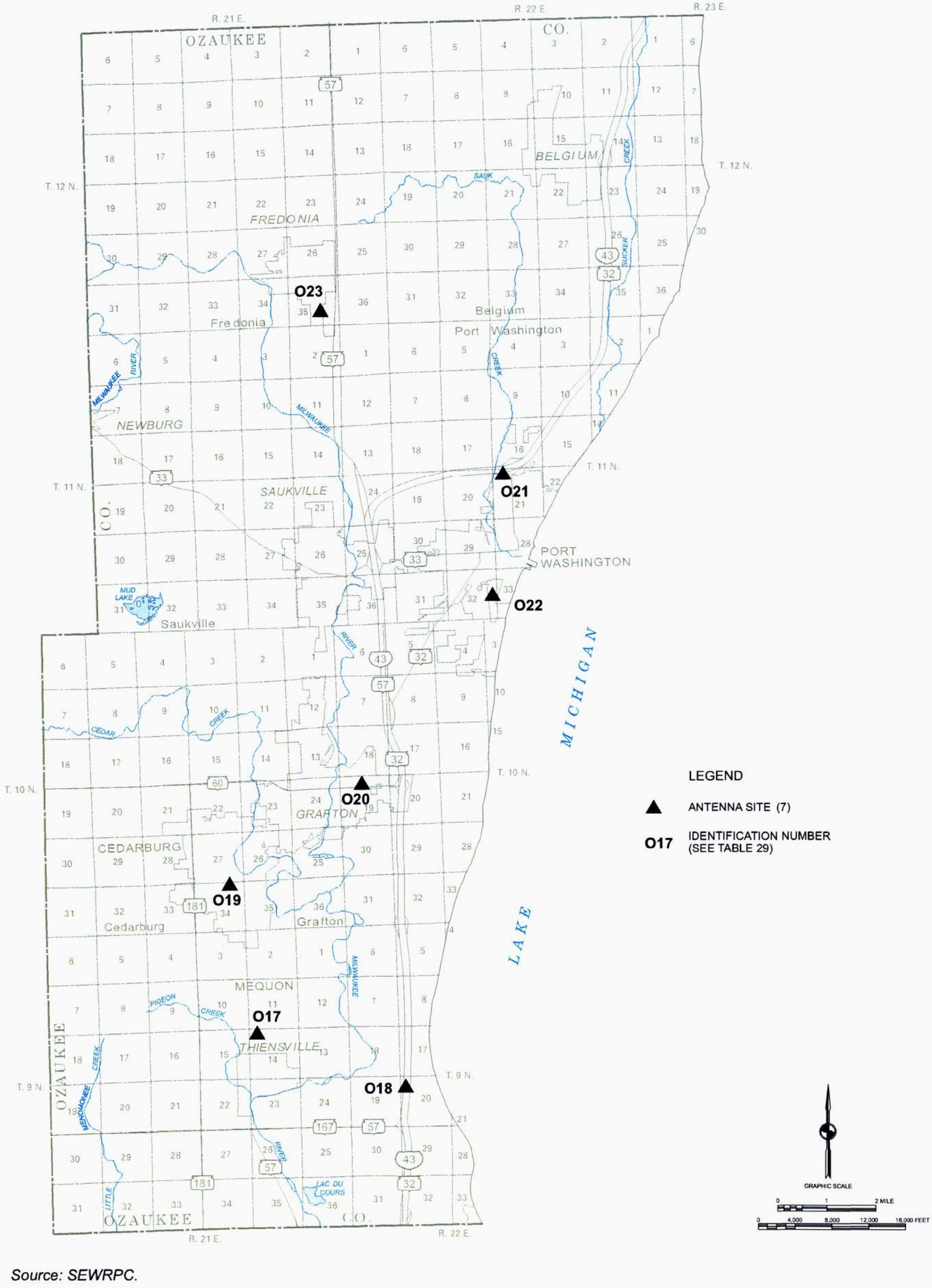
ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 26

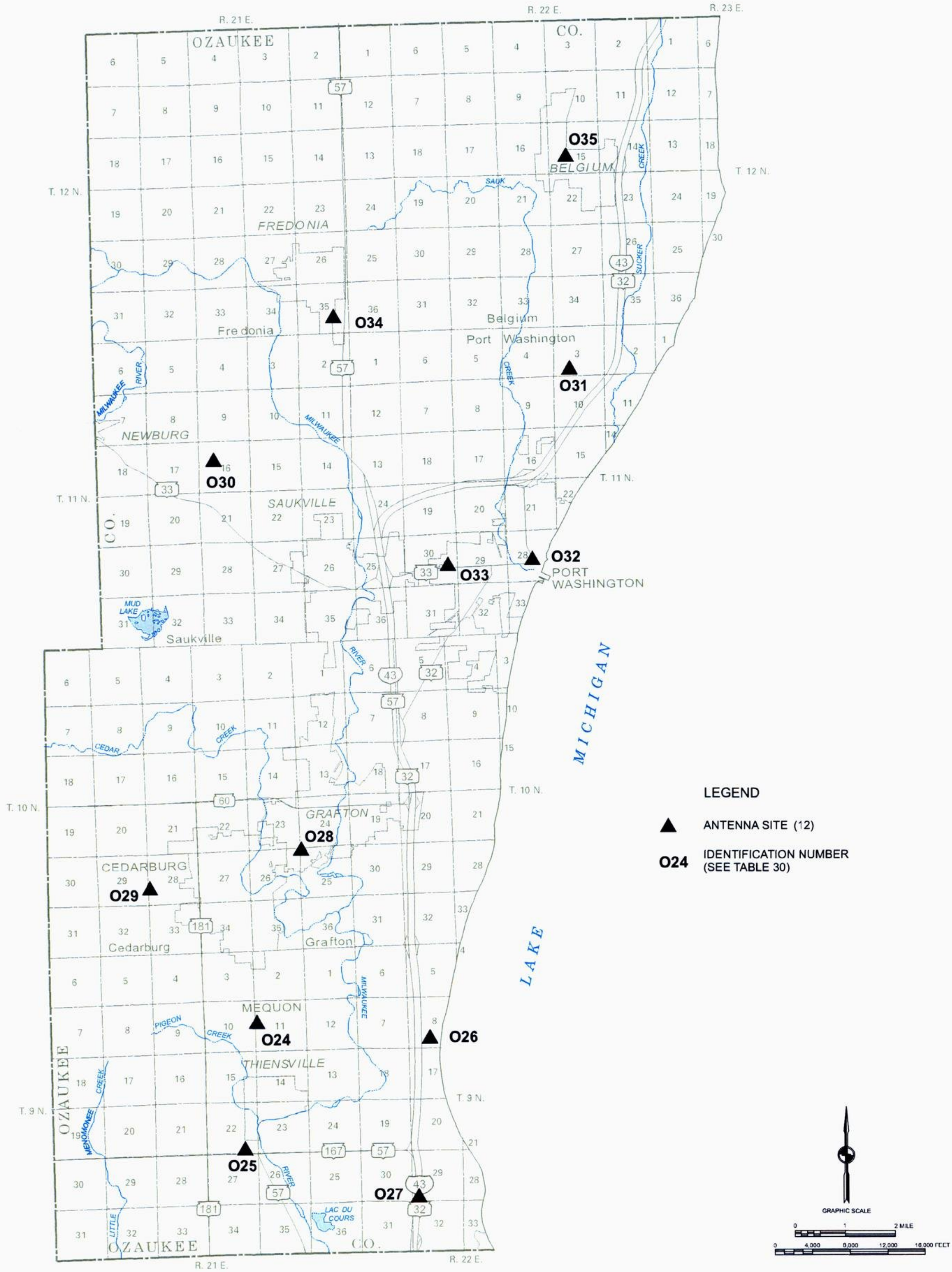
ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 27

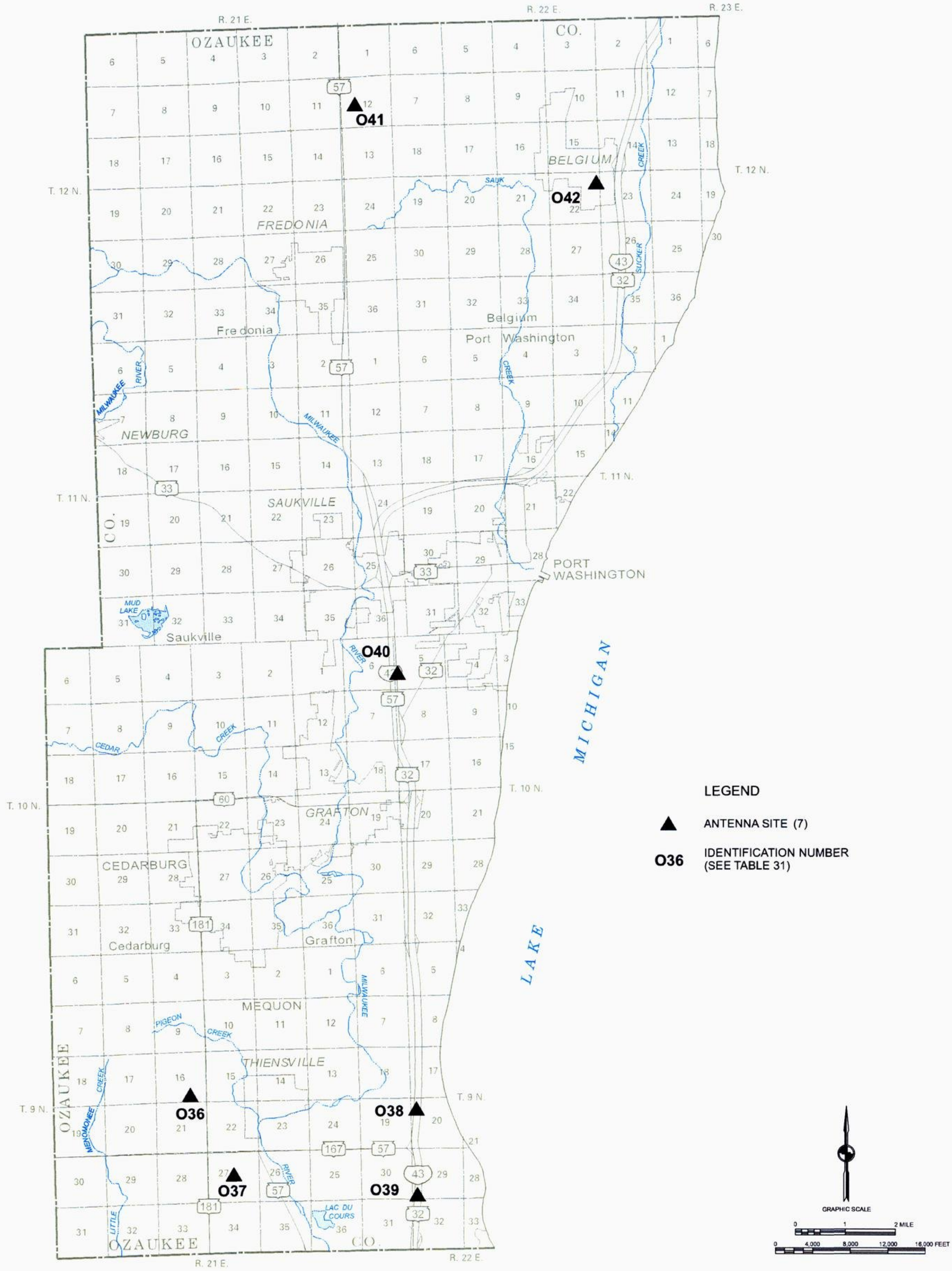
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 28

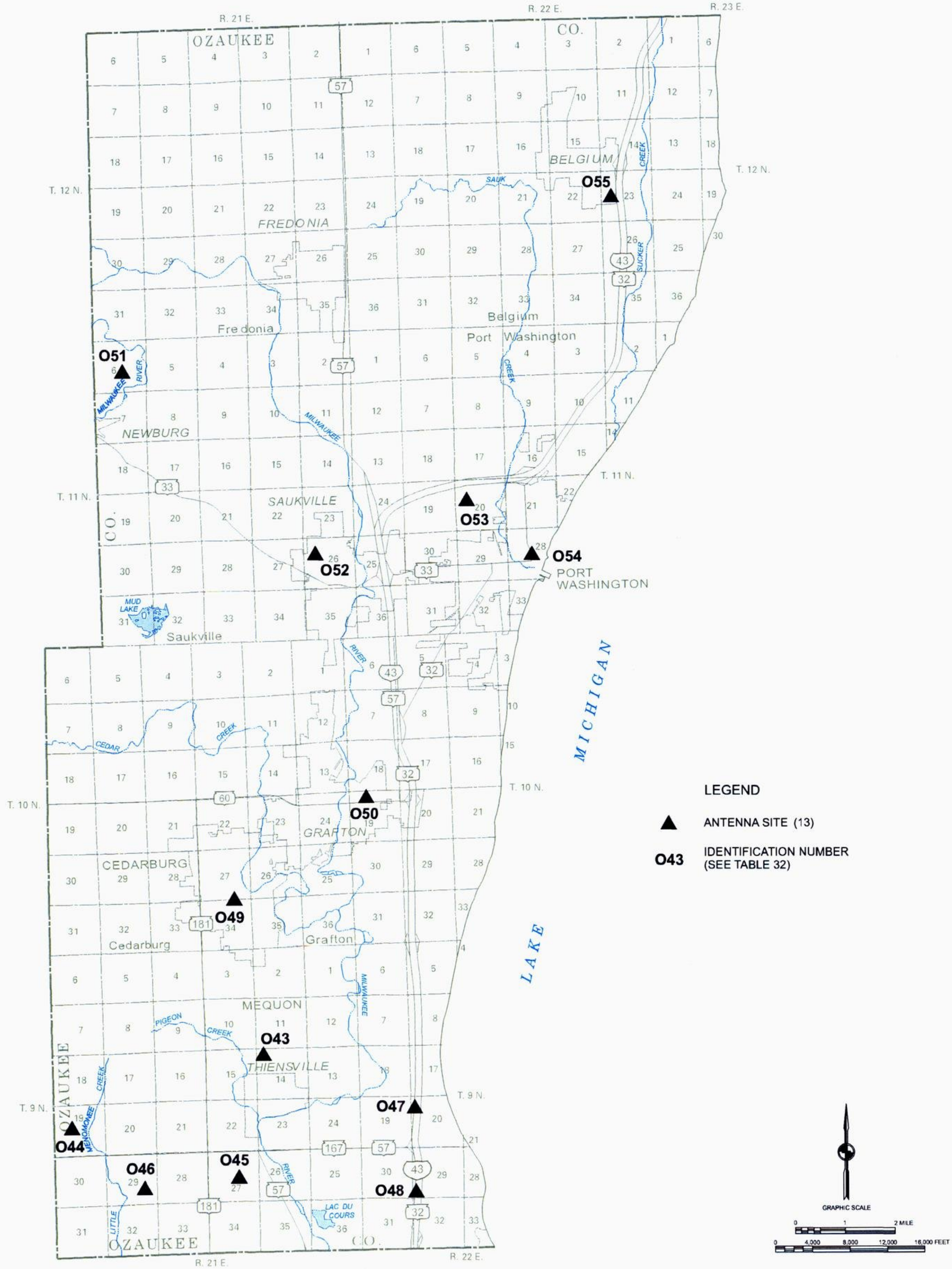
ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 29

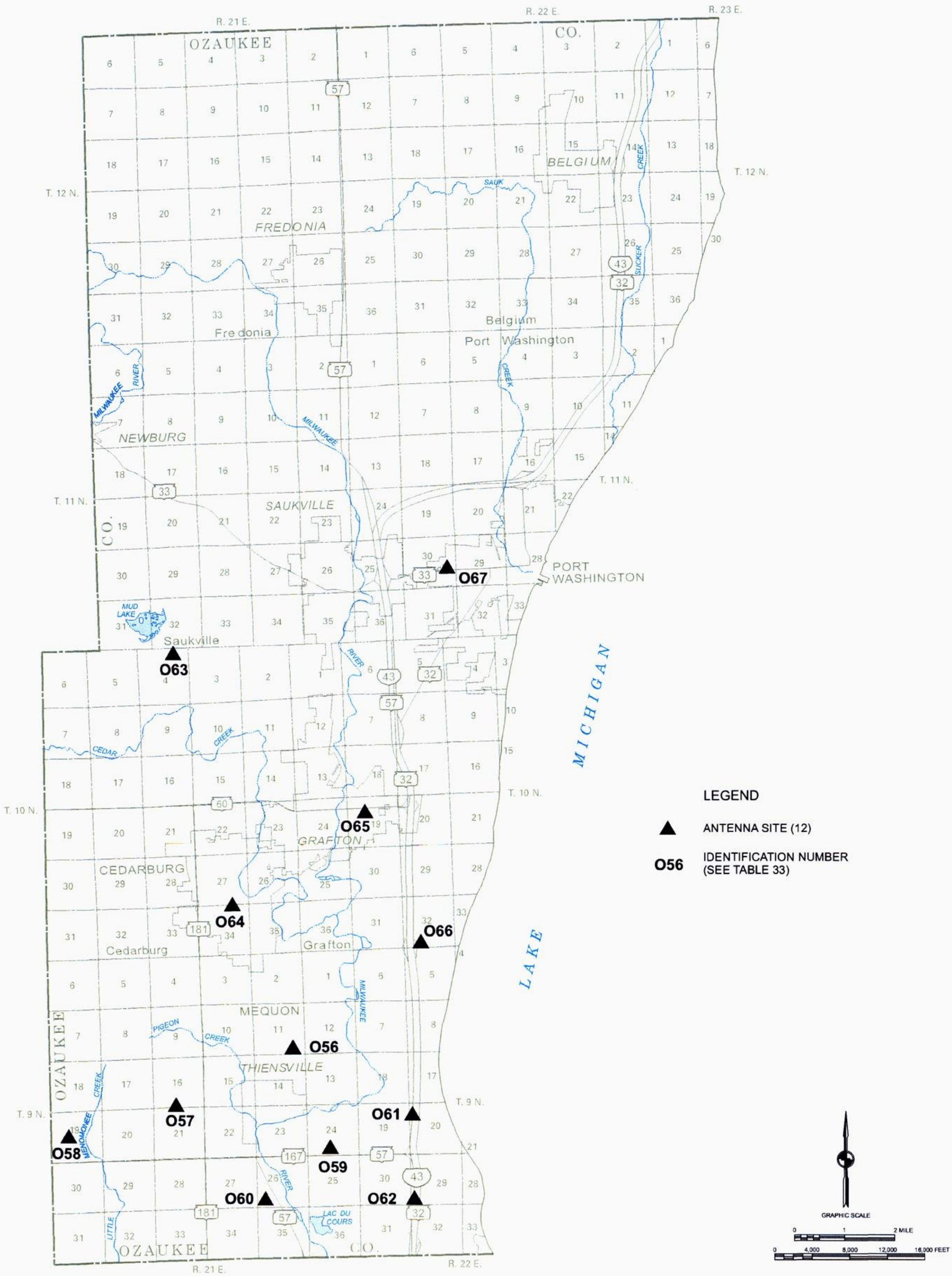
ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 30

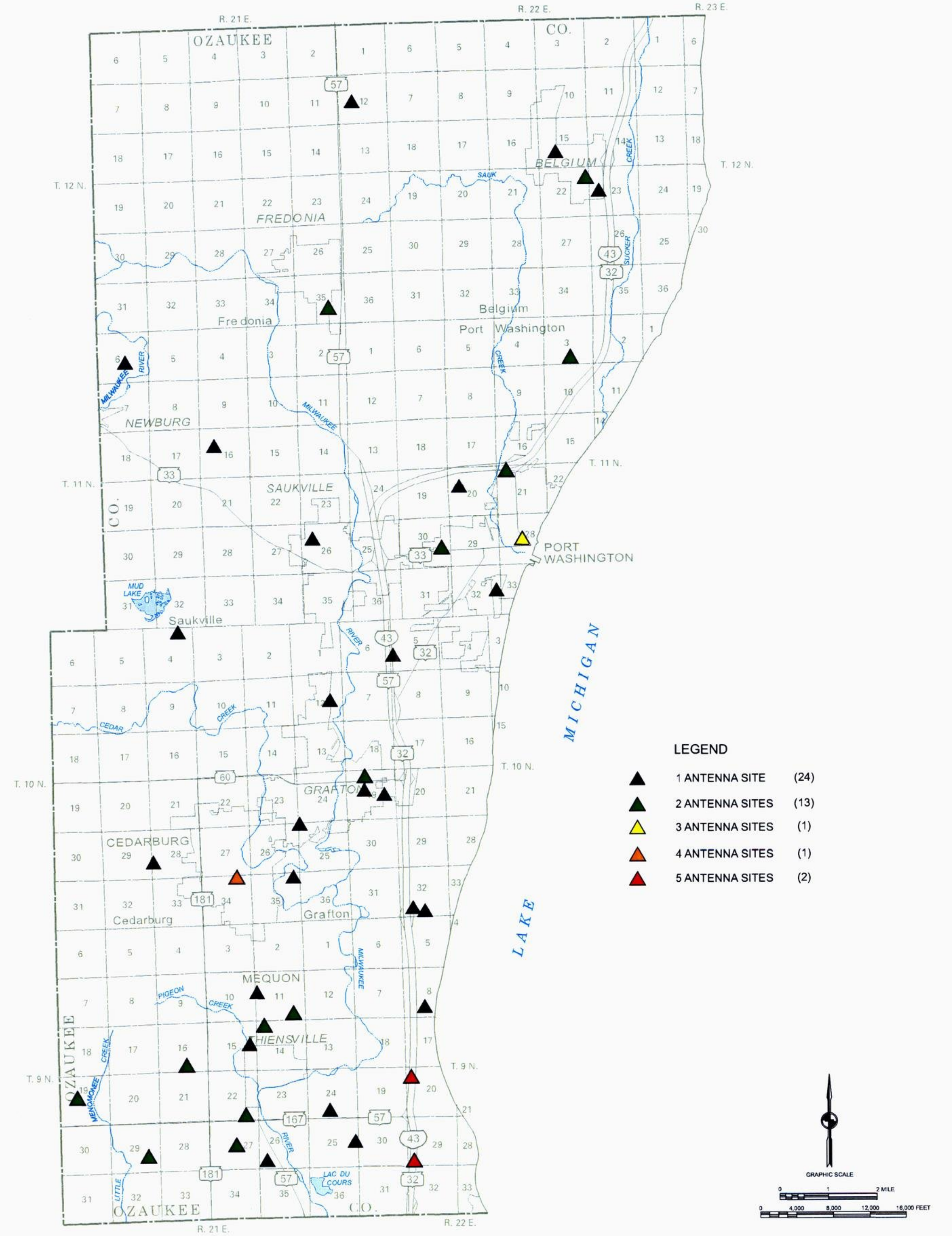
ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 31

ANTENNA SITE LOCATIONS IN OZAUKEE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Table 34

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 32)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R1	42-39-19	88-11-24	244,113	2,486,897	T. 2 N., R. 19 E. Sec. 1	6122 S. English Settlement Rd. Town of Burlington	98.4	S	N/A	891.51
R2	42-43-59	88-12-12	272,375	2,482,700	T. 3 N., R. 19 E. Sec. 12	28622 Rowntree Rd. Town of Rochester	160.8	S	N/A	891.51
R3	42-44-15	88-02-43	274,950	2,525,119	T. 3 N., R. 21 E. Sec. 8	East of STH 45 Town of Yorkville	180.4	O	N/A	N/A
R4	42-43-47	87-57-17	272,699	2,549,510	T. 3 N., R. 21 E. Sec. 12	611 S. Sylvania Ave. Town of Yorkville	173.9	O	N/A	N/A
R5	42-42-20	88-02-43	263,311	2,525,391	T. 3 N., R. 21 E. Sec. 25	18917 Spring St. Town of Yorkville	180.5	S	N/A	891.51
R6	42-41-54	87-57-45	261,212	2,527,700	T. 3 N., R. 21 E. Sec. 25	14225 58th St. Town of Yorkville	69.0	O	N/A	N/A
R7	42-45-18	87-54-36	282,207	2,561,292	T. 3 N., R. 22 E. Sec. 7	10307 Kraut Rd. Village of Mt. Pleasant	98.4	S	N/A	891.51
R8	42-42-20	87-50-57	264,608	2,578,091	T. 3 N., R. 22 E. Sec. 24	5812 21st St. City of Racine	111.6	O	N/a	N/A
R9	42-40-10	87-50-51	251,463	2,578,878	T. 3 N., R. 22 E. Sec. 36	5010 Wood Rd. Village of Mt. Pleasant	98.4	S	N/A	891.51
R10	42-44-27	87-48-18	277,770	2,589,621	T. 3 N., R. 23 E. Sec. 5	1600 Summit City of Racine	137.8	O	N/A	N/A
R11	42-43-34	87-46-54	272,572	2,596,030	T. 3 N., R. 23 E. Sec. 9	110 7th St. City of Racine	105.0	S	N/A	891.51
R12	42-43-33	87-48-55	272,233	2,587,004	T. 3 N., R. 23 E. Sec. 17	2510 Kinzie Ave. City of Racine	150.1	S	140.82	891.51
R13	42-42-27	87-48-04	265,654	2,590,985	T. 3 N., R. 23 E. Sec. 20	1828 DeKoven Ave. City of Racine	150.9	O	N/A	N/A
R14	42-50-11	88-07-06	310,530	2,504,683	T. 4 N., R. 20 E. Sec. 3	23620 Seven Mile Rd. Town of Norway	98.4	S	N/A	891.51
R15	42-47-38	88-10-07	294,744	2,491,450	T. 4 N., R. 20 E. Sec. 20	26922 Malchine Rd. Town of Norway	278.9	S	N/A	891.51
R16	42-48-58	88-04-03	303,453	2,518,485	T. 4 N., R. 21 E. Sec. 7	1580 122nd St. Town of Raymond	150.9	S	N/A	891.51
R17	42-49-30	87-57-12	307,423	2,549,031	T. 4 N., R. 21 E. Sec. 12	1137 27th St. Town of Raymond	150.9	O	N/A	N/A
R18	42-48-24	87-57-19	300,730	2,548,673	T. 4 N., R. 21 E. Sec. 13	2925 Five and One-half Mile Rd. Town of Raymond	98.4	S	N/A	891.51
R19	42-49-49	87-57-07	309,355	2,249,356	T. 4 N., R. 22 E. Sec. 6	7713 E. Frontage Rd. Village of Caledonia	157.5	O	N/A	N/A
R20	42-48-44	87-53-44	303,153	2,564,644	T. 4 N., R. 22 E. Sec. 16	6900 Nicholson Rd. Village of Caledonia	150.9	O	N/A	N/A
R21	42-46-39	87-51-57	290,705	2,572,941	T. 4 N., R. 22 E. Sec. 26	4601 STH 38 Village of Caledonia	183.7	O	N/A	N/A
R22	42-46-19	87-56-24	288,180	2,553,084	T. 4 N., R. 22 E. Sec. 30	12623 Northeastern Ave. Village of Caledonia	150.9	O	N/A	N/A

Table 34 (continued)

Site Number (See Map 32)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R23	42-46-27	87-50-05	307,923	2,580,850	T. 4 N., R. 23 E. Sec. 7	7801 Douglas Ave. Village of Caledonia	98.4	S	140.82	891.51
R24	42-49-02	87-49-00	305,519	2,585,758	T. 4 N., R. 23 E. Sec. 7	3120 Indian Tr. Village of Caledonia	124.7	O	N/A	N/A
R25	42-46-43	87-48-30	291,510	2,588,636	T. 4 N., R. 23 E. Sec. 29	4534 Douglas Ave. Village of Caledonia	137.8	S	140.82	891.51

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local governmental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed, wireless industry. For this reason, inventory data collection efforts will be concentrated on those companies of demonstrated stability and longevity. There are currently three known fixed wireless service providers operating in Racine County. The antenna site data for these providers are listed in Table 57 and shown on Map 59.

Inventory Findings–Geographic Coverage

As already noted originally, it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that such radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be provided only for the cooperating service providers in a separate report. The infrastructure inventory for non-cooperating service providers will be limited to antenna site location as provided in the tables previously referenced. Radio coverage maps of cooperating wireless service providers will be displayed in other separately issued publications.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the Commission regional wireless network monitoring system which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Table 35

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 33)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R26	42-39-18.1	88-11-23.3	244,023	2,486,951	T. 2 N., R. 19 E. Sec. 1	6122 S. English Settlement Rd. Town of Burlington	193.6	O	10	861.0875
R27	42-39-55	88-16-42	247,253	2,463,063	T. 2 N., R. 19 E. Sec. 5	700 McKinley St. City of Burlington	183.7	O	10	865.9375
R28	42-43-59	88-12-12	272,375	2,482,700	T. 3 N., R. 19 E. Sec. 12	28622 Rowntree Rd. Town of Rochester	190.3	O	N/A	865.9375
R29	42-41-28	88-09-34	257,349	2,494,827	T. 3 N., R. 20 E. Sec. 29	26615 Ketterhagen Rd. Town of Dover	190.3	O	125	865.9375
R30	42-41-07	88-03-14	255,868	2,523,249	T. 3 N., R. 21 E. Sec. 30	1118 12th Ave. Village of Union Grove	111.6	O	10	865.9375
R31	42-42-15	87-52-07	263,968	2,572,879	T. 3 N., R. 22 E. Sec. 23	2000 Oakes Rd. City of Racine	150.9	O	10	865.9375
R32	42-43-34	87-46-54	272,572	2,596,030	T. 3 N., R. 23 E. Sec. 9	110 7th St. City of Racine	95.1	O	77	865.9375
R33	42-47-38	88-10-07	294,744	2,491,540	T. 4 N., R. 20 E. Sec. 20	26922 Malchine Rd. Town of Norway	249.4	O	63	865.9375
R34	42-48-44.1	87-58-31.3	302,633	2,543,236	T. 4 N., R. 21 E. Sec. 14	4 miles southwest of IH 94 and STH 100 Town of Raymond	200.1	O	62	855.1625
R35	42-46-11	83-03-18	286,629	2,522,233	T. 4 N., R. 21 E. Sec. 31	4226 S. 108th St. Town of Raymond	121.4	O	10	865.9375
R36	42-45-36	87-57-53	283,665	2,546,554	T. 4 N., R. 21 E. Sec. 36	3916 W. Two Mile Rd. Town of Raymond	249.4	O	63	865.9375
R37	42-46-07	87-53-22	287,305	2,566,686	T. 4 N., R. 22 E. Sec. 34	8609 Industrial Dr. Village of Caledonia	200.1	O	30	865.9375
R38	42-46-43	87-48-30	291,510	2,588,363	T. 4 N., R. 23 E. Sec. 29	4534 Douglas Ave. Village of Caledonia	170.6	O	10	865.9375

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 114 base transceiver stations on 75 cellular–PCS mobile wireless antenna sites within Racine County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

Table 36

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 34)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R39	42-39-56.16	88-16-41.88	247,371	2,463,069	T. 2 N., R. 19 E. Sec. 5	700 McKinley St. City of Burlington	170.0	S	N/A	1931.25
R40	42-43-58.80	88-12-11.88	272,355	2,482,709	T. 3 N., R. 19 E. Sec. 12	28622 Rowntree Rd. Town of Rochester	180.0	S	N/A	1931.25
R41	42-41-39.12	88-05-04.92	258,927	2,514,892	T. 3 N., R. 20 E. Sec. 25	21425 Spring St. Town of Dover	143.0	S	N/A	1931.25
R42	42-43-04.80	87-57-42.12	268,383	2,547,740	T. 3 N., R. 21 E. Sec. 13	1400 Grandview Pkwy. Town of Yorkville	85.3	S	N/A	1931.25
R43	42-42-20.52	87-50-57.48	264,660	2,578,054	T. 3 N., R. 22 E. Sec. 24	5812 21st St. City of Racine	110.0	S	N/A	1932.50
R44	42-41-27.96	87-54-16.20	258,963	2,563,354	T. 3 N., R. 22 E. Sec. 28	Broadway Dr. Village of Sturtevant	114.0	S	N/A	1931.25
R45	42-45-14.40	87-49-01.20	282,483	2,586,272	T. 3 N., R. 23 E. Sec. 6	3000 Golf Ave City of Racine	74.0	S	N/A	1931.25
R46	42-43-33.60	87-48-55.80	272,292	2,586,942	T. 3 N., R. 23 E. Sec. 8	2510 Kinzie Ave. City of Racine	120.0	S	N/A	1932.50
R47	42-43-34.32	87-46-54.48	272,604	2,595,993	T. 3 N., R. 23 E. Sec. 9	1533 Erie St. City of Racine	91.9	S	N/A	1931.25
R48	42-44-25.08	87-47-12.84	277,705	2,594,487	T. 3 N., R. 23 E. Sec. 9	110 7th St. City of Racine	80.0	S	N/A	1931.25
R49	42-41-34	87-48-14.76	260,277	2,590,323	T. 3 N., R. 23 E. Sec. 29	3220 Coolidge Ave. City of Racine	133.0	S	N/A	1931.25
R50	42-46-57	88-16-59.88	289,939	2,460,848	T. 4 N., R. 19 E. Sec. 29	34001 Hill Valley Rd. Town of Waterford	200.0	S	N/A	1931.25
R51	42-48-24.84	87-57-19.08	300,815	2,548,665	T. 4 N., R. 21 E. Sec. 13	4226 S. 108th St. Town of Raymond	84.0	S	N/A	1931.25
R52	42-46-08.04	88-03-11.88	286,340	2,522,696	T. 4 N., R. 21 E. Sec. 31	2925 Five and One-half Mile Rd. Town of Raymond	135.0	S	N/A	1931.25
R53	42-46-06.24	87-53-21.84	287,229	2,566,700	T. 4 N., R. 22 E. Sec. 34	8609 Industrial Dr. Village of Caledonia	70.0	S	N/A	1931.25
R54	42-49-02.64	87-49-00.12	305,583	2,585,748	T. 4 N., R. 23 E. Sec. 7	3120 Indian Tr. Village of Caledonia	112.0	S	N/A	1931.25
R55	42-46-42.24	87-48-29.88	291,434	2,588,374	T. 4 N., R. 23 E. Sec. 29	4534 Douglas Ave. Village of Caledonia	80.0	S	N/A	1931.25

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

Table 37

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 35)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R56	42-43-59	88-12-12	272,375	2,482,700	T. 3 N., R. 19 E. Sec. 12	28622 Rowntree Rd. Town of Rochester	170.6	O	N/A	1970
R57	42-44-51	88-03-12	278,543	2,522,869	T. 3 N., R. 21 E. Sec. 6	2336 Colony Ave. Town of Yorkville	150.9	O	N/A	1970
R58	42-44-27	87-48-18	277,770	2,589,621	T. 3 N., R. 23 E. Sec. 5	1600 Summit Ave. City of Racine	98.4	O	N/A	1970
R59	42-44-58	87-49-36	280,755	2,583,720	T. 3 N., R. 23 E. Sec. 6	2503 Green Bay Rd. City of Racine	141.1	O	N/A	1970
R60	42-43-30	87-47-47	272,063	2,592,086	T. 3 N., R. 23 E. Sec. 16	1301 W. 6th St. City of Racine	131.2	O	N/A	1970
R61	42-42-30	87-49-04	265,839	2,586,499	T. 3 N., R. 23 E. Sec. 19	3314 19th St. City of Racine	111.6	O	N/A	1970
R62	42-45-36	87-57-53	283,665	2,546,554	T. 4 N., R. 21 E. Sec. 36	3916 W. Two Mile Rd. Town of Raymond	239.5	O	N/A	1970
R63	42-48-44	87-53-44	303,153	2,564,644	T. 4 N., R. 22 E. Sec. 16	6900 Nicholson Rd. Village of Caledonia	114.8	O	N/A	1990
R64	42-46-19	87-56-24	288,180	2,553,084	T. 4 N., R. 22 E. Sec. 30	12623 Northwestern Ave. Village of Caledonia	141.1	O	N/A	1970
R65	42-46-43	87-48-30	291,510	2,588,363	T. 4 N., R. 23 E. Sec. 29	4534 Douglas Ave. Village of Caledonia	150.9	O	N/A	1970

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

WALWORTH COUNTY

Antenna site data for Walworth County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases

   a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22

   b. For Nextel Communications, Inc.–Land Mobile–Commercial

2. Local governmental databases included data provided by the following local units of government in Walworth County: City of Burlington–0 sites; City of Delavan–7 sites; City of Elkhorn–5 sites; City of Lake Geneva–10 sites; City of Whitewater–3 sites; Village of Darien–0 sites; Village of East Troy–3 sites; Village of Fontana on Lake Geneva–4 sites; Village of Genoa City–0 sites; Village of Mukwonago–0 sites; Village of Sharon–0 sites; Village of Walworth–2 sites; Village of Williams Bay–4 sites; Town of Bloomfield–7 sites; Town of Darien–3

Table 38

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 36)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R66	42-39-19	88-11-24	244,113	2,486,897	T. 2 N., R. 19 E. Sec. 1	6122 S. English Settlement Rd. Town of Burlington	236.2	S	N/A	890.01
R67	42-39-40	88-18-10	245,600	2,456,520	T. 2 N., R. 19 E. Sec. 6	5937 Spring Valley Rd. Town of Burlington	180.5	S	100	890.01
R68	42-42-43	88-13-54	264,520	2,475,252	T. 3 N., R. 19 E. Sec. 22	503 S. Browns Lake Rd. City of Burlington	180.5	S	N/A	890.01
R69	42-44-53	88-09-11	278,135	2,496,084	T. 3 N., R. 20 E. Sec. 5	2421 Mealy Rd. Town of Dover	98.4	S	100	890.01
R70	42-44-51	88-03-12	278,543	2,522,869	T. 3 N., R. 21 E. Sec. 6	2336 Colony Ave. Town of Yorkville	141.1	S	140.82	890.01
R71	42-43-04	87-57-42	268,302	2,547,751	T. 3 N., R. 21 E. Sec. 13	1400 Grandview Pkwy. Town of Yorkville	98.4	S	N/A	890.01
R72	42-42-14	88-02-43	262,703	2,525,405	T. 3 N., R. 21 E. Sec. 20	18917 Spring St. Town of Yorkville	193.6	S	100	890.01
R73	42-40-56.9	87-57-14.5	255,489	2,550,119	T. 3 N., R. 21 E. Sec. 36	561 S. Hwy 41 Town of Yorkville	21.0	S	140.82	890.01
R74	42-44-27	87-52-24	277,295	2,571,269	T. 3 N., R. 22 E. Sec. 2	1545 Airline Rd. Village of Mt. Pleasant	190.3	S	N/A	890.01
R75	42-42-49	87-50-20	267,615	2,580,776	T. 3 N., R. 22 E. Sec. 13	1506 Perry Ave. City of Racine	75.5	S	140.82	890.01
R76	42-41-54.8	87-54-29.4	261,654	2,562,300	T. 3 N., R. 22 E. Sec. 21	10050 Durand Ave. Village of Sturtevant	128.0	S	140.82	890.01
R77	42-42-15	87-52-07	263,968	2,572,879	T. 3 N., R. 22 E. Sec. 23	2000 Oaks Rd. City of Racine	115.6	S	N/A	890.01
R78	42-40-56	87-50-58	256,105	2,578,235	T. 3 N., R. 22 E. Sec. 35	5720 Taylor Ave. Village of Mt. Pleasant	150.9	S	100	890.01
R79	42-45-05	87-47-56	281,659	2,591,160	T. 3 N., R. 23 E. Sec. 5	1542 Romayne Ave. City of Racine	78.7	S	N/A	890.01
R80	42-44-46	87-50-07	279,481	2,581,439	T. 3 N., R. 23 E. Sec. 6	2121 Green Bay Rd. Village of Mt. Pleasant	72.2	S	140.82	890.01
R81	42-43-38	87-46-57	272,971	2,595,795	T. 3 N., R. 23 E. Sec. 9	555 Main St. City of Racine	59.1	S	N/A	890.01
R82	42-43-30	87-47-47	272,063	2,592,086	T. 3 N., R. 23 E. Sec. 16	1301 W. 6th St. City of Racine	118.1	S	100	890.01
R83	42-41-33.9	87-48-14.9	260.258	2,590,313	T. 3 N., R. 23 E. Sec. 29	3220 Coolidge Ave. City of Racine	125.0	S	140.82	890.01
R84	42-48-42	88-16-41	300,596	2,462,036	T. 4 N., R. 19 E. Sec. 17	6838 Caldwell Rd. Town of Waterford	180.5	S	140.82	890.01
R85	42-45-51	88-13-60	283,539	2,474,401	T. 4 N., R. 19 E. Sec. 34	3526 Buena Park Rd. Town of Waterford	147.6	S	140.82	890.01
R86	42-48-37	88-09-40	300,760	2,493,421	T. 4 N., R. 20 E. Sec. 17	6801 Milwaukee Ave. Town of Norway	180.5	S	100	890.01

Table 38 (continued)

Site Number (See Map 36)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R87	42-50-25	87-57-10	312,993	2,549,043	T. 4 N., R. 21 E. Sec.1	561 27th St. Town of Raymond	19.7	S	N/A	890.01
R88	42-48-01	87-58-29	298,275	2,543,513	T. 4 N., R. 21 E. Sec. 23	4501 W. Five Mile Rd. Town of Raymond	180.5	S	100	890.01
R89	42-45-36	87-57-53	283,665	2,546,554	T. 4 N., R. 21 E. Sec. 36	3916 W. Two Mile Rd. Town of Raymond	121.4	S	140.82	890.01
R90	42-48-44	87-53-44	303,153	2,564,644	T. 4 N., R. 22 E. Sec. 16	6900 Nicholson Rd. Village of Caledonia	164.1	S	100	890.01
R91	42-49-27	87-50-05	307,923	2,580,850	T. 4 N., R. 23 E. Sec. 7	7801 Douglas Ave. Village of Caledonia	98.4	S	140.82	890.01
R92	42-46-43	87-48-28	291,514	2,588,513	T. 4 N., R. 23 E. Sec. 29	4544 Douglas Ave. Village of Caledonia	150.9	S	100	890.01

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

sites; Town of Delavan–2 sites; Town of East Troy–2 sites; Town of Geneva–5 sites; Town of Lafayette–7 sites; Town of LaGrange–3 sites; Town of Linn–5 sites; Town of Lyons–4 sites; Town of Richmond–3 sites; Town of Sharon–1 site; Town of Sugar Creek–1 site; Town of Troy–0 sites; Town of Walworth–0 sites; Town of Whitewater–0 sites. There are a total of 84 sites within Walworth County.

Antenna and Antenna Site Inventory–Cellular/PCS

The cellular/PCS antenna site inventory findings for Walworth County are summarized in Tables 40 through 44 reproduced on pages 123 through 127 one for each wireless service provider as follows: Table 40–Cingular Wireless–22 antenna sites, Table 41–Nextel Communications–14 antenna sites, Table 42–Sprint PCS–17 antenna sites, Table 43–U.S. Cellular–18 antenna sites, Table 44–Verizon Wireless–13 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 39 through 43. It should be noted that T-Mobile does not have any antenna sites in Walworth County. Map 44 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 40, 41 and 43 representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired from the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 42 and 44, representing the PCS service providers, were compiled almost entirely from local governmental databases since PCS sites were largely

Table 39

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS-WIRELESS ANTENNAS IN RACINE COUNTY, WISCONSIN: 2005

Site Number (See Map 37)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
R93	42-38-22	88-17-47	237,741	2,458,399	T. 2 N., R. 19 E. Sec. 18	7148 McHenry St. Town of Burlington	180.5	O	N/A	1990
R94	42-45-02	88-18-14	278,186	2,455,558	T. 3 N., R. 19 E. Sec. 6	35100 Fairview St. Town of Rochester	180.5	O	N/A	1990
R95	42-43-59	88-12-12	272,375	2,482,700	T. 3 N., R. 19 E. Sec. 12	28622 Rowntree Rd. Town of Rochester	144.4	O	N/A	1990
R96	42-40-49	88-17-04	252,685	2,461,307	T. 3 N., R. 19 E. Sec. 32	341 Origen St. City of Burlington	98.4	O	N/A	1990
R97	42-40-58	88-12-48	253,998	2,480,406	T. 3 N., R. 19 E. Sec. 35	29331 Durand Ave. Town of Burlington	180.5	O	N/A	1990
R98	42-45-09	88-05-31	280,125	2,512,459	T. 3 N., R. 20 E. Sec. 2	2535 Britton Rd. Town of Dover	180.5	O	N/A	1990
R99	42-41-28	88-09-34	257,349	2,494,827	T. 3 N., R. 20 E. Sec. 29	26615 Ketterhagen Rd. Town of Dover	150.9	O	N/A	1990
R100	42-44-36	88-00-13	277,340	2,536,258	T. 3 N., R. 21 E. Sec. 3	16436 50th Rd. Town of Yorkville	180.5	O	N/A	1990
R101	42-41-50	87-57-53	260,792	2,547,113	T. 3 N., R. 21 E. Sec. 25	3720 S. Sylvania Ave. Town of Yorkville	78.7	O	N/A	1990
R102	42-41-07	88-03-14	255,868	2,523,249	T. 3 N., R. 21 E. Sec. 30	1118 12th Ave. Village of Union Grove	144.4	O	N/A	1990
R103	42-42-18	87-52-07	264,272	2,572,871	T. 3 N., R. 22 E. Sec. 23	2100 Oakes Rd. City of Racine	98.4	O	N/A	1990
R104	42-44-20	87-48-32	275,213	2,588,643	T. 3 N., R. 23 E. Sec. 8	2230 Northwestern Ave. City of Racine	39.4	O	N/A	1990
R105	42-42-27	87-48-04	265,654	2,590,985	T. 3 N., R. 23 E. Sec. 20	1828 DeKoven Ave. City of Racine	141.1	O	N/A	1990
R106	42-48-42	88-16-41	300,596	2,462,036	T. 4 N., R. 19 E. Sec. 17	6838 Caldwell Rd. Town of Waterford	170.6	O	N/A	1990
R107	42-45-51	88-13-60	283,539	2,474,401	T. 4 N., R. 19 E. Sec. 34	3526 Buena Park Rd. Town of Waterford	154.2	O	N/A	1990
R108	42-47-38	88-10-07	294,744	2,491,540	T. 4 N., R. 20 E. Sec. 20	26922 Malchine Rd. Town of Norway	180.5	O	N/A	1990
R109	42-50-12	87-57-01	311,693	2,549,746	T. 4 N., R. 22 E. Sec. 6	IH 94 and Seven Mile Rd. Village of Caledonia	160.8	O	N/A	1990
R110	42-49-30	87-52-54	307,903	2,568,252	T. 4 N., R. 22 E. Sec. 10	7736 W. River Rd. Village of Caledonia	154.2	O	N/A	1990
R111	42-47-46	87-57-09	296,903	2,549,513	T. 4 N., R. 22 E. Sec. 19	2655 Hwy 41 Village of Caledonia	59.1	O	N/A	1990
R112	42-46-21	87-50-24	289,062	2,579,922	T. 4 N., R. 22 E. Sec. 25	4052 Hwy 31 Village of Caledonia	111.6	O	N/A	1990
R113	42-48-51	87-49-33	304,341	2,583,329	T. 4 N., R. 23 E. Sec. 7	NW Corner of Six Mile Rd. and Michna Rd. Village of Caledonia	160.8	O	N/A	1990
R114	42-46-43	87-48-28	291,514	2,588,513	T. 4 N., R. 23 E. Sec. 29	4544 Douglas Ave. Village of Caledonia	134.5	O	N/A	1990

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

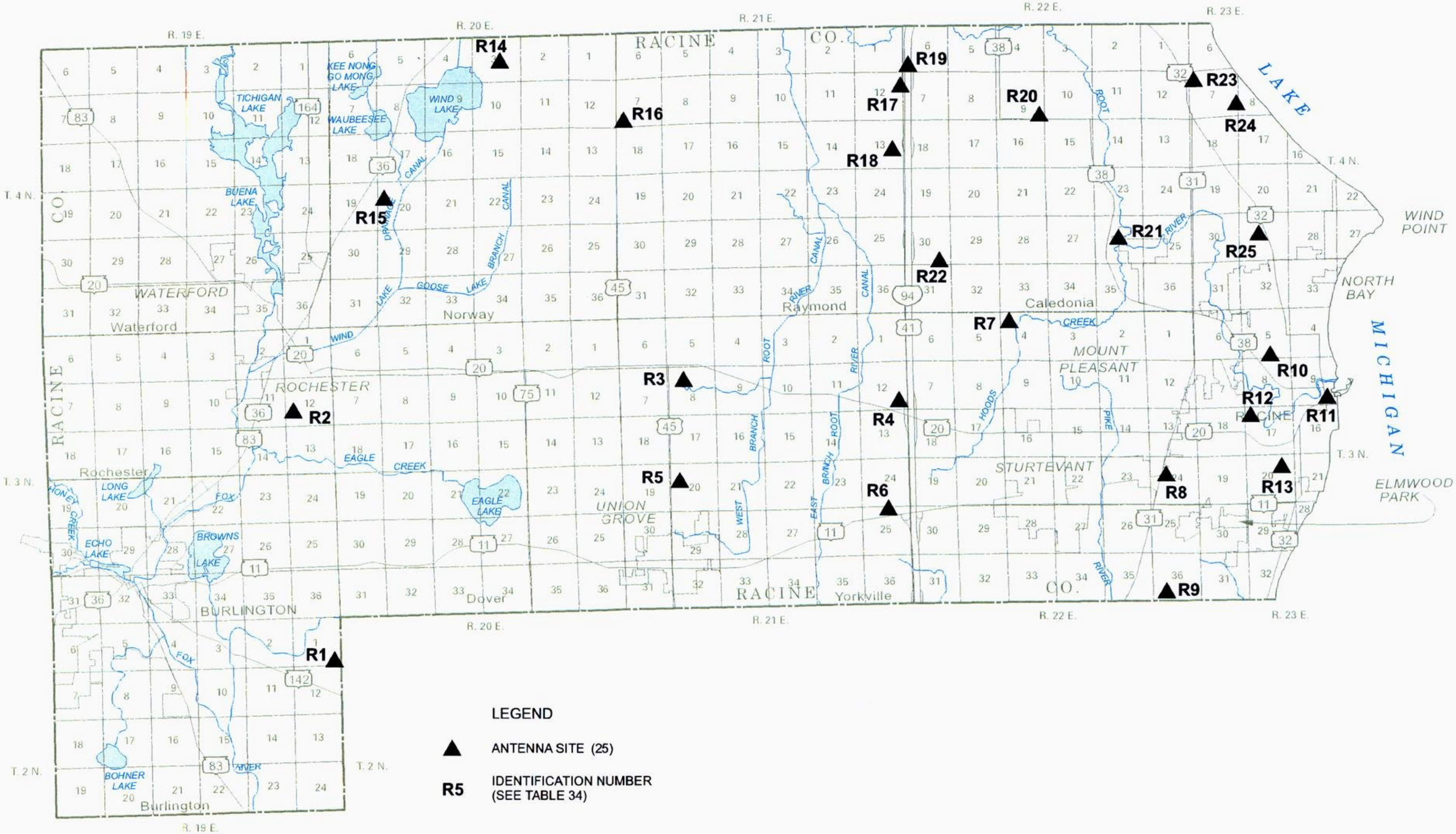
[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

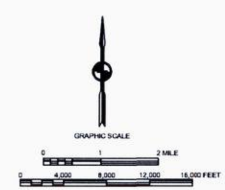
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Racine County and local municipalities of Racine County, Wisconsin and SEWRPC.

Map 32

ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN RACINE COUNTY, WISCONSIN: 2005

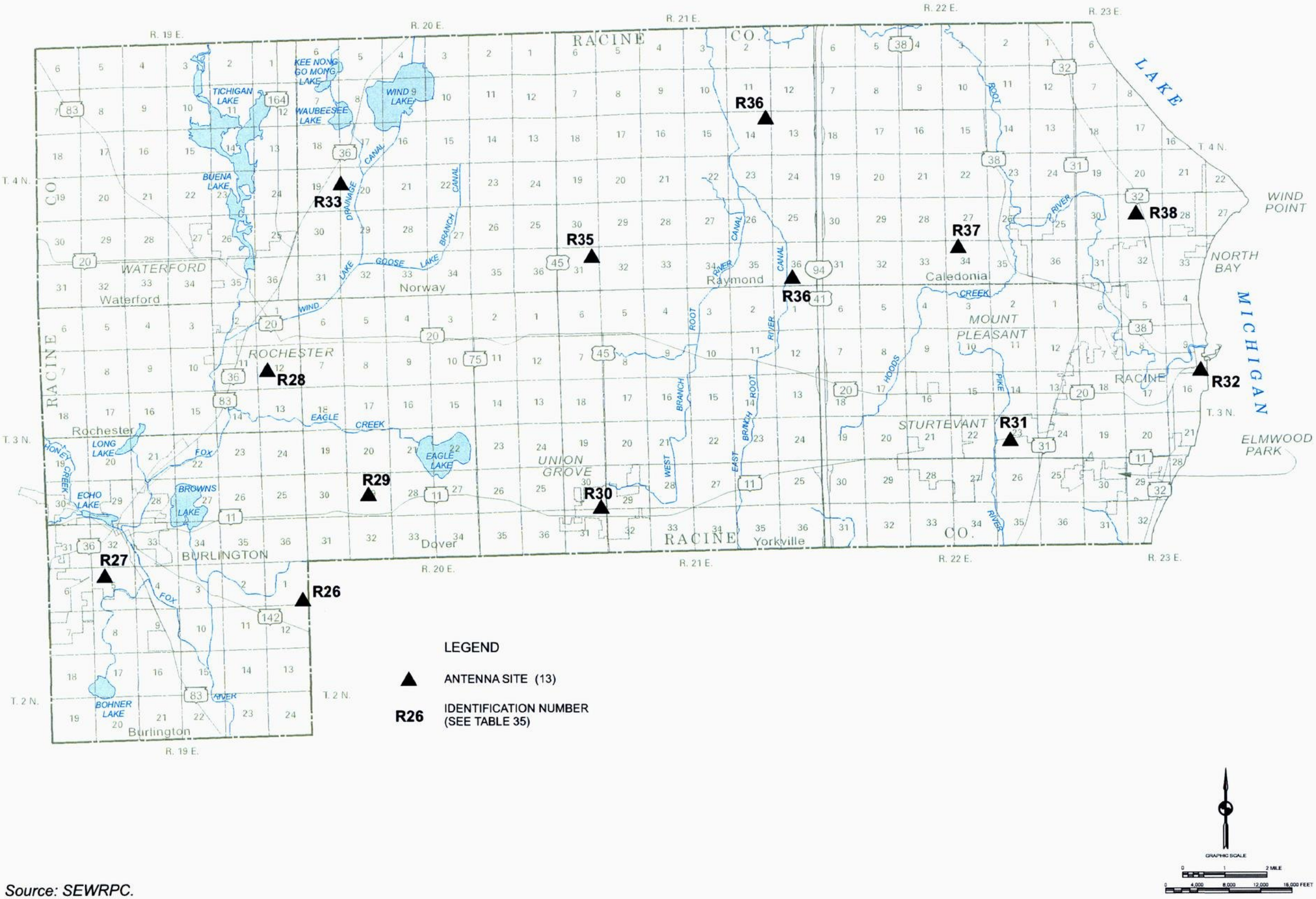




Source: SEWRPC.

Map 33

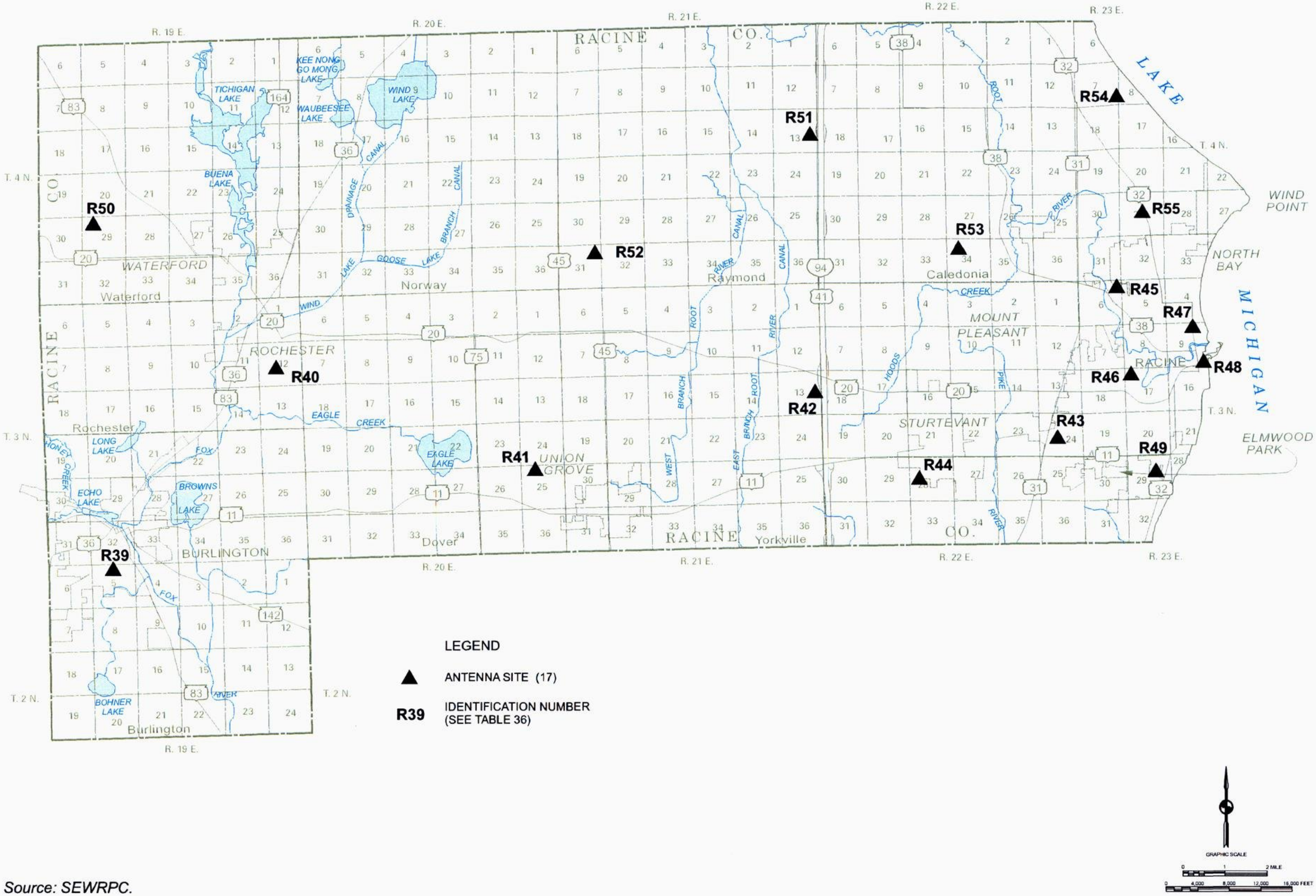
ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN RACINE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 34

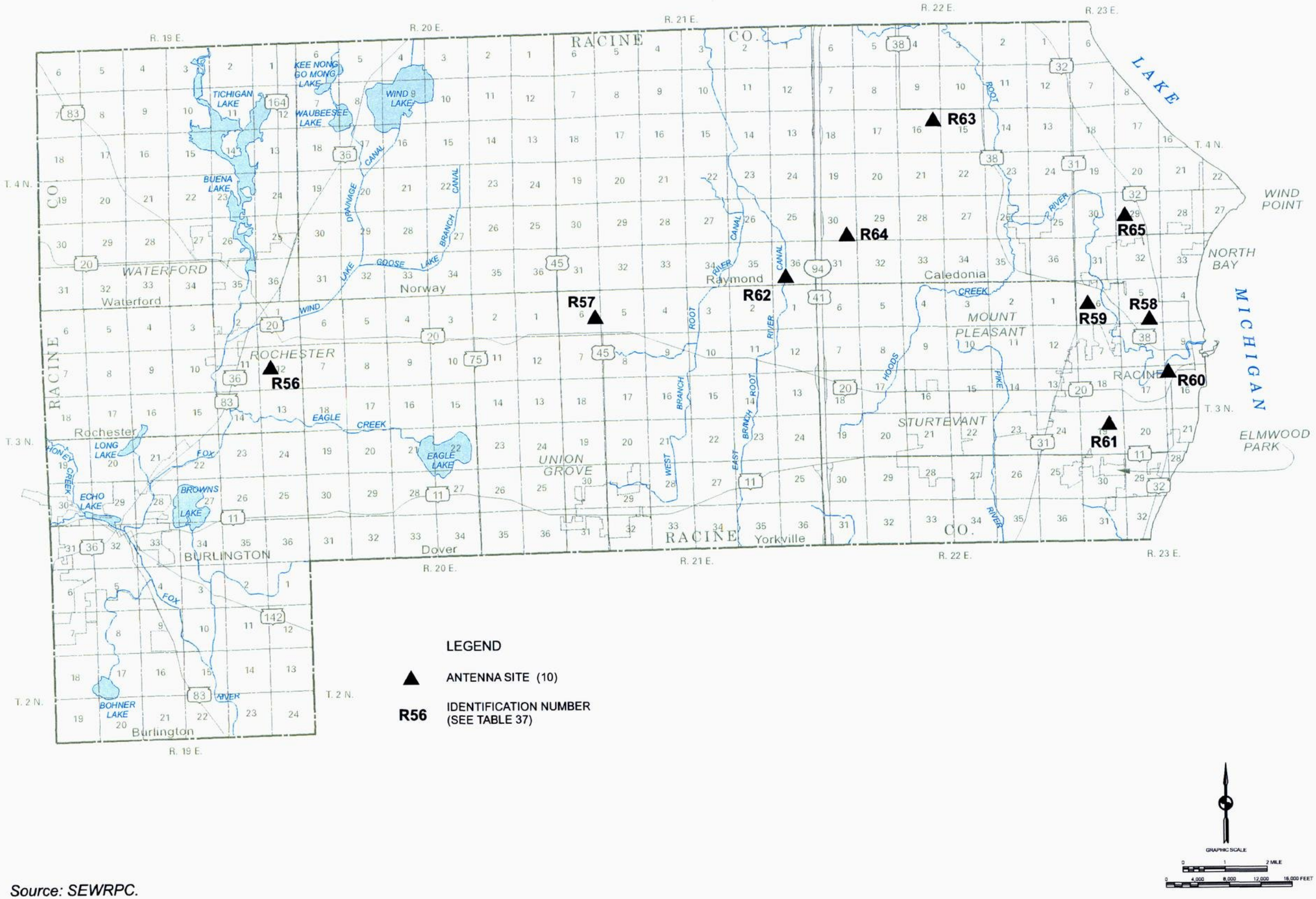
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN RACINE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 35

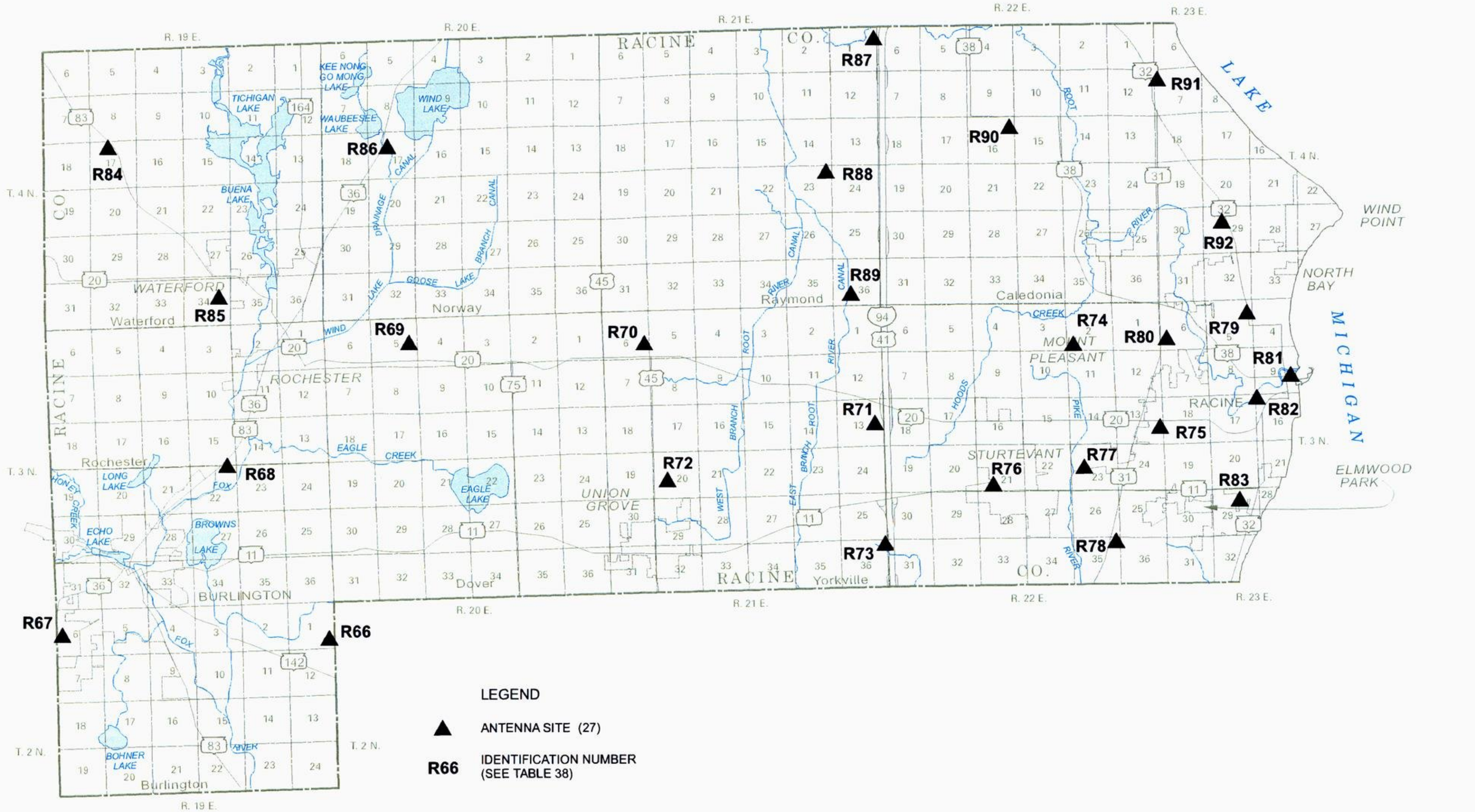
ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN RACINE COUNTY, WISCONSIN: 2005

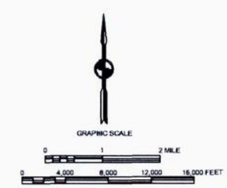


Source: SEWRPC.

Map 36

ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN RACINE COUNTY, WISCONSIN: 2005

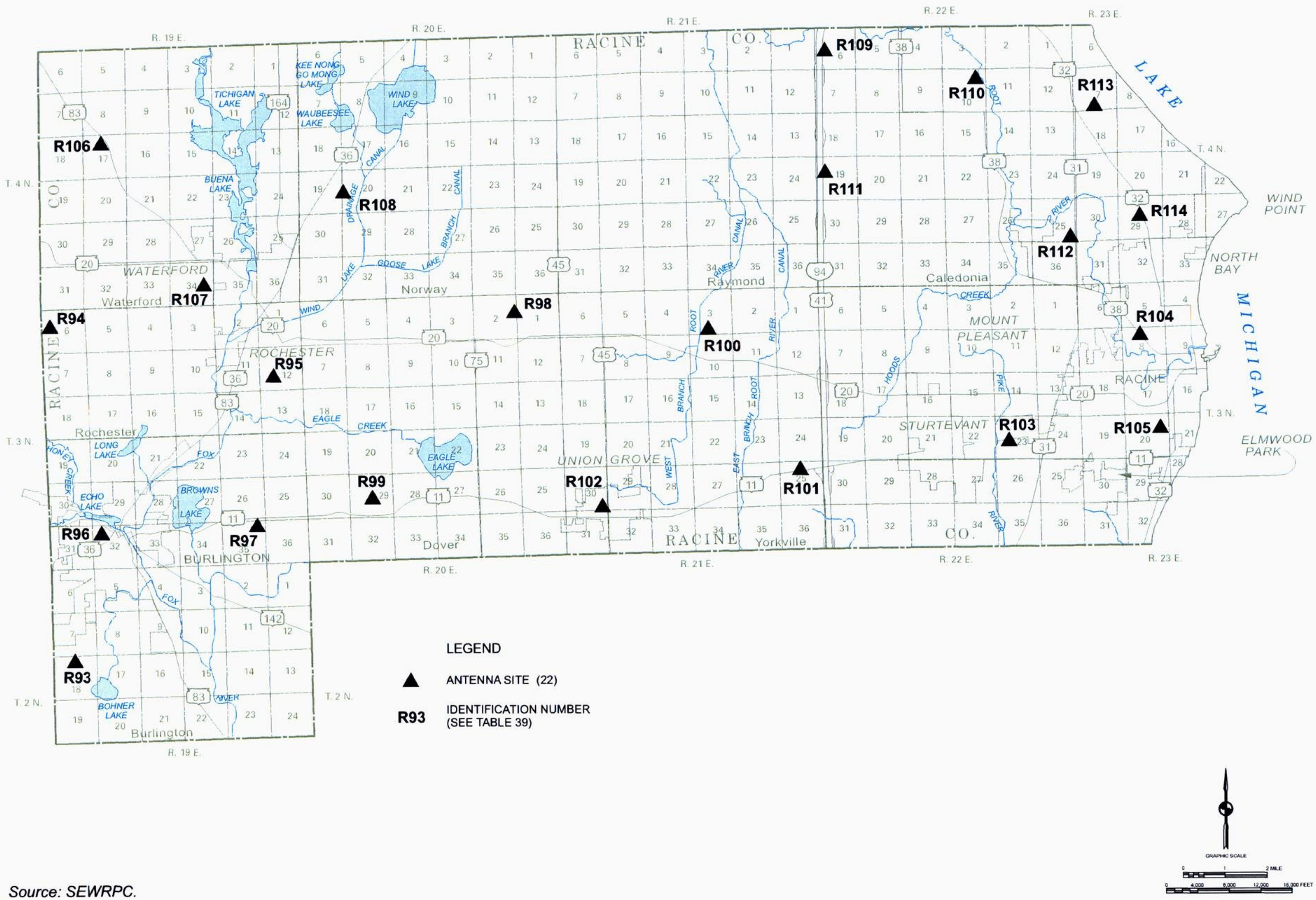




Source: SEWRPC.

Map 37

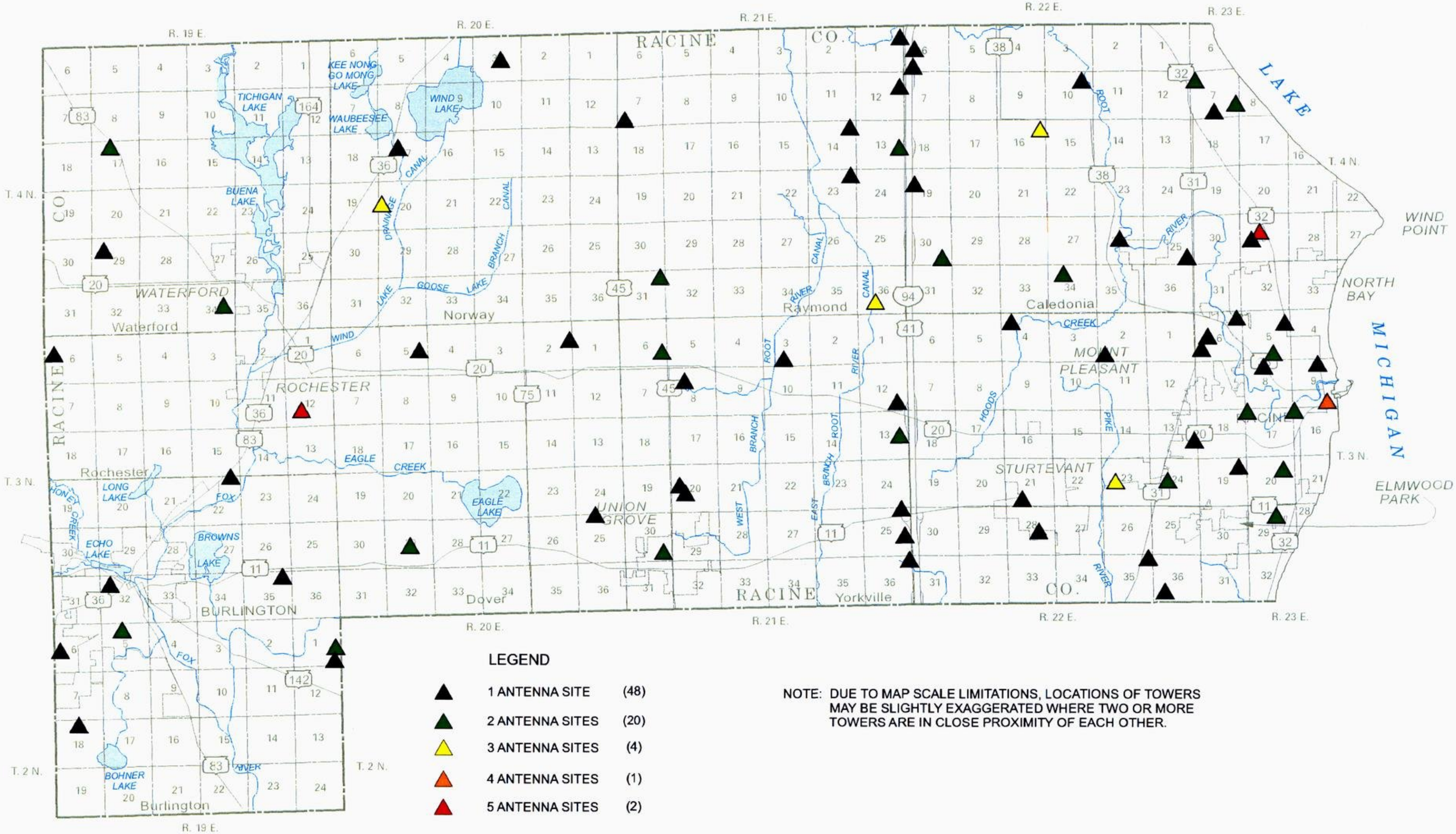
ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS IN RACINE COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 38

ANTENNA SITE LOCATIONS IN RACINE COUNTY, WISCONSIN: 2005



LEGEND

1 ANTENNA SITE	(48)
2 ANTENNA SITES	(20)
3 ANTENNA SITES	(4)
4 ANTENNA SITES	(1)
5 ANTENNA SITES	(2)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAY BE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.

GRAPHIC SCALE

Source: SEWRPC.

[redacted]

Table 40

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN WALWORTH COUNTY, WISCONSIN: 2005

Site Number (See Map 39)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WL1	42-33-11	88-35-02	204,812	2,381,531	T. 1 N., R. 16 E. Sec. 10	300 Wild Duck Rd. Village of Fontana on Geneva Lake	251.0	S	140.82	891.51
WL2	42-34-53	88-32-05	215,367	2,394,649	T. 1 N., R. 17 E. Sec. 6	Olive St. Village of Williams Bay	121.4	S	250	1900
WL3	42-34-35	88-31-20	213,604	2,398,048	T. 1 N., R. 17 E. Sec. 6	Potawatomi Rd. Village of Williams Bay	111.6	S	500	1900
WL4	42-32-04	88-30-48	198,362	2,400,714	T. 1 N., R. 17 E. Sec. 20	W4322 CTH B Town of Linn	180.5	O	N/A	N/A
WL5	42-34-26	88-19-32	213,695	2,451,033	T 1 N., R. 18 E. Sec. 2	W2121 N. Bloomfield Rd. Town of Bloomfield	180.5	O	N/A	N/A
WL6	42-34-45	88-25-01	215,137	2,426,383	T. 1 N., R. 18 E. Sec. 6	1003 Host Dr. City of Lake Geneva	141.1	O	N/A	N/A
WL7	42-32-48	88-19-56	203,739	2,449,413	T. 1 N., R. 18 E. Sec. 14	W672 Pell Lake Rd. Town of Bloomfield	183.1	O	140.82	891.51
WL8	42-37-57	88-40-20	233,372	2,357,323	T. 2 N., R. 15 E. Sec. 13	105 Autumn Dr. City of Delavan	164.1	O	1500	N/A
WL9	42-36-15	88-44-26	222,762	2,339,090	T. 2 N., R. 15 E. Sec. 31	W8954 Westbound Ln. Town of Darien	190.3	O	N/A	N/A
WL10	42-37-53	88-37-51	233,144	2,368,242	T. 2 N., R. 16 E. Sec. 17	1034 Ann St. City of Delavan	121.4	O	100	N/A
WL11	42-37-53	88-37-52	233,146	2,368,392	T. 2 N., R. 16 E. Sec. 17	1111 Edwards St. City of Delavan	124.7	O	1500	N/A
WL12	42-39-54	88-31-46	245,860	2,395,533	T. 2 N., R. 17 E. Sec. 6	McKenzie La. and Centralia St. City of Elkhorn	160.8	O	N/A	N/A
WL13	42-36-57	88-29-20	228,139	2,406,765	T. 2 N., R 17 E. Sec. 21	N3403 Bird Pl. Town of Geneva	298.6	O	N/A	N/A
WL14	42-35-45	88-29-09	221,031	2,416,694	T. 2 N., R. 17 E. Sec. 35	1887 Dodge St. City of Lake Geneva	111.6	O	N/A	N/A
WL15	42-35-26	88-26-04	219,198	2,421,592	T. 2 N., R. 17 E. Sec. 36	101 Broad St. City of Lake Geneva	105.0	O	N/A	N/A
WL16	42-38-46	88-23-23	239,671	2,433,243	T. 2 N., R 18 E. Sec. 8	6704 STH 36 Town of Lyons	193.6	O	N/A	N/A
WL17	42-43-38	88-44-54	267,574	2,336,323	T. 3 N., R. 15 E. Sec. 8	N6534 STH 36 Town of Richmond	298.6	O	N/A	N/A
WL18	42-44-03	88-26-58	271,454	2,416,580	T. 3 N., R. 17 E. Sec. 11	W2996 CTH D Town of Lafayette	200.1	O	N/A	N/A
WL19	42-40-14	88-31-13	247,928	2,397,963	T. 3 N., R 17 E. Sec. 32	4477 Stuart Dr. Town of Lafayette	278.9	O	N/A	N/A
WL20	42-44-26	88-22-41	274,146	2,435,712	T. 3 N, R. 18 E. Sec. 9	W1515 CTH D Town of Spring Prairie	150.9	O	N/A	N/A
WL21	42-46-03	88-37-38	282,763	2,368,622	T. 4 N., R. 16 E. Sec. 32	W6586 Territorial Rd. Town of La Grange	265.8	O	N/A	N/A
WL22	42 49 05	88-21-42	302,472	2,439,559	T. 4 N., R. 18 E. Sec. 10	N9080 CTH ES Town of East Troy	147.6	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Walworth County and local municipalities of Walworth County, Wisconsin and SEWRPC.

Table 41

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN WALWORTH COUNTY, WISCONSIN: 2005

Site Number (See Map 40)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WL23	42-33-54	88-45-37	208,409	2,333,993	T. 1 N., R. 15 E. Sec. 7	Temperance Tr. Town of Sharon	298.6	O	N/A	N/A
WL24	42-33-11	88-35-02	204,813	2,381,584	T. 1 N., R. 16 E. Sec. 10	300 Wild Duck Rd. Village of Fontana on Geneva Lake	180.5	O	N/A	N/A
WL25	42-33-02	88-35-22	203,887	2,380,072	T. 1 N., R. 16 E. Sec. 15	202 Main St. Village of Fontana on Geneva Lake	180.5	O	240	865.6125
WL26	42-30-38	88-28-50	189,816	2,409,677	T. 1 N., R. 17 E. Sec. 27	6.1 miles East of STH 67 and USH 41 Town of Linn	200.1	O	1000	856.3625
WL27	42-34-32	88-24-11	213,893	2,430,148	T. 1 N., R. 18 E. Sec. 5	1015 Bloomfield Rd. City of Lake Geneva	180.5	O	N/A	N/A
WL28	42-31-50	88-21-02	197,770	2,444,612	T. 1 N., R. 18 E. Sec. 22	W1031 Rosewood Dr. Town of Bloomfield	183.7	O	N/A	N/A
WL29	42-39-24	88-35-16	242,552	2,379,866	T. 2 N., R. 16 E. Sec. 3	5837 STH 11 Town of Delavan	131.2	O	39	853.5125
WL30	42-36-55	88-32-01	227,721	2,394,701	T. 2 N., R. 16 E. Sec. 24	N339 STH 67 Town of Delavan	449.5	O	265	865.5375
WL31	42-39-54	88-31-46	245,860	2,395,533	T. 2 N., R. 17 E. Sec. 6	McKenzie La. and Centralia St. City of Elkhorn	160.8	O	N/A	N/A
WL32	42-36-34	88-26-36	226,036	2,419,047	T. 2 N., R. 17 E. Sec. 26	N3230 CTH H City of Lake Geneva	278.9	O	83	860.1875
WL33	42-44-35	88-26-59	274,691	2,416,445	T. 3 N., R. 17 E. Sec. 2	W2919 CTH D Town of Lafayette	190.0	O	10	860.2875
WL34	42-44-03	88-26-58	271,454	2,416,580	T. 3 N., R. 17 E. Sec. 11	W2996 CTH D Town of Lafayette	200.1	O	N/A	N/A
WL35	42-50-12	88-43-24	307,558	2,342,430	T. 4 N., R. 15 E. Sec. 4	502 Cravath St. City of Whitewater	141.1	S	N/A	N/A
WL36	42-47-14	88-23-53	291,047	2,430,013	T. 4 N., R. 18 E. Sec. 20	2029 Young St. Village of East Troy	59.1	S	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Walworth County and local municipalities of Walworth County, Wisconsin and SEWRPC.

absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the

Table 42

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN WALWORTH COUNTY, WISCONSIN: 2005

Site Number (See Map 41)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WL37	42-33-00.36	88-35-20.76	203,713	2,380,198	T. 1 N., R. 16 E. Sec. 15	Village of Fontana on Geneva Lake	170.0	S	56.79	1931.25
WL38	42-32-04.2	88-30-48.6	198,382	2,400,669	T. 1 N., R. 17 E. Sec. 20	Town of Linn	160.0	S	56.79	1931.25
WL39	42-34-43.68	88-25-03	215,001	2,426,235	T.1 N., R. 18 E. Sec. 6	City of Lake Geneva	122.0	S	57.04	1931.25
WL40	42-32-36.6	88-20-19.32	202,551	2,447,713	T. 1 N., R. 18 E. Sec. 14	Town of Bloomfield	190.0	S	56.19	1931.25
WL41	42-36-09.36	88-44-26.52	222,190	2,339,060	T. 2 N., R. 15 E. Sec. 29	Town of Darien	195.0	S	56.79	1931.25
WL42	42-37-51.6	88-37-49.8	233,007	2,368,558	T. 2 N., R. 16 E. Sec. 17	City of Delavan	170.0	S	57.19	1932.5
WL43	42-39-45.36	88-31-46.2	244,985	2,395,534	T. 2 N., R. 17 E. Sec. 6	City of Elkhorn	150.0	S	57.04	1931.25
WL44	42-36-57.96	88-29-20.76	228,235	2,406,706	T. 2 N., R. 17 E. Sec. 21	Town of Geneva	190.0	S	56.79	1931.25
WL45	42-35-45.6	88-27-09	221,091	2,416,693	T. 2 N., R. 17 E. Sec. 35	City of Lake Geneva	110.0	S	57.19	1931.25
WL46	42-38-46.68	88-23-25.08	239,737	2,433,086	T. 2 N., R. 18 E. Sec. 8	Town of Lyons	195.0	S	56.79	1931.25
WL47	42-43-39.36	88-44-53.16	267,712	2,336,384	T. 3 N., R. 15 E. Sec. 8	Town of Richmond	150.0	S	56.69	1931.25
WL48	42-44-39.12	88-26-53.88	275,115	2,416,819	T. 3 N., R. 17 E. Sec. 2	Town of Lafayette	150.0	S	56.79	1931.25
WL49	42-41-38.04	88-24-12.96	257,013	2,429,176	T. 3 N., R. 18 E. Sec. 29	Town of Spring Prairie	150.0	S	57.04	1931.25
WL50	42-50-12.48	88-43-24.6	307,606	2,342,384	T. 4 N., R. 15 E. Sec. 4	City of Whitewater	131.0	S	54.59	1932.5
WL51	42-46-03.36	88-37-38.64	282,799	2,368,573	T. 4 N., R. 16 E. Sec. 32	Town of LaGrange	200.0	S	56.79	1931.25
WL52	42-49-31.08	88-25-50.88	304,755	2,420,963	T. 4 N., R. 17 E. Sec. 12	Town of Troy	170.0	S	54.69	1931.25
WL53	42-46-17.4	88-24-30.24	285,265	2,427,346	T. 4 N., R. 16 E. Sec. 27	Village of East Troy	65.0	S	57.19	1931.25

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Walworth County and local municipalities of Walworth County, Wisconsin and SEWRPC.

growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time

Table 43

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN WALWORTH COUNTY, WISCONSIN: 2005

Site Number (See Map 42)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WL54	42-34-55	88-33-43	215,442	2,387,315	T. 1 N., R. 16 E. Sec. 2	250 Olive St. Village of Williams Bay	125.0	O	890.01	140.82
WL55	42-32-35	88-36-02	201,094	2,377,154	T. 1 N., R. 16 E. Sec. 16	Main St. Village of Walworth	78.7	O	N/A	N/A
WL56	42-34-53	88-32-05	215,367	2,394,649	T. 1 N., R. 17 E. Sec. 6	Olive St. Village of Williams Bay	121.4	S	500	860
WL57	42-32-37	88-27-54	201,939	2,413,679	T. 1 N., R. 17 E. Sec. 15	N1457 Hillside Rd. Town of Linn	180.5	O	N/A	N/A
WL58	42-32-36.6	88-20-19.7	202,550	2,447,685	T. 1 N., R. 18 E. Sec. 14	775 Geranium Rd. Town of Bloomfield	174.9	S	890.01	140.82
WL59	42-36-46.1	88-42-30.8	226,042	2,347,657	T. 2 N., R. 15 E. Sec. 22	Old Highway 89 Town of Darien	184.7	S	890.01	140.82
WL60	42-32-36.1	88-36-04.4	201,202	2,376,973	T. 2 N., R. 16 E. Sec. 17	Main St City of Delavan	525.0	O	890.01	70.9
WL61	42-37-53.4	88-37-51.4	233,187	2,368,436	T. 2 N., R. 16 E. Sec. 17	1034 Ann St. City of Delavan	149.9	S	890.01	140.82
WL62	42-39-42	88-27-47	244,967	2,413,410	T. 2 N., R. 17 E. Sec 3	CTH NN Town of Geneva	278.9	O	N/A	N/A
WL63	42-39-54	88-31-46	245,860	2,395,533	T. 2 N., R. 17 E. Sec. 6	McKenzie La. and Centralia St. City of Elkhorn	160.8	O	N/A	N/A
WL64	42-36-57	88-29-20	228,139	2,406,765	T. 2 N., R 17 E. Sec. 21	N3403 Bird Pl. Town of Geneva	298.6	O	N/A	N/A
WL65	42-35-26	88-26-04	219,198	2,421,592	T. 2 N., R. 17 E. Sec. 36	101 Broad St. City of Lake Geneva	108.3	O	12	800
WL66	42-35-49	88-21-30.3	221,920	2,442,017	T. 2 N., R. 18 E. Sec. 27	STH 50 Town of Lyons	180.1	O	890.01	140.82
WL67	42-43-29	88-42-52	266,801	2,345,443	T. 3 N., R. 15 E. Sec. 15	CTH A Town of Richmond	180.5	O	N/A	N/A
WL68	42-43-29.6	88-32-26.5	267,630	2,392,126	T. 3 N., R. 17 E. Sec. 18	N6424 USH 12/STH 67 City of Elkhorn	164.7	S	890.01	140.82
WL69	42-50-18.6	88-44-27.1	233,719	2,337,719	T. 4 N., R. 15 E. Sec. 5	230 Prairie St. City of Whitewater	125.0	S	890.01	140.82
WL70	42-47-54.9	88-34-47.7	294,303	2,381,130	T. 4 N., R. 16 E. Sec. 23	N8481 Tamarack Rd. Town of LaGrange	184.7	S	890.01	140.82
WL71	42-45-23.5	88-26-00.2	279,682	2,420,740	T. 4 N., R. 17 E. Sec. 36	N7441 Townline Rd. Town of East Troy	180.1	O	890.01	140.82

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Walworth County and local municipalities of Walworth County, Wisconsin and SEWRPC.

Table 44

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS ANTENNAS IN WALWORTH COUNTY, WISCONSIN: 2005

Site Number (See Map 43)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WL72	42-32-34	88-36-00	200,995	2,377,306	T. 1 N., R. 16 E. Sec. 16	Main St. Village of Walworth	78.7	O	N/A	N/A
WL73	42-32-04	88-30-48	198,362	2,400,714	T. 1 N., R. 17 E. Sec. 20	W4322 CTH BB Town of Linn	180.5	O	N/A	N/A
WL74	42-34-26	88-19-32	213,695	2,451,033	T. 1 N., R. 18 E. Sec. 2	W2121 N. Bloomfield Rd. Town of Bloomfield	180.5	O	N/A	N/A
WL75	42-34-45	88-25-01	215,137	2,426,383	T. 1 N., R. 18 E. Sec. 6	1003 Host Dr. City of Lake Geneva	141.1	O	N/A	N/A
WL76	42-31-03	88-20-22	193,073	2,447,701	T. 1 N., R. 18 E Sec. 26	Twin Lakes Rd. Town of Bloomfield	180.45	O	N/A	N/A
WL77	42-37-53	88-37-52	233,146	2,368,392	T. 2 N., R. 16 E. Sec. 17	1111 Edwards St. City of Delavan	124.7	O	N/A	N/A
WL78	42-36-57	88-29-20	228,139	2,406,765	T. 2 N., R. 17 E. Sec. 21	N3403 Bird Pl. Town of Geneva	298.6	O	N/A	N/A
WL79	42-35-26	88-26-04	219,198	2,421,592	T. 2 N., R. 17 E. Sec. 36	101 Broad St. City of Lake Geneva	52.5	O	N/A	N/A
WL80	42-38-46	88-23-23	239,671	2,433,243	T. 2 N., R. 18 E. Sec. 8	6704 STH 36 Town of Lyons	193.6	O	N/A	N/A
WL81	42-44-03	88-26-58	271,454	2,416,580	T. 3 N., R. 17 E. Sec. 11	W2996 CTH D Town of Lafayette	200.1	O	N/A	N/A
WL82	42-40-14	88-31-13	247,928	2,397,963	T. 3 N., R. 17 E. Sec. 32	4477 Stuart Dr. Town of Lafayette	278.9	O	N/A	N/A
WL83	42-41-40	88-23-52	257,242	2,430,737	T. 3 N., R. 18 E. Sec. 29	W1960 Spring Prairie Rd. Town of Spring Prairie	249.4	O	N/A	N/A
WL84	42-46-17	88-24-30	285,225	2,427,364	T. 4 N., R. 18 E. Sec. 30	SW Corner of IH 43 and STH 120 Village of East Troy	72.2	S	N/A	N/A

[a]*State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b]*Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Walworth County and local municipalities of Walworth County, Wisconsin and SEWRPC.

division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

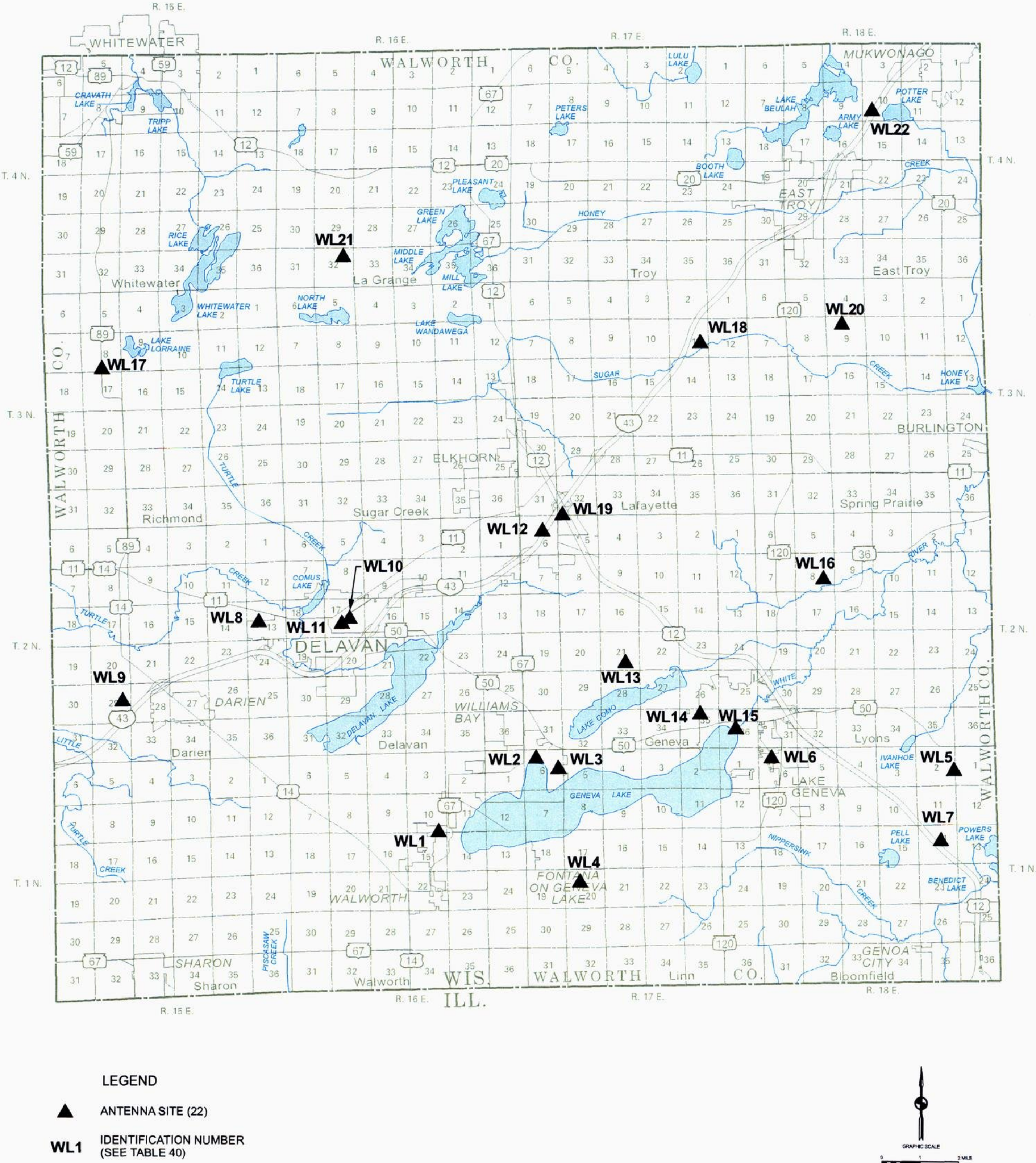
Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local governmental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed, wireless industry. For this reason, inventory data collection efforts will be concentrated on those companies of demonstrated stability and longevity. There is currently one known fixed wireless service provider operating in Walworth County. The antenna site data for this provider is listed in Table 57 and shown on Map 59.

Inventory Findings–Geographic Coverage

As already noted, originally, it was intended that geographic coverage maps for each wireless service

Map 39

ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

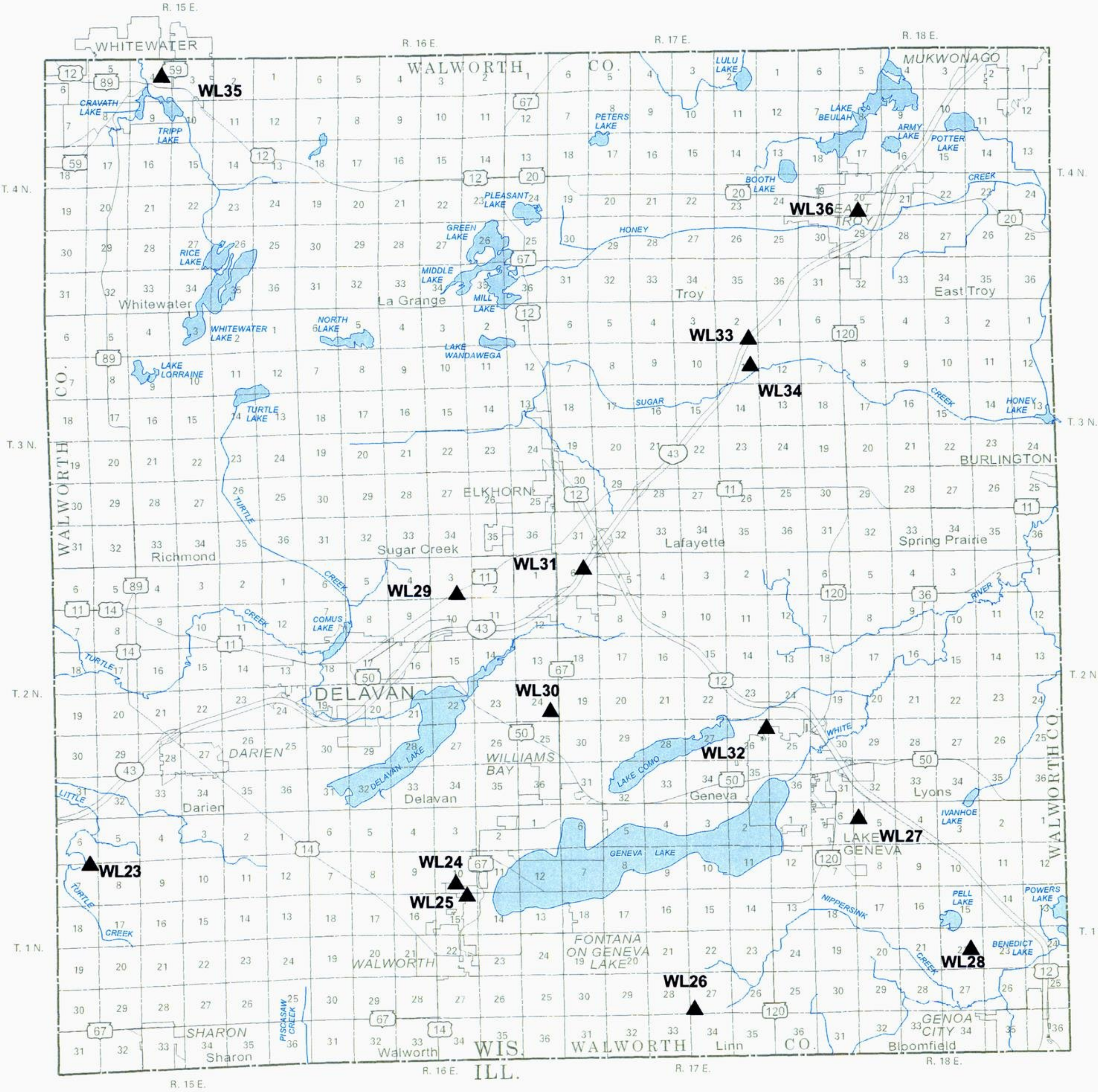
▲ ANTENNA SITE (22)

WL1 IDENTIFICATION NUMBER (SEE TABLE 40)

Source: SEWRPC.

Map 40

ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

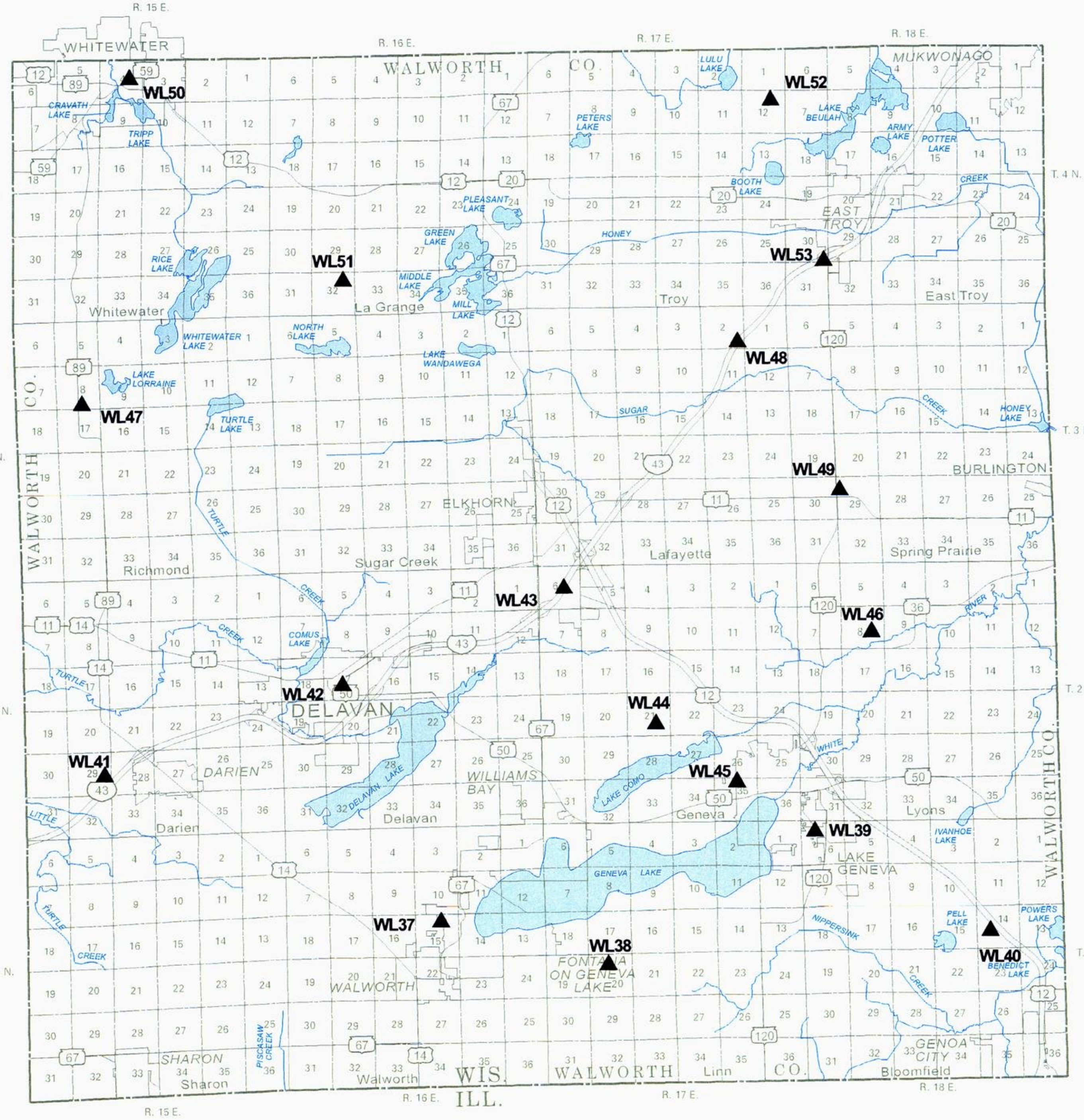
▲ ANTENNA SITE (14)

WL12 IDENTIFICATION NUMBER (SEE TABLE 41)

Source: SEWRPC.

Map 41

ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (17)

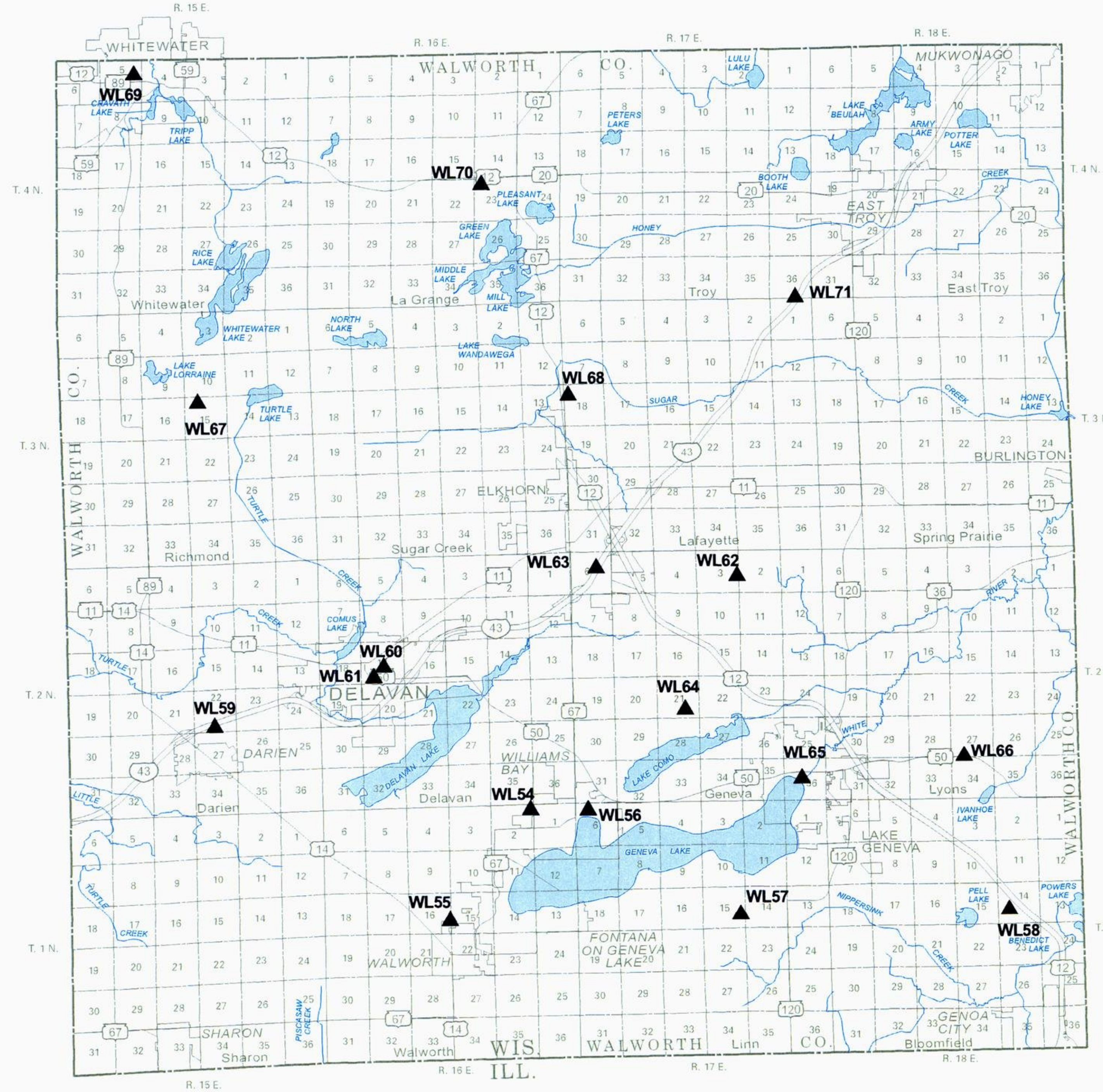
WL23 IDENTIFICATION NUMBER (SEE TABLE 42)

GRAPHIC SCALE 0 1 2 MILE; 0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 42

ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (18)

WL1 IDENTIFICATION NUMBER (SEE TABLE 43)

GRAPHIC SCALE

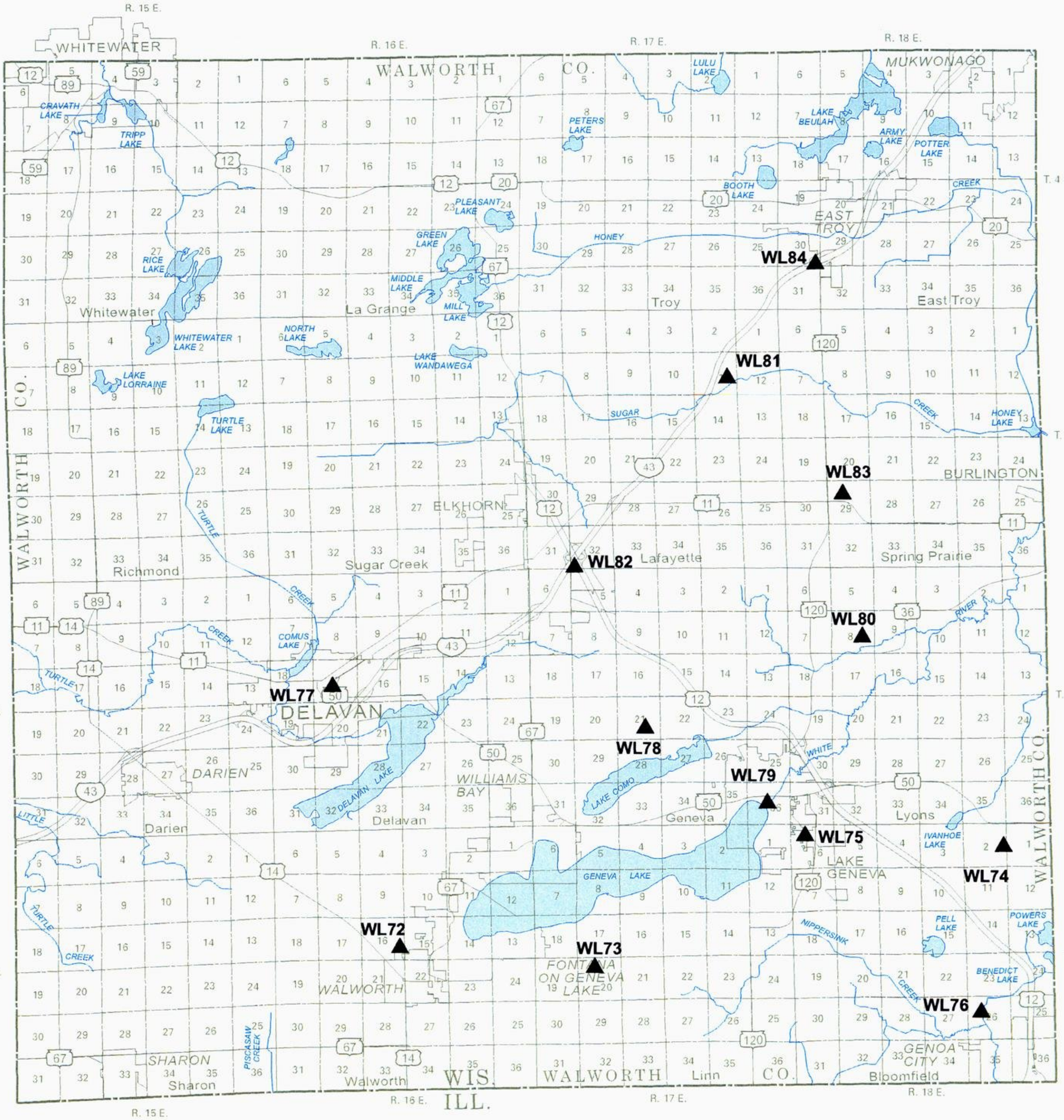
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 43

ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (13)

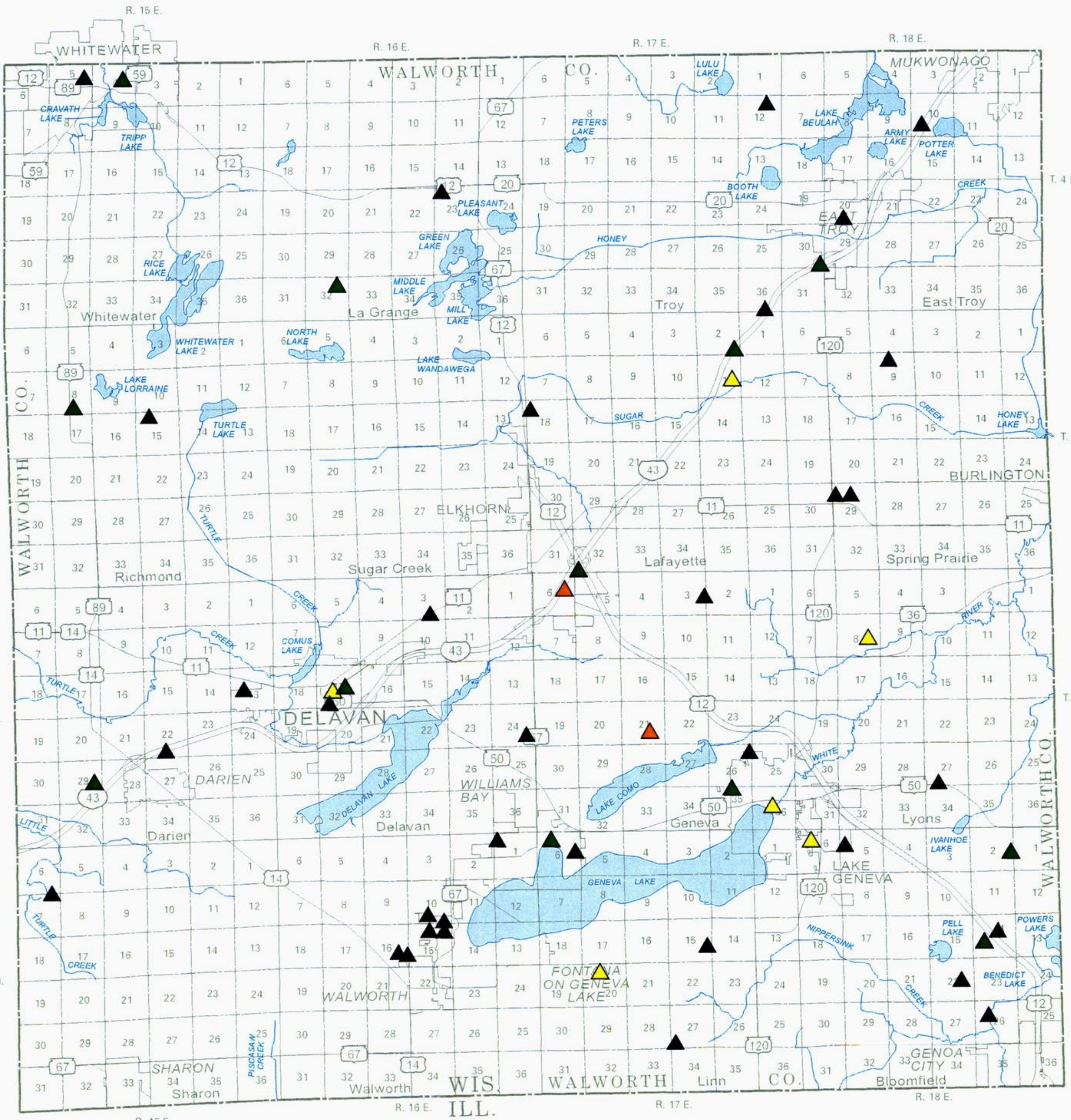
WL1 IDENTIFICATION NUMBER (SEE TABLE 44)

GRAPHIC SCALE

Source: SEWRPC.

Map 44

ANTENNA SITE LOCATIONS IN WALWORTH COUNTY, WISCONSIN: 2005



LEGEND

- ▲ 1 ANTENNA SITE (34)
- ▲ 2 ANTENNA SITES (12)
- △ 3 ANTENNA SITES (6)
- ▲ 4 ANTENNA SITES (2)
- ▲ 5 ANTENNA SITES (0)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAY BE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.

Source: SEWRPC.

provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be provided only for the cooperating service providers in a separate report. The infrastructure invent-tory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the Commission wireless network monitoring system which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 84 base transceiver stations on 59 cellular–PCS mobile wireless antenna sites within Walworth County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

WASHINGTON COUNTY

Antenna site data for Washington County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases

   a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22

   b. For Nextel Communications, Inc.–Land Mobile–Commercial

2. Local governmental databases included data provided by the following local units of government in Washington County: City of Hartford–6 sites; City of Milwaukee–0 sites; City of West Bend–13 sites; Village of Germantown–13 sites; Village of Jackson–2 sites; Village of Kewaskum–2 sites; Village of Newburg–1 site; Village of Slinger–5 sites; Town of Addison–10 sites; Town of Barton–6 sites; Town of Erin–4 sites; Town of Farmington–3 sites; Town of Germantown–0 sites; Town of Hartford–0 sites; Town of Jackson–10 sites; Town of Kewaskum–1 site; Town of Polk–8 sites; Town of Richfield–8 sites; Town of Trenton–1 site; Town of Wayne–7 sites; Town of West Bend–0 sites. There are a total of 100 sites within Washington County.

Antenna and Antenna Site Inventory–Cellular/PCS

The cellular/PCS antenna site inventory findings for Washington County are summarized in Tables 45 through 50 reproduced on pages 135 through 141 one for each wireless service provider as follows: Table 45–Cingular Wireless–26 antenna sites, Table 46–Nextel Communications–11 antenna sites, Table 47–Sprint PCS–16 antenna sites, Table 48–T-Mobile–12 antenna sites, Table 49–U.S. Cellular–20 antenna sites, Table 50–Verizon Wireless–15 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 45 through 50. Map 51 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 45, 46 and 49 representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of

Table 45

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 45)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS1	43-16-15	88-22-39	467,376	2,432,100	T. 9 N., R.18 E. Sec. 4	2931 STH 83 Town of Erin	295.3	O	N/A	N/A
WS2	43-13-46	88-15-44	452,914	2,463,111	T. 9 N., R. 18 E. Sec. 20	1100 STH 164 Town of Richfield	144.4	S	N/A	N/A
WS3	43-13-27	88-10-31	451,486	2,486,320	T. 9 N., R. 20 E. Sec. 19	W214 N11374 Appleton Ave. Village of Germantown	131.2	S	N/A	N/A
WS4	43-13-28	88-08-49	451,753	2,493,868	T. 9 N., R. 20 E. Sec.20	W190 N11393 Carnegie Dr. Village of Germantown	141.1	S	N/A	N/A
WS5	43-12-18	88-04-44	445,079	2,512,166	T. 9 N., R. 20 E. Sec. 36	N104 W13645 Donges Bay Rd. Village of Germantown	150.9	S	N/A	N/A
WS6	43-20-08	88-23-34	490,883	2,427,578	T. 10 N., R. 18 E. Sec. 6	1580 Airport Dr. City of Hartford	88.6	O	N/A	N/A
WS7	43-19-12	88-22-20	485,320	2,433,156	T. 10 N., R. 18 E. Sec. 21	206 Fifth St. City of Hartford	121.4	O	N/A	N/A
WS8	43-21-26	88-14-16	499,611	2,468,641	T. 10 N., R. 19 E. Sec. 3	4064 Pleasant Valley Rd. Town of Polk	180.5	O	N/A	N/A
WS9	43-20-14	88-11-28	492,589	2,481,207	T. 10 N., R. 19 E. Sec. 13	3035 CTH C Town of Polk	200.1	O	N/A	N/A
WS10	43-17-09	88-16-46	473,366	2,458,098	T. 10 N., R. 19 E. Sec. 32	2658 Slinger Rd. Town of Polk	200.1	O	N/A	N/A
WS11	43-17-07	88-11-56	473,616	2,479,547	T. 10 N., R. 19 E. Sec. 36	3230 Pioneer Rd. Town of Polk	193.6	O	N/A	N/A
WS12	43-21-41	88-04-00	502,138	2,514,102	T. 10 N., R. 20 E. Sec. 1	CTH NN Town of Jackson	193.6	O	N/A	N/A
WS13	43-22-09	88-08-49	504,487	2,492,696	T. 10 N., R. 20 E. Sec. 5	CTH NN Town of Jackson	180.5	O	N/A	N/A
WS14	43-18-06	88-05-34	480,216	2,507,658	T. 10 N., R. 20 E. Sec. 26	3095 Elm Rd. Town of Jackson	193.6	O	N/A	N/A
WS15	43-17-57	88-07-25	479,119	2,499,472	T. 10 N., R. 20 E. Sec. 28	CTH G Town of Jackson	193.6	O	N/A	N/A
WS16	43-26-35	88-18-33	530,495	2,449,024	T. 11 N., R. 18 E. Sec. 2	5380 St. Anthony Rd. Town of Addison	285.4	O	140.82	891.51
WS17	43-25-32	88-20-15	523,967	2,441,628	T. 11 N., R. 18 E. Sec. 15	6450 Weis St. Town of Addison	147.6	O	N/A	N/A
WS18	43-24-59	88-12-42	521,318	2,475,120	T 11 N., R. 19 E, Sec. 15	400 N. University Dr. City of West Bend	91.9	S	N/A	N/A
WS19	43-26-15	88-11-06	529,164	2,482,037	T. 11 N., R. 19 E. Sec. 11	1308 Fond du Lac St. City of West Bend	111.6	S	N/A	N/A
WS20	43-25-43	88-11-20	525,903	2,481,075	T. 11 N., R. 19 E. Sec. 11	530 N. 10th Ave. City of West Bend	173.9	S	N/A	N/A
WS21	43-23-40	88-11-35	513,429	2,480,238	T. 11 N., R. 19 E. Sec. 26	5666 Algen Dr. City of West Bend	131.2	S	N/A	N/A
WS22	43-25-08	88-04-17	523,060	2,512,362	T. 11 N., R. 20 E. Sec. 14	CTH I Town of Trenton	68.9	O	N/A	N/A
WS23	43-31-44	88-22-34	561,421	2,430,639	T. 12 N., R. 18 E. Sec. 8	W6775 STH 28 Town of Wayne	95.1	O	N/A	N/A

Table 45 (continued)

Site Number (See Map 45)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS24	43-28-35	88-21-00	542,425	2,437,941	T. 12 N., R. 18 E. Sec. 28	6433 Beechnut Dr. Town of Wayne	98.4	O	N/A	N/A
WS25	43-27-53	88-12-29	538,951	2,475,701	T. 12 N., R. 19 E. Sec. 34	7579 Friendly Dr. Town of Barton	200.1	S	N/A	N/A
WS26	43-28-45	88-07-08	544,736	2,499,249	T. 12 N., R. 20 E. Sec. 28	7960 Indian Lore Dr. Town of Farmington	295.3	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 47, 48, and 50 representing the PCS service providers were compiled almost entirely from local governmental databases since PCS sites were largely absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local governmental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed, wireless industry. For this reason, inventory data collection efforts will be concentrated on those companies of demonstrated stability and longevity.

Table 46

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 46)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS27	43-14-58	88-11-05.3	460,641	2,483,581	T. 9 N., R. 19 E. Sec. 13	2903 STH 167 Town of Richfield	249.4	O	53	860.7875
WS28	43-12-18	88-04-44	445,079	2,512,166	T. 9 N., R. 20 E. Sec. 36	N104 W13645 Donges Bay Rd. Village of Germantown	160.8	S	45	860.6625
WS29	43-18-22	88-21-07	480,365	2,438,652	T.10 N., R. 18 E. Sec. 27	1511 E. Monroe St. City of Hartford	118.1	O	N/A	N/A
WS30	43-20-14	88-11-28	492,589	2,481,207	T. 10 N., R. 19 E. Sec. 13	3035 CTH C Town of Polk	200.1	O	49	860.1125
WS31	43-19-57	88-15-35	490,480	2,462,994	T. 10 N., R. 19 E. Sec. 16	220 Lovers Ln. Village of Slinger	200.1	S	N/A	N/A
WS32	43-19-23	88-05-20	488,034	2,508,514	T. 10 N., R. 20 E. Sec. 14	STH 60 Town of Jackson	193.6	O	N/A	N/A
WS33	43-25-45	88-17-53.3	525,494	2,452,055	T. 11 N., R. 18 E. Sec. 12	6538 Aurora Rd. Town of Addison	380.6	O	500	865.3875
WS34	43-25-32	88-20-15	523,967	2,441,628	T. 11 N., R. 18 E. Sec. 15	6450 Weis St. Town of Addison	154.2	S	N/A	N/A
WS35	43-25-46	88-16-00.3	525,767	2,460,390	T. 11 N., R. 19 E. Sec. 7	STH 33 and Glacier Dr. Town of Barton	420.0	O	500	865.6625
WS36	43-25-05	88-11-26	522,047	2,480,716	T. 11 N., R. 19 E. Sec. 14	500 Summit Dr. City of West Bend	131.2	S	62	860.2875
WS37	43-31-44	88-22-34	561,421	2,430,639	T. 12 N., R. 18 E. Sec. 8	W6775 STH 28 Town of Wayne	95.1	O	10	860.2875

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

There are currently two known fixed wireless service providers operating in Washington County, Wisconsin. The antenna site data for these providers are listed in Table 57 and shown on Map 59.

Inventory Findings–Geographic Coverage

As already noted, originally, it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be

Table 47

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 47)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS38	43-16-14.88	88-22-36.84	467,368	2,432,261	T. 9 N., R. 18 E. Sec. 4	Town of Erin	187.1	S	N/A	1931.25
WS39	43-13-47.28	88-15-45	453,042	2,463,035	T. 9 N., R. 19 E. Sec. 20	Town of Richfield	187.6	S	N/A	1931.25
WS40	43-14-58.92	88-11-05.28	460,734	2,483,580	T. 9 N., R. 19 E. Sec.13	Town of Richfield	181.1	S	N/A	1931.25
WS41	43-13-41.52	88-08-27.24	453,158	2,495,448	T. 9 N., R. 20 E. Sec. 21	Village of Germantown	181.4	S	N/A	1931.25
WS42	43-12-18.72	88-04-44.04	445,152	2,512,161	T. 9 N., R. 20 E. Sec. 36	Village of Germantown	186.3	S	N/A	1932.5
WS43	43-19-10.56	88-22-49.8	485,132	2,430,957	T. 10 N., R. 18 E. Sec. 20	City of Hartford	181.1	S	N/A	1931.25
WS44	43-21-27.36	88-17-29.04	499,452	2,454,380	T. 10 N., R. 19 E. Sec. 6	Town of Polk	181.1	S	N/A	1931.25
WS45	43-20-14.64	88-11-28.68	492,653	2,481,155	T. 10 N., R. 19 E. Sec. 13	Town of Polk	181.1	S	N/A	1931.25
WS46	43-19-37.92	88-15-34.56	488,549	2,463,066	T. 10 N., R. 19 E. Sec. 16	Village of Slinger	181.1	S	N/A	1931.25
WS47	43-22-09.12	88-08-49.92	504,498	2,492,628	T. 10 N., R. 20 E. Sec. 5	Town of Jackson	181.1	S	N/A	1931.25
WS48	43-25-32.16	88-20-16.8	523,981	2,441,495	T. 11 N., R. 18 E. Sec. 15	Town of Addison	193.9	S	N/A	1931.25
WS49	43-25-46.92	88-16-08.72	525,847	2,459,767	T. 11 N., R. 19 E. Sec. 7	Town of Barton	181.1	S	N/A	1931.25
WS50	43-25-44.04	88-11-20.76	526,007	2,481,016	T. 11 N., R. 19 E. Sec. 11	City of West Bend	181.1	S	N/A	1932.5
WS51	43-30-47.88	88-22-21	555,759	2,431,707	T. 12 N., R. 18 E. Sec. 17	Town of Wayne	193.9	S	N/A	1931.25
WS52	43-31-24.24	88-13-40.08	560,221	2,470,006	T. 12 N., R. 19 E. Sec. 9	Village of Kewaskum	181.1	S	N/A	1931.25
WS53	43-31-06.6	88-06-24.48	559,141	2,502,132	T. 12 N., R. 20 E. Sec. 9	Town of Farmington	186.3	S	N/A	1931.25

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

provided only for the cooperating service providers in a separate report. The infrastructure inventory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the Commission wireless network monitoring system

Table 48

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 48)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS54	43-13-46	88-15-44	452,914	2,463,111	T. 9 N., R. 19 E. Sec. 20	1100 STH 164 Town of Richfield	164.0	S	N/A	N/A
WS55	43-13-27	88-10-31	451,486	2,486,320	T. 9 N., R. 20 E. Sec. 19	W214 N11374 Appleton Ave. Village of Germantown	141.1	S	N/A	N/A
WS56	43-12-18	88-04-44	445,079	2,512,166	T. 9 N., R. 20 E. Sec. 36	N104 W13645 Donges Bay Rd. Village of Germantown	170.6	S	N/A	N/A
WS57	43-20-30	88-16-33	493,731	2,458,639	T. 10 N., R. 19 E. Sec. 8	280 Cedar Creek Rd. Village of Slinger	200.1	O	N/A	N/A
WS58	43-21-41	88-04-00	502,138	2,514,102	T. 10 N., R. 20 E. Sec. 1	CTH NN Town of Jackson	193.6	O	N/A	N/A
WS59	43-18-06	88-05-34	480,216	2,507,658	T. 10 N., R. 20 E. Sec. 25	3095 Elm Rd. Town of Jackson	193.6	O	N/A	N/A
WS60	43-25-32	88-20-15	523,967	2,441,628	T. 11 N., R. 18 E. Sec. 15	6450 Weis St. Town of Addison	144.4	S	N/A	N/A
WS61	43-25-47	88-16-03	525,834	2,460,188	T. 11 N., R. 19 E. Sec. 7	4650 STH 33 Town of Barton	213.3	O	N/A	N/A
WS62	43-25-05	88-11-26	522,047	2,480,716	T. 11 N., R. 19 E. Sec. 14	500 Summit Dr. City of West Bend	124.7	S	N/A	N/A
WS63	43-23-34	88-11-09	512,863	2,482,170	T. 11 N., R. 19 E. Sec. 26	5579 CTH P City of West Bend	150.9	S	N/A	N/A
WS64	43-31-44	88-22-34	561,421	2,430,639	T. 12 N., R. 18 E. Sec. 8	W6775 STH 28 Town of Wayne	95.1	O	N/A	N/A
WS65	43-30-53	88-13-23	557,086	2,471,332	T. 12 N., R. 19 E. Sec. 9	USH 45 Village of Kewaskum	150.9	S	N/A	N/A

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.

[b]Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.

[c] The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 100 base transceiver stations on 69 cellular–PCS mobile wireless antenna sites within Washington County. These antenna sites represent a significant resource that can be used in planning and

Table 49

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 49)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS66	43-12-18	88-22-37	443,390	2,432,716	T. 9 N., R. 18 E. Sec. 33	366 STH 83 Town of Erin	183.7	S	N/A	N/A
WS67	43-16-49	88-14-09	471,584	2,469,751	T. 9 N., R. 19 E. Sec. 3	3959 Pioneer Rd. Town of Richfield	183.7	S	N/A	N/A
WS68	43-13-46	88-15-44	452,914	2,463,111	T. 9 N., R. 19 E. Sec. 20	1100 STH 164 Town of Richfield	134.5	S	N/A	N/A
WS69	43-16-20	88-04-15	469,622	2,513,746	T. 9 N., R. 20 E. Sec. 1	N140 W13600 Cedar Ln. Village of Germantown	75.5	S	N/A	N/A
WS70	43-14-17	88-07-17	456,865	2,500,566	T. 9 N., R. 20 E. Sec. 15	N122 W17177 Fond du Lac Ave. Village of Germantown	121.4	S	N/A	N/A
WS71	43-13-27	88-10-31	451,486	2,486,320	T. 9 N., R. 20 E. Sec. 19	W214 N11374 Appleton Ave. Village of Germantown	150.9	S	N/A	N/A
WS72	43-12-18	88-04-43	445,081	2,512,240	T. 9 N., R. 20 E. Sec. 36	N104 W13651 Donges Bay Rd. Village of Germantown	177.2	O	N/A	N/A
WS73	43-19-34	88-25-06	487,311	2,420,845	T. 10 N., R. 18 E. Sec. 19	7628 STH 60 City of Hartford	131.2	O	N/A	N/A
WS74	43-20-30	88-16-33	493,731	2,458,639	T. 10 N., R. 19 E. Sec. 8	280 Cedar Creek Rd. Village of Slinger	141.1	O	N/A	N/A
WS75	43-19-11	88-11-27	486,214	2,481,419	T. 10 N., R. 19 E. Sec. 24	USH 45 and STH 60 Village of Jackson	141.1	O	N/A	N/A
WS76	43-24-24	88-18-33	517,235	2,449,293	T. 11 N., R. 18 E. Sec. 23	5480 Mile Rd. Town of Addison	178.9	O	N/A	N/A
WS77	43-25-47	88-16-03	525,864	2,460,188	T. 11 N., R. 19 E. Sec. 7	4650 STH 33 Town of Barton	121.4	O	N/A	N/A
WS78	43-25-43	88-11-20	525,903	2,481,075	T. 11 N., R. 19 E. Sec. 11	530 N. 10th Ave. City of West Bend	91.9	S	N/A	N/A
WS79	43-24-31	88-10-08	518,731	2,486,546	T. 11 N., R. 19 E. Sec. 24	915 Indiana St. City of West Bend	95.1	S	N/A	N/A
WS80	43-23-34	88-11-09	512,863	2,482,170	T. 11 N, R. 19 E. Sec. 26	5579 CTH P City of West Bend	141.1	S	N/A	N/A
WS81	43-25-33	88-07-42	525,246	2,497,180	T. 11 N., R. 20 E. Sec. 17	345 Aerial Dr. City of West Bend	78.7	S	N/A	N/A
WS82	43-29-15	88-21-41	546,415	2,434,839	T. 12 N., R. 18 E. Sec. 21	8150 Midland Dr. Town of Wayne	98.4	O	N/A	N/A
WS83	43-31-31	88-15-21	560,749	2,462,558	T. 12 N., R. 19 E. Sec. 8	4481 STH 28 Town of Kewaskum	147.6	S	N/A	N/A
WS84	43-27-53	88-12-29	538,951	2,475,702	T. 12 N., R. 19 E. Sec. 34	7579 Friendly Dr. Town of Barton	278.9	S	N/A	N/A
WS85	43-31-06	88-06-24	559,081	2,502,169	T. 12 N., R. 20 E. Sec. 9	N9060 STH 144 Town of Farmington	150.9	S	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

Table 50

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS ANTENNAS IN WASHINGTON COUNTY, WISCONSIN: 2005

Site Number (See Map 50)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WS86	43-13-26	88-20-14	450,482	2,443,167	T. 9 N., R. 18 E. Sec. 23	936 CTH K Town of Erin	213.3	S	N/A	N/A
WS87	43-13-46	88-15-44	452,914	2,463,111	T. 9 N., R. 18 E. Sec. 20	1100 STH 164 Town of Richfield	154.2	S	N/A	N/A
WS88	43-13-16	88-05-40	450,854	2,507,885	T. 9 N., R. 20 E. Sec. 23	N112 W14400 Mequon Rd. Village of Germantown	98.4	O	N/A	N/A
WS89	43-19-20	88-23-05	486,065	2,429,814	T. 10 N., R. 18 E. Sec. 17	7280 STH 60 City of Hartford	121.4	O	N/A	N/A
WS90	43-21-26	88-14-16	499,611	2,468,641	T. 10 N., R. 19 E. Sec. 3	4064 Pleasant Valley Rd. Town of Polk	160.8	O	N/A	N/A
WS91	43-19-56	88-17-04	490,242	2,456,419	T. 10 N., R. 19 E. Sec. 18	Polk St. Village of Slinger	98.4	O	N/A	N/A
WS92	43-19-11	88-11-27	486,214	2,481,419	T. 10 N., R. 19 E. Sec. 24	USH and STH 60 Village of Jackson	141.1	O	N/A	N/A
WS93	43-21-33	88-04-45	501,251	2,510,798	T. 10 N., R. 20 E. Sec. 1	CTH M Town of Jackson	193.6	O	N/A	N/A
WS94	43-18-06	88-05-34	480,216	2,507,658	T. 10 N., R. 20 E. Sec. 26	3095 Elm Rd. Town of Jackson	193.6	O	N/A	N/A
WS95	43-25-33	88-19-40	524,119	2,444,208	T. 11 N., R. 18 E. Sec. 15	5821 STH 33 Town of Addison	78.7	O	N/A	N/A
WS96	43-23-44	88-18-04	513,229	2,451,515	T. 11 N., R. 18 E. Sec. 26	5621 Aurora Rd. Town of Addison	75.5	O	N/A	N/A
WS97	43-22-21	88-22-58	504,397	2,429,977	T. 11 N., R. 18 E. Sec. 31	4985 Level Rd. Town of Addison	180.5	S	N/A	N/A
WS98	43-26-15	88-11-06	529,164	2,482,037	T. 11 N., R. 19 E. Sec. 11	1308 Fond du Lac St. City of West Bend	154.2	S	N/A	N/A
WS99	43-26-12	88-03-17	529,641	2,516,638	T. 11 N., R. 20 E. Sec. 12	6779 Carmody Ct. Village of Newburg	150.9	S	N/A	N/A
WS100	43-31-44	88-22-34	561,421	2,430,639	T. 12 N., R. 18 E. Sec. 8	W6775 STH 28 Town of Wayne	95.1	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

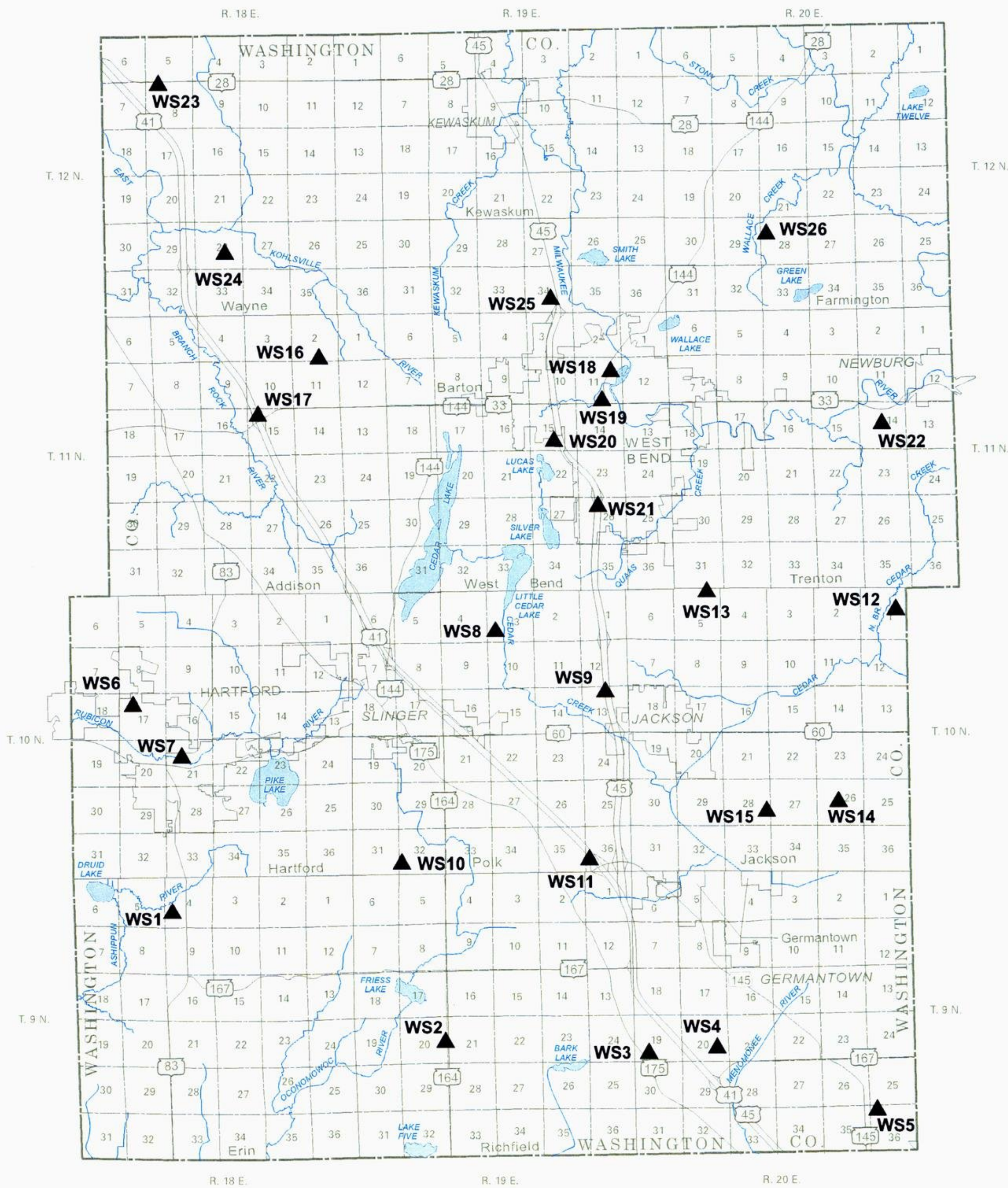
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

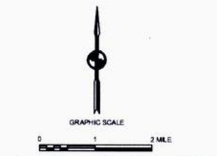
Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Washington County and local municipalities of Washington County, Wisconsin and SEWRPC.

developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

Map 45

ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005





LEGEND

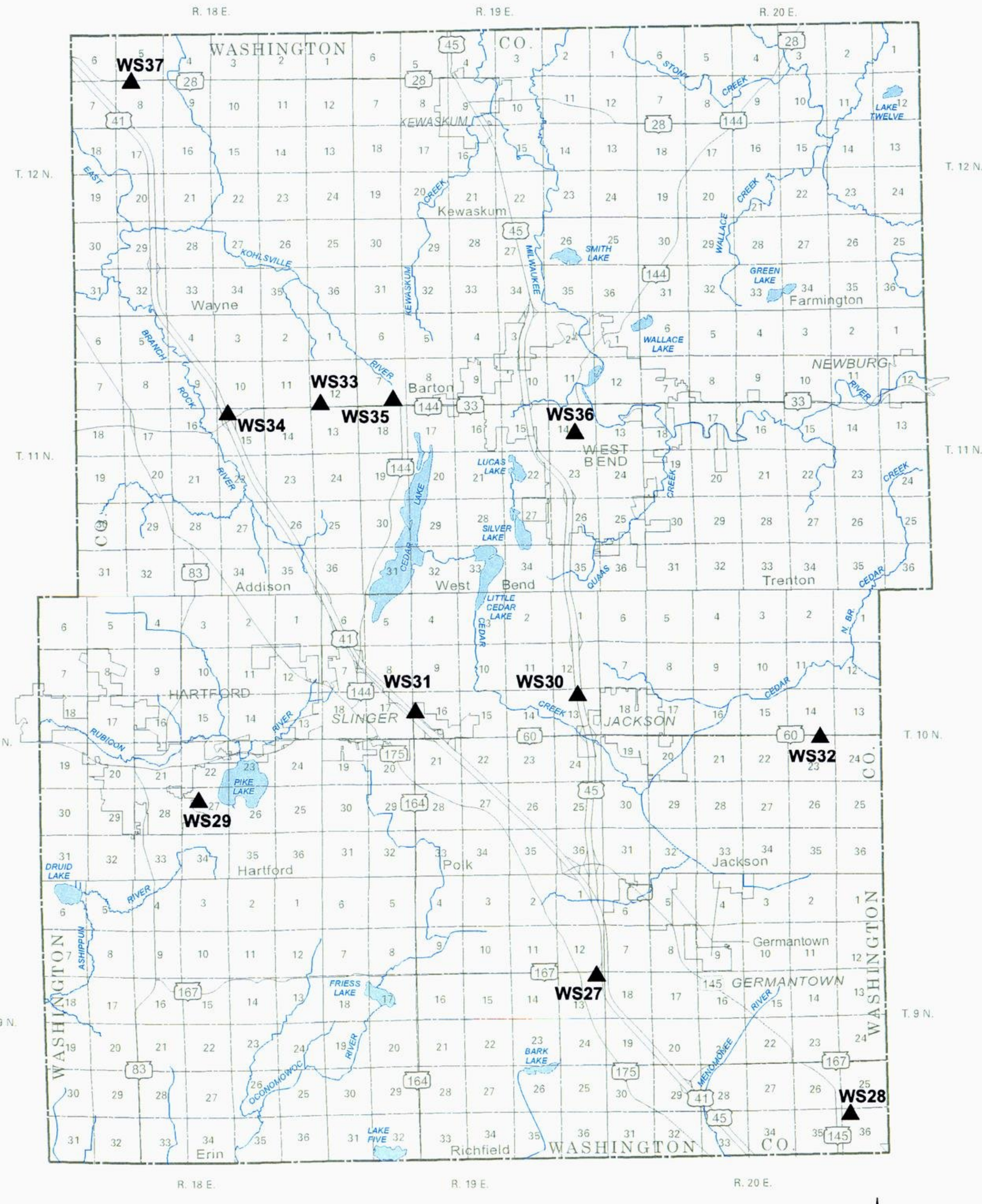
▲ ANTENNA SITE (26)

WS1 IDENTIFICATION NUMBER (SEE TABLE 45)

Source: SEWRPC.

Map 46

ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (11)

WS27 IDENTIFICATION NUMBER (SEE TABLE 46)

GRAPHIC SCALE

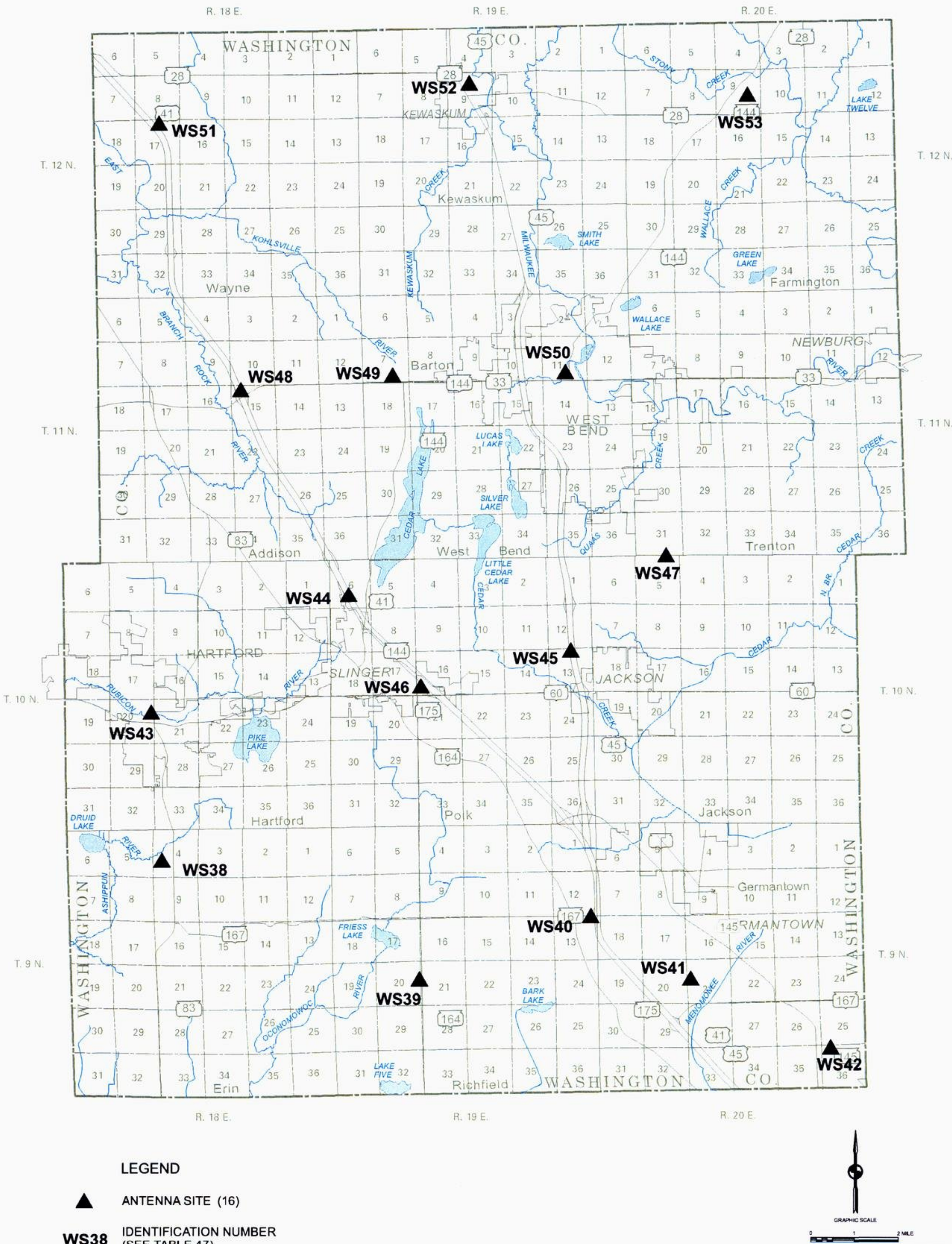
0 1 2 MILE

0 4,000 8,000 12,000 16,000 FEET

Source: SEWRPC.

Map 47

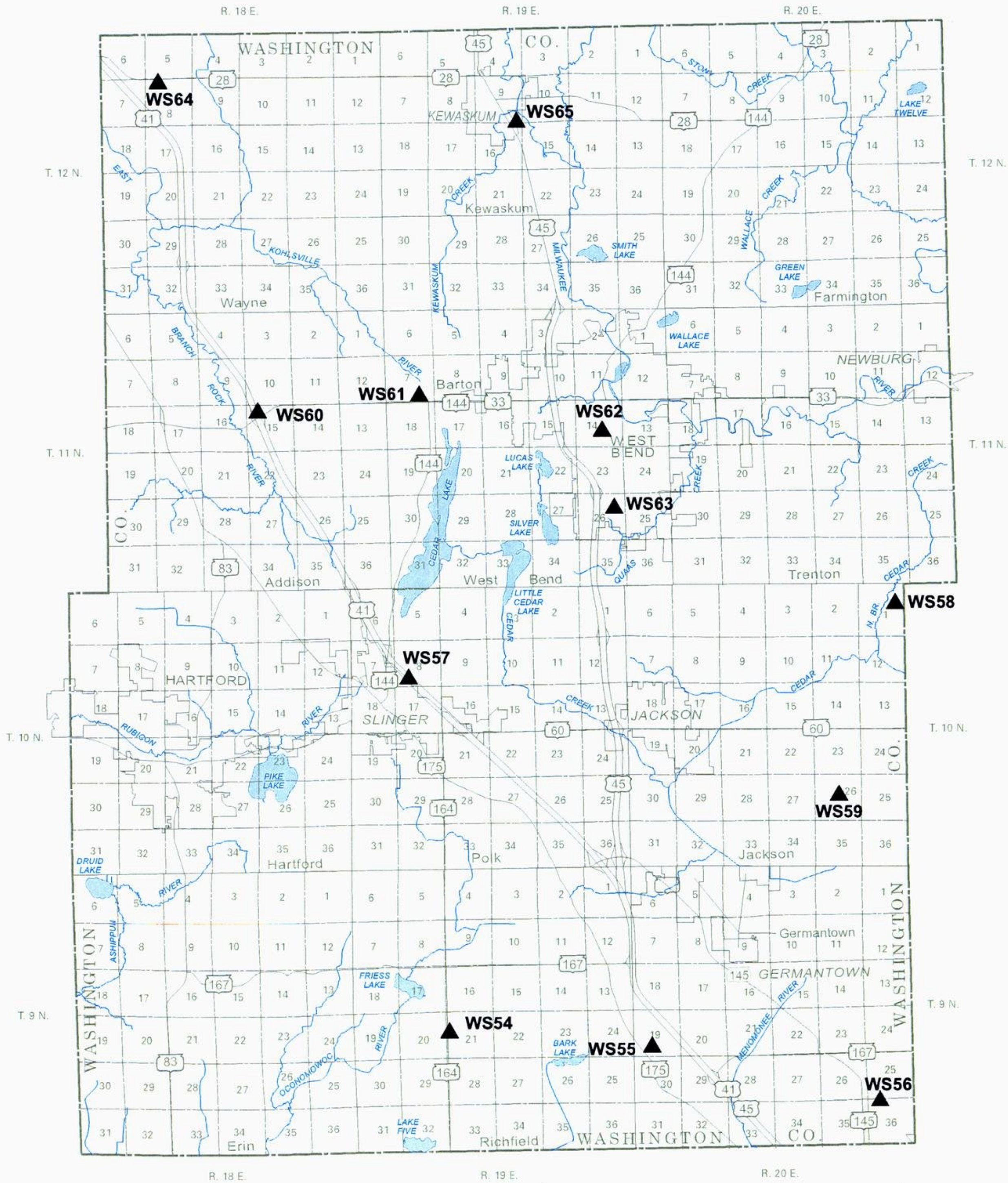
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 48

ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005



LEGEND

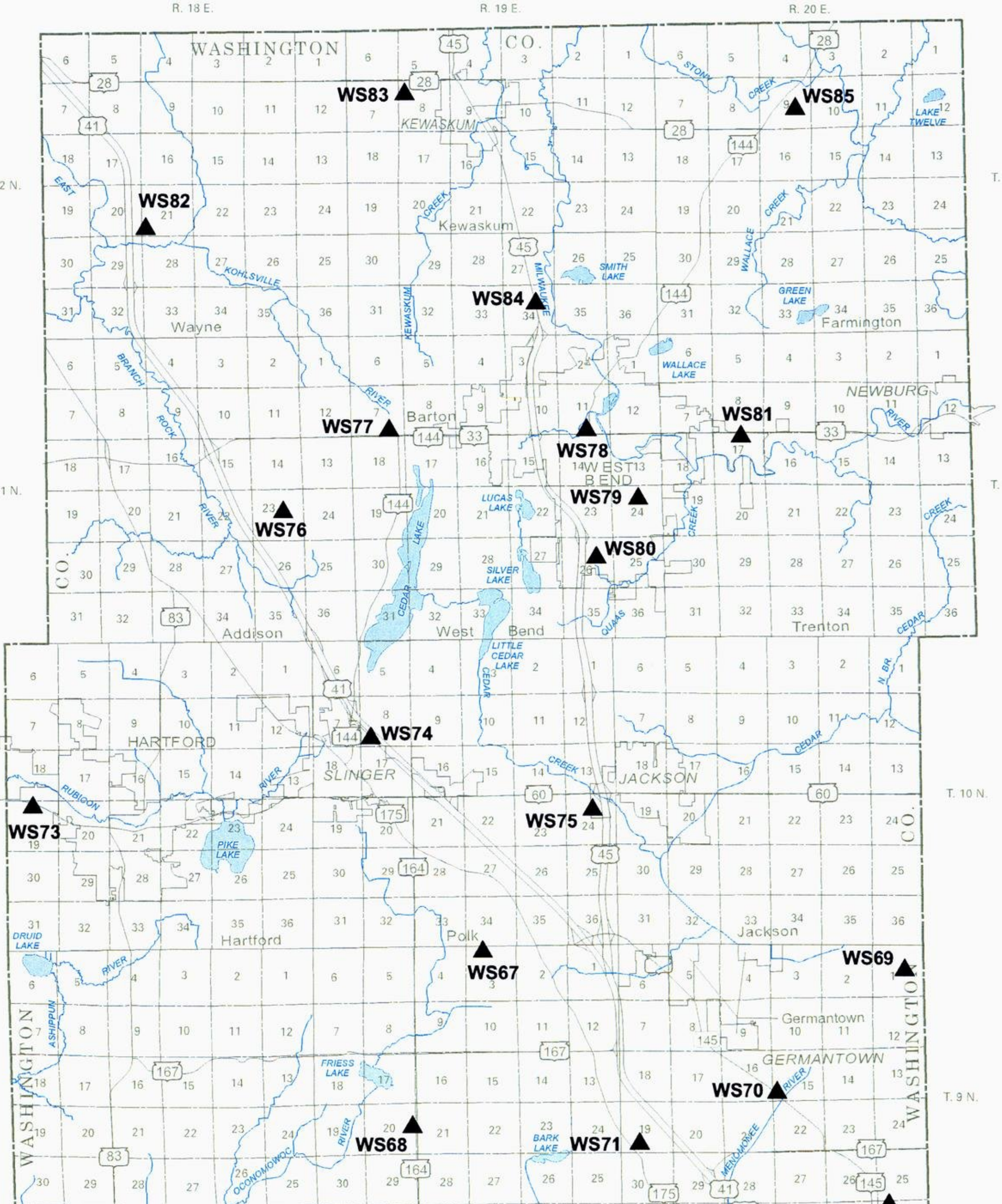
▲ ANTENNA SITE (12)

WS54 IDENTIFICATION NUMBER (SEE TABLE 48)

Source: SEWRPC.

Map 49

ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005



LEGEND

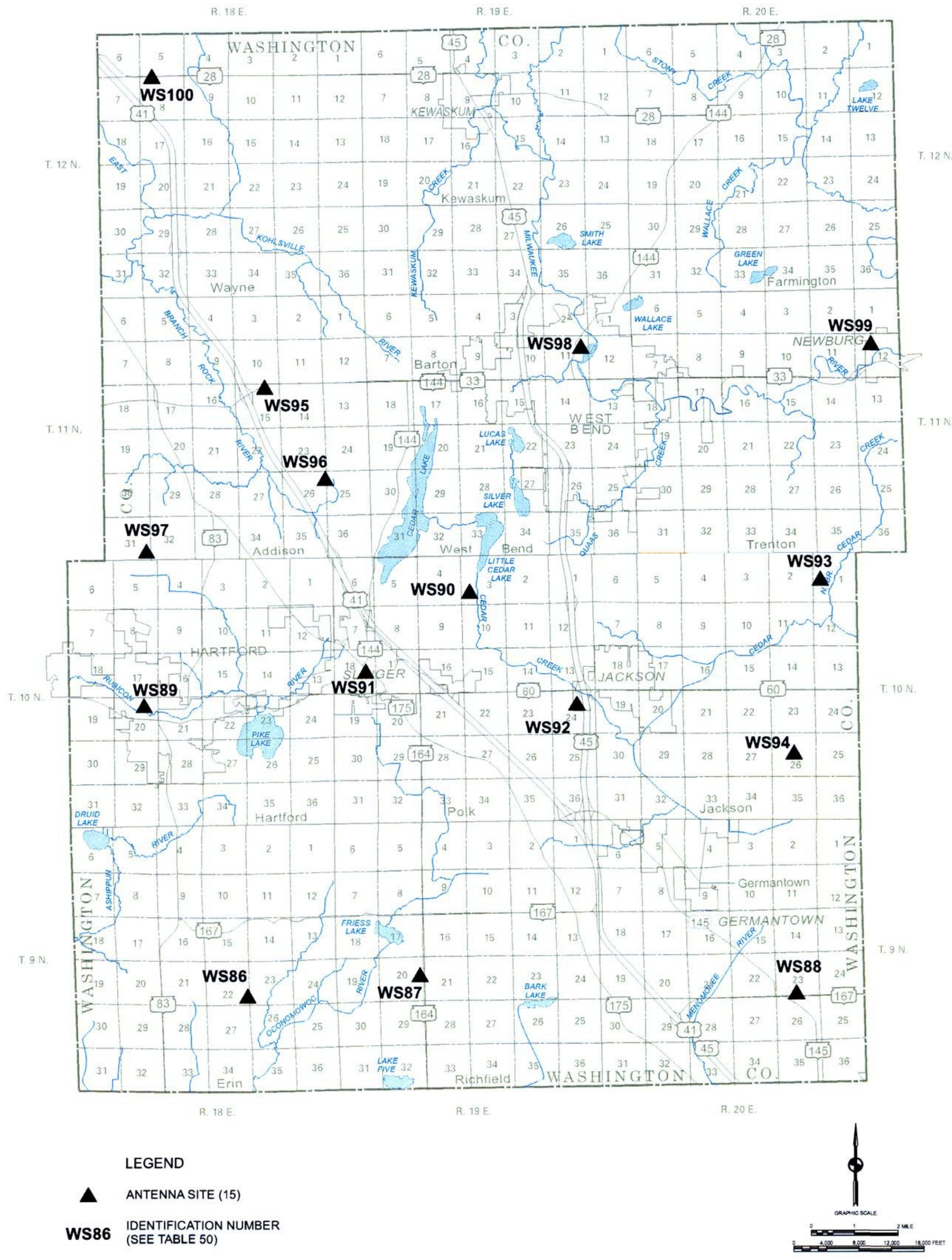
▲ ANTENNA SITE (20)

WS66 IDENTIFICATION NUMBER (SEE TABLE 49)

Source: SEWRPC.

Map 50

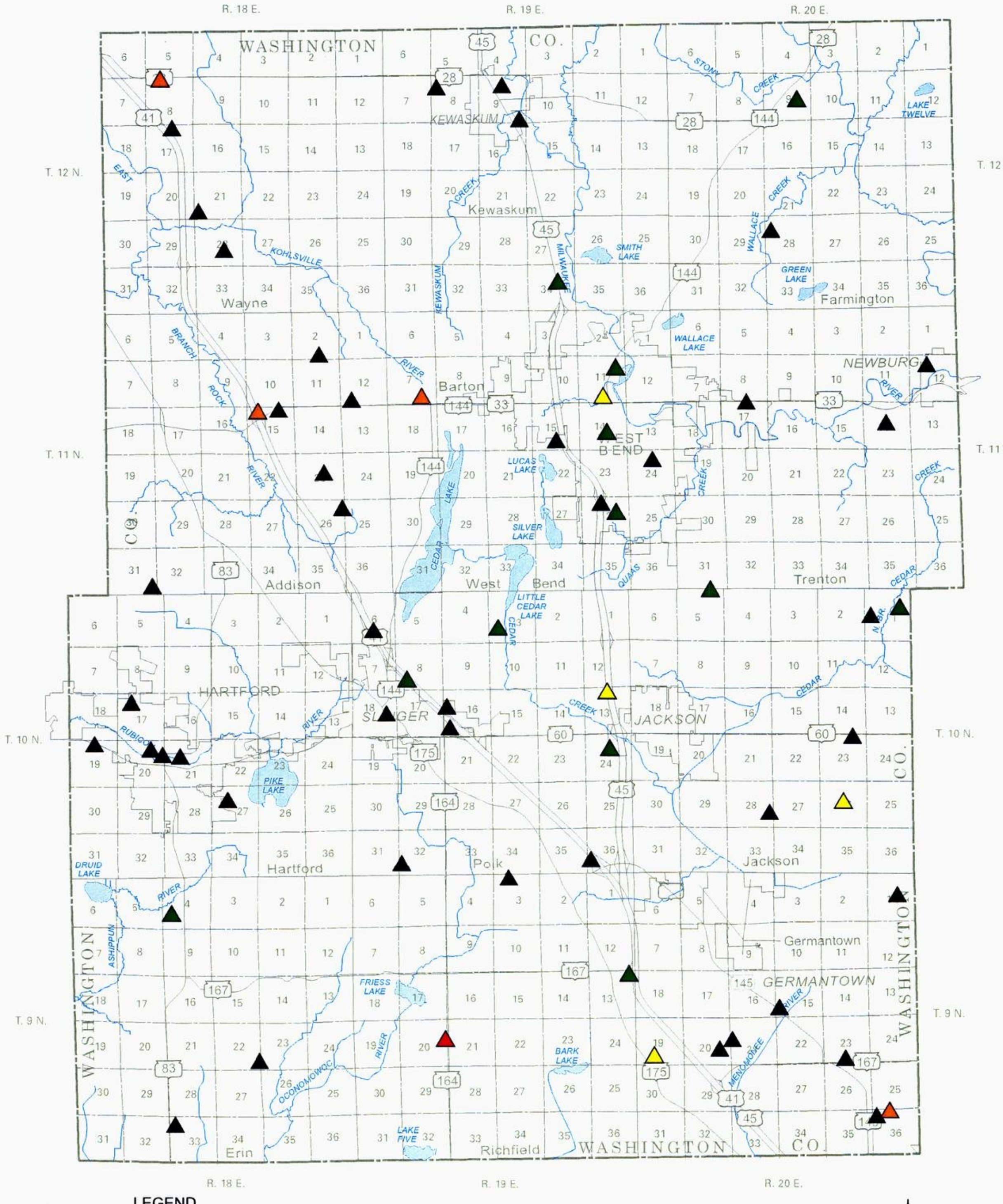
ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS IN WASHINGTON COUNTY, WISCONSIN: 2005



Source: SEWRPC.

Map 51

ANTENNA SITE LOCATIONS IN WASHINGTON COUNTY, WISCONSIN: 2005



LEGEND

- 1 ANTENNA SITE (43)
- 2 ANTENNA SITES (12)
- 3 ANTENNA SITES (4)
- 4 ANTENNA SITES (4)
- 5 ANTENNA SITES (1)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAY BE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.

Source: SEWRPC.

WAUKESHA COUNTY

Antenna site data for Waukesha County were compiled from the following sources:

1. Federal Communications Commission (FCC) databases

   a. For Cellular (800-900MHz) sites-cellular-47 CFR Part 22

   b. For Nextel Communications, Inc.–Land Mobile–Commercial

2. Local governmental databases included data provided by the following local units of government in Waukesha County: City of Brookfield–30 sites; City of Delafield–13 sites; City of Milwaukee–0 sites; City of Muskego–17 sites; City of New Berlin–15 sites; City of Oconomowoc–10 sites; City of Pewaukee–13 sites; City of Waukesha–26 sites; Village of Big Bend–1 site; Village of Butler–1 site; Village of Chenequa–1 site; Village of Dousman–2 sites; Village of Eagle–2 sites; Village of Elm Grove–5 sites; Village of Hartland–4 sites; Village of Lac La Belle–0 sites; Village of Lannon–3 sites; Village of Menomonee Falls–28 sites; Village of Merton–0 sites; Village of Mukwonago–5 sites; Village of Nashotah–0 sites; Village of North Prairie–4 sites; Village of Oconomowoc Lake–1 site; Village of Pewaukee–9 sites; Village of Sussex–1 site; Village of Wales–1 site; Town of Brookfield–7 sites; Town of Delafield–7 sites; Town of Eagle–2 sites; Town of Genesee–16 sites; Town of Lisbon–18 sites; Town of Merton–7 sites; Town of Mukwonago–5 sites; Town of Oconomowoc–6 sites; Town of Ottawa–0 sites; Town of Summit–0 sites; Town of Vernon–9 sites; Town of Waukesha–7 sites. There are a total of 276 sites within Waukesha County.

Antenna and Antenna Site Inventory – Cellular/PCS

The cellular/PCS antenna site inventory findings for Waukesha County are summarized in Tables 51 through 56 reproduced on pages 150 through 163 one for each wireless service provider as follows: Table 51–Cingular Wireless–66 antenna sites, Table 52–Nextel Communications–24 antenna sites, Table 53–Sprint PCS–47 antenna sites, Table 54–T-Mobile–38 antenna sites, Table 55–U.S. Cellular–51 antenna sites, Table 56–Verizon Wireless–50 antenna sites.

Antenna site maps, one for each provider, are displayed on Maps 52 through 57. Map 58 shows tower site locations that have either a single provider antenna or multiple provider antennas co-located on a single tower site.

The data presented in Tables 51, 52 and 55 representing the cellular (800-900 MHz) service providers, are based on the compilation and reconciliation of data from the FCC and local government data base. Positional data from Nextel were also used to reconcile data on the geographic positions of the sites. In general, power and frequency data were acquired from the FCC data bases since these types of data were mostly absent from local governmental files.

Tables 53, 54, and 56 representing the PCS service providers were compiled almost entirely from local governmental databases since PCS sites were largely absent from the FCC data bases. Positional data from Sprint PCS were used to reconcile data on the geographic positions of the sites.

Antenna Site Inventory–Fixed Wireless Service Providers

In addition to the cellular/PCS mobile wireless communications networks just described, a second set of fixed private wireless service provider networks operate in the Region. Although these networks are very small in terms of the number of antenna sites involved in comparison with cellular/PCS networks, they promise to become more prominent in the coming years with the growth of WiFi and WiMAX networks in the Region. Most, if not all fixed wireless service providers are Internet Service Providers (ISPs). Their original market involved connecting dialup phone customers to the Internet. With the growing expansion of broadband Internet services from telephone company DSL and cable modems, however, the dialup Internet market is in decline. To adapt to the shift to broadband communications, many ISPs have offered some form of fixed broadband wireless communications. Most regional fixed wireless service providers operate in the 900 MHz, 2.4 GHz or 5.7 GHz unlicensed spectral bands. Most providers also employ Motorola Canopy equipment which is based upon traditional time

Table 51

LOCATIONS AND SELECTED CHARACTERISTICS OF CINGULAR WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 52)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK1	42-54-35	88-20-37	335,969	2,443,738	T. 5 N., R. 18 E. Sec. 11	W299 S7404 STH 83 Town of Mukwonago	111.64	O	N/A	N/A
WK2	42-52-26	88-19-34	323,006	2,448,688	T. 5 N., R. 18 E. Sec. 23	262 CTH NN East Village of Mukwonago	164.1	O	N/A	N/A
WK3	42-50-56	88-19-35	313,895	2,448,796	T. 5 N., R. 18 E. Sec. 35	981 Greenwald Ct. Village of Mukwonago	180.5	O	N/A	N/A
WK4	42-54-16	88-15-44	334,659	2,473,615	T. 5 N., R. 19 E. Sec. 9	S74 W25755 Hi-Lo Dr. Town of Vernon	88.6	O	N/A	N/A
WK5	42-54-25	88-13-24	335,620	2,475,977	T. 5 N., R. 19 E. Sec. 11	W236 S7575 High Point Ct. Town of Vernon	150.9	O	N/A	N/A
WK6	42-53-50	88-16-24	331,796	2,462,657	T. 5 N., R. 19 E. Sec. 17	S81 W26220 National Ave. Town of Vernon	180.5	O	N/A	N/A
WK7	42-55-45	88-05-49	344,464	2,509,647	T. 5 N., R. 20 E. Sec. 2	W146 S6360 Tess Corners Dr. City of Muskego	118.1	O	N/A	N/A
WK8	42-54-44	88-11-14	337,752	2,485,608	T. 5 N., R. 20 E. Sec. 7	W219 S7278 Crowbar Rd. City of Muskego	150.9	O	N/A	N/A
WK9	42-54-05	88-07-14	334,200	2,503,553	T. 5 N., R. 20 E. Sec. 15	S79 W16464 Woods Dr. City of Muskego	88.6	O	N/A	N/A
WK10	42-53-49	88-09-01	331,390	2,495,649	T. 5 N., R. 20 E. Sec. 17	W198 S8235 Mercury Dr. City of Muskego	180.5	O	N/A	N/A
WK11	42-53-08	88-08-54	328,264	2,496,240	T. 5 N., R. 20 E. Sec. 21	W183 S8750 Racine Ave. City of Muskego	131.2	O	N/A	N/A
WK12	42-55-52	88-25-28	343,344	2,421,939	T. 6 N., R. 17 E. Sec. 36	S62 W34052 Piper Rd. Village of North Prairie	170.6	O	N/A	N/A
WK13	43-00-54	88-25-08	373,940	2,422,847	T. 6 N., R. 18 E. Sec. 6	S15 W33950 Wolf Rd. Town of Genesee	177.2	O	N/A	N/A
WK14	42-85-21	88-21-35	358,759	2,438,973	T. 6 N., R. 18 E. Sec. 22	W304 S3925 Brookhill Rd. Town of Genesee	154.2	O	N/A	N/A
WK15	42-58-14	88-18-21	358,339	2,453,407	T. 6 N., R. 18 E. Sec. 24	S40 W28091 Genesee Rd. Town of Genesee	150.1	O	N/A	N/A
WK16	42-56-16	88-23-55	345,905	2,428,810	T. 6 N., R. 18 E. Sec. 32	109 Oakridge Dr. Village of North Prairie	141.1	O	N/A	N/A
WK17	43-00-33	88-11-50	373,017	2,482,166	T. 6 N., R. 19 E. Sec. 1	1700 Pearl St. City of Waukesha	180.5	O	N/A	N/A
WK18	43-00-39	88-13-34	373,459	2,474,428	T. 6 N., R. 19 E. Sec. 2	801 N. East Ave. City of Waukesha	98.4	O	N/A	N/A
WK19	42-58-48	88-11-51	362,388	2,482,321	T. 6 N., R. 19 E. Sec. 13	1727 Hunter Rd. City of Waukesha	187.0	O	N/A	N/A
WK20	42-59-14	88-14-23	364,779	2,470,969	T. 6 N., R. 19 E. Sec. 15	S31 W24651 Sunset Dr. Town of Waukesha	134.5	O	N/A	N/A
WK21	42-58-25	88-15-07	359,750	2,467,804	T. 6 N., R. 19 E. Sec. 21	1009 Morris Dr. City of Waukesha	118.1	O	N/A	N/A
WK22	43-58-05	88-11-19	358,088	2,484,794	T. 6 N., R. 19 E. Sec. 25	S42 N22080 Beeheim Rd. Town of Waukesha	479.0	O	N/A	N/A
WK23	42-56-00	88-13-10	345,258	2,476,813	T. 6 N., R. 19 E. Sec. 35	W235 S6089 Big Bend Rd. Town of Waukesha	157.5	O	N/A	N/A
WK24	42-58-48	88-06-19	362,935	2,506,994	T. 6 N., R. 20 E. Sec. 14	15345 W. Coffee Rd. City of New Berlin	114.8	O	N/A	N/A

Table 51 (continued)

Site Number (See Map 52)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK25	43-05-09	88-28-49	399,446	2,405,960	T. 7 N., R. 17 E. Sec. 10	965 Canon Gate Rd. City of Oconomowoc	49.2	S	N/A	N/A
WK26	43-06-19	88-21-29	407,151	2,438,466	T. 7 N., R. 19 E. Sec. 3	671 Hill St. Village of Hartland	196.9	S	N/A	N/A
WK27	43-03-23	88-25-13	389,015	2,422,190	T. 7 N., R. 18 E. Sec. 19	250 Enterprise Dr. City of Delafield	131.2	S	N/A	N/A
WK28	43-03-19	88-22-14	388,866	2,435,484	T. 7 N., R. 18 E. Sec. 21	2979 Golf Rd. City of Delafield	121.4	O	N/A	N/A
WK29	43-02-14	88-19-10	382,558	2,449,275	T. 7 N., R. 18 E. Sec. 25	W289 N520 Elmhurst Rd. Town of Delafield	259.2	O	N/A	N/A
WK30	43-02-44	88-21-16	385,408	2,439,860	T. 7 N., R. 18 E. Sec. 27	3820 Kettle Court East City of Delafield	160.8	O	N/A	N/A
WK31	43-01-08	88-19-25	375,855	2,448,296	T. 7 N., R. 18 E. Sec. 36	S12 W28925 Summit Ave. Town of Delafield	190.3	O	N/A	N/A
WK32	43-05-43	88-16-41	403,938	2,459,901	T. 7 N., R. 19 E. Sec. 5	1010 Quinlan Dr. Village of Pewaukee	98.4	O	N/A	N/A
WK33	43-04-48	88-13-33	398,663	2,473,966	T. 7 N., R. 19 E. Sec. 10	1515 Sunnyridge Rd. Village of Pewaukee	55.8	O	N/A	N/A
WK34	43-14-26	88-11-34	396,626	2,482,843	T. 7 N., R. 19 E. Sec. 13	Green Rd. City of Pewaukee	111.6	O	N/A	N/A
WK35	43-04-32	88-13-35	397,041	2,473,852	T. 7 N., R. 19 E. Sec. 15	W240 N3065 Pewaukee Rd. City of Pewaukee	157.5	O	N/A	N/A
WK36	43-03-10	88-15-54	388,524	2,463,710	T. 7 N., R. 19 E. Sec. 21	3000 N. Grandview Blvd. City of Waukesha	124.7	O	N/A	N/A
WK37	43-03-07	88-12-36	388,531	2,478,414	T. 7 N., R. 19 E. Sec. 23	N16 W23217 Stoneridge Dr. City of Pewaukee	65.6	O	N/A	N/A
WK38	43-02-14	88-17-05	382,747	2,458,556	T. 7 N., R. 19 E. Sec. 29	Meadowbrook Rd. City of Pewaukee	88.6	O	N/A	N/A
WK39	43-01-16	88-14-00	377,163	2,472,417	T. 7 N., R. 19 E. Sec. 34	500 Riverview Ave. City of Waukesha	118.1	O	N/A	N/A
WK40	43-01-29	88-11-14	378,743	2,484,717	T. 7 N., R. 19 E. Sec. 36	2150 Davidson Rd. City of Waukesha	88.6	O	N/A	N/A
WK41	43-05-26	88-06-25	403,208	2,505,634	T. 7 N., R. 20 E. Sec. 3	15740 W. Capitol Dr. City of Brookfield	68.9	O	N/A	N/A
WK42	43-04-26	88-04-52	397,293	2,512,673	T. 7 N., R. 20 E. Sec. 13	13595 W. Burleigh Rd. City of Brookfield	164.1	O	N/A	N/A
WK43	43-04-04	88-07-21	394,814	2,501,667	T. 7 N., R. 20 E. Sec. 15	16900 Pheasant Dr. City of Brookfield	150.9	O	N/A	N/A
WK44	43-03-33	88-09-05	391,504	2,494,018	T. 7 N., R. 20 E. Sec. 20	19305 Alta Vista Cir. City of Brookfield	118.1	O	N/A	N/A
WK45	43-03-29	88-07-27	391,262	2,501,301	T. 7 N., R. 20 E. Sec. 22	2100 N. Calhoun Rd. City of Brookfield	124.7	O	N/A	N/A
WK46	43-02-52	88-10-16	387,238	2,488,840	T. 7 N., R. 20 E. Sec. 19	City of Brookfield	157.5	O	N/A	N/A
WK47	43-02-23	88-04-26	384,888	2,514,889	T. 7 N., R. 20 E. Sec. 25	900 Wall St. Village of Elm Grove	131.2	S	N/A	N/A
WK48	43-01-56	88-09-06	381,685	2,494,162	T. 7 N., R. 20 E. Sec. 29	19125 Janacek Ct. Town of Brookfield	88.6	O	N/A	N/A
WK49	43-01-42	88-06-42	380,305	2,504,891	T. 7 N., R. 20 E. Sec. 34	127 S. Moorland Rd. City of Brookfield	108.3	O	N/A	N/A

Table 51 (continued)

Site Number (See Map 52)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK50	43-07-02	88-31-57	410,635	2,391,811	T. 8 N., R. 17 E. Sec. 31	W394 N5313 Reddelein Rd. Town of Oconomowoc	180.5	O	N/A	N/A
WK51	43-06-32	88-28-59	407,834	2,405,066	T. 8 N., R. 17 E. Sec. 33	163 Sheldon Ave. City of Oconomowoc	118.1	O	N/A	N/A
WK52	43-09-37	88-22-14	427,127	2,434,737	T. 8 N., R. 18 E. Sec. 16	W314 N7796 Kilbourne Rd. Town of Merton	180.5	O	N/A	N/A
WK53	43-08-55	88-24-05	422,716	2,426,593	T. 8 N., R. 18 E. Sec. 19	W330 N7101 West Shore Dr. Town of Merton	180.5	O	N/A	N/A
WK54	43-09-50	88-15-48	429,020	2,463,312	T. 8 N., R. 19 E. Sec. 8	N80 W26020 Plainview Rd. Town of Lisbon	180.5	O	250	1990
WK55	43-08-25	88-13-28	420,635	2,473,869	T. 8 N., R. 19 E. Sec. 22	W240 N6749 Maple Ave. Town of Lisbon	164.1	O	N/A	N/A
WK56	43-06-34	88-12-20	409,508	2,479,151	T. 8 N., R. 19 E. Sec. 35	W229 N5087 Duplainville Rd. Town of Lisbon	49.2	O	N/A	N/A
WK57	43-11-30	88-03-49	440,314	2,516,351	T. 8 N., R. 20 E. Sec. 1	W124 N9585 Boundary Rd. Village of Menomonee Falls	98.4	O	N/A	N/A
WK58	43-11-01	88-05-49	437,175	2,507,531	T. 8 N., R. 20 E. Sec. 2	W156 N90000 Pilgrim Rd. Village of Menomonee Falls	42.7	On	N/A	N/A
WK59	43-11-10	88-07-51	437,881	2,498,474	T. 8 N., R. 20 E. Sec. 4	W178 N9290 Water Tower Pl. Village of Menomonee Falls	141.1	O	N/A	N/A
WK60	43-11-09	88-08-45	437,691	2,494,476	T. 8 N., R 20 E. Sec. 5	W188 N9273 Maple Rd. Village of Menomonee Falls	88.6	O	N/A	N/A
WK61	43-10-18	88-06-08	432,790	2,506,222	T. 8 N., R. 20 E. Sec. 11	Pilgrim Rd. Village of Menomonee Falls	134.5	O	N/A	N/A
WK62	43-10-10	88-04-27	432,152	2,513,723	T. 8 N., R. 20 E. Sec. 12	N83 W13330 Leon Rd. Village of Menomonee Falls	150.9	O	N/A	N/A
WK63	43-09-22	88-09-06	426,826	2,493,161	T. 8 N., R. 20 E. Sec. 17	W193 N7700 Becker Dr. Village of Lannon	426.5	O	N/A	N/A
WK64	43-08-16	88-10-58	419,964	2,485,007	T. 8 N., R. 20 E. Sec. 19	W220 N6660 Town Line Rd. Village of Menomonee Falls	95.1	O	N/A	N/A
WK65	43-07-34	88-07-09	416,089	2,502,078	T. 8 N., R. 20 E. Sec. 27	N60 W16765 Kohler Ln. Village of Menomonee Falls	114.8	O	N/A	N/A
WK66	43-06-36	88-08-13	410,112	2,497,464	T. 8 N., R. 20 E. Sec. 33	W180 N5063 Marcy Rd. Village of Menomonee Falls	131.2	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

division multiplexing technology. At least one provider uses Alvarion frequency hopping spread spectrum technology operating in the same frequency bands.

Relating to the antenna site inventory, fixed wireless providers often locate at unrecorded antenna sites present in neither the FCC nor the local governmental data bases. Antennas are often located on the sides or tops of prominent buildings or other undocumented sites. There is also a great deal of instability in the fixed, wireless industry. For this reason, inventory data collection efforts were concentrated on those companies of demonstrated stability and longevity. There are currently two known fixed wireless service providers operating in Waukesha County. The antenna site data for these providers are listed in Table 57 and shown on Map 59.

Table 52

LOCATIONS AND SELECTED CHARACTERISTICS OF NEXTEL WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 53)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK67	42-53-09	88-28-54	326,561	2,406,917	T. 5 N., R. 17 E. Sec. 22	545 Anton Ct. Village of Eagle	167.3	O	N/A	N/A
WK68	42-50-56	88-19-35	313,905	2,448,774	T. 5 N., R. 18 E. Sec. 36	N9518 Stone School Rd. Village of Mukwonago	173.9	O	N/A	N/A
WK69	42-54-08	88-11-08	334,118	2,486,134	T. 5 N., R. 20 E. Sec. 7	W219 S7884 Crowbar Rd. City of Muskego	298.6	O	250	859.8875
WK70	43-00-54	88-24-40	373,980	2,424,927	T. 6 N., R. 18 E. Sec. 6	S14 W33507 USH 18 Town of Genesee	249.4	O	N/A	N/A
WK71	42-58-21	88-21-35	358,760	2,438,973	T. 6 N., R. 18 E. Sec. 22	W304 S3925 Brookhill Rd. Town of Genesee	154.2	O	N/A	N/A
WK72	43-00-33	88-11-50	373,018	2,482,166	T. 6 N., R. 19 E. Sec. 1	1700 Pearl St. City of Waukesha	180.5	O	N/A	N/A
WK73	43-00-38	88-14-30	373,270	2,470,270	T. 6 N., R. 19 E. Sec. 3	725 American Ave. City of Waukesha	68.9	O	10	860.2875
WK74	42-58-05	88-11-20	358,086	2,484,698	T. 6 N., R. 19 E. Sec. 25	S42 W22080 Beeheim Rd. Town of Waukesha	479.0	O	25	865.8625
WK75	43-05-09	88-28-48	399,448	2,406,036	T. 7 N., R. 17 E. Sec. 10	965 Canon Gate Rd. City of Oconomowoc	19.7	S	N/A	N/A
WK76	43-04-08	88-22-00	393,846	2,436,427	T. 7 N., R. 18 E. Sec. 16	1605 STH 83 City of Delafield	98.4	S	38	855.3125
WK77	43-03-22	88-25-14	388,913	2,422,118	T. 7 N., R. 19 E. Sec. 19	250 Enterprise Dr. City of Delafield	131.0	S	N/A	N/A
WK78	43-04-48	88-13-33	398,664	2,473,966	T. 7 N., R. 19 E. Sec. 10	1515 Sunnyridge Rd. Village of Pewaukee	88.6	O	31	855.4375
WK79	43-04-22	88-13-36	396,027	2,473,777	T. 7 N., R. 19 E. Sec. 15	W240 N2989 Pewaukee Rd. Village of Pewaukee	29.5	O	2	855.3625
WK80	43-03-10	88-15-54	388,524	2,463,711	T. 7 N., R. 19 E. Sec. 21	3000 N. Grandview Blvd. City of Waukesha	124.7	O	N/A	N/A
WK81	43-03-09	88-12-35	388,735	2,478,485	T. 7 N., R. 19 E. Sec. 23	N16 W23233 Stoneridge Dr. City of Pewaukee	65.5	O	N/A	N/A
WK82	43-05-25	88-07-37	402,986	2,500,295	T. 7 N., R. 20 E. Sec. 4	17340 W. Capitol Dr. City of Brookfield	150.9	O	N/A	N/A
WK83	43-02-23	88-04-26	384,889	2,514,890	T. 7 N., R. 20 E. Sec. 25	900 Wall St. Village of Elm Grove	173.9	S	500	860.7875
WK84	43-01-56	88-09-06	381,685	2,494,162	T. 7 N., R. 20 E. Sec. 29	19245 Janacek Ct. Town of Brookfield	341.2	O	10	857.3625
WK85	43-01-40	88-06-42	380,305	2,504,891	T. 7 N., R. 20 E. Sec. 34	127 S. Moorland Rd. City of Brookfield	154.2	O	N/A	N/A
WK86	43-08-17	88-28-50	418,474	2,405,510	T. 8 N. R. 17 E. Sec. 22	1.9 Miles NE of STH 67 and STH 16 Town of Oconomowoc	62.3	O	250	864.1375

Table 52 (continued)

Site Number (See Map 53)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK87	43-06-32	88-28-59	407,835	2,405,066	T. 8 N., R. 17 E. Sec. 33	163 Sheldon Ave. City of Oconomowoc	150.9	S	N/A	N/A
WK88	43-09 37	88-22-14	427,127	2,434,737	T. 8 N., R. 18 E. Sec.16	W314 N7796 Kilbourne Rd. Town of Merton	239.5	O	N/A	N/A
WK89	43-06-48	88-12-21	410,924	2,479,047	T. 8 N., R. 19 E. Sec. 35	N52 W23038 CTH K Town of Lisbon	150.9	O	N/A	N/A
WK90	43-11-10	88-07-51	437,882	2,498,474	T. 8 N., R. 20 E. Sec. 4	W178 N9290 Water Tower Pl. Village of Menomonee Falls	150.9	O	10	860.6625

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

Inventory Findings–Geographic Coverage

As already noted, originally it was intended that geographic coverage maps for each wireless service provider would be prepared based on the antenna site inventory findings and the use of radio propagation modeling. The EDX Signal Pro™ software package and various terrain databases were to be used for the radio propagation studies. To be accurate, such modeling requires detailed technical data on the types of antennas being employed by each service provider and their radiation patterns. Such data are typically available only from the individual service provider. For this reason, it was determined that radio coverage maps would be prepared only for those service providers willing to cooperate with the Commission in coverage map preparation. As of December 1, 2005, one of the five service providers operating in the Region agreed to work with the Commission and share the data necessary for such radio coverage mapping and negotiations were in progress with some of the other service providers. Coverage maps and a near term 2G-3G antenna site location plan will be provided only for the cooperating service providers in a separate report. The infrastructure inventory for noncooperating service providers will be limited to antenna site location as provided in the tables previously referenced.

A separate source of geographic radio coverage information is used in Chapter VI of this publication to provide performance data for all regional wireless service providers. This source employs data from the Commission wireless network monitoring system which will record performance data on the packet-switched wireless networks in the Region. Such performance evaluation will extend beyond basic coverage to indications of circuit availability, data transmission rates, and other measures of system performance. The findings of this performance inventory are described in Chapter VI following.

Summary

The findings of the base transceiver station, antenna site and related infrastructure inventory as herein reported, document the existence–as of December 31, 2005–of 276 base transceiver stations on 154 cellular–PCS mobile wireless antenna sites within

Table 53

LOCATIONS AND SELECTED CHARACTERISTICS OF SPRINT WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 54)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK91	42-54-09	88-28-34.32	332,661	2,408,271	T. 5 N., R. 17 E. Sec. 10	Town of Eagle	160.0	S	N/A	1931.25
WK92	42-50-57.12	88-19-37.20	314,005	2,448,631	T. 5 N., R. 18 E. Sec. 35	Town of Mukwonago	175.0	S	N/A	1931.25
WK93	42-54-06.48	88-13-26.40	333,743	2,475,839	T. 5 N., R. 19 E. Sec. 11	Town of Vernon	160.0	S	N/A	1931.25
WK94	42-55-45.12	88-05-49.56	344,476	2,509,605	T. 5 N., R. 20 E. Sec. 2	City of Muskego	100.0	S	N/A	1931.25
WK95	42-53-39.84	88-09-02.16	331,474	2,495,561	T. 5 N., R. 20 E. Sec. 17	City of Muskego	103.5	S	N/A	1931.25
WK96	42-50-51.72	88-07-42.96	314,590	2,501,837	T. 5 N., R. 20 E. Sec. 34	City of Muskego	190.0	S	N/A	1931.25
WK97	43-00-06.12	88-28-32.16	368,811	2,407,771	T. 6 N., R. 17 E. Sec. 10	Village of Dousman	75.0	S	N/A	1931.25
WK98	43-00-41.76	88-22-39.72	372,913	2,433,885	T. 6 N., R. 18 E. Sec. 4	Village of Wales	190.0	S	N/A	1931.25
WK99	42-58-14.88	88-18-22.68	358,426	2,453,281	T. 6 N., R. 18 E. Sec. 24	Town of Genesee	150.0	S	N/A	1931.25
WK100	42-55-51.96	88-21-05.40	343,718	2,441,172	T. 6 N., R. 18 E. Sec. 34	Town of Genesee	90.0	S	N/A	1931.25
WK101	43-00-37.80	88-13-52.32	373,309	2,473,070	T. 6 N., R. 19 E. Sec. 3	City of Waukesha	52.9	S	N/A	1932.50
WK102	42-59-29.04	88-16-19.20	366,121	2,462,304	T. 6 N., R. 19 E. Sec. 8	City of Waukesha	120.0	S	N/A	1931.25
WK103	42-59-23.64	88-14-12.48	365,771	2,471,731	T. 6 N., R. 19 E. Sec. 10	City of Waukesha	70.0	S	N/A	1931.25
WK104	42-59-44.88	88-11-43.08	368,159	2,482,786	T. 6 N., R. 19 E. Sec. 12	Town of Waukesha	110.0	S	N/A	1932.50
WK105	42-58-22.80	88-14-10.32	359,617	2,472,022	T. 6 N., R. 19 E. Sec. 22	City of Waukesha	90.0	S	N/A	1931.25
WK106	42-59-46.68	88-07-38.28	368,742	2,500,970	T. 6 N., R. 20 E. Sec. 12	City of New Berlin	138.0	S	N/A	1932.50
WK107	42-57-46.08	88-04-23.52	356,866	2,515,722	T. 6 N., R. 20 E. Sec. 24	City of New Berlin	120.0	S	N/A	1932.50
WK108	42-57-14.76	88-06-15.48	353,505	2,507,471	T. 6 N., R. 20 E. Sec. 26	City of New Berlin	100.0	S	N/A	1931.25
WK109	42-56-28.68	88-09-50.40	348,483	2,491,595	T. 6 N., R. 20 E. Sec. 32	City of New Berlin	85.0	S	N/A	1931.25
WK110	43-05-13.92	88-28-38.28	399,959	2,406,747	T. 7 N., R. 17 E. Sec. 10	City of Oconomowoc	156.0	S	N/A	1931.25
WK111	43-03-21.96	88-25-15.24	388,907	2,422,026	T. 7 N., R. 18 E. Sec. 19	City of Delafield	90.0	S	N/A	1931.25
WK112	43-03-19.44	88-22-14.52	388,910	2,435,445	T. 7 N., R. 18 E. Sec. 21	City of Delafield	70.0	S	N/A	1931.25
WK113	43-02-55.68	88-20-39.84	386,643	2,442,521	T. 7 N., R. 18 E. Sec. 23	Town of Delafield	102.0	S	N/A	1932.50

Table 53 (continued)

Site Number (See Map 54)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK114	43-04-48.72	88-13-33.60	398,736	2,473.920	T. 7 N., R. 19 E. Sec. 10	City of Pewaukee	68.0	S	N/A	1931.25
WK115	43-04-32.52	88-15-53.28	396,878	2,463,590	T. 7 N., R. 19 E. Sec. 9	Village of Pewaukee	85.0	S	N/A	1932.50
WK116	43-04-10.92	88-15-38.88	394,714	2,464,704	T.7 N., R. 19 E. Sec. 16	City of Pewaukee	115.0	S	N/A	1931.25
WK117	43-02-53.52	88-12-11.08	387,207	2,480,294	T. 7 N., R. 19 E. Sec. 24	City of Pewaukee	62.0	S	N/A	1932.50
WK118	43-01-38.28	88-16-13.80	379,210	2,462,433	T. 7 N., R. 19 E. Sec. 32	City of Waukesha	50.0	S	N/A	1931.25
WK119	43-06-03.96	88-04-28.92	407,247	2,514,157	T. 7 N., R. 20 E. Sec. 1	Village of Butler	80.0	S	N/A	1931.25
WK120	43-05-26.16	88-07-37.92	403,102	2,500,225	T. 7 N., R. 20 E. Sec. 4	City of Brookfield	75.0	S	N/A	1931.25
WK121	43-03-29.88	88-07-27.84	391,350	2,501,237	T. 7 N., R. 20 E. Sec. 22	City of Brookfield	90.0	S	N/A	1931.25
WK122	43-02-23.64	88-04-26.76	384,952	2,514,832	T. 7 N., R. 20 E. Sec. 25	Village of Elm Grove	150.0	S	N/A	1932.50
WK123	43-01-59.52	88-09-01.08	382,050	2,494,520	T. 7 N., R. 20 E. Sec. 29	Town of Brookfield	54.0	S	N/A	1931.25
WK124	43-01-40.44	88-06-42.84	380,349	2,504,828	T. 7 N., R. 20 E. Sec. 34	City of Brookfield	90.0	S	N/A	1932.50
WK125	43-11-11.76	88-31-18.48	435,967	2,394,219	T. 8 N., R. 17 E. Sec. 6	Town of Oconomowoc	120.0	S	N/A	1931.25
WK126	43-07-11.64	88-31-19.2	411,660	2,394,597	T. 8 N., R. 17 E. Sec. 31	City of Oconomowoc	68.0	S	N/A	1931.25
WK127	43-06-51.48	88-27-43.2	409,909	2,410,652	T. 8 N., R. 17 E. Sec. 34	Town of Oconomowoc	120.0	S	N/A	1931.25
WK128	43-08-55.68	88-24-06.12	422,784	2,426,509	T. 8 N., R. 18 E. Sec. 19	Town of Merton	140.0	S	N/A	1931.25
WK129	43-06-19.08	88-21-29.88	407,158	2,438,401	T. 7 N., R. 18 E. Sec. 3	Village of Hartland	160.0	S	N/A	1932.50
WK130	43-09-48.6	88-12-49.32	429,158	2,476,555	T. 8 N., R. 19 E. Sec. 11	Town of Lisbon	160.0	S	N/A	1931.25
WK131	43-09-28.44	88-17-04.20	426,721	2,457,712	T. 8 N., R. 19 E. Sec. 18	Town of Lisbon	100.0	S	N/A	1931.25
WK132	43-06-53.64	88-17-29.4	411,014	2,456,166	T. 8 N., R. 19 E. Sec. 31	Town of Lisbon	57.0	S	N/A	1931.25
WK133	43-06-35.64	88-12-20.52	409,674	2,479,109	T. 8 N., R. 19 E. Sec. 35	Town of Lisbon	130.0	S	N/A	1931.25
WK134	43-11-10.68	88-07-51.96	437,949	2,498,402	T. 8 N., R. 20 E. Sec. 4	Village of Menomonee Falls	130.0	S	N/A	1932.50
WK135	43-09-03.96	88-07-24.60	425,169	2,500,717	T. 8 N., R. 20 E. Sec. 15	Village of Menomonee Falls	100.0	S	N/A	1931.25

Table 53 (continued)

Site Number (See Map 54)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK136	43-07-29.64	88-03-57.6	415,973	2,516,278	T. 8 N., R. 20 E. Sec. 25	Village of Menomonee Falls	80.0	S	N/A	1932.50
WK137	43-07-40.80	88-07-21.36	416,757	2,501,146	T. 8 N., R. 20 E. Sec. 27	Village of Menomonee Falls	110.0	S	N/A	1931.25

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

Waukesha County. These antenna sites represent a significant resource that can be used in planning and developing future fixed wireless networks within the County. As previously noted, geographic coverage maps will be prepared only for cooperating service providers and set forth in separate reports. Geographic coverage and other performance information based on the regional network monitoring system are presented in Chapter VI of this report.

SUMMARY AND CONCLUSIONS

This chapter documents an inventory of the cellular/PCS mobile wireless network infrastructure within the Southeastern Wisconsin Region. The inventory found that as of December 2005, there were 1,010 antenna sites within the Region. The geographic location and technical characteristics of the antennas concerned are documented in this chapter. These 1,010 antenna sites were distributed throughout the seven counties as listed: Kenosha–94 sites; Milwaukee–275 sites; Ozaukee–67 sites; Racine–114 sites; Walworth–84 sites; Washington–100 sites; and Waukesha–276 sites.

The inventory data were collated from three primary sources: Federal Communications Commission (FCC) databases,

1. Local units of government permit records, and

2. Individual wireless service providers.

The Federal Communications Commission (FCC) database was found to have a significant number of omissions and errors. Local units of government provided the most comprehensive source of the needed data covering all frequency bands and technologies. These first two sources were supplemented by information from two wireless carriers—Sprint PCS and Nextel Communications. Sprint furnished a complete set of network infrastructure data embracing all of their antenna sites in the seven-county Region except for Kenosha County. Nextel furnished only the geographic positional information for their sites. Data from these sources were reconciled into a composite data set which was then used to complete the site tables and site location maps presented in this chapter. The inventory findings provide not only current information on the wireless infrastructure of the Region, but also provide a resource for consideration of future wireless system deployment.

Table 54

LOCATIONS AND SELECTED CHARACTERISTICS OF T-MOBILE WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 55)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK138	42-54-35	88-20-37	335,970	2,443,739	T. 5 N., R. 18 E. Sec. 11	W299 S7404 STH 83 Town of Mukwonago	121.4	O	N/A	N/A
WK139	42-54-51	88-12-48	338,310	2,478,600	T. 5 N., R. 19 E. Sec. 11	W233 S7200 Vernon Ln. Village of Big Bend	121.4	S	N/A	N/A
WK140	42-53-50	88-16-24	331,797	2,462,658	T. 5 N., R. 19 E. Sec. 17	S81 W26220 National Ave. Town of Vernon	180.5	O	N/A	N/A
WK141	42-53-39	88-09-01	331,391	2,495,650	T. 5 N., R. 20 E. Sec. 17	W198 S8235 Mercury Dr. City of Muskego	180.5	O	N/A	N/A
WK142	42-50-51	88-07-43	314,517	2,501,836	T. 5 N., R. 20 E. Sec. 34	S108 W17185 Loomis Rd. City of Muskego	180.5	O	N/A	N/A
WK143	42-58-14	88-18-21	358,340	2,453,407	T. 6 N., R. 18 E. Sec. 6	S40 W28091 Genesee Rd. Town of Genesee	150.1	O	N/A	N/A
WK144	43-00-54	88-25-08	373,841	2,422,847	T. 6 N., R. 18 E. Sec. 24	S15 W33950 Wolf Rd. Town of Genesee	177.2	O	N/A	N/A
WK145	42-56-16	88-23-55	345,905	2,428,810	T. 6 N., R. 18 E. Sec. 32	109 Oakridge Dr. Village of North Prairie	141.1	O	N/A	N/A
WK146	42-55-51	88-21-04	343,623	2,441,578	T. 6 N., R. 18 E. Sec. 34	S63 W30100 Road X Town of Genesee	150.1	O	N/A	N/A
WK147	43-00-39	88-13-34	428,116	2,473,265	T. 6 N., R. 19 E. Sec. 2	801 N. East Ave. City of Waukesha	98.4	O	N/A	N/A
WK148	42-59-38	88-15-04	367,144	2,467,872	T. 6 N., R. 19 E. Sec. 9	900 Sentry Dr. City of Waukesha	150.9	O	N/A	N/A
WK149	42-58-48	88-11-51	362,389	2,482,322	T. 6 N., R. 19 E. Sec. 13	1727 Hunter Rd. City of Waukesha	187.0	O	N/A	N/A
WK150	42-59-49	88-07-37	368,979	2,501,060	T. 6 N., R. 20 E. Sec. 10	2600 S. Calhoun Rd. City of New Berlin	177.2	O	N/A	N/A
WK151	43-05-09	88-28-49	399,447	2,405,961	T. 7 N., R. 17 E. Sec. 10	965 Canon Gate Rd. City of Oconomowoc	19.7	S	N/A	N/A
WK152	43-05-35	88-19-55	402,836	2,445,527	T. 7 N., R. 18 E. Sec. 2	734 Coventry Ln. Village of Hartland	88.6	O	N/A	N/A
WK153	43-03-23	88-25-13	389,015	2,422,190	T. 7 N., R. 18 E. Sec. 19	250 Enterprise Dr. City of Delafield	131.2	S	N/A	N/A
WK154	43-02-44	88-21-16	385,408	2,439,860	T. 7 N., R. 18 E. Sec. 27	3820 Kettle Court East City of Delafield	160.8	O	N/A	N/A
WK155	43-01-08	88-19-25	375,855	2,448,296	T. 7 N., R. 18 E. Sec. 36	S12 W28925 Summit Ave. Town of Delafield	190.3	O	N/A	N/A
WK156	43-05-43	88-16-41	403,938	2,459,902	T. 7 N., R. 19 E. Sec. 5	1010 Quinlan Dr. Village of Pewaukee	183.7	O	N/A	N/A
WK157	43-04-11	88-15-38	394,723	2,464,770	T. 7 N., R. 19 E. Sec. 16	800 Main St. Village of Pewaukee	124.7	O	N/A	N/A
WK158	43-01-48	88-14-59	380,310	2,467,968	T. 6 N., R. 19 E. Sec. 33	1520 Evergreen Dr. City of Waukesha	88.6	O	N/A	N/A
WK159	43-05-25	88-07-37	402,986	2,500,295	T. 7 N., R. 20 E. Sec. 4	17340 W. Capitol Dr. City of Brookfield	78.7	O	N/A	N/A
WK160	43-04-26	88-04-52	397,293	2,485,398	T. 7 N., R. 20 E. Sec. 13	13595 W. Burleigh Rd. City of Brookfield	101.7	O	N/A	N/A

Table 54 (continued)

Site Number (See Map 55)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK161	43-03-04	88-11-02	388,378	2,485,398	T. 7 N., R. 20 E. Sec. 19	21225 Enterprise Ave. City of Brookfield	150.1	O	N/A	N/A
WK162	43-03-29	88-07-27	391,262	2,501,301	T. 7 N., R. 20 E. Sec. 22	2100 N. Calhoun Rd. City of Brookfield	141.1	O	N/A	N/A
WK163	43-01-40	88-06-42	380,505	2,504,891	T. 7 N., R. 20 E. Sec. 34	127 S. Moorland Rd. City of Brookfield	141.1	O	N/A	N/A
WK164	43-11-23	88-27-40	437,398	2,410,382	T. 8 N., R. 17 E. Sec. 3	W361 N9317 Brown St. Town of Oconomowoc	193.6	O	N/A	N/A
WK165	43-07-11	88-31-18	411,597	2,394,687	T. 8 N., R. 17 E. Sec. 31	1306 W. Wisconsin Ave. City of Oconomowoc	65.6	S	N/A	N/A
WK166	43-09-37	88-22-14	427,127	2,434,737	T. 8 N., R. 18 E. Sec. 16	W314 N7796 Kilbourne Rd. Town of Merton	249.4	O	N/A	N/A
WK167	43-11-21	88-12-10	438,573	2,479,267	T. 8 N., R. 19 E. Sec. 2	W230 N9401 Colgate Rd. Town of Lisbon	160.8	O	N/A	N/A
WK168	43-09-48	88-12-49	429,089	2,476,580	T. 8 N., R. 19 E. Sec. 11	W235 N8019 Woodside Rd. Town of Lisbon	180.5	O	N/A	N/A
WK169	43-09-28	88-17-03	426,678	2,457,801	T. 8 N., R. 19 E. Sec. 18	N76 W27030 Bartlett Pkwy. Town of Sussex	160.8	O	N/A	N/A
WK170	43-06-48	88-12-21	410,942	2,479,047	T. 8 N., R. 19 E. Sec. 35	N52 W23096 Lisbon Rd. Village of Sussex	154.2	S	N/A	N/A
WK171	43-06-48	88-12-21	410,942	2,479,047	T. 8 N., R. 19 E. Sec. 35	N52 W23038 CTH K Town of Lisbon	150.9	O	N/A	N/A
WK172	43-10-10	88-04-27	432,153	2,513,724	T. 8 N., R. 20 E. Sec. 12	N83 W13330 Leon Rd. Village of Menomonee Falls	141.1	O	N/A	N/A
WK173	43-08-53	88-06-23	424,163	2,505,307	T. 8 N., R. 20 E. Sec. 22	W156 N7419 Pilgrim Rd. Village of Menomonee Falls	78.7	O	N/A	N/A
WK174	43-09-22	88-09-06	426,827	2,493,162	T. 8 N., R. 20 E. Sec. 18	W193 N7700 Becker Dr. Village of Lannon	426.5	O	N/A	N/A
WK175	43-07-09	88-07-09	416,090	2,502,078	T. 8 N., R. 20 E. Sec. 27	N60 W16765 Kohler Ln. Village of Menomonee Falls	88.6	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*
[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*
[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

Table 55

LOCATIONS AND SELECTED CHARACTERISTICS OF U.S. CELLULAR WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 56)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK176	42-54-08	88-28-33	332,561	2,408,371	T. 5 N., R. 17 E. Sec. 10	S78 W36600 Wilton Rd. Town of Eagle	180.5	O	N/A	N/A
WK177	42-52-41	88-24-11	324,120	2,428,037	T. 5 N., R. 18 E. Sec. 20	S92 W32778 CTH N Town of Mukwonago	229.7	O	N/A	N/A
WK178	42-50-56	88-19-35	313,895	2,448,797	T. 5 N., R. 18 E. Sec. 5	981 Greenwald Ct. Village of Mukwonago	180.5	O	N/A	N/A
WK179	42-54-16	88-15-44	334,490	2,465,580	T. 5 N., R. 19 E. Sec. 9	S74 W25755 Hi-Lo Dr. Town of Vernon	88.6	O	N/A	N/A
WK180	42-52-30	88-17-23	323,609	2,458,433	T. 5 N., R. 19 E. Sec. 19	S93 W27180 Karlstadt Dr. Town of Vernon	147.6	O	N/A	N/A
WK181	42-55-45	88-05-49	344,465	2,509,647	T. 5 N., R. 20 E. Sec. 2	W146 S6360 Tess Corners Dr. City of Muskego	131.2	O	N/A	N/A
WK182	42-53-47	88-08-33	332,247	2,497,715	T. 5 N., R. 20 E. Sec. 15	W182 S8200 Racine Ave. City of Muskego	98.4	O	N/A	N/A
WK183	43-00-42	88-25-32	372,444	2,407,716	T. 6 N., R. 17 E. Sec. 3	160 W. Ottawa Ave. Village of Dousman	141.1	S	N/A	N/A
WK184	42-55-52	88-55-52	343,344	2,421,939	T. 6 N., R. 17 E. Sec. 36	S62 W34052 Piper Rd. Village of North Prairie	180.5	O	N/A	N/A
WK185	43-00-54	88-24-40	373,980	2,424,927	T. 6 N., R. 18 E. Sec. 6	S14 W33507 USH 18 Town of Genesee	249.4	O	N/A	N/A
WK186	42-58-21	88-21-35	358,760	2,438,973	T. 6 N., R. 18 E. Sec. 22	W304 S3925 Brookhill Rd. Town of Genesee	154.2	O	N/A	N/A
WK187	42-55-51	88-21-04	343,623	2,441,578	T. 6 N., R. 18 E. Sec. 34	S63 W30100 Road X Town of Genesee	150.9	O	N/A	N/A
WK188	43-00-40	88-13-44	373,545	2,473,683	T. 6 N., R. 19 E. Sec. 3	222 Park Pl. City of Waukesha	68.9	O	N/A	N/A
WK189	42-59-28	88-16-18	366,017	2,462,395	T. 6 N., R. 19 E. Sec. 8	2211 Badger Ct. City of Waukesha	180.5	O	N/A	N/A
WK190	42-59-44	88-11-42	368,071	2,482,868	T. 6 N., R. 19 E. Sec. 12	W227 S2698 Racine Ave. Town of Waukesha	118.1	O	N/A	N/A
WK191	43-00-43	88-05-18	374,679	2,511,261	T. 6 N., R. 20 E. Sec. 2	1711 S. Sunnyslope Rd. City of New Berlin	121.4	O	N/A	N/A
WK192	42-58-02	88-05-46	358,336	2,509,554	T. 6 N., R. 20 E. Sec. 23	4333 S. Sunnyslope Rd. City of New Berlin	124.7	O	N/A	N/A
WK193	43-06-04	88-25-41	405,273	2,419,804	T. 7 N., R. 17 E. Sec. 1	4430 Sawyer Rd. Village of Oconomowoc Lake	150.9	O	N/A	N/A
WK194	43-05-09	88-28-46	399,451	2,406,184	T. 7 N., R. 17 E. Sec. 10	965 Canon Gate Rd. City of Oconomowoc	13.1	O	N/A	N/A
WK195	43-05-47	88-19-36	404,079	2,446,912	T. 7 N., R. 18 E. Sec. 2	N44 W29190 Oxford Dr. Town of Delafield	249.4	O	N/A	N/A
WK196	43-03-23	88-25-13	389,015	2,422,190	T. 7 N., R. 18 E. Sec. 19	250 Enterprise Dr. City of Delafield	131.2	S	N/A	N/A
WK197	43-03-02	88-22-21	387,135	2,434,999	T. 7 N., R. 18 E. Sec. 21	2725 Heritage Dr. City of Delafield	32.8	O	N/A	N/A
WK198	43-02-44	88-21-16	385,408	2,439,860	T. 7 N., R. 18 E. Sec. 27	3820 Kettle Ct. East City of Delafield	160.8	O	N/A	N/A
WK199	43-01-08	88-19-25	375,855	2,448,296	T. 7 N., R. 18 E. Sec. 36	S12 W28925 Summit Ave. Town of Delafield	190.3	O	N/A	N/A
WK200	43-05-43	88-16-41	403,938	2,459,902	T. 7 N., R. 19 E. Sec. 5	1010 Quinlan Dr. Village of Pewaukee	108.3	O	N/A	N/A

Table 55 (continued)

Site Number (See Map 56)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK201	43-04-32	88-13-35	397,041	2,473,852	T. 7 N., R. 19 E. Sec. 10	W240 N3065 Pewaukee Rd. City of Pewaukee	157.5	O	N/A	N/A
WK202	43-03-02	88-16-40	387,644	2,460,313	T. 7 N., R. 19 E. Sec. 20	2810 Golf Rd. City of Waukesha	124.7	O	N/A	N/A
WK203	43-02-01	88-12-18	381,880	2,479,895	T. 7 N., R. 19 E. Sec. 25	W230 N233 Wolf Rd. City of Pewaukee	170.6	O	N/A	N/A
WK204	43-02-03	88-14-44	381,852	2,469,049	T. 7 N., R. 19 E. Sec. 27	1210 Northview Rd. City of Waukesha	108.3	O	N/A	N/A
WK205	43-05-26	88-06-25	403,208	2,505,634	T. 7 N., R. 20 E. Sec. 3	15740 W. Capitol Dr. City of Brookfield	68.9	O	N/A	N/A
WK206	43-05-06	88-10-32	400,775	2,487,356	T. 7 N., R. 20 E. Sec. 7	21195 W. Gumina Rd. Town of Brookfield	52.5	O	N/A	N/A
WK207	43-04-57	88-04-03	400,514	2,516,236	T. 7 N., R. 20 E. Sec. 12	3545 N. 124th St. City of Brookfield	68.9	O	N/A	N/A
WK208	43-03-47	88-05-42	393,260	2,504,053	T. 7 N., R. 20 E. Sec. 14	2465 Mound Zion Woods Ct. City of Brookfield	95.1	O	N/A	N/A
WK209	43-04-04	88-07-21	394,814	2,501,667	T. 7 N., R. 20 E. Sec. 15	16900 Pheasant Dr. City of Brookfield	160.8	O	N/A	N/A
WK210	43-03-04	88-11-02	388,378	2,485,398	T. 7 N., R. 20 E. Sec. 19	21225 Enterprise Ave. City of Brookfield	118.1	O	N/A	N/A
WK211	43-02-23	88-04-26	384,889	2,514,890	T. 7 N., R. 20 E. Sec. 25	900 Wall St. Village of Elm Grove	121.4	S	N/A	N/A
WK212	43-02-04	88-08-08	382,590	2,498,450	T. 7 N., R.20 E. Sec. 28	300 N. Corporate Dr. City of Brookfield	45.9	O	N/A	N/A
WK213	43-02-06	88-08-59	382,709	2,494,660	T. 7 N., R. 20 E. Sec. 29	280 Regency Ct. Town of Brookfield	39.4	O	N/A	N/A
WK214	43-01-40	88-06-42	380,305	2,504,891	T. 7 N., R. 20 E. Sec. 34	127 S. Moorland Rd. City of Brookfield	98.4	O	N/A	N/A
WK215	43-01-29	88-05-25	379,322	2,510,634	T. 7 N., R. 20 E. Sec. 35	Sunnyslope Rd. and IH 94 City of Brookfield	49.2	O	N/A	N/A
WK216	43-07-02	88-31-57	410,635	2,391,811	T. 8 N., R. 17 E. Sec. 31	W394 N5313 Reddelein Rd. Town of Oconomowoc	180.5	O	N/A	N/A
WK217	43-09-34	88-20-40	426,961	2,441,709	T. 8 N., R. 18 E. Sec. 15	N76 W30200 CTH W Town of Merton	190.3	O	N/A	N/A
WK218	43-07-11	88-22-02	412,366	2,435,916	T. 8 N., R. 18 E. Sec. 33	STH 83 and CTH K Village of Chenequa	150.9	O	N/A	N/A
WK219	43-08-03	88-14-34	418,305	2,469,024	T. 8 N., R. 19 E. Sec. 22	W249 N6424 STH 164 Town of Lisbon	180.5	O	100	885
WK220	43-07-46	88-11-24	416,886	2,483,146	T. 8 N., R. 19 E. Sec. 25	W220 N5161 Town Line Rd. Town of Lisbon	88.6	O	N/A	N/A
WK221	43-11-09	88-08-45	437,691	2,494,477	T. 8 N., R. 20 E. Sec. 5	W188 N9273 Maple Rd. Village of Menomonee Falls	78.7	O	N/A	N/A
WK222	43-10-18	88-06-08	432,791	2,506,223	T. 8 N., R. 20 E. Sec. 11	Pilgrim Rd. Village of Menomonee Falls	121.4	O	N/A	N/A
WK223	43-09-44	88-09-52	428,978	2,489,704	T. 8 N., R. 20 E. Sec. 18	W204 N7987 Lannon Rd. Village of Menomonee Falls	180.5	O	N/A	N/A

Table 55 (continued)

Site Number (See Map 56)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
WK224	43-08-53	88-06-23	424,163	2,505,307	T. 8 N., R. 20 E. Sec. 22	W156 N7149 Pilgrim Rd. Village of Menomonee Falls	85.3	O	N/A	N/A
WK225	43-07-34	88-06-16	416,179	2,506,008	T. 8 N., R. 20 E. Sec. 26	N58 W14810 Shawn Cir. Village of Menomonee Falls	121.4	O	N/A	N/A
WK226	43-06-36	88-08-13	410,113	2,497,464	T. 8 N., R. 20 E. Sec. 33	W180 N5063 Marcy Rd. Village of Menomonee Falls	150.9	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

It should be noted that in an attempt to verify antenna site data for all regional wireless service providers, letters were sent to the current five carriers operating in the Region asking for their cooperation in submitting antenna site data that could be used, not only to verify the antenna site inventory data, but to prepare 2G-3G geographic coverage maps that would guide future planning of wireless services in the Region. A thirty day response period was allowed. All five wireless service providers failed to respond during this period. Lacking such additional information, this chapter was finalized with no plans for future revisions incorporating wireless service provider data.

Table 56

LOCATIONS AND SELECTED CHARACTERISTICS OF VERIZON WIRELESS ANTENNAS IN WAUKESHA COUNTY, WISCONSIN: 2005

Site Number (See Map 57)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK227	42-53-09	88-28-54	326,561	2,406,917	T.5 N., R. 17 E. Sec. 22	545 Anton Ct. Village of Eagle	180.5	O	N/A	N/A
WK228	42-54-35	88-20-37	335,970	2,443,739	T. 5 N., R. 18 E. Sec. 11	W299 S7404 STH 83 Town of Mukwonago	131.2	O	N/A	N/A
WK229	42-52-26	88-19-34	323,006	2,448,688	T. 5 N., R. 18 E. Sec. 23	262 CTH NN East Village of Mukwonago	164.1	O	N/A	N/A
WK230	42-53-38	88-13-26	330,861	2,475,930	T. 5 N., R. 19 E. Sec. 14	S82W23600 Artesian Ave. Town of Vernon	160.8	O	N/A	N/A
WK231	42-53-50	88-16-24	331,797	2,462,658	T. 5 N., R. 19 E. Sec. 17	S81 W26220 National Ave. Town of Vernon	180.5	O	N/A	N/A
WK232	42-55-45	88-05-49	344,465	2,509,647	T. 5 N., R. 20 E. Sec. 2	W146 S6360 Tess Corners Dr. City of Muskego	150.9	O	N/A	N/A
WK233	42-54-11	88-04-48	335,055	2,514,403	T. 5 N., R. 20 E. Sec. 12	S77 W12929 McShane Dr. City of Muskego	98.4	O	N/A	N/A
WK234	42-53-29	88-09-01	331,391	2,495,650	T. 5 N., R. 20 E. Sec. 17	W198 S8235 Mercury Dr. City of Muskego	118.1	O	N/A	N/A
WK235	42-50-51	88-07-43	314,517	2,501,836	T. 5 N., R. 20 E. Sec. 34	S108 W17185 Loomis Rd. City of Muskego	170.6	O	N/A	N/A
WK236	43-00-54	88-25-08	373,941	2,422,847	T. 6 N., R. 18 E. Sec. 6	S15 W33950 Wolf Rd. Town of Genesee	177.2	O	N/A	N/A
WK237	42-58-21	88-21-35	358,760	2,438,973	T. 6 N., R. 18 E. Sec. 22	W304 S3925 Brookhill Rd. Town of Genesee	154.2	O	N/A	N/A
WK238	42-58-14	88-18-21	358,340	2,435,407	T. 6 N., R. 18 E. Sec. 24	S40 W28091 Genesee Rd. Town of Genesee	150.9	O	N/A	N/A
WK239	43-00-17	88-14-20	371,160	2,471,058	T. 6 N., R. 19 E. Sec. 3	550 Elizabeth St. City of Waukesha	68.9	O	N/A	N/A
WK240	42-59-29	88-16-18	366,118	2,462,393	T. 6 N., R. 19 E. Sec. 8	2211 Badger Ct. City of Waukesha	141.1	O	N/A	N/A
WK241	42-59-10	88-12-32	364,550	2,479,227	T. 6 N., R. 19 E. Sec. 14	1505 E. Sunset Dr. City of Waukesha	78.7	O	N/A	N/A
WK242	42-56-27	88-13-16	347,981	2,476,309	T. 6 N., R. 19 E. Sec. 26	W235 S5849 Big Bend Rd. Town of Waukesha	137.8	O	N/A	N/A
WK243	43-00-36	88-08-14	373,674	2,498,204	T. 6 N., R. 20 E. Sec. 4	1833 S. Calhoun Rd. City of New Berlin	114.8	O	N/A	N/A
WK244	42-59-47	88-06-31	368,887	2,505,967	T. 6 N., R. 20 E. Sec. 11	2665 S. Moorland Rd. City of New Berlin	42.7	O	N/A	N/A
WK245	42-59-47	88-05-13	369,019	2,511,763	T. 6 N., R. 20 E. Sec. 12	2600 S. Sunnyslope Rd. City of New Berlin	95.1	O	N/A	N/A
WK246	42-58-13	88-10-14	359,003	2,489,608	T. 6 N., R. 20 E. Sec. 19	4150 S. Swartz Rd. City of New Berlin	150.9	O	N/A	N/A
WK247	42-57-51	88-04-23	357,364	2,515,749	T. 6 N., R. 20 E. Sec. 24	12660 W. Beloit Rd. City of New Berlin	150.9	O	N/A	N/A
WK248	42-56-28	88-09-49	348,417	2,491,701	T. 6 N., R. 20 E. Sec. 32	20015 W. National Ave. City of New Berlin	118.1	O	N/A	N/A
WK249	42-56-39	88-07-04	349,804	2,503,945	T. 6 N., R. 20 E. Sec. 34	15310 S. Small Rd. City of New Berlin	98.4	O	N/A	N/A

Table 56 (continued)

Site Number (See Map 57)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
	Latitude	Longitude	North	East						
WK250	43-05-09	88-28-49	399,446	2,405,960	T. 7 N., R. 17 E. Sec. 10	965 Canon Gate Rd. City of Oconomowoc	39.4	O	N/A	N/A
WK251	43-06-19	88-21-29	407,151	2,438,466	T. 7 N., R. 18 E. Sec. 3	671 Hill St. Village of Hartland	98.4	O	N/A	N/A
WK252	43-02-44	88-21-16	385,408	2,439,860	T. 7 N., R. 18 E. Sec. 27	3820 Kettle Court East City of Delafield	160.8	O	N/A	N/A
WK253	43-01-08	88-19-25	375,855	2,448,296	T. 7 N., R. 18 E. Sec. 36	S12 W28925 Summit Ave. Town of Delafield	190.3	O	N/A	N/A
WK254	43-04-11	88-15-38	394,723	2,464,770	T. 7 N., R. 19 E. Sec. 16	800 Main St. Village of Pewaukee	141.1	O	N/A	N/A
WK255	43-03-21	88-13-32	389,859	2,474,228	T. 7 N., R. 19 E. Sec. 22	STH 164 City of Pewaukee	52.5	O	N/A	N/A
WK256	43-02-01	88-12-18	381,880	2,479,895	T. 7 N., R. 19 E. Sec. 25	W230 N229 Wolf Rd. City of Pewaukee	173.9	O	N/A	N/A
WK257	43-01-38	88-16-13	379,183	2,462,493	T. 7 N., R. 19 E. Sec. 32	1020 University Dr. City of Pewaukee	65.6	O	N/A	N/A
WK258	43-05-25	88-07-37	402,986	2,500,295	T. 7 N., R. 20 E. Sec. 4	17340 W. Capitol Dr. City of Brookfield	144.4	O	N/A	N/A
WK259	43-05-06	88-10-32	400,775	2,487,356	T. 7 N., R. 20 E. Sec. 7	21195 W. Gumina Rd. Town of Brookfield	52.5	O	N/A	N/A
WK260	43-03-47	88-05-42	393,260	2,509,053	T. 7 N., R. 20 E. Sec. 14	2465 Mound Zion Woods Ct. City of Brookfield	85.3	O	N/A	N/A
WK261	43-03-04	88-11-02	388,378	2,485,398	T. 7 N., R. 20 E. Sec. 19	21225 Enterprise Dr. City of Brookfield	98.4	O	N/A	N/A
WK262	43-03-29	88-07-27	391,262	2,501,301	T. 7 N., R. 20 E. Sec. 19	2100 N Calhoun Rd. City of Brookfield	150.9	O	N/A	N/A
WK263	43-02-23	88-04-26	384,889	2,514,890	T. 7 N., R. 20 E. Sec. 25	900 Wall St. Village of Elm Grove	160.8	S	N/A	N/A
WK264	43-01-56	88-09-06	381,685	2,494,162	T. 7 N., R. 20 E. Sec. 29	19245 Janacek Ct. Town of Brookfield	341.2	O	N/A	N/A
WK265	43-01-40	88-06-42	380,305	2,504,891	T. 7 N., R. 20 E. Sec. 34	127 S. Moorland Rd. City of Brookfield	131.2	O	N/A	N/A
WK266	43-09-37	88-22-14	427,127	2,434,737	T. 8 N., R. 18 E. Sec. 16	W314 N7796 Kilbourne Rd. Town of Merton	229.7	O	N/A	N/A
WK267	43-11-21	88-12-10	438,573	2,479,667	T. 8 N., R. 19 E. Sec. 2	W230 N9401 Colgate Rd. Town of Lisbon	160.8	O	N/A	N/A
WK268	43-10-01	88-14-39	430,241	2,468,402	T. 8 N., R. 19 E. Sec. 9	W250 N8243 Hillside Rd. Town of Lisbon	180.5	O	N/A	N/A
WK269	43-06-52	88-17-28	410,850	2,456,272	T. 8 N., R. 19 E. Sec. 31	N55 W27163 CTH K Town of Lisbon	59.0	O	500	1990
WK270	43-06-34	88-12-20	409,508	2,479,151	T. 8 N., R. 19 E. Sec. 35	W229 N5087 Duplainville Rd. Town of Lisbon	49.2	O	500	1990
WK271	43-11-29	88-06-24	439,950	2,504,874	T. 8 N., R. 20 E. Sec. 3	N96 W15885 County Line Rd. Village of Menomonee Falls	78.7	O	N/A	N/A
WK272	43-09-51	88-08-16	429,844	2,496,801	T. 8 N., R. 20 E. Sec. 9	W180 N8085 Town Hall Rd. Village of Menomonee Falls	75.5	O	N/A	N/A

Table 56 (continued)

Site Number (See Map 57)	Location						Antenna Characteristics			
	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Street Address	Height (feet)	Type[b]	Power[c] (watts)	Frequency (Megahertz)
WK273	43-09-22	88-09-06	426,827	2,493,162	T. 8 N., R. 20 E. Sec. 17	W193 N7700 Becker Dr. Village of Lannon	426.5	O	N/A	N/A
WK274	43-08-53	88-06-23	424,163	2,505,307	T. 8 N., R. 20 E. Sec. 22	W156 N7149 Pilgrim Rd. Village of Menomonee Falls	98.4	O	N/A	N/A
WK275	43-07-26	88-05-04	415,491	2,511,364	T. 8 N., R. 20 E. Sec. 25	Lilly Rd. Village of Menomonee Falls	98.4	O	N/A	N/A
WK276	43-06-42	88-07-17	410,813	2,501,604	T. 8 N., R. 20 E. Sec. 34	N51 W18900 Fair Oak Pkwy. Village of Menomonee Falls	108.3	O	N/A	N/A

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

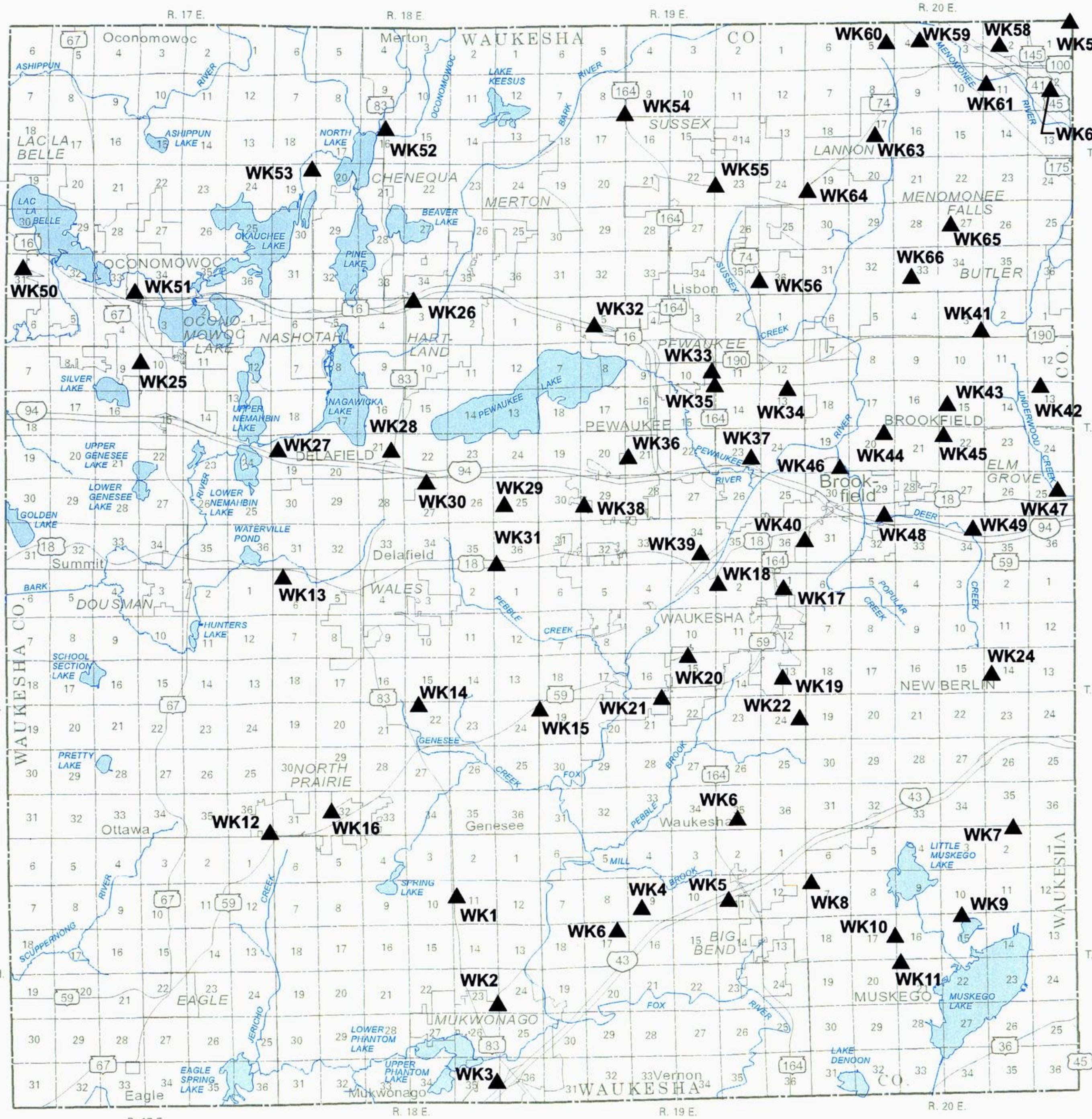
[b] *Antenna Types: S=Sectoral, O=Omni. A Sectoral antenna uses a more complex antenna structure and transmits and receives over a sector with the total number of sectors covering a 360 degrees pattern. An Omnidirectional uses a monoplex antenna and receives and transmits over a 360 degree pattern.*

[c] *The antenna power listed as collated from FCC data represent the maximum power output authorized for the particular installation concerned. N/A indicates data not available.*

Source: Federal Communications Commission, Universal Licensing System Cellular License Database, Waukesha County and local municipalities of Waukesha County, Wisconsin and SEWRPC.

Map 52

ANTENNA SITE LOCATIONS FOR CINGULAR WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

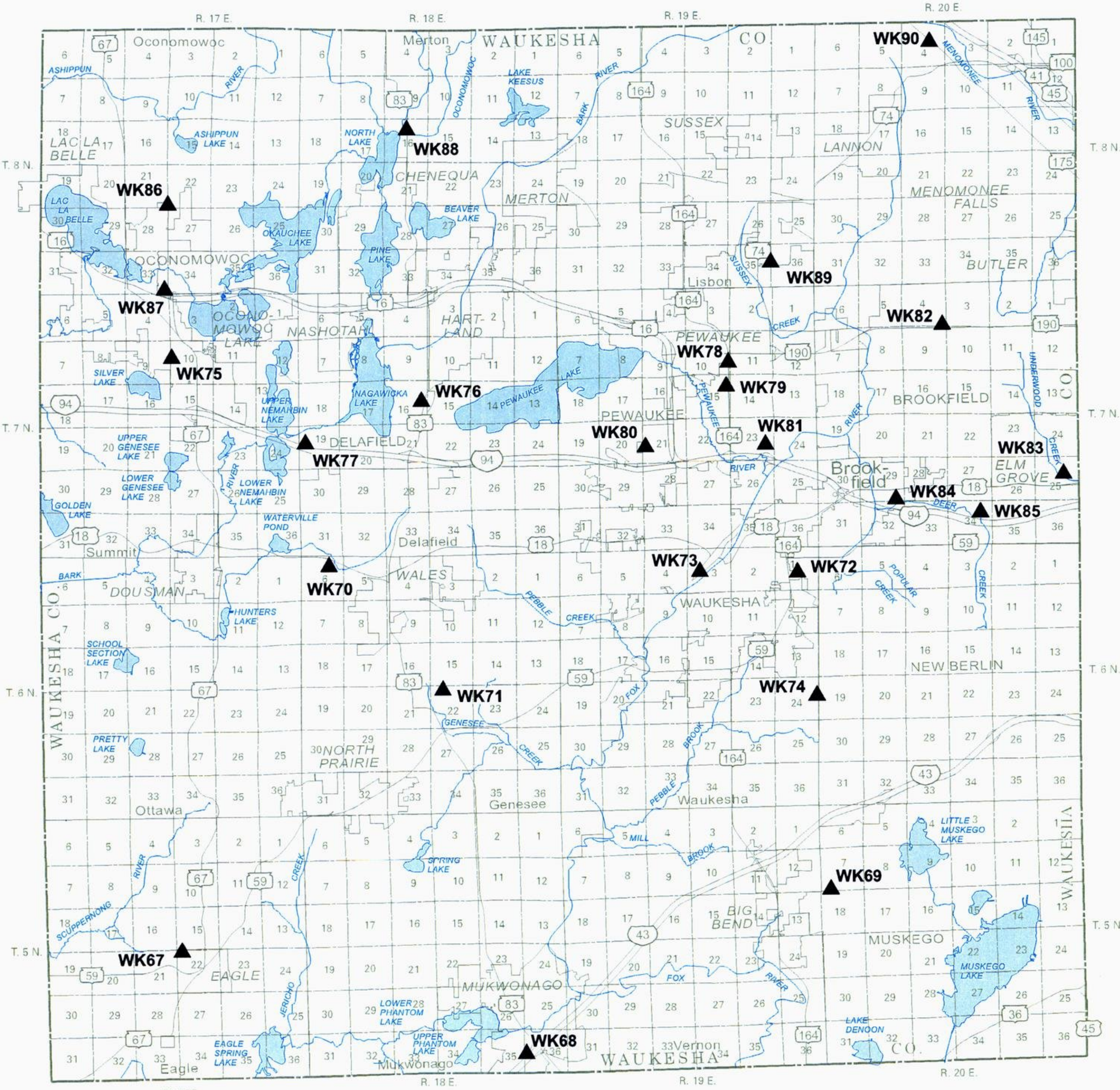
▲ ANTENNA SITE (66)

WK1 IDENTIFICATION NUMBER (SEE TABLE 51)

Source: SEWRPC.

Map 53

ANTENNA SITE LOCATIONS FOR NEXTEL WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

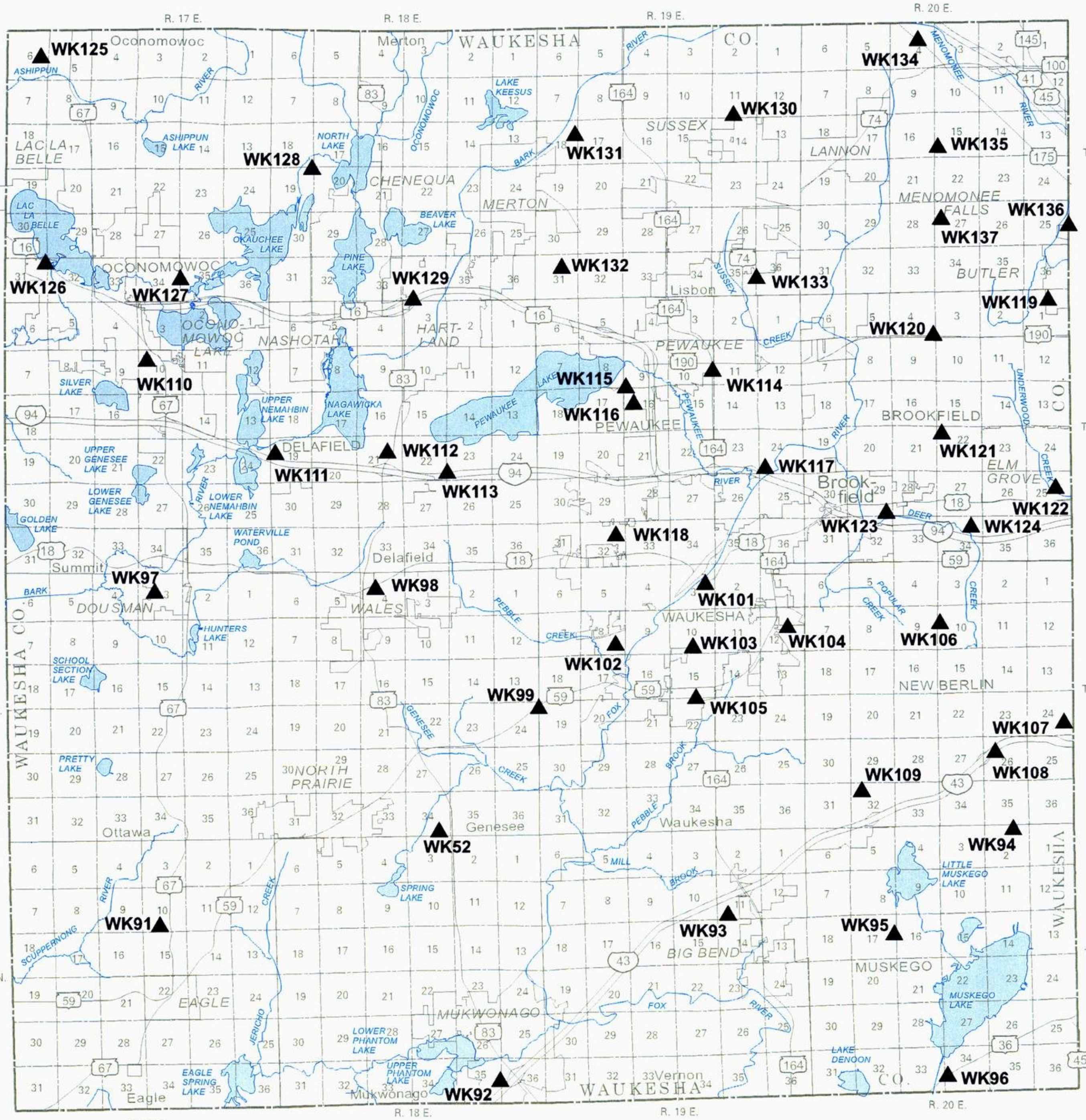
▲ ANTENNA SITE (24)

WK67 IDENTIFICATION NUMBER (SEE TABLE 52)

Source: SEWRPC.

Map 54

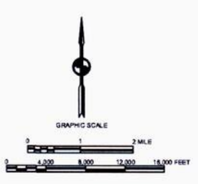
ANTENNA SITE LOCATIONS FOR SPRINT WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (47)

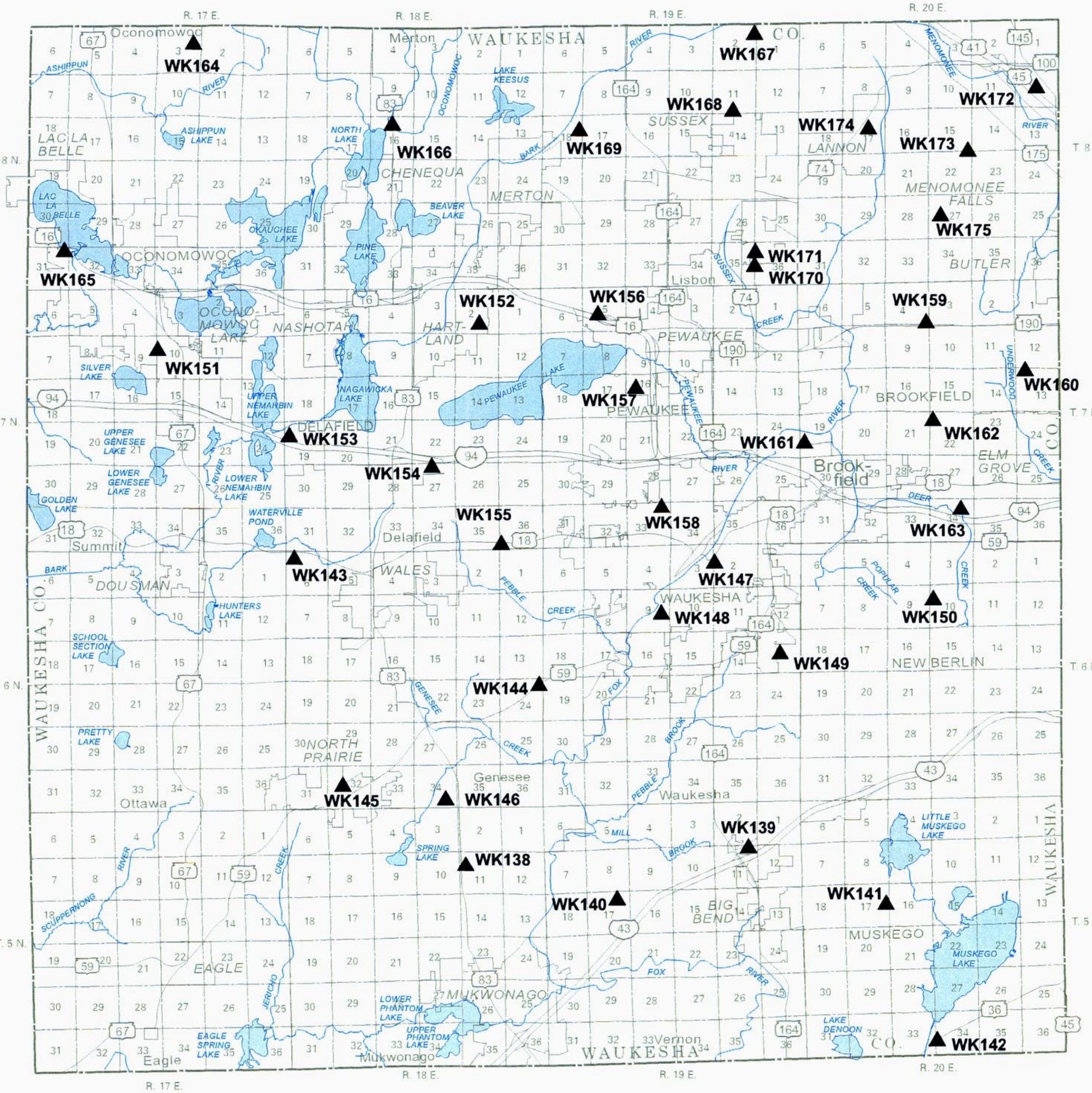
WK91 IDENTIFICATION NUMBER (SEE TABLE 53)



Source: SEWRPC.

Map 55

ANTENNA SITE LOCATIONS FOR T-MOBILE WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

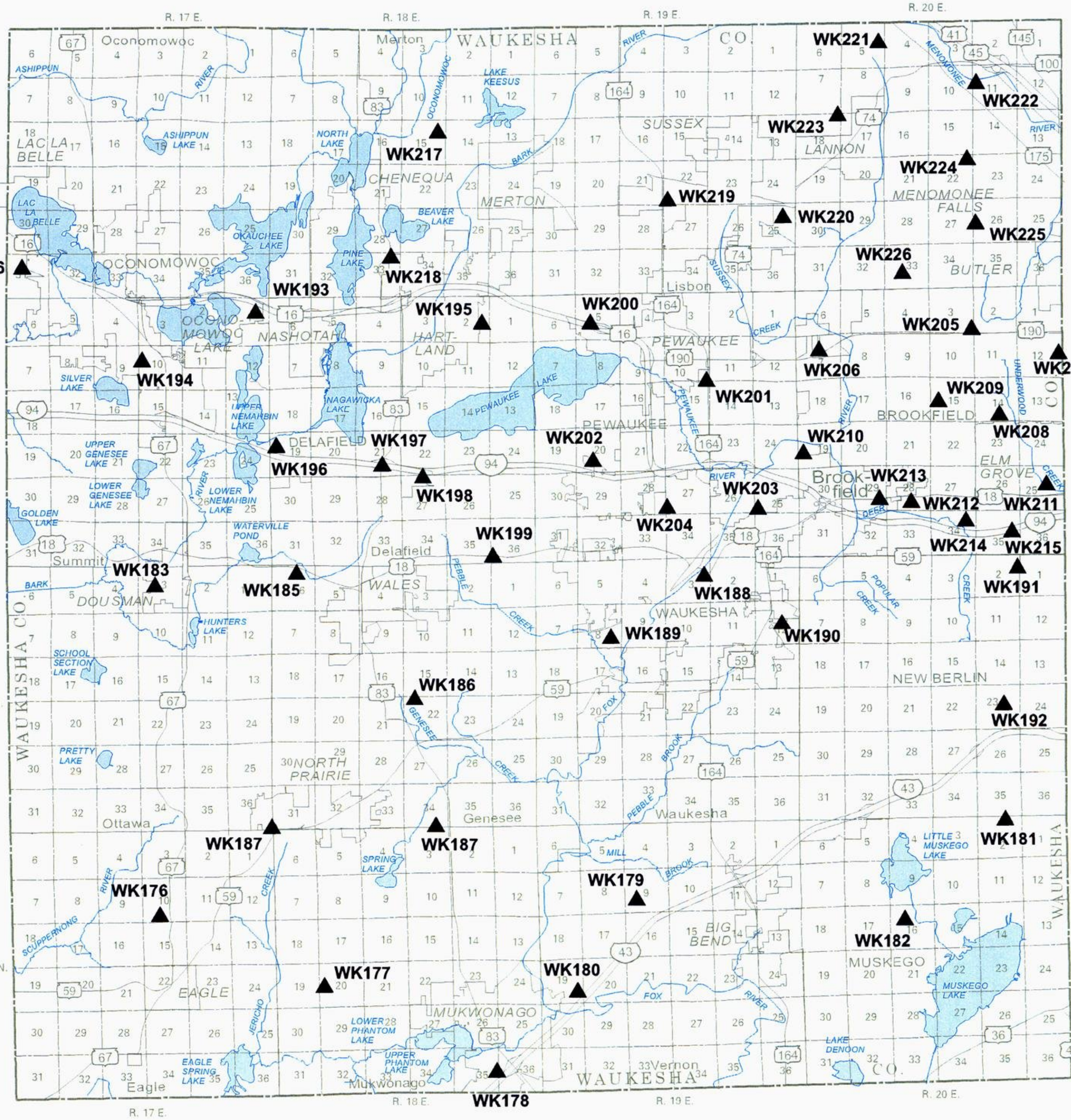
▲ ANTENNA SITE (33)

WK138 IDENTIFICATION NUMBER (SEE TABLE 54)

Source: SEWRPC.

Map 56

ANTENNA SITE LOCATIONS FOR U.S. CELLULAR WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (51)

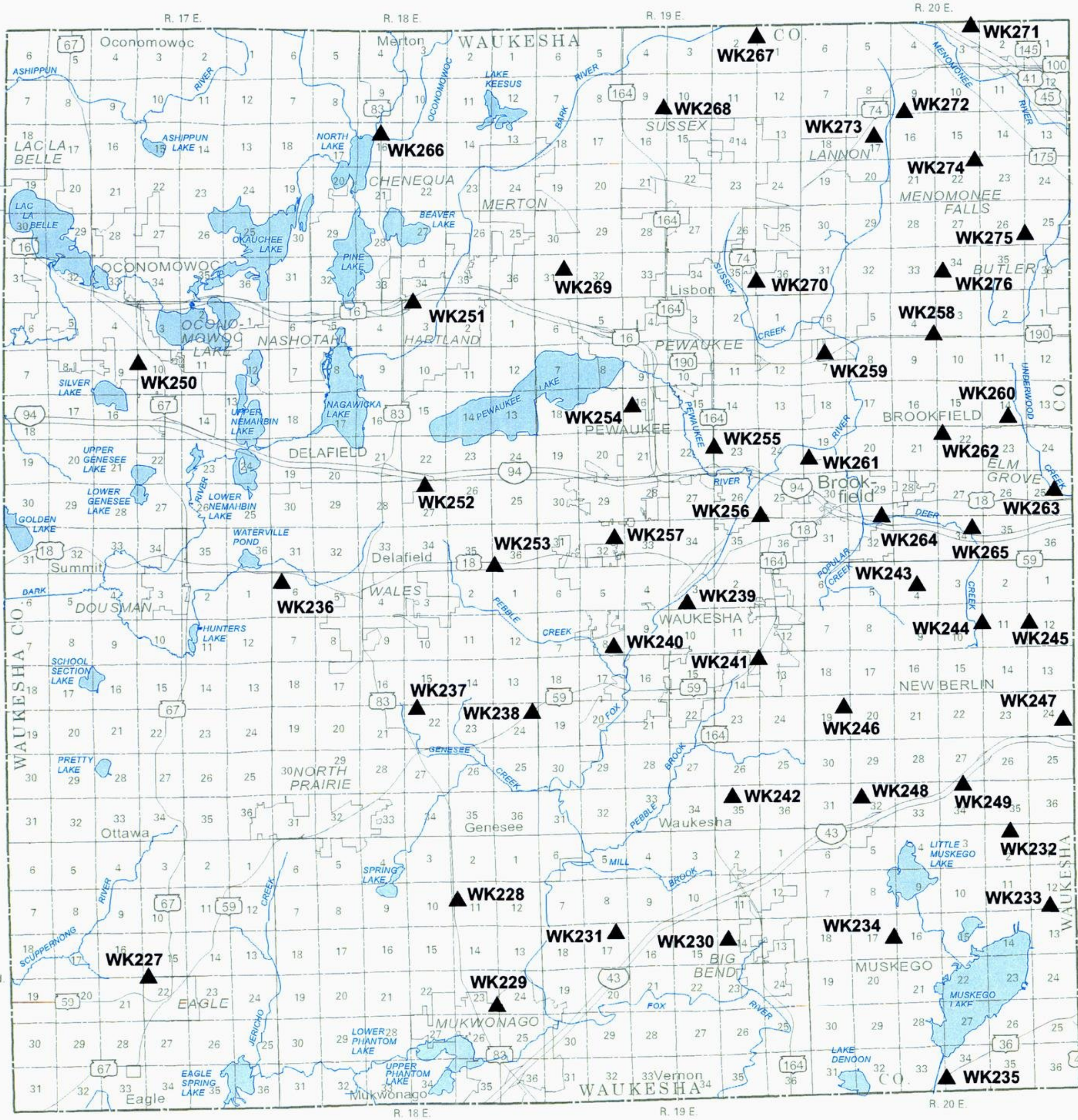
WK176 IDENTIFICATION NUMBER (SEE TABLE 55)

GRAPHIC SCALE

Source: SEWRPC.

Map 57

ANTENNA SITE LOCATIONS FOR VERIZON WIRELESS-WIRELESS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

▲ ANTENNA SITE (50)

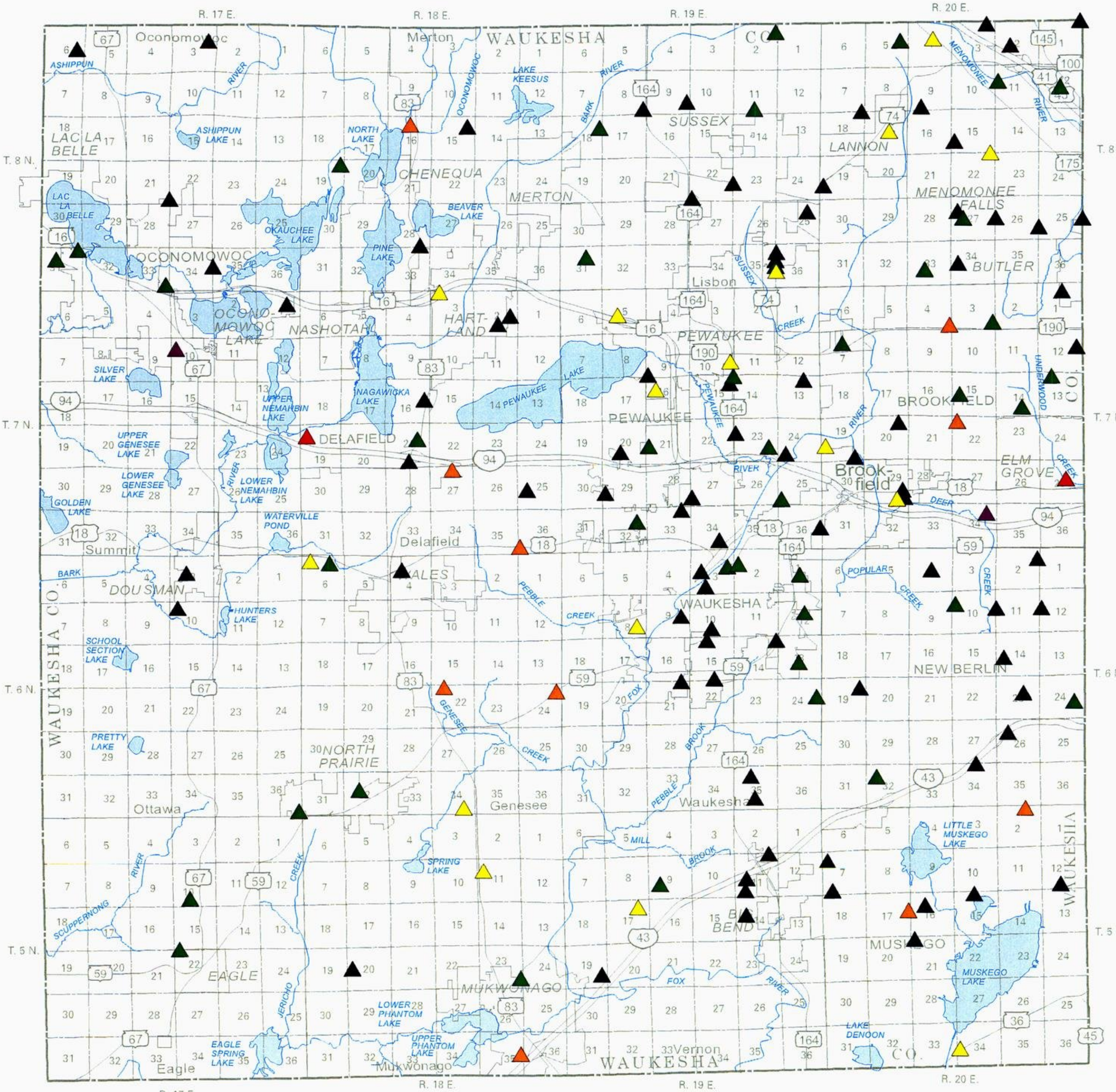
WK227 IDENTIFICATION NUMBER (SEE TABLE 56)

GRAPHIC SCALE

Source: SEWRPC.

Map 58

ANTENNA SITE LOCATIONS IN WAUKESHA COUNTY, WISCONSIN: 2005



LEGEND

▲	1 ANTENNA SITE	(82)
▲	2 ANTENNA SITES	(42)
▲	3 ANTENNA SITES	(16)
▲	4 ANTENNA SITES	(10)
▲	5 ANTENNA SITES	(2)
▲	6 ANTENNA SITES	(2)

NOTE: DUE TO MAP SCALE LIMITATIONS, LOCATIONS OF TOWERS MAYBE SLIGHTLY EXAGGERATED WHERE TWO OR MORE TOWERS ARE IN CLOSE PROXIMITY OF EACH OTHER.

Source: SEWRPC.

Table 57

LOCATIONS OF FIXED WIRELESS PROVIDERS
WITHIN THE SOUTHEASTERN WISCONSIN REGION: 2005

Site Number (See Map 59	County	Provider	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Municipality
			Latitude	Longitude	North	East		
1	Kenosha	Cyberlynk	42-33-10	87-53-37	208,641	2,567,555	T. 1 N., R. 22 E. Sec. 10	Village of Pleasant Prairie
2	Kenosha	Wisconsin Internet	42-38-20	88-04-43	238,812	2,516,993	T. 2 N., R. 20 E. Sec. 13	Town of Brighton
3	Milwaukee	Cyberlynk	43-02-13	87-58-57	384,454	2,539,340	T. 7 N., R. 21 E. Sec. 26	City of Milwaukee
4	Racine	Cyberlynk	42-43-06	87-50-54	269,270	2,578195	T. 3 N., R. 22 E. Sec. 13	Village of Mount Pleasant
5	Racine	Cyberlynk	42-43-31	87-47-07	272,244	2,595,068	T. 3 N., R. 23 E. Sec. 16	City of Racine
6	Racine	Cyberlynk	42-46-16	87-57-18	287,778	2,549,066	T. 4 N., R. 21 E. Sec. 36	Town of Raymond
7	Racine	Netwurx	42-39-45	88-31-46	244,949	2,395,549	T. 2 N., R. 19 E. Sec. 5	City of Burlington
8	Racine	Wisconsin Internet	42-39-19	88-11-24	244,113	2,486,897	T. 2 N., R. 19 E Sec. 1	Town of Burlington
9	Racine	Wisconsin Internet	42-42-26	87-54-49	264,776	2,560,759	T. 3 N., R. 22 E. Sec. 21	Village of Sturtevant
10	Racine	Wisconsin Internet	42-40-10	87-50-51	251,464	2,578,879	T. 3 N., R. 22 E. Sec. 36	Village of Mount Pleasant
11	Racine	Wisconsin Internet	42-43-30	87-47-03	272,150	2,595,369	T. 3 N., R. 23 E. Sec. 16	City of Racine
12	Racine	Wisconsin Internet	42-45-36	87-57-53	283,666	2,546,555	T. 4 N., R. 21 E. Sec. 36	Town of Raymond
13	Walworth	Netwurx	42-39-45	88-31-46	244,949	2,395,549	T. 2 N., R. 17 E. Sec 6	City of Elkhorn
14	Walworth	Netwurx	42-46-00	88-40-39	282,241	2,355,127	T. 4 N., R 15 E. Sec 36	Town of Whitewater
15	Washington	Nconnect	43-16-15	88-22-39	467,377	2,432,101	T. 9 N.,R. 18 E. Sec. 4	Town of Erin
16	Washington	Nconnect	43-14-39	88-19-40	457,921	2,445,536	T. 9 N., R. 18 E. Sec. 14	Town of Erin
17	Washington	Nconnect	43-22-05	88-21-48	502,878	2,435,178	T. 10 N., R. 18 E. Sec. 4	Town of Hartford
18	Washington	Nconnect	43-20-08	88-23-34	490,883	2,427,578	T. 10 N., R. 18 E. Sec. 17	City of Hartford
19	Washington	Nconnect	43-20-11	88-16-38	491,800	2,458,309	T. 10 N., R 19 E. Sec. 17	Village of Slinger
20	Washington	Nconnect	43-19-56	88-17-04	490,242	2,456,419	T. 10 N., R. 19 E. Sec. 18	Village of Slinger
21	Washington	Nconnect	43-19-28	88-14-06	487,683	2,469,632	T. 10 N., R. 19 E. Sec. 22	Town of Polk
22	Washington	Nconnect	43-17-18	88-06-23	475,275	2,504,146	T 10 N., R 20 E. Sec. 34	Town of Jackson
23	Washington	Nconnect	43-24-58	88-21-40	520,401	2,435,424	T. 11 N., R 18 E Sec.17	Town of Addison
24	Washington	Nconnect	43-25-32	88-12-32	524,675	2,475,787	T. 11 N., R. 19 E. Sec. 15	City of West Bend
25	Washington	Nconnect	43-23-00	88-09-03	509,626	2,491,548	T. 11 N., R 20 E. Sec. 31	Town of Trenton
26	Washington	Nconnect	43-29-18	88-21-46	546,711	2,434,465	T. 12 N., R 18 E. Sec 20	Town of Wayne
27	Washington	Nconnect	43-29-36	88-13-33	549,276	2,470,761	T. 12 N., R 19 E. Sec. 21	Town of Kewaskum
28	Washington	Nconnect	43-31-06	88-06-24	559,081	2,502,169	T. 12 N., R 20 E. Sec. 9	Town of Farmington
29	Washington	Netwurx	43-16-15	88-22-39	467,377	2,432,101	T. 9 N., R 18 E. Sec. 4	Town of Erin

Table 57 (continued)

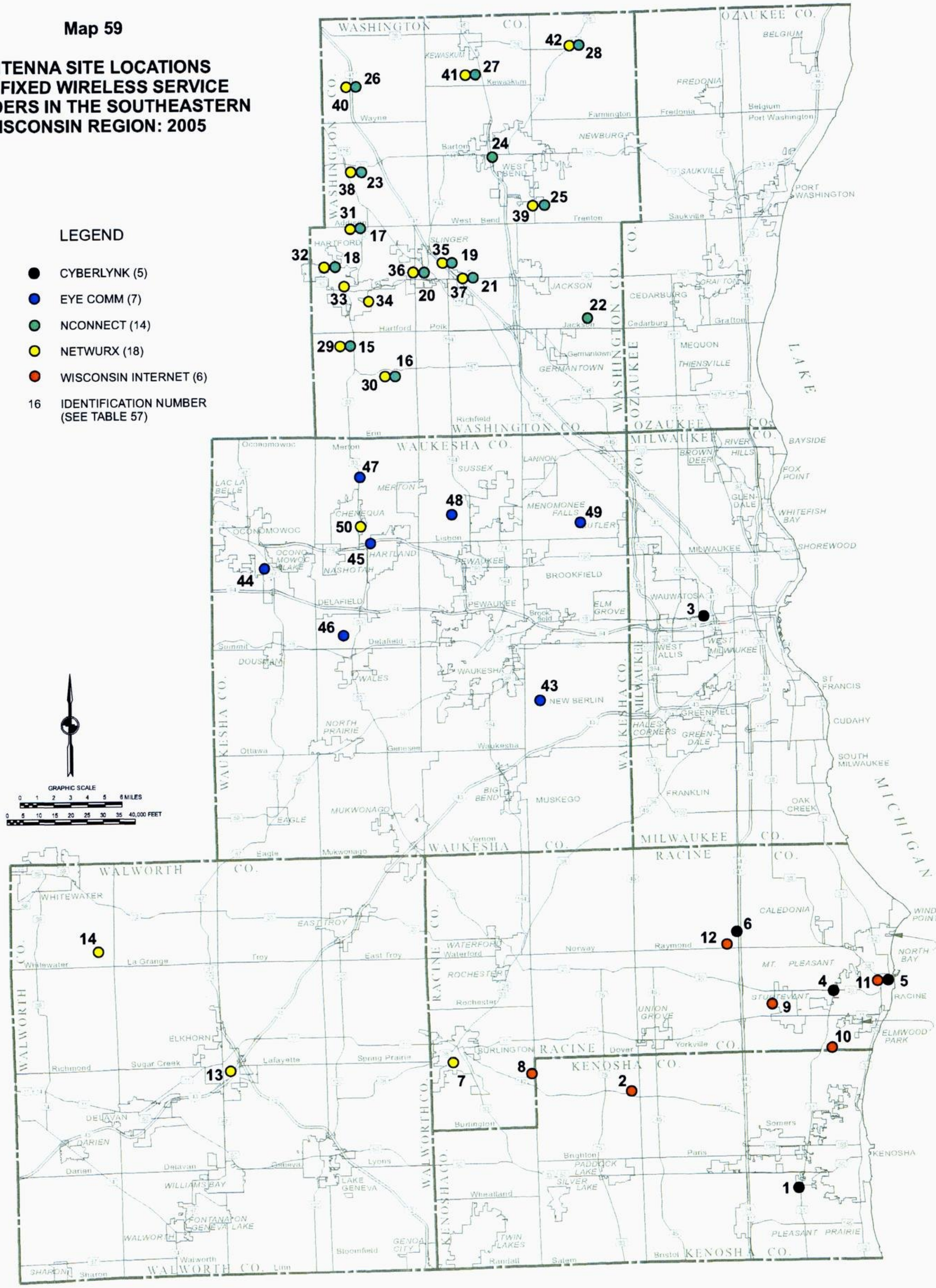
Site Number (See Map 59	County	Provider	Geographic Coordinates		State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Municipality
			Latitude	Longitude	North	East		
30	Washington	Netwurx	43-14-39	88-19-40	457,921	2,445,536	T. 9 N., R 18 E. Sec. 14	Town of Erin
31	Washington	Netwurx	43-22-05	88-21-48	502,878	2,435,178	T. 10 N., R 18 E. Sec 4	Town of Hartford
32	Washington	Netwurx	43-20-08	88-23-34	490,883	2,427,578	T. 10 N., R. 18 E. Sec.17	City of Hartford
33	Washington	Netwurx	43-19-10	88-22-49	485,076	2,431,017	T. 10 N., R. 18 E. Sec. 20	City of Hartford
34	Washington	Netwurx	43-19-10	88-22-49	485,076	2,431,017	T. 10 N., R. 18 E. Sec. 20	City of Hartford
35	Washington	Netwurx	43-20-11	88-16-38	491,800	2,458,309	T. 10 N., R 19 E. Sec. 17	Village of Slinger
36	Washington	Netwurx	43-19-56	88-17-04	490,242	2,456,419	T. 10 N., R. 19 E. Sec. 18	Village of Slinger
37	Washington	Netwurx	43-19-28	88-14-06	487,682	2,469,632	T. 10 N., R 19 E. Sec. 22	Town of Polk
38	Washington	Netwurx	43-24-58	88-21-40	520,401	2,435,424	T 11 N., R 18 E. Sec 17	Town of Addison
39	Washington	Netwurx	43-23-00	88-09-03	509,626	2,491,548	T. 11 N., R. 20 E. Sec. 31	Town of Trenton
40	Washington	Netwurx	43-29-18	88-21-46	546,711	2,434,465	T. 12 N., R 18 E. Sec 20	Town of Wayne
41	Washington	Netwurx	43-29-36	88-13-33	549,276	2,470,761	T. 12 N., R. 19 E. Sec. 21	Town of Kewaskum
42	Washington	Netwurx	43-31-06	88-06-24	559,081	2,502,169	T. 12 N., R 20 E. Sec. 9	Town of Farmington
43	Waukesha	Eyecomm	42-58-13	88-10-15	359,002	2,489,534	T. 6 N., R. 20 E. Sec. 19	City of New Berlin
44	Waukesha	Eyecomm	43-05-09	88-28-49	399,447	2,405,961	T. 7 N., R. 17 E. Sec. 10	City of Oconomowoc
45	Waukesha	Eyecomm	43-06-19	88-21-29	407,151	2,438,466	T. 7 N., R. 18 E. Sec. 3	Village of Hartland
46	Waukesha	Eyecomm	43-01-42	88-23-32	378,935	2,429,884	T. 7 N., R 18 E. Sec. 32	Town of Delafield
47	Waukesha	Eyecomm	43-09-39	88-22-12	427,332	2,434,881	T. 8 N., R. 18 E. Sec. 16	Town of Merton
48	Waukesha	Eyecomm	43-07-38	88-15-54	415,650	2,463,147	T. 8 N., R 19 E. Sec. 29	Town of Lisbon
49	Waukesha	Eyecomm	43-07-05	88-07-10	413,153	2,502,070	T. 8 N., R 20 E. Sec 34	Village of Menomonee Falls
50	Waukesha	Netwurx	43-07-11	88-22-02	412,366	2,435,916	T. 8 N.,R. 18 E. Sec. 33	Village of Chenequa

[a] *State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.*

Source: Cyberlynk, Eyecomm, Nconnect, Netwurx, Wisconsin Internet, and SEWRPC.

Map 59

ANTENNA SITE LOCATIONS FOR FIXED WIRELESS SERVICE PROVIDERS IN THE SOUTHEASTERN WISCONSIN REGION: 2005



Source: SEWRPC.

Chapter VI

WIRELESS TELECOMMUNICATIONS PERFORMANCE INVENTORY FINDINGS

INTRODUCTION

Chapter V presented the infrastructure component of the regional wireless communications inventory in terms of the antenna sites and certain associated technical characteristics. This chapter deals with the performance of the existing regional cellular-PCS wireless networks based on the performance standards set forth in Chapter III of this report and in SEWRPC Technical Design Study Memorandum No. 7. The data represents the output of a regional network performance monitoring system developed by the Commission. The system is believed to be the first in the United States to provide comprehensive performance monitoring of cellular-PCS wireless networks. Only the performance of the packet-switched wireless networks operating within the Region were monitored. The monitoring system utilized a central server computer and a supervisory desktop computer together with a number of portable remote laptop computers to carry out the performance measurements. These remote laptop computers and their associated provider-specific communications equipment were rotated on a planned schedule throughout the Region over a 16-week time period. The performance data collected over that 16-week time period provides the basis for the performance inventory findings herein reported.

WIRELESS PERFORMANCE MONITORING SYSTEM

The major equipment components of the network performance monitoring system include:

1. Network Management System (NMS) Server Computer—located at the Commission offices.
2. Supervisory NMS Desktop Computer—located at the Commission offices.
3. Five Laptop Computer Agents—located at various rotating locations throughout the Region.
4. Five Transceiver Interface Access Cards—one for each wireless cellular/PCS service provider and each integrated with one of the five laptop computers.

The above listed equipment were operated using the NetIQ AppManager. The AppManager collected data on the packet-switched network parameters defined below.

NETWORK MONITORING PARAMETERS—PACKET-SWITCHED

Packet-switched network performance is evaluated based on three performance parameters: availability, throughput, and response time.

Availability

During any monitoring session, lack of network availability is time duration recorded as a lack of service. Lack of service time on packet-switched networks is recorded as a "zero" on a one-zero availability chart over the monitoring period. Chart data was then accumulated to determine overall availability expressed as a percentage of user operating time.

Throughput

For packet-switched networks, data throughput is recorded in bits per second. In the current cellular/PCS networks within the Region, data rates are in the kilobits per second range. For a given network, there are two relevant throughput data rates—burst and sustained. Small files transmit at burst rates while larger files transmit at slow to reduced sustained rates. The Federal Communications Commission (FCC) defines the minimum "little-broadband" data rate as 200 kilobits per second. Current 3G wireless networks are achieving around 300 kilobits per second.

Response Time

Response time data for packet-switched networks are recorded by network application such as Domain Name Service (DNS) IP address lookup, POP3/SMTP (e-mail) protocol, Hyper Text Transfer Protocol (HTTP)—text or graphic, and HTTPS—the secure version of HTTP. The response time is recorded in seconds over a monitoring time period. While there is no specific standard for data traffic response time, these times should be consistent with throughput data rate standards.

NETWORKS—PACKET-SWITCHED

The performance of packet-switched networks was monitored for each of the following five of the six service providers operating within the Region: U. S. Cellular, Verizon Wireless, Nextel, Cingular, and Sprint PCS. The sixth provider—T-Mobile—was not monitored because of technical difficulties encountered in configuring the necessary connections. Each of the five laptop computers used in packet-switched monitoring has a transceiver card for one of the above providers. This laptop/transceiver combination allows each laptop to initiate, monitor, and terminate packet-switched transactions from the remote endpoint to the network management station (NMS) at the SEWRPC offices. A management server at the NMS recorded the performance parameters of the transaction. Five of the six regional cellular/PCS wireless packet-switched networks proved to be quite compatible with network performance monitoring. T-Mobile was the only service provider network that continually dropped out of a monitoring cycle for reasons that were never ascertained.

NETWORK—CIRCUIT-SWITCHED

It was decided that monitoring of the performance of circuit-switched networks was unnecessary, due in large part to the anticipated eventual phasing out of circuit-switched systems. Some providers, such as U.S. Cellular, have already begun to transition their circuit-switched networks to packet-switched technology, and the Commission anticipates that this trend will continue.

CALL DURATION AND VOLUMES

Packet-switched measurements were taken every five minutes, 24 hours per day, seven days per week with an eight hour gap separating each cycle. The scheduled days included Saturdays and Sundays as well as weekdays. These call rates produced 288 packet-switched data points per day for each wireless service provider over the 16 week monitoring period. With calls placed seven days per week 25,536 packet-switched measurements were made for each provider. A total of 127,680 packet-switched measurements were collected in the initial inventory.

MONITORING LOCATION SCHEDULING

Monitoring equipment was rotated to the next site twice per week, with two half-days per week designated for equipment rotation. Deployment was county-oriented, with two-week deployments in each county. At the beginning of each two-week cycle, six community sites were randomly selected from the civil divisions in each county. One service provider's equipment set was initially located at each of these six sites. The monitoring site within each civil division usually consisted of the city, village or town hall; a school; or a government building designated by local officials. After the initial monitoring period, the equipment sets were rotated to the next of the six sites. This cycled rotation occurred two more times during each two-week testing period for a total of four site locations for each provider. After the two-week period, the sets of equipment were moved to the next county where the process was repeated: random site selection followed by four monitoring sites for each provider in that county. At the end of the 16 week period, 28 location sites for each provider, or 146 location sites in all, were monitored.

Beginning in Ozaukee County, the initial set of six remote agent locations was randomly selected from the set of 16 civil divisions in the County. Over a two-week period, each provider set was sequentially located in four of these six locations, with the initial assignments made on a random basis. Subsequent location assignments were then accomplished by rotating the providers cyclically through the six selected county locations. Following this initial monitoring sequence in Ozaukee County, the agent equipment set was moved to Washington County where the two-week cycle was repeated, at six randomly selected sites for a two-week monitoring sequence. Once again, service providers sets were rotated to four county locations for monitoring.

All seven counties were monitored in the 16-week wireless performance monitoring inventory period. Monitoring for subsequent calendar quarters is to be continued following the same pattern except that previously selected sites will be removed from the random selection pool.

Some selected monitoring sites did not have adequate radio signal coverage for the designated provider. In such instances, the monitoring equipment was relocated to the first of the two unused sites of the six county sites for that provider. After that test period, the placement of the provider equipment was resumed on the regular schedule.

The civil division location model worked quite well in the suburban and rural areas of the Region. In a major urban area such as the City of Milwaukee, however, a higher spatial resolution required another source of monitoring site candidates. Initially, precinct police stations were selected.

A total of 42 randomly selected monitoring locations were used within the Region. A list of civil divisions within the seven county Southeastern Wisconsin Region together with their code numbers is given in Appendix A. A map of the civil divisions together with the locations of the monitoring stations is given in Appendix B. The locations of the selected monitoring sites in each county are given in Appendix C. The actual monitoring deployment dates and times are given in Appendix D. Site assignments for each time period are given in Appendix E. The start date of the initial network monitoring cycle was November 14, 2005.

PERFORMANCE MONITORING REPORTING

The Wireless Network Monitoring System recorded the packet-switched performance parameters for each transaction based on the transaction scheduling previously specified. The principal indicators of packet-switched network performance are the hourly, daily, weekly, and total summaries of parameter performance.

Packet-switched network performance reporting here includes the following summaries:

Regional-Level

- Number of locations
- Number of transactions (data points)
- Mean Availability (percent of time)
- Mean Throughput (kilobits/second) (upload and download)
- Mean Response Time (seconds)

Service Provider Level

- Same categories as regional level

County Level

- Same categories as regional level

Technology Categories

- Global System for Mobil Communication (GSM)
  - Same categories as regional level
- Code Division Multiple Access (CDMA)
  - Same categories as regional level
- Integrated Dispatches Enhanced Network (iDEN)
  - Same categories as regional level

CELLULAR/PCS NETWORK PERFORMANCE (November 14, 2005 – March 2, 2006)

Table 58 tabulates the composite performance of all wireless service providers segmented by county and averaged at the regional level. Tables 59 through 63 provides this same performance data for each of the

Table 58

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR ALL PACKET-SWITCHED CELLULAR/PCS WIRELESS NETWORKS: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[a]	Data Points[a]	Total Number of Data Points	Percent Availability
Kenosha	0.519	6,962	57.23	9,113	165.32	6,151	18,734	85.81
Milwaukee	0.255	4,318	79.25	4,652	347.73	4,468	9,665	92.81
Ozaukee	0.553	8,300	69.03	8,891	0.00	0	19,394	88.64
Racine	0.592	7,398	67.02	8,536	114.83	6,622	18,070	88.18
Walworth	0.645	2,140	67.36	2,229	76.45	2,536	5,111	85.48
Washington	0.618	4,428	65.16	4,655	0.00	0	10,125	89.71
Waukesha	0.558	9,377	50.57	9,521	0.00	0	20,356	92.84
Regionwide:	0.537	42,923	63.26	47,597	178.23	19,777	101,455	89.22

[a]*The download data presented originated only in the Sprint and Verizon wireless networks. The data represent weighted averages of the data for these two providers, with the weighing being based on the number of data points collected for each provider. Security features—firewalls—in place by the other wireless service providers prevented the collection of other download throughput data. Collection of download throughput data, unlike the other monitoring parameters, required initiation of the transaction outside of the service provider's network by a server located at SEWRPC. Such transaction initiations were blocked by firewalls at all service providers except Sprint and Verizon.*

Source: SEWRPC.

Table 59

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED CINGULAR CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kpbst[a]	Data Points[a]	Total Number of Data Points	Percent Availability
Kenosha	1.242	13	21.95	15	0	0	43	65.12
Milwaukee	0	0	0	0	0	0	0	0
Ozaukee	0.968	1,296	40.06	1,406	0	0	391	87.42
Racine	1.165	13	23.22	16	0	0	45	64.44
Walworth	1.091	14	58.54	16	0	0	53	56.60
Washington	0.907	550	38.28	487	0	0	1,204	86.13
Waukesha	0.688	2,240	48.32	2,058	0	0	4,344	98.94
Regionwide:	0.810	4,126	44.03	3,998	0	0	7,870	92.53

[a]*Security features—firewalls—in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC

Table 60

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED NEXTEL COMMUNICATIONS CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[a]	Data Points[a]	Total Number of Data Points	Percent Availability
Kenosha	5.157	61	15.82	1,535	0	0	1,982	80.52
Milwaukee	4.676	5	29.25	531	0	0	598	89.63
Ozaukee	0.725	1,189	17.31	1,230	0	0	2,634	91.84
Racine	3.982	115	15.86	1,282	0	0	1,662	84.06
Walworth	4.265	40	13.77	33	0	0	102	71.57
Washington	0	0	0	0	0	0	0	0
Waukesha	0.773	1,687	18.02	1,618	0	0	3,352	98.60
Regionwide:	1.011	3,097	17.83	6,229	0	0	10,330	90.28

[a]*Security features—firewalls—in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC.

Table 61

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED SPRINT PCS WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Kenosha	0.356	3,262	72.03	3,481	223.80	3,474	7,212	93.50
Milwaukee	0.218	1,651	93.61	1,653	364.55	1,729	3,517	93.94
Ozaukee	0.472	1,965	95.47	1,885	0.00	0	3,911	98.44
Racine	0.545	3,192	77.27	3,104	82.68	3,376	6,792	92.70
Walworth	0.550	992	80.11	1,070	75.75	1,213	2,335	88.31
Washington	0.554	401	88.76	351	0.00	0	761	98.82
Waukesha	0.409	1,195	83.07	1,192	0.00	0	2,392	99.79
Regionwide:	0.430	12,658	81.75	12,736	181.66	9,792	26,920	94.33

Source: SEWRPC.

Table 62

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED U.S. CELLULAR - CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[a]	Data Points[a]	Total Number of Data Points	Percent Availability
Kenosha	0.588	1,217	52.68	1,636	0	0	4,111	69.40
Milwaukee	0.637	51	51.47	70	0	0	170	71.18
Ozaukee	0.601	1,094	51.53	1,579	0	0	3,786	70.60
Racine	0.590	1,110	53.20	1,129	0	0	3,027	73.97
Walworth	0.589	228	51.30	222	0	0	678	66.37
Washington	0.582	531	52.65	869	0	0	1,919	72.95
Waukesha	0.591	1,354	50.51	1,921	0	0	4,365	75.03
Regionwide:	0.592	5,585	51.90	7,426	0	0	18,056	72.06

[a]*Security features—firewalls—in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC.

Table 63

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED VERIZON PCS WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Kenosha	0.584	2,409	65.40	2,446	89.42	2,677	5,386	90.14
Milwaukee	0.262	2,611	81.24	2,398	337.12	2,739	5,380	93.10
Ozaukee	0.323	2,756	98.45	2,791	0	0	5,972	92.88
Racine	0.510	2,968	83.68	3,005	148.26	3,246	6,544	91.27
Walworth	0.595	866	58.17	888	77.08	1,323	1,943	90.27
Washington	0.579	2,946	70.48	2,948	0	0	6,241	94.44
Waukesha	0.380	2,901	57.40	2,732	0	0	5,903	95.43
Regionwide:	0.448	17,457	75.39	17,208	174.86	9,985	37,369	92.76

Source: SEWRPC.

Table 64

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE THREE WIRELESS TECHNOLOGIES: NOVEMBER 14, 2005 TO MARCH 2, 2006

Technology	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
CDMA	0.464	35,700	72.89	37,370	178.23	19,777	82,345	88.74
GSM	0.810	4,126	44.03	3,998	0	0	7,870	92.53
iDEN	1.011	3,097	17.83	6,229	0	0	10,330	90.28

Source: SEWRPC.

Table 65

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THIRD GENERATION (3G) CELLULAR/PCS WIRELESS NETWORKS: NOVEMBER 14, 2005 TO MARCH 2, 2006

Provider	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Sprint	0.246	3,569	74.33	3,746	330.87	3,803	7,737	94.55
Verizon	0.261	3,294	84.44	3,133	341.05	3,445	6,830	94.10

Source: SEWRPC.

five wireless service providers monitored. Table 64 summarizes regional network performance for each of the three wireless technologies deployed in Southeastern Wisconsin. Table 65 separates out third generation (3G) performance data for the two 3G service providers in the Region.

SUMMARY AND CONCLUSIONS

The initial seven-county regional wireless network performance inventory is based on 90,520 packet-switched total transactions (data points) measuring four performance parameters with individual transaction totals and average performance values as follows:

Response Time	- 537 milliseconds - 42,923 transactions
Upload Throughput	- 63.26 kilobits per second - 47,597 transactions
Download Throughput	- 178.2 kilobits per second - 19,777 transactions
Availability	- 89.22 percent - 101,455 transactions

The above performance data summary includes both 2G and 3G transactions, with the majority representing 2G transactions. When the 3G performance data are tabulated separately, a higher level of communications performance is indicated:

Response Time	- 253 milliseconds - 6,863 transactions
Upload Throughput	- 78.93 kilobits per second - 6,879 transactions
Download Throughput	- 336.0 kilobits per second - 7,248 transactions
Availability	- 94.34 percent - 14,567 transactions

Even with the upgrade to third generation technology, cellular/PCS wireless network performance does not approach the specified standards established in Chapter III of this planning report except in the response time standard. With respect to this finding, it should be noted that the performance standards set forth in Chapter III of this report are intended to specify performance for 4G networks and are not intended to specify the performance of existing networks.

Response Time	- 250 milliseconds
Upload Throughput	- 20 megabits per Second
Download Throughput	- 20 megabits per Second
Availability	- 99.9 percent

The most critical of the above performance parameters are throughput and availability. These are the parameters that are most deficient in current wireless networks. The asymmetric nature of current wireless networks is also noteworthy. Although current day Internet users typically require more download than upload throughput performance, emerging video applications, such as video-conferencing, require high speed performance in both directions to maintain quality.

Beyond comparisons with 4G standards, other features of this initial wireless performance inventory that should be noted are:

1. Regional Geographic Performance Variability
   - Variability in performance between counties is not significant except for Milwaukee County where the recent introduction of 3G networks by Sprint and Verizon skews results to a higher level of performance.

2. Service Provider Performance Variability
   - Sprint and Verizon Wireless significantly out-performed the other wireless carriers in every performance category including network availability. These two service providers were also the most reliable for monitoring, accounting for 27 percent (Sprint) and 36 percent (Verizon) of all of the transactions. Even if the third generation (3G) transactions are removed, these two carriers led in every performance category. In the critical throughput performance category, Sprint had a slight lead over Verizon.

3. Technology Performance Variability
   - CDMA technology (Sprint, Verizon, U.S. Cellular) out-performed the GSM (Cingular) and iDEN (Nextel) technologies in every performance category.

4. Third Generation (3G) Technology Performance
   - The 3G CDMA technologies introduced by Sprint and Verizon demonstrated throughput performance far below the much heralded theoretical throughput of 2 megabits per second. Average download throughput is still under 350 kilobits per second.

5. Service Provider Cooperation
   - The network monitoring system program could benefit significantly from better cooperation from the wireless service providers. Verizon Wireless was the most helpful in this regard. In many instances, lack of cooperation resulted from the inability of the Commission to find provider personnel with in-depth knowledge of their networks.

Overall, the initial network monitoring effort was considered a success. Potential additional monitoring efforts should emphasize more detailed parameters, such as packet loss rates, that are primary determinants of network performance for both data communications and future multimedia applications.

Chapter VII

A REGIONAL WIRELESS TELECOMMUNICATIONS PLAN FOR SOUTHEASTERN WISCONSIN

INTRODUCTION

Previous chapters of this report have presented background for the contents of this chapter that sets forth a recommended fourth generation (4G) regional broadband wireless network plan for Southeastern Wisconsin. The objectives and standards of Chapter III provide the criteria for judging the merits of the recommended plan and alternatives thereto. The findings of the antenna site inventory documented in Chapter V provide the geographic and structural bases for plan design and implementation. The findings of the performance inventory of Chapter VI reveal both the capabilities and shortcomings of the present second (2G) and third (3G) generation networks serving the planning area. Table 66 defines the characteristics of 2G, 3G and 4G wireless telecommunications network technologies.

It is important to understand that the fourth generation (4G) regional broadband wireless plan for Southeastern Wisconsin as set forth in this chapter represents one of a number of possible plans by which the objectives and standards set forth in Chapter III of this report might be achieved. The plan herein set forth is not intended to impede the implementation of alternative plans prepared and put forth by private providers, or by counties or municipalities within the Region, that would move the existing level of service within the Region toward the agreed upon objectives and standards or to achieve those objectives and standards. It is, however, hoped that the plan herein presented would serve as a point of departure for further telecommunication planning by private providers and public agencies.

The telecommunications plan presented in this chapter represents an "all-wireless" plan in that both the access networks and the backhaul networks are wireless in nature. This all-wireless designation, however, must be qualified in that all wireless networks must eventually connect to a national—or international—wireline network such as the Internet in order to reach message or call destinations outside of the Region. Even intra-regional calls outside of the wireless network itself must be routed through the Internet or telephone (POTS) networks. As an all-wireless network, the proposed plan design encounters basic technological problems that must be addressed if the planned network is to achieve the specified objectives and standards. The performance standards relating to transmission rate and accuracy are particularly difficult to achieve and are well beyond those achievable with current 3G systems. These performance standards, specified in Chapter III, call for data transmission rates in the 20 to 200 megabits per second range and maximum packet loss of 10 percent or less. Fundamental changes in both hardware and protocol software technologies will be required to achieve these standards.

It is important to note that the recommended wireless telecommunication plan herein presented is also intended to provide one of the alternative plans to be considered in the development of the comprehensive regional telecommunications plan also proposed to be prepared under the regional telecommunications planning program. Other alternative plans to be considered in the development of the comprehensive plan may place more emphasis on the use of fiber transport, particularly in lieu of the wireless backhaul portions of the recommended wireless plan herein

Table 66

COMPARISON OF 2G, 3G, AND 4G NETWORK TECHNOLOGIES

Key Features	2G Networks	3G Networks	4G Networks
Data rate	60 kbps	384 kbps to 2Mbps	20-100Mbps
Frequency band	0.8-1.9 GHz	1.8–2.4 GHz	2-8 GHz
Bandwidth	Variable	5MHz	About 100 MHz
Switching Technique	Circuit- and packet-switched	Circuit- and packet-switched	Completely digital with packet voice
Radio Access Technology	GSM, GPRS, Edge, CDMA, iDEN	UMTS, HSDPA, WCDMA, CDMA-2000.	OFDMA, MC-CDMA, HSUPA, WiFi, WiMAX
IP	IPv4.0	IPv4.0, IPv5.0, IPv6.0	IPv6.0

Source: SEWRPC.

presented. Communication needs, however, now and in the future will in any case require wireless components to serve the needs of mobile communications since fiber telecommunications and other technologies do not provide for such mobility. The recommended comprehensive regional telecommunications plan may therefore contain as an integral component a modification of the wireless plan herein presented.

It is also very possible that hybrid plans involving the wireless part of this plan in some areas of the Region will be integrated with wireless plans in other parts of the Region to provide a mixed wireless/wireline plan that may be most cost effective for the Region.

Preparation of a wireless network plan involves a sequence of design activities that include:

1. Selecting a basic communications technology or set of technologies: GSM and its derivatives; CDMA and its derivatives; or WiFi/WiMAX and their derivatives;

2. Selecting accessory technologies in supporting system elements such as antennas and network management;

3. Identifying and defining the equipment requirements for various classes of network users: fixed enterprise, fixed residential, nomadic laptop computer, mobile phone and other hand-held devices as well as motorized vehicles; and

4. Selecting base station or access point locations with their associated antenna types, heights, patterns and powers and their respective geographic coverage areas.

The end result of this sequence of design activities is a proposed regional network infrastructure that supports a wide variety of broadband users with a fourth generation (4G) systems deployment.

Accordingly, this chapter describes a range of technologies, presenting their advantages and disadvantages, and selecting a set deemed best suited to future application in the Region. The chapter also defines network architecture at both the access level and the core level, with the final output being an antenna site and related infrastructure plan that defines the recommended all wireless regional telecommunications system.

TECHNOLOGICAL ALTERNATIVES

There are three current sources for evolving wireless communications technologies:

1. Proprietary Cellular/PCS, Mobile Wireless Technologies

2. Proprietary Fixed Wireless Technologies

3. Standards-Based Fixed/Mobile Wireless Technologies

Proprietary Cellular/PCS Mobile Technologies
Each of these sources of technologies can be further classified by the specific type of wireless technology. Beginning with cellular/PCS technologies, there are five primary technologies currently in use:

1. Advanced Mobile Phone Service (AMPS) based on analog signals. This technology is largely obsolete and out-of-service except in some rural areas of the United States.

2. Time Division Multiple Access (TDMA), a digital technology still in use but lacking a development path to 3G and beyond service. This technology may be expected to be replaced in the foreseeable future by other technologies.

3. Global System for Mobile Communications (GSM). This is one of the two primary current 2G/3G digital wireless technologies, and has a path to 3G and beyond as Universal Mobile Telecommunications System (UMTS) and High Speed Downlink Packet Access (HSDPA). Cingular and T-Mobile employ GSM technology in the Region.

4. Code Division Multiple Access (CDMA). This is the second primary current digital wireless technology. It has a path to 3G and beyond: Evolutionary Data Optimized (EV-DO). Sprint, Verizon and U.S. Cellular employ this technology in the Region.

5. Integrated Dispatch Enhanced Network (iDEN). This is a proprietary digital Motorola technology used by Nextel—now part of Sprint—but still a separate network. This technology is a variant of TDMA and is known for its push-to-talk feature. It does not have a known 3G and beyond path. The "push to talk" feature may be expected to be incorporated into other technologies.

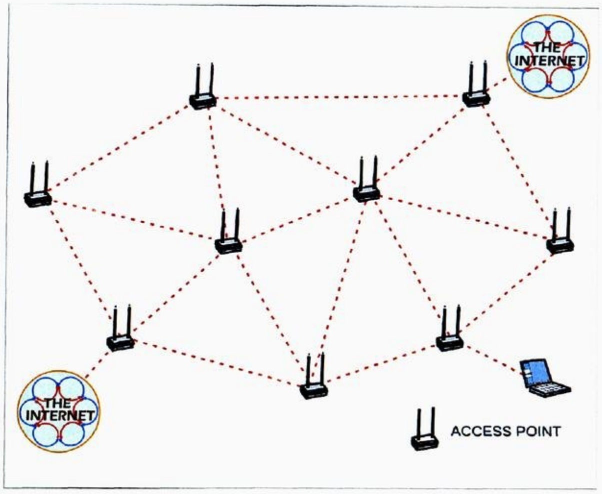
Proprietary Fixed Wireless Technologies
While fixed wireless represents a different kind of wireless communications service, the technologies tend to be similar to those employed either in cellular/PCS or standards-based technologies. An example of a cellular technology is the Motorola Canopy System which is based on TDMA. An example of a standards technology is the Alvarion Frequency Hopping Spread Spectrum (FHSS) System which employs a methodology close to an earlier version of IEEE Standard 802.11 (WiFi). The relatively small size of the fixed wireless market has limited the amount of innovation possible in this area. Future trends also indicate the merging of fixed and mobile wireless into a single network, so that fixed wireless networks will probably cease to be independent entities.

Standards-Based
Fixed/Mobile Wireless Technologies
Standards technologies for wireless communications emerged from wireless local area networks (WLANS) applications. These standards were developed under the aegis of the Institute of Electrical and Electronic Engineers (IEEE). IEEE in its standards setting activities establishes committees with knowledgeable representatives from the communications industry to develop communication technologies in the form of design specifications that manufacturers are intended to adhere to in their finished equipment designs. Standards-based technologies have the advantages of better performance as a result of multiple design creation resources and lower costs because of the higher production volumes typically associated with standards base equipment.

WiFi
The first broadband wireless standard was IEEE 802.11 or WiFi. The 802.11 standard was introduced in 1997, using the frequency hopping spread spectrum (FHSS) technology operating in the 2.4 gigahertz band. The frequency hopping spread spectrum technology originally used in WiFi service was abandoned and WiFi standards technologies were specified as either direct sequence spread spectrums (DSSS-IEEE standards 802.11b), or orthogonal frequency division multiplanning (OFDM-IEEE standard 802.11g) for physical layer operation. Initially, the speed of the network was considered too slow at only 1 to 2 megabits per second. A new standard, 802.11b, was then introduced with an average connection speed of 5.5 megabits per second with a maximum speed of 11 megabits per second. The 802.11b standard became popular as the "hot spot" WiFi which was deployed in coffee shops, airports, schools, homes, and other locations throughout the United States and other countries. It represented a significant connection speed upgrade compared not only to dialup access, but also to some wireline broadband services such as digital subscriber

Figure 9

CONCEPTUAL MESH NETWORK



Source: Tropos and SEWRPC.

line (DSL). Over the last few years, the number of WiFi hot spots has grown rapidly both in the Region and elsewhere in the United States and throughout the world. The 802.11b standard has now been superseded by 802.11g which has connection speeds up to 54 megabits per second. A third 802.11 standard, 802.11a, operates at a higher frequency, 5.2-5.8 gigahertz (GHz), also with a maximum rate of 54 megabits per second. The "a" standard has been used primarily for backhaul networks to Internet access points. Aside from public hot spots, a second major application for WiFi has been the wireless home. Many home users now employ a WiFi router to establish a home-based wireless local area network to interconnect multiple desktop/laptop computers and other devices.

A second stage of WiFi communications development has been the mesh network in which an entire metropolitan area is blanketed with WiFi coverage. A mesh network involves the interconnection of the WiFi access points—hot spots—into a mesh topology. In such a network, shown in Figure 9, each access point serves as both a direct wireless connection and as a router passing messages from the other access points on to their destination. A message transmission may require multiple "hops" across access points prior to reaching its destination within the mesh network or to Internet connection points, known as gateways, which are scattered throughout the network. A mesh network differs from a collection of WiFi hot spots in that the access points are interconnected in a mesh structure and with Internet access only at selected gateway locations. A mesh network topology has some significant advantages as well as some disadvantages which are described in a later section on network topology.

A number of American cities have entered into agreements with private service providers to install WiFi mesh networks, including among others, the Cities of Milwaukee, Philadelphia, and San Francisco. The first known major city to install a citywide wireless mesh network is Taipei, Taiwan, a city of about 2.6 million people. Nortel Networks has been installing the Taipei network over the last few years, and it now covers about half of that city's approximately 106 square mile area and with 3,300 wireless access points, or 63 access points per square mile. Tropos Networks has installed a WiFi mesh network in Chaska, Minnesota, a city of about 18,000 residents with an area of about 16 square miles. Tropos installed 250 access points to cover the City of Chaska for a density of 16 access points per square mile, considerably less than the Nortel experience in Taipei, Taiwan. High density cities generally require higher access point densities for two reasons: (1) to overcome the effects of "clutter" attendant to the presence of numerous high-rise structures; and (2) to provide the needed capacity to serve higher user density and demand.

Mesh networking has brought new applications and continuing growth to 802.11 WiFi technologies. The scope and capabilities of 802.11 also continue to grow and expand with new versions of the technology in process for later release. An example is standard 802.11n which will extend the range and increase the throughput of WiFi using phased array multiple input multiple output (MIMO) antennas. A second example is 802.11s which concern WiFi networks using mesh network topologies. A third that is very pertinent to the regional plan and its impact on transportation is 802.11p which is developing a roadside version of WiFi called wireless access in vehicular environments (WAVE) which will provide mobile communications on a special licensed 5.9 GHz frequency band.

WiMAX

A new major IEEE standard 802.16 (WiMAX) is due for release in 2006 in the form of standard 802.16d. WiMAX is an acronym for Worldwide Interoperability for Microwave Access. Orignally conceived as a technology for metropolitan area networks, WiMAX was promoted as a long range version of 802.11 WiFi. Some experts even forecast the decline and eventual demise of WiFi. WiMAX capabilities included extending the range of WiFi from 300 feet to up to 30 miles. After a number of years of some confusion, the relative roles—at least in the short-term—of WiFi and WiMAX, have now been clarified. WiFi is well established as a low cost, high speed access network for direct interconnection with end users. Since WiFi continues to grow in performance and capabilities, it may be expected to be difficult to dislodge from its primary role in wireless Internet access and potentially Internet-based voice communications (VoIP). WiMAX with its orientation to wide area networks is well positioned to serve as a backhaul network for localized WiFi access networks. Using WiMAX as an upper level backhaul network will minimize the need for fiber wireline Internet gateways. It is important to understand, however, that there is nothing inherent in the WiMAX technology that extends the range of operation of an antenna base station. Operating in the same frequency band—such as 5.8 GHz—with the same power output through the same antenna, a WiMAX base station would have the same range as an 802.11a WiFi base station. This is true in spite of the contradiction with the original objectives to increase the range of WiFi. To function as a backhaul network, WiMAX will require higher gain transmitters and antennas as well as more sensitive and noise-free receivers.

WiMAX does, however, have technical features and capabilities that potentially enhance its role in a backhaul network. Such features and capabilities include:

1. WiMAX can provide an improved quality of service through a better media access control (MAC) protocol that can share a radio channel among hundreds of users. It should be noted, however, that a WiFi group 802.11e is working to include a similar feature in WiFi.

2. WiMAX can provide higher data transmission rates from the same bandwidth as measured by bits per second transmitted versus Hertz of bandwidth used.

3. WiMAX has mandatory encryption for security. It should again be noted, however, that a WiFi 802.11i group is working to incorporate better security in WiFi.

4. The 802.16e version of WiMAX will have mobile capabilities. A WiMAX 802.11p work group is moving rapidly to provide this capability on a special 5.9 GHz band for application along roadway networks.

The introduction of WiMAX is behind schedule. Originally scheduled for release in its 802.16d version in late 2005, certification is expected in 2006 with equipment availability following. The mobile version of WiMAX (802.16e) is scheduled for release in the 2007 to 2008 timeframe.

There are at least two scenarios under which WiMAX would provide user access as well as backhaul network services. The first is in rural areas where a community based WiFi network may not be cost effective. The other is in mobile public safety networks where law enforcement, fire, and emergency medical rescue services will have their own operating band in the 4.9 GHz region. This report does not address planning for the mobile public safety networks, which networks are intended to be addressed in a separate Commission planning effort and the results documented in a separate Commission planning report. In the rural application, however, there are cost issues, since WiMAX equipment will probably be more costly than WiFi equipment for some years. Such high costs may limit broadband wireless development in rural areas.

Mobile-Fi (IEEE 802.20)

A third standards-based wireless technology deserves consideration here since it may influence later versions of the regional broadband wireless communications plan. The 802.20 Mobile Broadband Wireless Access Working Group was established in December 2002, with a mission of developing a mobile broadband wireless technology. Unlike WiMAX which began with an emphasis on fixed users, Mobile-Fi was focused on mobile communications from the start. To date, little is known about Mobile-Fi except that it is focused at bands below 3.5 GHz. It also seems to be focused on licensed carriers rather than the unlicensed bands. Early versions of WiMAX also seem to have a licensed band bias. Given the existence of 802.11p WiFi for vehicular communications, the outcome of competition with a standards-based mobile broadband wireless communications is at this time uncertain.

COMMUNICATIONS TECHNOLOGY SELECTION

For use in plan preparation, a selection must be made from an array of known technological alternatives available for use in a fourth generation regional wireless telecommunications system. The primary criteria for such selection should be standards compliance. If multiple technologies comply with the standards, then the most cost effective technology should be selected. From the previous presentations on alternative technologies, the four alternative technology candidates are:

1. GSM/UMTS and its beyond 3G HSDPA extensions;

2. CDMA and its beyond 3G EV-DO extensions;

3. WiFi and all of its 802.11 variants and extensions; and

4. WiMAX and its planned variants.

Although all of the alternative plans considered will be rated using all of the objectives and supporting standards set forth in Chapter III, many of the standards are not relevant to technology selection, but only to the evaluation of a geographically deployed plan. A review of the standards was, therefore, conducted to identify a subset of criteria for use in technology selection including:

1. Performance Standards
   - Throughput – 20 to 200 megabits per second
   - Availability – 99.9 percent
   - Voice quality – Mean Opinion Score (MOS) greater than 4.0
   - Packet loss – less than 10 percent

2. Universal Service Standard
   - Independent of technology selection

3. Redundancy Standard
   - Independent of technology selection

4. Antenna Site Number Optimization
   - Independent of technology selection

5. Most Demanding Application

6. The most demanding applications relate to video communications with transmission data rate requirements up to 200 megabits per second. Network Infrastructure Cost Minimization Standard
   - The sum total of capital investment and discounted operating costs should be minimized. Full use should be made of existing site facilities.

7. Antenna Site Aesthetics and Safety
   - Independent of technology selection

8. Public Safety Emergence Preference Standard
   - Independent of technology selection

Based upon the foregoing review, technology selection was based upon the performance, most demanding application, and cost minimization standards. All of the above technologies are being improved to meet higher performance standards particularly for the throughput standard beyond the current 3G standard peak transmission rate of 2 megabits per second. It is not clear, however, that either of the proprietary wireless technologies—GSM and CDMA—in their advanced versions are even specifying throughput rates as high as 100 megabits per second. In fact, both technologies envision eventually switching to Orthogonal Frequency Division Multiplexing (OFDM) technology, the same radio technology currently employed in both WiFi and WiMAX.

Even if the specifications for GSM/HSDPA and CDMA/ED-DO were revised upward to comply with the throughput standards, they would fail to qualify under standard number six for cost minimization. A major justification for the development of standards technologies has been cost minimization. The past history of Ethernet and WiFi both testify to the ability of standards based technologies to drastically reduce user costs. Such a cost minimization history inevitably moves the technology selection toward standards-based technologies—WiFi and WiMAX. Aside from standards compliance, the proprietary technologies also suffer from the disadvantage of favoring the mobile user. The 4G regional wireless plan must provide for both fixed and mobile users. Selecting a mobile-alone wireless technology inevitably compromises performance for the fixed user. The technology choice is thus reduced to a selection between WiFi (IEEE 802.11) and WiMAX (IEEE 802.16).

WiFi technology has the advantage of proven performance particularly relating to access networks. Its disadvantage is typically stated in terms of its limited range—about 300 feet—but this limitation is a function of the network topology and the equipment employed not of the technology itself. WiFi has also been lacking in important aspects related to security and quality of service, but almost every current limitation of the technology is being addressed by an IEEE subcommittee with the goal of upgrading future versions of the standard.

WiMAX technology was originally introduced as a longer range higher quality version of WiFi (IEEE 802.11). As previously stated, there is nothing inherent in WiMAX technology that extends the range of operation. Given the same antenna with the same power output transmitting to the same class of receiver, WiFi and WiMAX will have identical range performance. A number of desirable features have been introduced into the WiMAX technology that will make WiMAX networks more secure with a better quality of service. The design viewpoint inherent in WiMAX is one of a wide area network, and the technology has many design features that make it well suited for use in regional wireless backhaul networks.

An important consideration with WiMAX, however, is its higher costs. As a new technology being introduced in 2006, the costs of WiMAX network elements may be expected to exceed the cost of equivalent WiFi elements for some time to come. For that reason alone, WiFi technology must be favored for access networks restricting WiMAX for those applications where its features most apply.

Weighing the advantages and disadvantages of the two potential technologies, WiFi is the preferred choice for access networks, with WiMAX providing the regional wireless backhaul network. WiMAX would also be a possible choice for the provision of direct access in rural areas of the Region. Thus, WiFi networks would be the preferred choice for access except in rural areas where the deployment of a community WiFi network would not be cost effective. A WiFi-WiMAX combination would build upon the strengths of both technologies and should provide for minimal capital costs as called for in Standard Number Six.

This hybrid set of technologies would also allow for early buildup of WiFi-based community networks which will inevitably be part of any regional telecommunications plan, and allow for later cost benefit comparisons between wireless and fiber wireline backhaul networks. Since WiMAX wireless technology is in its initial application stage, the preferred choice for regional backhaul can be evaluated prior to the ready availability of WiMAX equipment.

Having identified the combination of technologies deemed to be best suited to achieving the performance objectives and standards set forth in Chapter III, it is important to identify some shortcomings of these technologies that must be overcome if the plan design standards are to be achieved. Certain technical argumentations in both equipment performance and network protocols will be necessary to fully meet the standards previously specified.

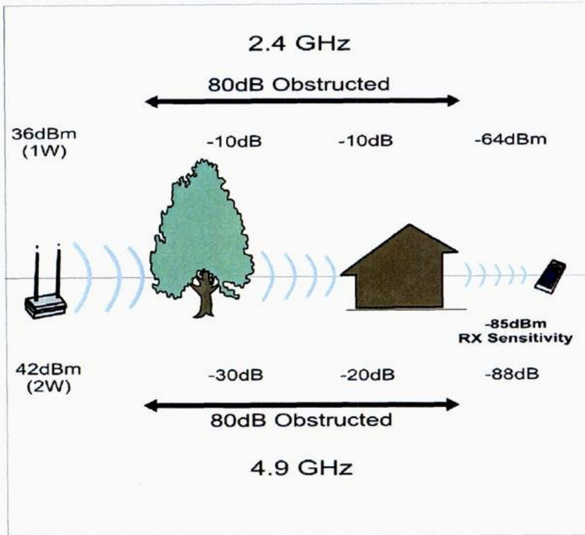
Accessory Technologies for Standards Compliance

Recent experience with mesh networks in smaller cities such as Chaska, Minnesota (Tropos Networks) and Buffalo, Minnesota (Motorola) have demonstrated that WiFi technology in its current state (802.11g, 802.11a) will not achieve the performance standards for both throughput—20 megabits per second—and associated packet loss rate—10 percent—specified in Chapter III. Two shortcomings of these technologies combine to limit system performance. The first relates to signal levels achievable given the FCC specified power output levels and the signal attenuations caused by natural foliage and man-made structures. This "clutter" problem is illustrated in Figure 10 where the extra attenuations caused by foliage and structures is illustrated for two frequencies. While the attenuation caused at the 4.9 GHz band—a public safety band—is worse than the attenuation at the 2.4 GHz band—a WiFi band—both bands suffer from natural and man-made transmission losses. These lower signal levels even when detected by the network user result in slower data rates than those called for in the performance standards. These lower signal levels also result in higher packet loss rates that further reduce data rate levels because of the need to retransmit loss packets. Signal level problems may be resolved in one of two ways—increasing the power output of the transmitter, or increasing the sensitivity of the receiver. Since the FCC limits the power output of WiFi/WiMAX transmitters, the only recourse is improving receiver sensitivity.

The technology shortcomings concerned are best understood by reference to Shannon's Law which defines the channel capacity—maximum transmission

Figure 10

RADIO PROPAGATION CLUTTER LOSSES



Source: Tropos 2004 and SEWRPC.

rate—for any communications link. According to this law, channel capacity—throughput—depends *only* upon:

- Bandwidth of the medium
- Signal power at the receiver; and
- Noise power at the receiver.

Stated mathematically:

$$C = B \times \log_2(1 + S/N)$$

C – channel capacity – bits/second

B – bandwidth – Hertz

S – signal power – milliwatts

N – noise power – milliwatts

Most considerations of broadband communications focus on the bandwidth of the medium which in the case of wireless communications is the radio bandwidth of the frequency channel allocated by the Federal Communications Commission (FCC). In the case of WiFi, a typical bandwidth is 20 megahertz, which should at a minimum (100 percent spectral efficiency) produce a 20 megabits per second data transfer rate. In IEEE standard 802.11g, spectral efficiency will exceed 100 percent. Bandwidth from the above equation, however, is only one determinant. If the signal to noise ratio of the receiver does not allow for the bandwidth potential data rate, then degraded performance results. For example, in a Tropos mesh network, a signal level of -77 decibel-milliwatts (dBm) is required at the access point receiver to achieve the maximum data rate of 54 megabits per second. To qualify under the IEEE standard 802.11g, a laptop network interface card and its associated antenna must be able to process 54 megabits per second with a signal level of -65 dBm. Since the signal levels in most WiFi mesh networks are much weaker than -65 dBm, the achievable data rates are generally under 3 megabits per second.

Such improvements in receiver sensitivity must be accomplished without changing the IEEE 802.11g standard related to WiFi and/or IEEE standard 802.16 related to WiMAX. The only such components in the two technologies that are independent of the standards are the antennas and the radio frequency receivers at both the access point and user ends.

To increase the signal levels at both the access points and the remote users, the gain of an antenna-preamplifier combination must be improved on the order of 20 decibels or more to achieve the maximum data rates of 54 megabits per second. Since laptop users are typically limited by the antenna and amplifier built into the laptop itself, antenna-preamplifier upgrading must be limited to the infrastructure access points and to residential and other fixed location users who have antenna-preamplifier options in their receiver system configurations. It will be shown in the 4G wireless plan presented that with antenna-preamplifier augmentations in the infrastructures and fixed end user equipment that the throughput and packet loss performance specifications can be achieved.

The throughput rates actually achieved in operational mesh WiFi networks—such as those installed by Tropos Networks and Motorola—are considerably less than those predicted based on signal levels. This discrepancy arises from the high packet loss rates experienced in these networks which range from under 10 percent to as high as 40 percent. Every lost packet must be retransmitted to maintain data integrity. These high packet loss rates are exacerbated by the manner in which the Internet routing and transport protocol (TCP/IP) handles their detection and retransmission. The TCP/IP protocol was developed for wireline networks with packet loss rates well under 1 percent. In such a wireline environment, the TCP part of the TCP/IP protocol functions quite well. In a wireless communications environment, however, with its high packet loss rates, the TCP protocol aggravates the situation by slowing the transmission rate further reducing link throughput. Since almost all wireless data traffic is controlled by the TCP/IP Internet protocol, this protocol's wireless network shortcomings place a limit on WiFi-WiMAX technology performance even if received signal levels are improved through receiver enhancements as previously described. The solution is a revised backward compatible TCP/IP protocol that is more attuned to the packet loss situation characteristic of wireless network environments. Such a protocol is currently being developed by Architecture Technology Corporation of Minneapolis, Minnesota under the Defense Advanced Research Project Agency of the United States Department of Defense. This protocol will be available for Beta testing in the Region by September 2006. Such testing will be incorporated as part of the regional broadband wireless plan to allow for achieving the agreed upon performance objectives and standards.

It is important to emphasize, however, that even without the new TCP/IP protocol, the receiver equipment enhancements for improved signal levels will dramatically improve throughput regional coverage and packet loss rates for much higher wireless system performance.

User Requirements and System Performance

Differences in potential user equipment capabilities require a precise definition of the various potential users and their transceiver specifications in order to develop a meaningful region-wide wireless communications plan. The network user classes to be served by the 4G regional wireless plan include:

1. The nomadic laptop user
2. The mobile WiFi phone user
3. The fixed location residential, small business or enterprise user

Providing high quality service to the nomadic laptop computer users presents the greatest challenge to network system design because of the poor receiver sensitivity and low transmit power characteristic of this equipment. Mobile WiFi phone users may have even worse sensitivity and lower transmit power, but this class of users does not have high data rate requirements—at most 64 kilobits per second—for voice communications. This reduced need is true even though some data and video communications are accomplished. The fixed location users will have the advantages of high receiver sensitivity and higher transmit power for the best level of telecommunications throughput performance.

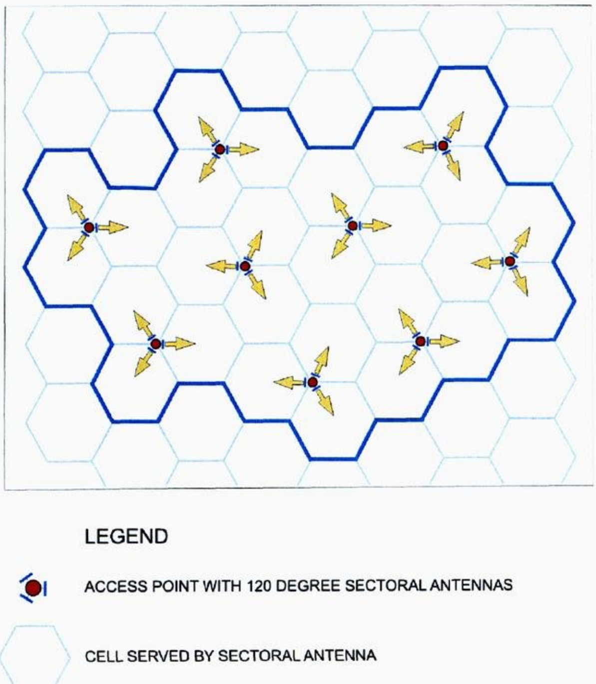
The system plan will be designed to serve the nomadic laptop computer user as the weakest and most demanding of network users. The approach will involve the synthesis of a network design that provides broadband performance to the nomadic laptop user as the primary objective of the wireless plan. Other users such as the fixed location residential or business users will then experience better throughput performance because of their higher signal levels. While the reality experienced in low density rural areas may sometimes require compromises to this objective, wireless broadband communications will still be available to all three classes of users throughout the Region.

These three classes of users must then be specified in terms of the equipment characteristics required to achieve the agreed upon objectives and standards, namely:

1. The nomadic laptop user:
   - Transmit power – 200 milliwatts = 23 decibel-milliwatts
   - Receiver sensitivity – (-82 decibel-milliwatts) at 6 megabits per second
   - Antenna gain – 5 dBi (decibels isotropic)
2. The mobile WiFi phone user:
   - Transmit power – 100 milliwatts = 20 decibel-milliwatts
   - Receiver sensitivity – (-82 decibel-milliwatts) at 11 megabits per second
   - Antenna gain – 0 dBi (decibels isotropic)
3. The fixed location residential, small business or enterprise user:
   - Transmit power – 200 milliwatts = 23 decibel-milliwatts

Figure 11

CONCEPTUAL SECTORAL CELLULAR NETWORK



Source: SEWRPC.

- Receiver sensitivity – (-74 decibel-milliwatts) at 24 megabits per second
- Antenna gain – 13 dbi (decibels-isotropic)
- Preamplifier gain – 22 decibels

Network Topology

A basic consideration in any wireless network system design is the network topology—or interconnection structure—of the network layout. Two major classes of network topologies are currently employed in wireless communications: network cellular topologies and mesh topologies. In cellular networks, as shown in Figure 11, the service area is subdivided into cells with each cell serviced by a sector of an individual base station. Each base station is then connected through a backhaul link directly or indirectly either to a core telephone or Internet network. A mesh network topology, as shown in Figure 9, employs a series of access points, that like cellular base stations service a defined area. Unlike cellular networks, however, these access points are interconnected with many other access points in a mesh. Such a mesh network allows data traffic to find its way through a series of access points to its destination either within the local network or to outside destinations through an Internet connection. Most cell phone service providers employ the cellular topology in their networks using GSM, CDMA or other wireless technologies. WiFi networks, however, evolving from a network of isolated "hot spots" have generally employed the mesh network topology. Mesh networks are sometimes seen to provide an advantage over cellular network with respect to redundancy and reliability. The mesh networks are seen as largely "self-healing" in that the failure of a single access point does not disable the entire network. In this respect, however, it should be noted that the failure of a single access point in a cellular network—while leading to a loss of service in a relatively small sub-area of the total service area of the network—does not lead to failure of the entire network. Mesh networks also suffer from major disadvantages that are critical to their adoption, such as higher infrastructure costs.

These disadvantages are best confirmed by comparing the infrastructure cost and performance of networks designed with both topologies for the same geographic areas. Such a comparison will be provided below for two community network designs for the Cedarburg-Grafton area in Ozaukee County.

Assumptions Concerning Use Of Licensed And Unlicensed Bands In The Broadcast Spectrum

The existing private wireless telecommunication providers within the Region have as a part of the development of their service network acquired—at substantial cost—Federal licenses to the exclusive use of a specific bandwidth of the radio frequency. In the preparation of the wireless telecommunication service plan set forth in this Chapter, it was assumed that plan implementation could occur through either private or public action, with the implementing agency deciding whether to utilize the licensed or unlicensed part of the radio frequency spectrum. It is important to note, however, that no costs were provided in the plan for acquisition of exclusive use licenses.

4G Plan Description

The proposed 4G plan, as previously discussed, will combine a Regional WiMAX-based wireless backhaul network with a multitude of community WiFi-based access networks. The rationale for a regional backhaul network is primarily economic. Significant infrastructure installation cost savings and continuing operating cost savings are possible with the higher volume of data traffic linked to the Internet through a backhaul network. The alternative is a more costly piecemeal approach, with each community seeking its own Internet gateway connection with the attendant higher installation and operating costs.

The 4G Regional Wireless Communications System Plan will be presented in two parts:

1. Regional Wireless Backhaul Network Plan

2. Sample Community Broadband Wireless Network Plan
   — based on the City of Cedarburg and the Village of Grafton as an integrated combined network

Regional Wireless Backhaul Network
Map 60 illustrates the regional backhaul network in its entirety. In total there are 54 base stations in the Regional Backhaul Network with a county breakdown as follows:

Kenosha	5
Milwaukee	7
Ozaukee	4
Racine	4
Walworth	10
Washington	10
Waukesha	14

The plan was prepared using a combination of radio propagation modeling and a SEWPRC mathematical programming model that minimizes the number of base stations required to provide backhaul coverage throughout the Region. Radio propagation modeling operates in conjunction with a "clutter" data base that records the topographic terrain along with natural (wooded areas) and artificial (buildings) features that obstruct and attenuate radio signals. Based on antenna height, transmit power, and receiver sensitivity, the radio propagation model estimates the geographic coverage of each potential antenna base station. This coverage data provide input to a mathematical programming model that determines the minimal number of antenna sites required to provide total coverage. A regional antenna site database of 755 existing cellular antenna sites was used as the starting point for backhaul network design optimization. The mathematical programming model evaluates in a systematic fashion various combinations of antenna sites until it iteratively determines the minimal number for total regional coverage. The input to the model is a set of "w" vectors that define the quarter sections covered by each potential base station and thc output is a designated set of optimal sites.

There are two types of antenna base stations in the wireless backhaul network: a backhaul station and a backhaul gateway (POP) station. A backhaul station collects backhaul data from surrounding community WiFi network access points over 802.11a WiFi links operating in the 5.8 GHz frequency band. This same station forwards all incoming data directly to a backhaul gateway station for entry into the Internet. A typical backhaul station is shown on Figure 12, and would include the following elements:

1. Antennas:
   4 – 16 dBi 90 degree sectorals (802.11a)
   1 – 21 dBi directional (802.16d)

2. Transceivers:
   2 – 802.11a WiFi
   1 – 802.16 WiMAX

3. Power Conditioning and Backup:
   1 – UPS Battery Backup Unit

All antennas are proposed to be mounted on a co-location basis on existing cellular/PCS towers at a height of 100 feet or higher. All transceiver equipment will be mounted at antenna height with the power conditioning equipment housed in a small ground structure.

The gateway backhaul station provides all of the services of a backhaul station servicing community networks in its coverage area. In addition, the gateway links community networks to the Internet through a high-end multi-protocol label switching (MPLS) router. Supplementing the equipment listed above for a regular backhaul station, the following additional equipment is needed at a gateway backhaul station:

1. MPLS Router

2. Fiber interconnection equipment

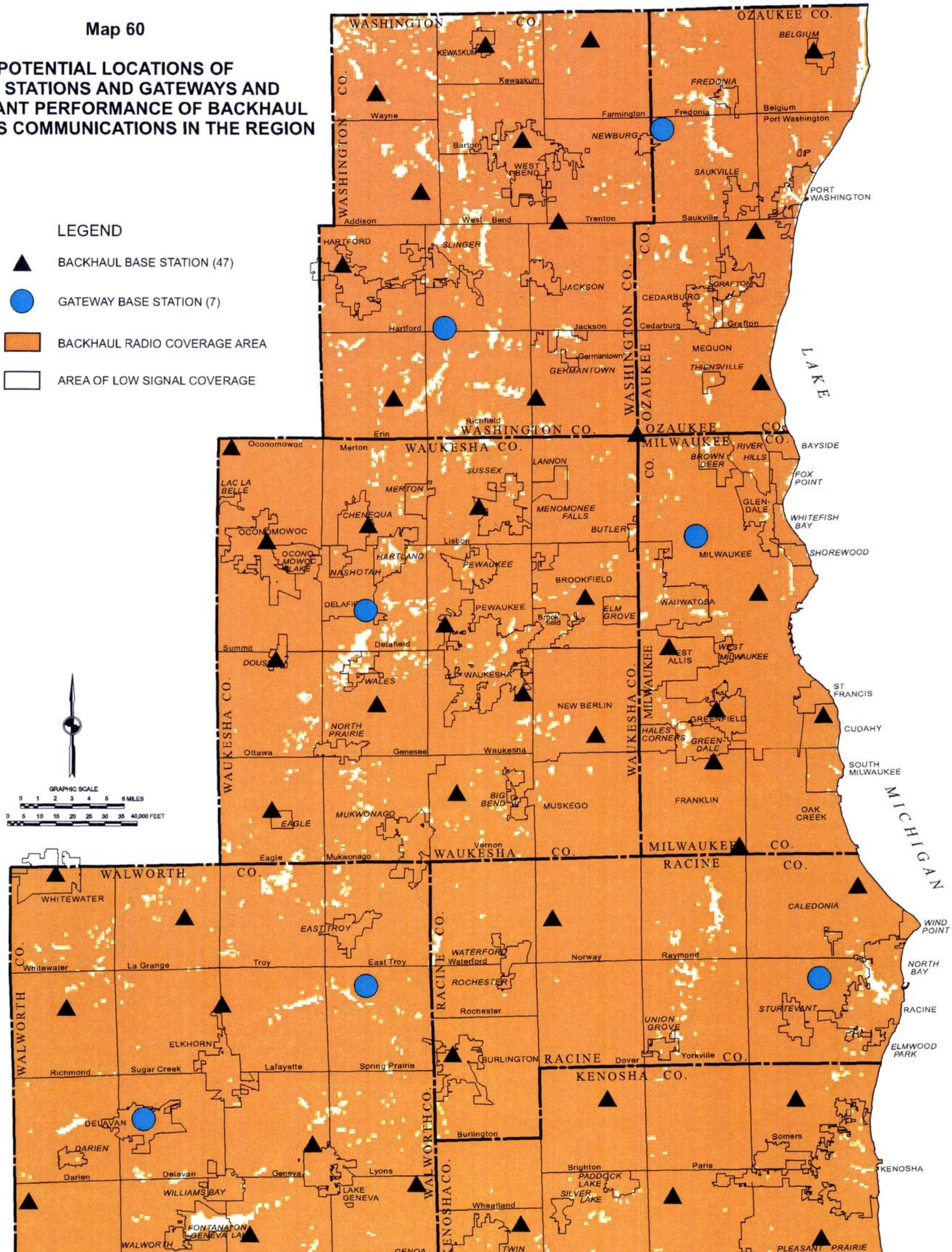
Following the optimal selection of a backhaul station set, a second stage of mathematical optimization was used to select the minimal number of gateway stations needed to service the backhaul network.

Map 60

POTENTIAL LOCATIONS OF BASE STATIONS AND GATEWAYS AND ATTENDANT PERFORMANCE OF BACKHAUL WIRELESS COMMUNICATIONS IN THE REGION

LEGEND

- BACKHAUL BASE STATION (47)
- GATEWAY BASE STATION (7)
- BACKHAUL RADIO COVERAGE AREA
- AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

Figure 12

TYPICAL BACKHAUL BASE STATION ANTENNA TOWER

A typical 100 feet high WiFi/WiMAX Backhaul Base Station Antenna Tower. The Tower structure is triangular. The shed houses ancillary electric equipment.

Source: SEWRPC.

Minimizing the number of backhaul gateway stations is important not only to minimize the additional investment that each of these gateways requires, but also to minimize ongoing network operating costs. The cost of a megabit/second unit of bandwidth declines by about 32 percent for a 8:1 ratio of gateways to base stations.

Based on a regional backhaul network of 54 base stations, 7 of which provide gateways, the following initial infrastructure costs are estimated: A detailed support listing of the components of these estimated costs are included in Appendix F.

Backhaul Network with Co-located Sites

1. Forty-Seven Backhaul Base Stations: approximately $1.10 million

2. Seven Gateway Stations: approximately $640,000

3. Project Management and Engineering: approximately $350,000
   Total: approximately $ 2.09 million

Backhaul Network Costs with New Tower Sites

1. Forty-Seven Backhaul Base Stations: approximately $1.80 million

2. Seven Gateway Stations: approximately $740,000

3. Project Management and Engineering: approximately $350,000

   Total: approximately $2.90 million

The backhaul network costs given for new tower sites are based on use of a 100 feet high steel tower with a concrete foundation. Such antenna towers have been recently built and are operational in the Canadian provinces of British Columbia and Saskatchewan serving wireless systems of Waveteq Communications, Inc., of British Columbia, Canada. The materials for these antenna tower structures are manufactured by AN Wireless Tower Company of Johnstown, Pennsylvania. They are available in heights from 20 feet to 120 feet, constructed from 50 KSI galvanized steel, and are specified for wind loadings of up to 120 miles per hour. AN Wireless Towers are currently deployed throughout North America. These towers need not be restricted to a single user, but can accommodate multiple users. In fact, the Waveteq towers in Canada are serving multiple users, so that the single user categorization is not applicable to these towers. It is, however, important to understand that these types of towers are not intended for support of large, eight feet diameter parabolic reflector antennas which would be attended by severe wind loadings. Point-to-point microwave links may require antenna structures costing $30,000 or more. The proposed antenna tower structures are intended to support point-to-multipoint communication, WiFi, WiMAX, and related technologies.

The foregoing estimate of costs includes only the costs of equipment and associated installation. Importantly, these costs do not include operation or maintenance costs; nor such costs as exclusive use license fees, if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental charges, if any, for use of municipal structures to mount antennas; nor legal fees. The capital costs of the antenna base stations and gateway stations set forth on page 197, should, therefore, be considered as minimal. These costs will need to be refined as implementation proceeds based upon field tests and inspections, and on site specific analyses. If such further investigations indicate the impracticality of co-location of antenna on any given existing structure identified in the plan, an alternative structure will have to be found for co-location, or a new base station with attendant tower constructed. The capital costs could range up to about $2.9 million if new base station installations had to be constructed for each of the backhaul and gateway base stations shown on the plan. In any case, it must be recognized that the costs provided are based upon a system level of planning; and refinement of those costs should be expected as plan implementation proceeds through the preliminary engineering and final design stages.

The operational cost savings from such a network would depend on the traffic volume on the network, but if each of the 47 base stations and 7 gateway stations were operating at a capacity of 100 megabits per second, the increased transport volume at each gateway would be approximately 8 times the volume of each base station connecting to the Internet individually. Such an increase in volume would result in a 32.6 percent cost savings based on the Light Point transport rate tables listed in Appendix H. Each base station, therefore, would save 32.6 percent of its monthly transport cost of $7,400 per month, or $2,412 per month. The total cost savings for a 54 station network would then be $130,240 per month or $1,562,926 per year. The annual savings would approximate 54 percent of the cost of the original network of $2,855,754. Following the return of the initial investment, an annual savings of $1.56 million would be realized.

These same antenna base station sites could be used to implement a 4.9 GHz broadband public safety communications system throughout the Region. Such a network would provide full regional interoperability first for high speed data transfer and later for voice traffic. A preliminary analysis of radio coverage for public safety vehicles indicates that such a co-located system network is feasible although preparation of a plan for such a network is not within the scope of this planning report.

The estimated cost of the Regional Wireless Backhaul Network was based upon equipment cost quotations from a WiFi/WiMAX equipment manufacturer. The costs of WiMAX equipment are less certain than WiFi equipment since the first WiMAX equipment will enter the market only this year. WiFi equipment costs are well established in a competitive marketplace.

Part of the project engineering costs quoted would support field testing to verify the performance of the backhaul network. These field tests would result in signal level coverage maps of the Region. Such coverage maps verify the placement of the base stations and help to insure successful operation of the network. The pre-startup engineering effort would also establish a network monitoring system that provide the tools for ongoing network monitoring and management.

Two alternative business models are proposed as alternatives for plan implementation. The first and preferred alternative would involve a private investor-operator who would finance, install, and operate the regional backhaul network. The second option would involve multi-county ownership and operation of the system, if an acceptable and qualified investor-operator firm does not receive approval of a multi-county regional consortium. Both models provide this critical component of the regional telecommunication plan. Both models also call for an experienced network operator from either the private or public sector: Since there is no existing regional telecommunications authority, a public ownership initiative would require some multi-county consortium to effect the installation and operation of the system.

Although the deployment and operation of the proposed regional wireless backhaul network system could serve as the key infrastructure component of the regional economic development initiatives, the development of such a regional backhaul network system in a timely manner within the Region is unlikely, since no institutional structure presently exists for the development of such a network. Moreover, it is likely that community level networks will be developed first, with such networks being connected on a case by case basis to the closest available fiber cable interconnection. This probable sequence of development will tend to negate the need for an integrated regional backhaul network.

Sectoral Cellular Cedarburg-Grafton Wireless Network Plan

The sectoral cellular wireless plan for the Cedarburg-Grafton area is shown in Maps 61 and 62. There are 41 proposed access points shown by numbered dot symbol designations on these maps. The State Plane Coordinate locations of the numbered access points are given in Table 67. The two color coverage pattern in Map 61 designates two ranges of performance for the nomadic laptop computer user. The orange area designates throughput performance in the 24 to 54 megabits per second range. The yellow area indicates throughput performance in the 6 to 24 megabits per second range. The laptop computer equipment is assumed to have the technical characteristics previously defined for this class of user.

In Map 62 the same access points are shown, but the single color coverage map indicates that all fixed users would experience throughput performance in the 24 to 54 megabits per second range. The fixed user differs from the nomadic user in both transmit power and receiver sensitivity. The fixed user equipment would be as previously described, except that no preamplifiers are assumed to be employed.

A typical access point station is shown on Figure 13. The equipment configuration at a typical access point would include:

1. 3 – 802.11g transceivers
2. 1 – 801.11a backhaul transceiver
3. 1 – 120 degree sectorized antenna
4. Electrical and lightning surge protective equipment
5. Power over ethernet (POE) power injector
6. Ethernet and coaxial cabling
7. Weatherproof enclosures for auxiliary equipment
8. Mounting hardware

Plans call for the use of heavy duty wall brackets to mount the communications equipment at each access point. Four equipment modules will be pole-mounted: transceiver modules (2), sectorized antenna (1), and auxiliary equipment enclosure (1).

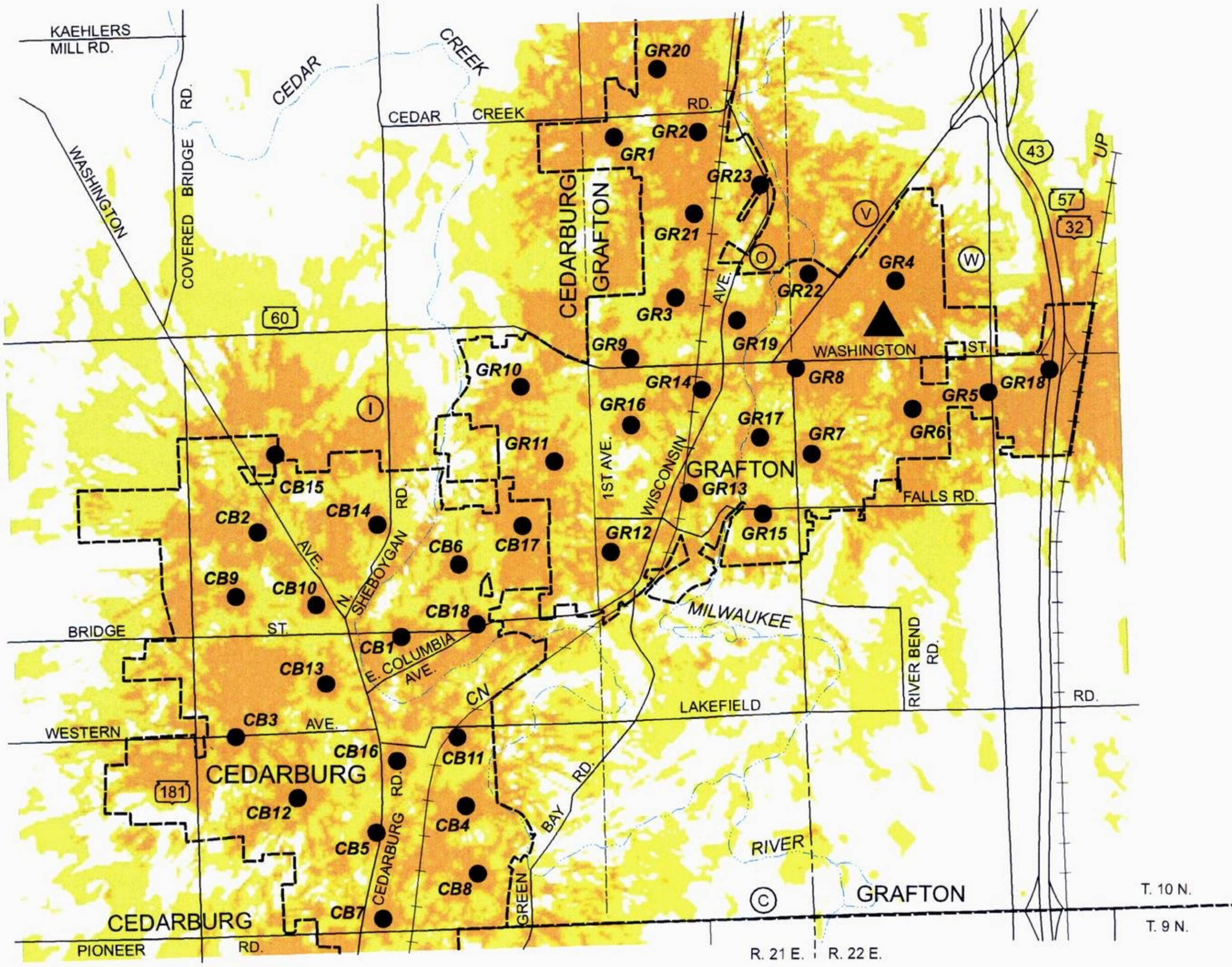
It is also assumed that the access point equipment generally will not employ preamplifiers. Such preamplifiers will be required, however, in low density rural areas of the Region. Without such preamplifiers, rural broadband communications to the agreed upon throughput standards would not be possible. All access point equipment is assumed to be mounted on street lampposts or equivalent structures at an assumed height of about 20 feet. Small variations in heights should not significantly alter the structure of the network. Variations in geographic position within a range of 100 feet also should not significantly alter the network structure. User to access point communication would employ IEEE standard 802.11g equipment. All access points would backhaul to a single WiMAX base station as shown on Maps 61 and 62. Equipment based on IEEE standard 802.11a would be used for backhaul communication to the nearest WiMAX base station.

The WiMAX backhaul network previously shown in Map 60 would also serve to provide alternate backhaul base stations as may be required.

The estimated cost of cellular infrastructure deployment for the Cedarburg-Grafton area was based upon equipment cost quotations from a WiFi/WiMAX equipment manufacturer. Total cost of the infrastructure was determined based upon the cost of each access point plus the cost of Internet access—whether the access is provided through the WiMAX backhaul network or through a direct point-of-presence (POP) connection to a optical fiber network. In either case, additional equipment would be required at the POP point for the Internet interconnection.

Map 61

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR NOMADIC USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO USER



LEGEND

EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION

RECOMMENDED LOCATION OF WiFi ACCESS POINT

GR3 IDENTIFICATION NUMBER (SEE TABLE 67)

RECEIVED POWER AT REMOTE: -70dBmW TO -79dBmW, THROUGHPUT: 24 Mbps to 54Mbps

RECEIVED POWER AT REMOTE: -79dBmW to -87dBmW, THROUGHPUT: 6 Mbps to 24 Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE

GRAPHIC SCALE

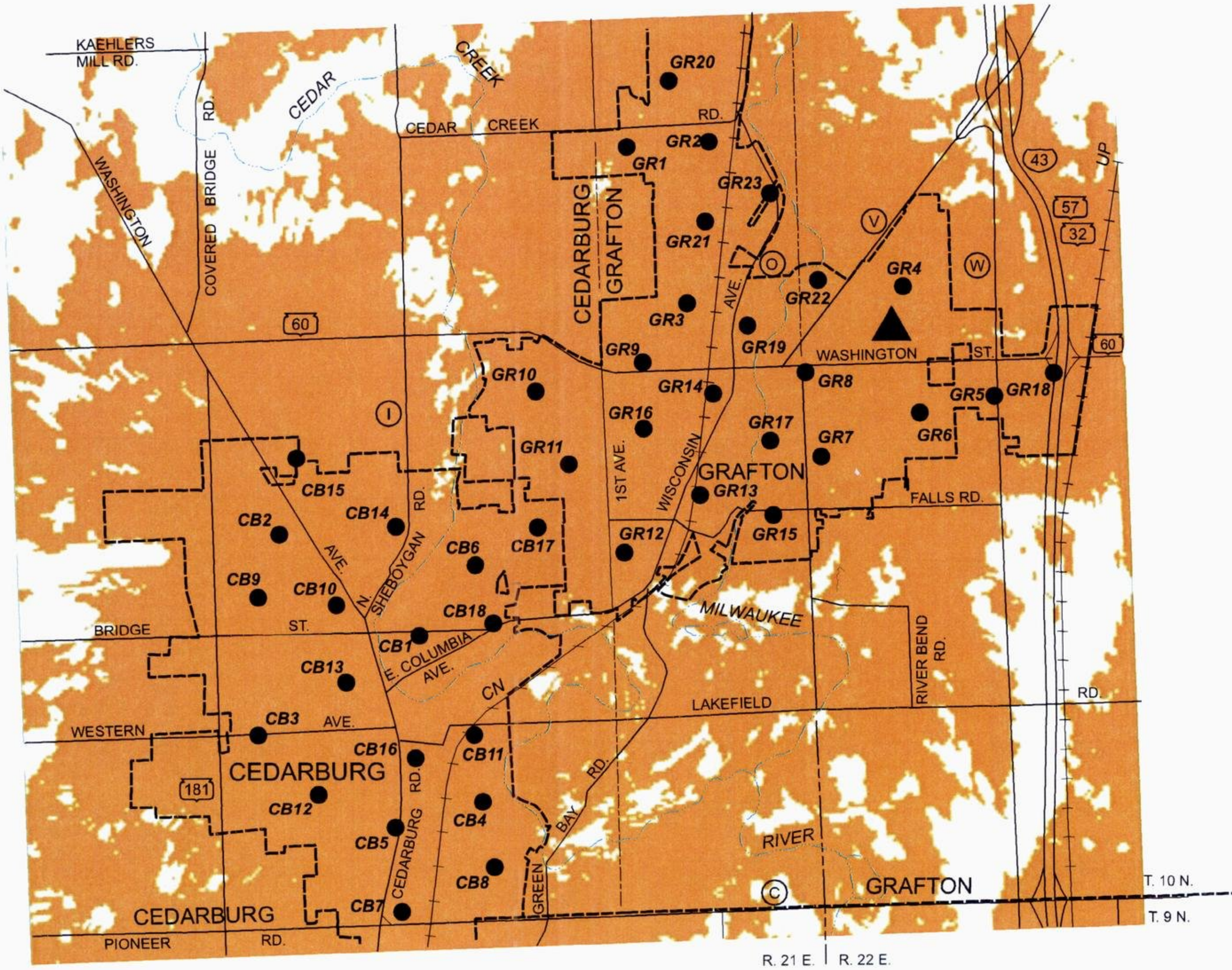
0 1 MILE

0 4,000 8,000

Source: SEWRPC.

Map 62

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO REMOTE



LEGEND

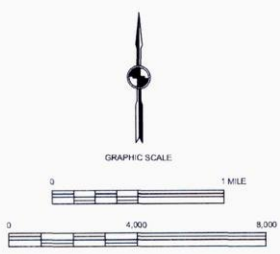
EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION

RECOMMENDED LOCATION OF WiFi ACCESS POINT

GR3 IDENTIFICATION NUMBER (SEE TABLE 2)

RECEIVED POWER AT REMOTE: -70dBmW TO -87dBmW, THROUGHPUT: 24 Mpbs to 54Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Table 67

LOCATIONS OF RECOMMENDED WIRELESS ACCESS POINTS TO BE USED FOR WiFi PURPOSES IN THE CITY OF CEDARBURG AND VILLAGE OF GRAFTON, OZAUKEE COUNTY, WISCONSIN

Site Number (See Maps 61 and 62)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
GR1	493,567	2,542,022	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GB2	488,807	2,545,318	T. 10 N., R. 21 E. Sec.13	Village of Grafton
GR3	489,372	2,543,603	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR4	489,971	2,549,446	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR5	486,743	2,551,950	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR6	486,450	2,549,905	T.10 N., R. 22 E. Sec. 19	Village of Grafton
GR7	485,296	2,547,322	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR8	487,628	2,546,826	T. 10 N., R. 22 E. Sec. 19	Village of Grafton
GR9	487,928`	2,542,530	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR10	487,149	2,539,665	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR11	485,188	2,540,599	T. 10 N., R. 21 E. Sec. 23	Village of Grafton
GR12	482,694	2,541,918	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR13	484,267	2,544,017	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR14	487,002	2,544,322	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR15	483,683	2,545,926	T. 10 N., R. 21 E. Sec. 25	Village of Grafton
GR16	485,980	2,542,482	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR17	485,633	2,545,878	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR18	487,463	2,553,785	T. 10 N., R. 21 E. Sec. 26	Village of Grafton
GR19	488,807	2,545,318	T. 10 N., R. 21 E. Sec. 24	Village of Grafton
GR20	495,301	2,543,229	T. 10 N., R. 21 E. Sec. 12	Village of Grafton
GR21	491,564	2,544,215	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
GR22	490,090	2,547,290	T. 10 N., R. 22 E. Sec. 18	Village of Grafton
GR23	492,355	2,546,028	T. 10 N., R. 21 E. Sec. 13	Village of Grafton

Site Number (See Maps 61 and 62)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
CB1	480,488	2,536,424	T. 10 N., R. 21 E. Sec.26	City of Cedarburg
CB2	483,338	2,532,805	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB3	477,856	2,532,271	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB4	475,954	2,538,218	T. 10 N., R. 21 E. Sec. 25	City of Cedarburg
CB5	475,207	2,535,812	T.10 N., R. 21 E. Sec. 24	City of Cedarburg
CB6	482,317	2,537,883	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB7	473,063	2,535,915	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB8	474,070	2,538,428	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB9	481,530	2,532,094	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB10	481,367	2,534,206	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB11	477,791	2,537,969	T. 10 N., R. 21 E. Sec. 35	City of Cedarburg
CB12	476.276	2,533,937	T. 10 N., R. 21 E. Sec. 34	City of Cedarburg
CB13	479,193	2,534,415	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB14	483,477	2,535,790	T. 10 N., R. 21 E. Sec. 27	City of Cedarburg
CB15	483,417	2,533,281	T. 10 N., R. 21 E. Sec. 22	City of Cedarburg
CB16	477,206	2,536,337	T. 10 N., R. 21 E. Sec. 24	City of Cedarburg
CB17	483,309	2,539,755	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg
CB18	480,689	2,538,419	T. 10 N., R. 21 E. Sec. 26	City of Cedarburg

[a]State Plane Coordinates are from the Wisconsin State Plane Coordinate System, South Zone, North American Datum of 1927. Coordinates are rounded to the nearest foot.

Source: SEWRPC.

Figure 13

TYPICAL ACCESS POINT ANTENNA

Source: SEWRPC.

Power connections at network access points will be site-specific based on the situation in each community. If street lights are controlled by a local photo sensor, then power interconnection through the sensor enclosure should be a simple and low-cost procedure. Where the operation of the street lights are centrally controlled, the provision of electric power to access point transceivers could require the laying of sub-surface power cables at substantial additional cost. The extent of such costs are indicated by recent experience in the City of Waukesha where WE Energies quoted a charge of \$800 per pole power installation. Provision for power and associated metering for access points located on electric power poles should also be relatively low in cost. For the WE Energy quote noted above, the power company did not require metering, but quoted a fixed unmetered rate of \$6.00 per month per access point.

Based on the 41 access points deployed—18 for Cedarburg and 23 for Grafton—the infrastructure deployment cost was estimated at \$353,336, expressed in year 2006 real dollars. This total cost included the cost of the equipment and equipment installation for each access point estimated at \$6,196 each or \$254,036; Internet access equipment—in the form of a WiMAX or fiber connection - \$34,600; a network monitoring system - \$10,000; and project management and engineering costs of \$55,000. The foregoing estimate of costs include only the costs of equipment and equipment installation.

Operating and maintenance costs including network management and utility pole rental costs are detailed in Appendix G. Total continuing costs are estimated at \$112 per month for each access point.

Part of the project engineering cost would support field testing to verify the performance of the access point locations in providing specified signal levels throughout their individual coverage areas. The cost estimate encompasses only the network infrastructure and does not include the cost of user equipment which would be purchased by individual users.

Mesh Network Evaluation of a Cedarburg-Grafton Deployment

Sufficient experience with WiFi-based mesh networks has been reported to allow for comparative cost and performance estimates of a potential wireless mesh network deployment in the Cedarburg-Grafton area. The Tropos Networks report on a mesh network deployment in Chaska, Minnesota is particularly helpful in this respect. Tropos is the reported leader in the number of wireless mesh networks deployed in American communities. Tropos is also purported to be the supplier for the forthcoming Milwaukee wireless network. In Chaska, Tropos required an access point density of 16 per square mile at a cost of approximately \$3,100 per access point. Applying these cost rates and point densities to the Cedarburg-Grafton area, a total access point deployment cost of \$381,300 is indicated.

Adding the costs of a network monitoring system and project management and engineering would place the total cost at about $456,300. Other mesh network manufacturers such as Nortel Networks and Motorola specify higher access point densities for their networks. Nortel specified 30 access points per square mile for suburban areas which would increase the mesh network deployment cost for the Cedarburg-Grafton area to over $800,000.

Even with these increased costs, mesh network throughput performance does not rise to the standards specified for a 4G network. Based on the Tropos Chaska experience, data throughput in the 0.5 to 3.0 megabits per second range was achieved. This performance is below the low threshold of 6.0 megabits per second in the cellular network alternative and well below the 24 to 54 megabits per second to be provided to the fixed location user in the recommended cellular plan.

On a cost-performance basis, the cellular wireless plan is decidedly superior. Two primary characteristics are believed to account for the difference in mesh network performance:

1. Omnidirectional Antennas
   The nature of a mesh network requires the use of omnidirectional antennas which have significantly lower gain than the directional antennas used in the cellular system. These lower gain antennas result in reduced signal levels and correspondingly lower data transmission rates.

2. High packet loss rates
   The lower signal levels in turn cause high packet loss rates which further reduce throughput performance. Such reduction is compounded by the procedures followed by the Internet TCP/IP protocol in handling packet losses.

A final comment concerning WiFi-based mesh networks is relevant here. Because these networks employ proprietary routing protocols and other vendor specific features, they no longer qualify as IEEE standards technologies with the lower costs and other benefits of standards-based technologies. A future WiFi standard for mesh networks, IEEE 802.11s, attempts to standardize mesh networks, but it is still in preparation, and current mesh networks are nonstandard with variations from one manufacturer to another.

Multimedia Extensions
The cellular broadband wireless system plan described here for the Cedarburg-Grafton area will initially provide data services for Internet access. The structure of the network with short latency times and low packet loss rates will make it readily expandable for voice communications based on VoIP technology. Latency times and packet loss rates are the primary determinants of voice quality in a telephony network. As previously stated, latency times and packet loss rates tend to limit the potential of mesh networks with their currently high packet loss rates and extended latency times. With transmission rates exceeding 20 megabits per second for fixed user installations and moving higher in the coming years, video services over the network become a strong possibility.

ENVIRONMENTAL ASSESSMENT

Commission policy as well as Federal and State regulations require the Commission to prepare an environmental assessment in connection with the development of any elements of the Commission's comprehensive plan for the physical development of the Region. Such an assessment, focusing on radiation hazards, would be presented to the Committee for review and comment at a future date.

SUMMARY

A five-step plan development sequence has been presented for a fourth generation (4G) wireless network plan for Southeastern Wisconsin. This sequence includes the following work activities:

1. Selecting a basic wireless communications technology.

2. Supporting this basic technology with accessory technologies required to achieve performance standards.

3. Identifying and defining equipment requirements for various classes of network users to be serviced by the new wireless network.

4. Planning an optimized WiMAX-based regional wireless backhaul network to service multiple community WiFi networks.

5. Formulating a community-level WiFi network plan for a sample community—the Cedarburg-Grafton area in Ozaukee County.

A standards-based WiFi-WiMAX wireless communications technology was selected as the foundation for the regional wireless network plan. WiFi would serve as the access network for individual local communities, and WiMAX would provide the backhaul connection to other WiFi networks and the Internet. Competing proprietary wireless technologies are more costly and less likely to achieve 4G performance standards.

Achieving throughput and other 4G performance standards required an improvement in receiver sensitivity performance. An approach to achieving this higher level receiver performance was described in some detail.

Two classes of current users were defined—the nomadic laptop computer user and the fixed location user. A plan objective was to support the laptop user as the defining measure for plan design with a strong broadband communications capability. The fixed location user could then benefit with higher data rate performance because of enhanced equipment capabilities.

Pilot system plans were prepared for both a WiMAX-based Regional Wireless Backhaul network and a community-based WiFi network. The regional wireless backhaul network would result in both infrastructure and operation savings that allow for an investment pay-back period of less than one year. A sectoral cellular network plan was generated based on radio propagation modeling for the Cedarburg-Grafton area that provided high speed data transmission rates of 24 to 54 megabits/second to all fixed location users at a system infrastructure cost of approximately $295,000 compared with approximately $456,000 for an equivalent Tropos mesh network that does not achieve the performance standards.

Chapter VIII

REGIONAL WIRELESS NETWORK PLAN IMPLEMENTATION

INTRODUCTION

In order for a publicly prepared wireless telecommunications plan to fully achieve its potential benefits, the plan must be implemented through actual network development. Given the predominance of the private sector in wireless network development, a specific well-defined procedure for plan implementation is an important element of the plan itself. This chapter will describe such a plan implementation procedure for both the regional wireless backhaul network element of the wireless telecommunications plan, and for a community-level access network plan.

Plan implementation as presented here extends beyond the physical and technical development of the network to the business and operational models required to effectively finance, market, and operate the networks concerned. The business model addresses the economics of a wireless communications system in terms of the user charge rates required for economically viable operation and the marketing activities needed to establish and operate the services envisioned in the plan. The operational model is concerned with network management and an associated network monitoring system necessary to supervise network operation.

Although a presentation of the regional wireless backhaul network plan implementation process followed by a presentation of the community access networks plan implementation process would seem the logical sequence, this order will be reversed here since the community access networks may be expected to be developed earlier than the regional backhaul network. This may be expected because:

1. The regional backhaul network is based on WiMAX technology which is a new standards technology scheduled for release in 2006. The community access networks are based on WiFi technology which is well established with ready equipment availability.

2. There is no regional institutional framework for regional wireless backhaul system plan implementation. Individual counties or a consortium of counties may be required for such a deployment even if a private service provider installs and operates the system.

3. Local units of governments provide a strong institutional structure for community access networks, and this implementation process is already underway.

COMMUNITY LEVEL WiFi NETWORKS PLAN IMPLEMENTATION

The currently prevailing wireless telecommunication system development process within the United States, as established by Federal law, places the responsibility for system development generally within the private sector, that process being, however, regulated by Federal and State laws and regulations. Therefore, the system development process is driven by decisions made within national corporate structures in response to competitive market forces. Public telecommunication service planning efforts, such as that conducted by the Southeastern Wisconsin Regional Planning Commission, are intended not to replace, but rather to influence this competitive, market driven process in the public interest. To be effective, the introduction of public planning requires some changes in the current entirely private development process. The modified system development process, then, consists of the following sequence of steps:

1. At the specific request of a constituent county or municipality, the Commission will prepare a broadband wireless system service plan for areas designated in the request;

2. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;

3. Field studies to verify or modify the preliminary plan as may be found necessary;

4. Final review and approval of system plan by the municipalities comprising each service area concerned;

5. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;

6. Selection of infrastructure development vendor;

7. Issuance of a request for proposals to operate system;

8. Selection of an internet service provider to operate the system; and

9. System operation

Plan preparation using radio propagation modeling and design optimization model tools would take place as previously described in Chapter VII, and would be initiated by the Commission upon request of the community. Each community level wireless plan would then be presented to the appropriate local governing body and advisory committees to that body for review and approval. Upon approval, the community would submit a letter requesting the Commission to move to step 3—field study verification of the community wireless plan.

Field study plan verification involves an extensive series of radio frequency signal intensity measurements using temporarily located access point equipment, equivalent to that planned for use in the network infrastructure. A truck-mounted antenna mast is employed for a series of temporary access point locations. For each temporary access point location, a signal-level coverage map is prepared based on a large number of radio frequency signal level measurements collected in a moving vehicle equipped with a WiFi-enabled laptop computer with a professional site survey software package. A variety of network performance measures will be recorded including signal level, noise level, throughput (packet speed) and packet retry and loss rates. In small networks with a few access points as in rural areas, all of the access points can be coverage and performance verified. In larger networks, a randomly selected set of access points can be used to statistically verify network coverage and performance. The field survey will identify weak coverage or performance areas which may require additional or relocated access points to achieve network coverage and performance objectives.

Following the completion of the field survey studies, the adjusted plan is resubmitted to the community for final review and approval. Upon approval, the plan implementation process would move to the final five stages which involve various aspects of vendor selection and system startup. The manner in which these final stages are approached depends on the general business model selected. If private service providers are asked and respond to a formal request for proposal, then steps 5 through 8 would be accomplished as a continuous final single stage process. If an alternative government ownership model is chosen, then infrastructure deployment and ISP (Internet Service Provider) selection would be executed as a two-stage process.

Whether the private or public version of a business model is selected, this business model plan must detail the marketing, training, financial and general business aspects of the proposed network operation in order to generate confidence in the economic viability of the new venture in a competitive environment.

Operational management of the new wireless system would be based on a network management system that employs real-time network monitoring to measure network performance in order to provide information for rapid trouble-shooting of network outages, and early identification and correction of network bottlenecks or areas of weak signal coverage.

The end result of the community-based WiFi network plan implementation process would be an operating broadband wireless network system that achieves the agreed upon performance objectives and is able to grow and adapt to an expanding network clientele. A wireless communications network system can be well managed only through constant observation of its dynamic nature as it grows its user base and adapts to changing traffic patterns.

REGIONAL WiMAX WIRELESS BACKHAUL NETWORK PLAN IMPLEMENTATION

The technical and operational aspects of a regional wireless backhaul network are similar to community-level WiFi network only on a larger scale. A backhaul network operates as an interconnection service to a multitude of community-level access networks linking their access points to fiber-based core networks that provide the regional and national backbone of the Internet.

The eight step plan implementation process just presented for community-level access networks can be applied in a modified form for the regional backhaul network. The initial regional wireless backhaul network plan has already been prepared and is documented in Chapter VII of this report. Identification of the review agency concerned would be either a county or a consortium of two or more counties—desirably of the seven counties comprising the planning region. Lacking a multi-county consortium, sequential review on a county-by-county basis provides the only alternative. If a favorable response is received from the first few county presentations, the climate may be improved for a more desirable region-wide initiative.

The step 3 field studies phase of backhaul network verification introduces challenges much greater than those encountered in a community access network. Antenna heights on backhaul base stations approximate 100 feet, while access points on community networks average around 20 feet. The latter height is suitable for truck mounting of antennae and rapid field testing. The former antenna base station situation does not lend itself to such truck mounting. At the same time, the need for field test verification for a backhaul network prior to deployment is even more compelling than for a lower cost access network. Needed is an approach capable of temporarily elevating two antenna fixtures at heights in the 100 feet range. Lower heights would be acceptable where two locations concerned provided line-of-sight connection. As long as a line-of-sight wireless link connection is established above the "clutter level," field test conditions will emulate future backhaul network operation. One possible approach would utilize a pair of traveling cranes in which the antennas would be crane-mounted at sufficient height to create a clean line-of-sight connection between the two base station locations being tested. Although increased costs would be encountered with such an approach, the size of the infrastructure investment for a wireless regional backhaul network justifies such testing costs.

Following a final review and approval of the verified network, the remaining steps of regional backhaul plan implementation would depend upon the network ownership model selected. If private ownership, infrastructure deployment, and network operation is the choice, then a multi-county consortium would probably be required as the institutional framework for issuing requests for proposals, reviewing, proposals and selecting a provider. It is questionable whether private service providers would be interested in a county-by-county implementation since the economic justification for the wireless backhaul relates primarily to lower cost data transmission rates achieved mainly through region-wide implementation. With a multi-county consortium, it would be possible to follow the same review and selection process previously presented for community access networks. Lacking a multi-county consortium, a county-by-county plan implementation approach may be necessary, with emphasis on public ownership.

SUMMARY

This Chapter has set forth a procedure for implementation of a 4th generation regional wireless network plan for the seven county Southeastern Wisconsin Region. As noted in the body of the Chapter, the currently prevailing wireless telecommunications system development process within the United States places the responsibility for system development largely within the private sector. Therefore, the system development process is defined by decisions made within the national corporate structure in response to competitive market forces. Public telecommunication service planning efforts, such as that conducted by the Southeastern Regional

Planning Commission, are intended, not to respond, but to influence this competitive market defining process in the public interest. To be effective, the introduction of public planning requires some changes in the current entirely private development process. The modified system development process consists of the following sequence of steps:

Public preparation of a broadband wireless system plan for designated service areas;

1. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;

2. Field studies to verify or modify the preliminary plan as may be found necessary;

3. Final review and approval of system plan by the municipalities comprising each service area concerned;

4. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;

5. Selection of infrastructure development vendor;

6. Issuance of a request for proposals to operate system;

7. Selection of an internet service provider to operate the system; and

8. System operation

With respect to the development of community level WiFi networks, the plan implementation process would be initiated through requests from a local community, or group of communities, to the Commission and would be directed through the nine steps by a community level advisory committee created for this purpose. Infrastructure development and system operation would desirably take place in the private sector, that sector responding to requests for proposals issued by the community or communities concerned based upon the approved plan. Failure of the private sector to respond to such requests would require consideration of public system development and operation.

With respect to the regional WiMAX wireless backhaul network plan implementation, the same nine step process would be followed. The initiation and directing agencies, however, would consist of a county or a consortium of two or more counties—preferably of all seven counties comprising the Southeastern Wisconsin Planning Region.

Chapter IX

SUMMARY

SUMMARY

This planning report documents the findings and recommendations of the planning process conducted by the Southeastern Wisconsin Regional Planning Commission to develop a wireless telecommunications system plan for the seven-county Southeastern Wisconsin Region. The planning process concerned was initiated in August 2004. The wireless telecommunications element of the planning process was completed in May 2006. The findings and recommendations are presented in the eight chapters which together with this summary comprise the report.

Chapter I presents background information about the Regional Planning Commission, the regional planning concept in Southeastern Wisconsin, and about the seven-county planning Region; including basic information on the size, resident population, employment, real property valuation, and governmental structure of the Region. The Chapter also contains a brief description of the work programs undertaken by the Commission from its creation in 1960 through 2004. Importantly, the Chapter describes the importance of telecommunications to the continued sound social and economic development of the Region, and the need for regional telecommunications planning. The Chapter notes that the regional telecommunications planning effort was being conducted in accordance with a Prospectus adopted by the Commission in December 2003. This Prospectus envisioned the regional telecommunications plan to be comprised of two principal elements: a wireless antenna siting and related infrastructure plan, and an overall telecommunications network plan.

Chapter II sets forth the basic principles and concepts underlying the regional telecommunications planning process; describes that process; and, importantly, describes the technologies involved including mobile and fixed wireless networks.

Chapter III sets forth a set of eight objectives that should be met by the regional telecommunications system, together with their supporting principles and standards. These objectives relate to system performance, as measured by data transmission rate, availability, quality of voice transmission, error rate, and packet loss; universality of service; redundancy; antenna site number optimization; application to be served; cost minimization; antenna site aesthetics and safety; and use in public safety emergencies. The objectives and supporting quantitative standards were intended to be used in plan design and evaluation of alternative plans and the selection of a recommended plan.

Chapter IV presents inventory findings relating to pertinent background within the Region, conditions including information on the demographic and economic base, land use, and supporting transportation facilities and services.

Chapter V catalogues the locations and certain technical characteristics of the 755 mobile—cellular—PCS and fixed wireless antenna sites within the seven-county planning area. These antenna sites not only provide the infrastructure for the existing mobile and fixed wireless networks within the Region, but also serve as potential co-location sites for new advanced wireless network antennas. Such co-located sites reduce new infrastructure costs and minimize environmental impact.

Chapter VI documents the findings of the Commission inventory and the performance of the existing cellular—PCS mobile wireless networks operating within the Region. The performance of five service providers are evaluated in terms of network availability, upload and download, through-put, and response time. Significant performance differences were observed between both the individual service provider networks and the technologies used in these networks. Performance data for both second generation (2G) and third generation (3G) packet-switched networks were acquired. Although the 3G networks demonstrated considerable improvement over the 2G networks, performance was still far below the theoretical target for throughput performance of 2 megabits per second, and far below the agreed upon service objectives for the Region.

Chapter VII describes the recommended wireless telecommunications plan for the seven-county Southeastern Wisconsin Region. The recommended plan consists of two levels of wireless networks—a wireless backhaul network plan, and a pilot, community level, wireless access network plan. The proposed backhaul network would service a multitude of community level access points that would forward data to the backhaul network for cost effective Internet connection. The higher volumes of data that would be processed through the envisioned regional network may be expected to lead to significantly lower Internet charge rates and would allow for recovery of the backhaul infrastructure capital costs in approximately one year. An illustrative pilot community level access network plan was prepared and presented for the Cedarburg-Grafton area of Ozaukee County. A sectoral cellular network structure served as the framework for the plan design which provided for 4G-level performance, with data transmission rates above 20 megabits per second. The illustrative pilot plan is compliant with the objectives and performance standards specified in Chapter III. An alternative community access plan based upon a mesh topology was also designed and was found to be more costly than the cellular network structure plan. Moreover, the mesh network plan did not achieve the specified objective and performance standards.

Chapter VIII sets forth an approach to implementation for both the community level wireless access network plans and for the regional wireless backhaul network. The proposed plan implementation process is intended not to replace, but rather to influence the extant competitive market driven, private sector planning in order to promote the public interest within the Region. The proposed modified system development process consists of the following sequence of steps:

1. Public preparation of a broadband wireless system plan for designated service areas;
2. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;
3. Field studies to verify or modify the preliminary plan as may be found necessary;
4. Final review and approval of system plan by the municipalities comprising each service area concerned;
5. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;
6. Selection of infrastructure development vendor;
7. Issuance of a request for proposals to operate system;
8. Selection of an internet service provider to operate the system; and
9. System operation

With respect to the development of the community level access network plans, the plan implementation process would be initiated through requests from a local community, or group of communities to the Commission, and would be directed through the nine steps by a community level advisory committee created for this purpose. Infrastructure development and system operation would desirably take place in the private sector, that sector responding for requests for proposals issued by the community or communities concerned based upon the above plan.

The same nine-step plan implementation process would be followed with respect to the regional backhaul network plan. The initiating and directing agencies, however, would consist of a county or consortium of two or more counties—desirably of all seven counties—comprising the planning Region.

APPENDICES

Appendix A

CIVIL DIVISION CODES

LIST OF CIVIL DIVISIONS WITHIN THE SOUTHEASTERN WISCONSIN REGION BY COUNTY AND THE ATTENDANT CODE AS ASSIGNED BY THE REGIONAL PLANNING COMMISSION

KENOSHA COUNTY -100

101 Brighton Town
102 Bristol Town
103 Kenosha City
104 Paddock Lake Village
105 Paris Town
106 Pleasant Prairie Village
107 Randall Town
108 Salem Town
109 Silver Lake Village
110 Somers Town
111 Twin Lakes Village
112 Wheatland Town
113 Genoa City Village (Part) See 512

OZAUKEE COUNTY - 200

201 Belgium Town
202 Belgium Village
203 Cedarburg City
204 Cedarburg Town
205 Fredonia Town
206 Fredonia Village
207 Grafton Town
208 Grafton Village
209 Mequon City
210 Port Washington City
211 Port Washington Town
212 Saukville Town
213 Saukville Village
214 Thiensville Village
215 Bayside Village (Part) See 401
216 Newburg Village (Part) See 620

RACINE COUNTY - 300

301 Burlington City (Part) See 529
302 Burlington Town
303 Caledonia Town
304 Dover Town
305 Elmwood Park Village
306 Mt. Pleasant Village
307 North Bay Village
308 Norway Town
309 Wind Lake (U)
310 Racine City
311 Raymond Town
312 Rochester Town
313 Rochester Village
314 Sturtevant Village
315 Union Grove Village
316 Waterford Town
317 Waterford Village
318 Wind Point Village
319 Yorkville Town

MILWAUKEE COUNTY-400

401 Bayside Village (Part) See 215
402 Brown Deer Village
403 Cudahy City

MILWAUKEE COUNTY-400

404 Fox Point Village
405 Franklin City
406 Glendale City
407 Greendale Village
408 Greenfield City
409 Hales Corners Village
410 Milwaukee City (Part) See 621, 739
411 Oak Creek City
412 River Hills Village
413 St. Francis City
414 Shorewood Village
415 South Milwaukee City
416 Wauwatosa City
417 West Allis City
418 West Milwaukee Village
419 Whitefish Bay Village

WALWORTH COUNTY - 500

501 Bloomfield Town
502 Darien Town
503 Darien Village
504 Delavan City
505 Delavan Town
506 Delavan Lake (U)
507 East Troy Town
508 East Troy Village
509 Elkhorn City
510 Fontana on Lake Geneva Village
511 Geneva Town
512 Genoa City Village (Part) See 113
513 LaFayette Town
514 LaGrange Town
515 Lake Geneva City
516 Linn Town
517 Lyons Town
518 Richmond Town
519 Sharon Town
520 Sharon Village
521 Spring Prairie Town
522 Sugar Creek Town
523 Troy Town
524 Walworth Town
525 Walworth Village
526 Whitewater City (Part)*
527 Whitewater Town
528 Williams Bay Village
529 Burlington City (Part) See 301
530 Mukwonago Village (Part)

WASHINGTON COUNTY

601 Addison Town
602 Barton Town
603 Erin Town
604 Farmington Town
605 Germantown Town
606 Germantown Village

*Partially outside of the Southeastern Wisconsin Region

U - Unincorporated

WASHINGTON COUNTY - 600

607 Hartford City (Part)*
608 Hartford Town
609 Jackson Town
610 Jackson Village
611 Kewaskum Town
612 Kewaskum Village (Part)*
613 Polk Town
614 Richfield Town
615 Slinger Village
616 Trenton Town
617 Wayne Town
618 West Bend City
619 West Bend Town
620 Newburg Village (Part) See 216
621 Milwaukee City (Part) See 410, 739

WAUKESHA COUNTY - 700

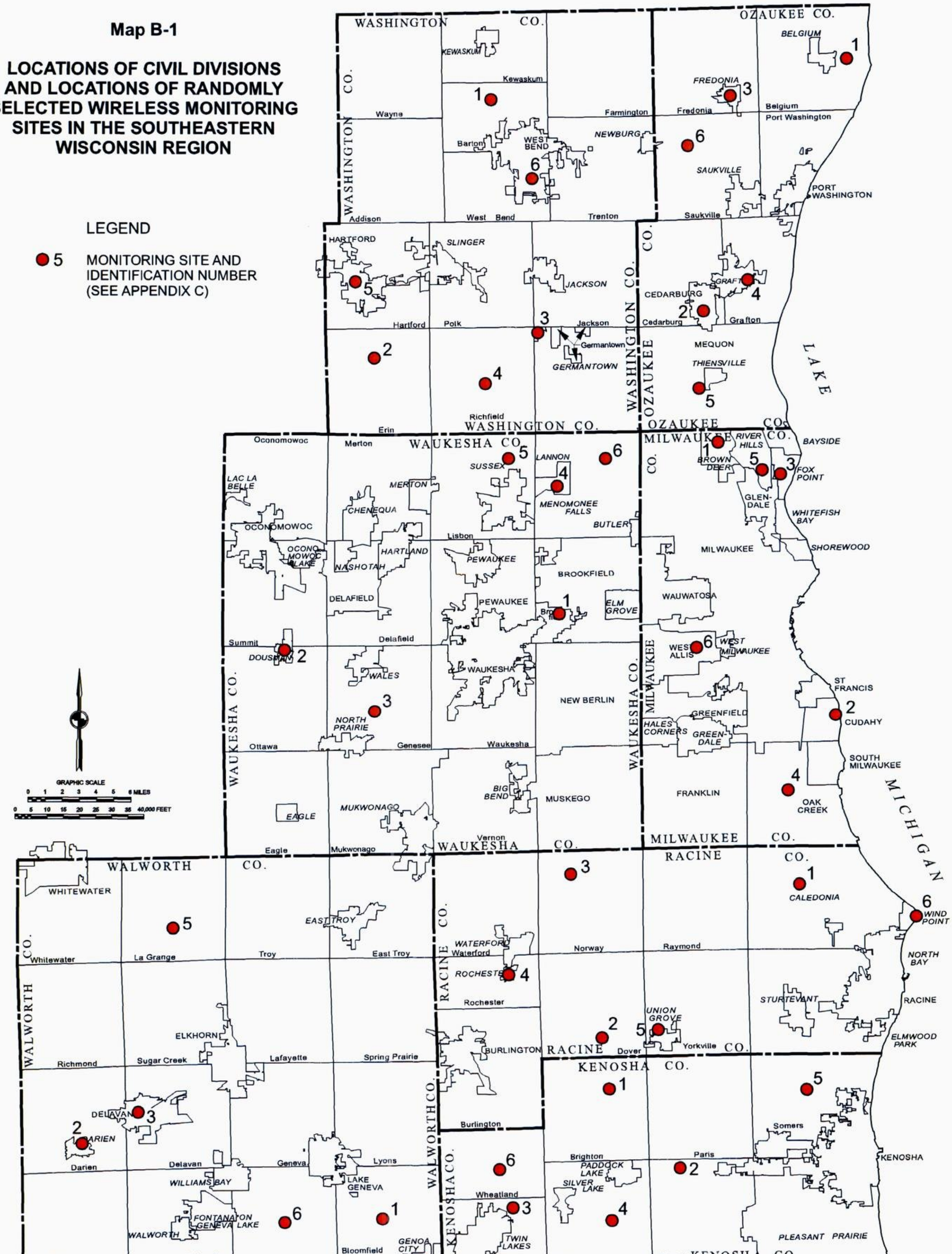
701 Big Bend Village
702 Brookfield City
703 Brookfield Town
704 Butler Village
705 Chenequa Village
706 Delafield City
707 Delafield Town
708 Dousman Village
709 Eagle Town
710 Eagle Village
711 Elm Grove Village
712 Genesee Town
713 Hartland Village
714 Lac La Belle Village (Part)*
715 Lannon Village
716 Lisbon Town
717 Menomonee Falls Village
718 Merton Town
719 Merton Village
720 Mukwonago Town
721 Mukwonago Village (Part)
722 Muskego City
723 Nashotah Village
724 New Berlin City
725 North Prairie Village
726 Oconomowoc City
727 Oconomowoc Town
728 Okauchee (U)
729 Oconomowoc Lake Village
730 Ottawa Town
731 Pewaukee City
732 Pewaukee Village
733 Summit Town
734 Sussex Village
735 Vernon Town
736 Wales Village
737 Waukesha City
738 Waukesha Town
739 Milwaukee City (Part) See 410, 621

Appendix B

LOCATIONS OF CIVIL DIVISIONS AND LOCATIONS OF RANDOMLY SELECTED WIRELESS MONITORING SITES IN THE SOUTHEASTERN WISCONSIN REGION

Map B-1

LOCATIONS OF CIVIL DIVISIONS AND LOCATIONS OF RANDOMLY SELECTED WIRELESS MONITORING SITES IN THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Appendix C

RANDOMLY SELECTED WIRELESS MONITORING SITES

LOCATIONS AND ADDRESSES OF RANDOMLY SELECTED WIRELESS MONITORING SITES BY COUNTY

KENOSHA COUNTY – 100

1	Brighton Town	Town Hall 25000 Burlington Rd. Town of Brighton
2	Bristol Town	Kenosha County Department of Public Works 19600 75th St. Town of Bristol
3	Randall Town	Town Hall 34530 Bassett Rd. Town of Randall
4	Salem Town	Town Hall 9814 Antioch Rd. Town of Salem
5	Somers Town	Town Hall 7511 12th St. Town of Somers
6	Wheatland Town	Town Hall 34315 Geneva Rd. Town of Wheatland

OZAUKEE COUNTY - 200

1	Belgium Town	St. Marys School 675 County Road D Town of Belgium
2	Cedarburg City	Police Department W75 N444 Wauwatosa Rd. City of Cedarburg
3	Fredonia Village	Village Hall 4126 Fredonia Ave. Village of Fredonia
4	Grafton Village	Police Department 1981 Washington Ave Village of Grafton
5	Mequon City	Police Department 11300 N. Buntrock Ave. City of Mequon
6	Saukville Town	Town Hall 3762 Lakeland Rd. Town of Saukville

MILWAUKEE COUNTY – 400

1	Brown Deer Village	Village Hall 4800 Green Brook Dr. Village of Brown Deer
2	Cudahy City	City Hall 5050 S. Lake Dr. City of Cudahy
3	Fox Point Village	Municipal Building 7200 N Santa Monica Blvd. Village of Fox Point
4	Oak Creek City	City Hall 8640 S. Howell Ave. City of Oak Creek
5	River Hills Village	Village Hall 7650 N. Pheasant Ln. Village of River Hills
6	West Allis City	City Hall 7525 W. Greenfield Ave. City of West Allis

RACINE COUNTY - 300

1	Caledonia Village	Village Hall 6922 Nicholson Rd. Village of Caledonia
2	Dover Town	Town Hall 4110 S. Beaumount Ave. Town of Dover
3	Norway Town	Municipal Building 6419 Heg Park Rd. Town of Norway
4	Rochester Village	Village and Town Hall 203 W. Main St. Village of Rochester
5	Yorkville Town	Town Hall 720 Main St. Town of Yorkville
6	Wind Point Village	Village Clerk's Office 215 E. Four Mile Rd. Village of Wind Point

WALWORTH COUNTY – 500

1	Bloomfield Town	Town Hall 1100 Town Hall Rd. Town of Bloomfield
2	Darien Village	Village Hall 24 N. Wisconsin St. Village of Darien
3	Delavan City	City Hall 123 S. 2nd St. City of Delavan
4	Genoa City Village	Village Hall 715 Walworth St. Village of Genoa City
5	LaGrange Town	Town Hall N7899 County Rd. H Town of LaGrange
6	Linn Town	Town Hall W3728 Franklin Walsh St. Town of Linn

WASHINGTON COUNTY – 600

1	Barton Town	Town Hall 3482 Town Hall Rd. Town of Barton
2	Erin Town	Town Hall 1846 STH 83 Town of Erin
3	Germantown Town	Town Clerk's Residence N142 W21825 Marquette Rd. Town of Germantown
4	Richfield Town	Town Hall 4128 Hubertus Rd. Town of Richfield
5	Hartford City	City Hall 109 N. Main St. City of Hartford
6	West Bend City	City Hall 1115 S. Main St. City of West Bend

Source: SEWRPC

WAUKESHA COUNTY - 700

1	Brookfield Town	Town Hall 645 North Janacek Rd. Town of Brookfield
2	Dousman Village	Village/Town Hall 118 S. Main St. Village of Dousman
3	Genesee Town	Town Hall S41 W31391 STH 83 Town of Genesee
4	Lannon Village	Village Hall 20399 W. Main St. Village of Lannon
5	Lisbon Town	Town Hall W234 N8676 Woodside Rd. Town of Lisbon
6	Menomonee Falls Village	Village Hall W156 N8480 Pilgrim Rd. Village of Menomonee Falls

Appendix D

MONITORING SCHEDULE

MONITORING SCHEDULE

All monitoring periods began on either a Monday or Thursday unless that day conflicted with a holiday. In that case the period began on the day before or the day after the holiday, as appropriate. All monitoring periods followed the time schedule shown below.

Monday Period:

Installation:	Monday:	0800-1600
Monitoring:	Monday:	1600-2400
	Tuesday:	0000-2400
	Wednesday:	0000-2400
	Thursday:	0000-0800

Thursday Period:

Installation:	Thursday:	0800-1600
Monitoring:	Thursday:	1600-2400
	Friday:	0000-2400
	Saturday:	0000-2400
	Sunday:	0000-2400
	Monday:	0000-0800

The scheduled assignments for each location and test period are indicated in Appendix E.

Appendix E

MONITORING SITE ASSIGNMENTS

MONITORING SITE ASSIGNMENTS

OZAUKEE COUNTY-200	November 14, 2005	November 17, 2005	November 21, 2005	November 23, 2005
1 Belgium Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Cedarburg City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Fredonia Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Mequon City	Cingular	Verizon	Sprint	Nextel
5 Grafton Village	T-Mobile	Cingular	Verizon	Sprint
6 Saukville Town	U.S. Cellular	T-Mobile	Cingular	Verizon
WASHINGTON COUNTY-600	November 28, 2005	December 1, 2005	December 5, 2005	December 8, 2005
1 Barton Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Erin Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Germantown Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Richfield Town	Cingular	Verizon	Sprint	Nextel
5 Wayne Town	T-Mobile	Cingular	Verizon	Sprint
6 West Bend City	U.S. Cellular	T-Mobile	Cingular	Verizon
WAUKESHA COUNTY-700	December 12, 2005	December 15, 2005	December 19, 2005	December 22, 2005
1 Brookfield Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Dousman Village	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Genesee Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Lannon Village	Cingular	Verizon	Sprint	Nextel
5 Lisbon Town	T-Mobile	Cingular	Verizon	Sprint
6 Menomonee Falls Village	U.S. Cellular	T-Mobile	Cingular	Verizon
WALWORTH COUNTY-500	December 27, 2005	December 29, 2005	January 3, 2006	January 5, 2006
1 Bloomfield Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Delavan City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Darien Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Genoa City Village (Part)	Cingular	Verizon	Sprint	Nextel
5 LaGrange Town	T-Mobile	Cingular	Verizon	Sprint
6 Linn Town	U.S. Cellular	T-Mobile	Cingular	Verizon
KENOSHA COUNTY-100	January 9, 2006	January 12, 2006	January 16, 2006	January 19, 2006
1 Brighton Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Bristol Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Somers Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Randall Town	Cingular	Verizon	Sprint	Nextel
5 Salem Town	T-Mobile	Cingular	Verizon	Sprint
6 Wheatland Town	U.S. Cellular	T-Mobile	Cingular	Verizon
RACINE COUNTY-300	January 23, 2006	January 26, 2006	January 30, 2006	February 2, 2006
1 Caledonia Village	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Dover Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 North Bay Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Norway Town	Cingular	Verizon	Sprint	Nextel
5 Rochester Village	T-Mobile	Cingular	Verizon	Sprint
6 Yorkville Town	U.S. Cellular	T-Mobile	Cingular	Verizon
MILWAUKEE COUNTY-400	February 6, 2006	February 9, 2006	February 13, 2006	February 16, 2006
1 Brown Deer Village	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Cudahy City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Fox Point Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Oak Creek City	Cingular	Verizon	Sprint	Nextel
5 River Hills Village	T-Mobile	Cingular	Verizon	Sprint
6 West Allis City	U.S. Cellular	T-Mobile	Cingular	Verizon

Source: SEWRPC.

Appendix F

INFRASTRUCTURE COST ESTIMATE TABULATIONS

COMMUNITY WiFi NETWORK (802.11)
ACCESS POINT EQUIPMENT

WiFi (802.11 a,g) Access Point

1.	Transceiver Modules	
	2 at $1,500 =	$3,000
2.	Sectorized Antenna	995
3.	Auxiliary Equipment	841
4.	Installation and Testing	
	17 hours at $80	1,360
	Total	$6,196

For rural wireless network, add:
Three sets of preamplifiers, connectors and power injectors - $645

WiFi Network Cost Summary - Cedarburg-Grafton Area

1.	Access Points	
	41 at $6,196 =	$254,036
2.	Gateway Stations	
	2 at $17,300 =	34,600
3.	Network Monitoring System	10,000
4.	Project Management and	
	Engineering	55,000
	Total	$353,336

BACKHAUL WiMAX/WiFi NETWORK (802.11, 802.16)
BASE STATION EQUIPMENT

Co-located Site

1.	Site Preparation and Cleanup	$ 1,000
2.	Enclosures	200
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	21 dBi Antenna	150
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Installation and Testing	
	40 hours at $80	3,200
9.	Miscellaneous	
	(Freight, cabling and travel)	2,250
	Total	$23,024

New Site

1.	Items 1-9 of co-located site above		$23,024
2.	Tower Erection		
	100 foot tower	$7,200	
	Foundation	4,100	
	Labor	2,200	
	Climb Shield	1,000	14,500
	Total		$37,524

Gateway Station

1.	Site Preparation and Cleanup	$ 1,000
2.	Enclosures	10,850
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	31.2 dBi Antenna	3,874
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Internet Interconnection	
	MPLS Router	30,420
	Fiber Interconnect Equipment	20,000
9.	Installation and Testing	
	80 hours at $80	6,400
10.	Miscellaneous	
	(Freight, cabling and travel)	2,750
	Total	$91,518
	If new tower required	14,500
		$106,018

Backhaul Network Cost Summary – Co-Location

1.	Antenna Base Stations	
	47 at $23,024 =	$1,082,128
2.	Gateway Stations	
	7 at $91,518 =	640,626
3.	Project Management and	
	Engineering	350,000
	Total	$2,072,754

Backhaul Network Cost Summary – New Tower Sites

1.	Antenna Base Stations	
	47 at $37,524 =	$1,763,628
2.	Gateway Stations	
	7 at $106,018 =	742,126
3.	Project Management and	
	Engineering	350,000
	Total	$2,855,754

Appendix G

OPERATING COST ESTIMATE TABULATIONS

Access Point
Community WiFi Network

1.	Electric Power	
	50 watts at $0.05/kwh	$ 1.80/month
2.	Maintenance and Network Management	25.00/month
3.	Pole Rental	10.00/month
	Total	$ 36.80/month

Backhaul Base Station
WiFi/WiMAX Network – Co-location

1.	Electric Power	
	200 watts at $0.05/kwh	$ 7.20/month
2.	Maintenance and Network Management	100.00/month
3.	Base Station Rental	
	$4/foot/month	
	100 foot tower	400.00/month
4.	Transport Costs (100 Mbps)	
	74 x 100 =	7,400.00/month
	Total	$7,907.20/month

Backhaul Base Station
WiFi/WiMAX Network – New Towers

1.	Electric Power	
	200 watts at $0.05/kwh	$ 7.20/month
2.	Maintenance and Network Management	100.00/month
3.	Land usage fee	1,060.00/month
4.	Transport Costs (100 Mbps)	
	74 x 100 =	$7,400.00/month
		$8,507.20/month

Note:
Base station operators are often required to have liability insurance in the range of $1-3 million for each base station site. Less often they are required to post performance bonds for the contingency of tower abandonment. Neither of these costs are included here.

Appendix H

INTERNET ACCESS AND TRANSPORT BUDGETARY RATES

INTERNET ACCESS AND TRANSPORT BUDGETARY RATES[a]

Transport	
Speed	24 Month
2Mb	$400
5Mb	$765
10Mb	$1,035
20Mb	$1,410
30Mb	$1,565
40Mb	$1,720
50Mb	$1,875
60Mb	$2,035
70Mb	$2,195
80Mb	$2,355
90Mb	$2,515
100Mb	$2,625
ICB	- -

Direct Internet Access					
Committed	12 Month	24 Month	36 Month	48 Month	60 Month
10Mbps	$108	$107	$106	$105	$104
20Mbps	$100	$99	$98	$97	$96
30Mbps	$92	$91	$90	$89	$88
40Mbps	$89	$88	$87	$86	$85
50Mbps	$86	$85	$84	$83	$82
60Mbps	$84	$83	$82	$81	$80
70Mbps	$81	$80	$79	$78	$77
80Mbps	$80	$79	$78	$77	$76
90Mbps	$76	$75	$74	$73	$72
100Mbps	$74	$73	$72	$71	$70
110Mbps	$72	$71	$70	$69	$68
120Mbps	$70	$69	$68	$67	$66
130Mbps	$68	$67	$66	$65	$64
140Mbps	$66	$65	$64	$63	$62
150Mbps	$64	$63	$62	$61	$60
250Mbps	$62	$61	$60	$59	$58

[a]Rates provided by LightPoint Networks, 1807 N. Center Street, Beaver Dam, WI 53916, via letter from Mr. Daniel W. Matson, Sales Agent, dated June 19, 2006.

Appendix I

ENVIRONMENTAL IMPACT ASSESSMENT OF THE REGIONAL BROADBAND WIRELESS SYSTEM PLAN FOR SOUTHEASTERN WISCONSIN

Introduction

It has been the long-standing policy of the Southeastern Wisconsin Regional Planning Commission to perform an environmental assessment of its recommended plans, and to include the findings of such assessments in the planning reports which set forth the Commission recommended plans. Accordingly, this Appendix sets forth the findings of an environmental assessment of the Commission's recommended wireless telecommunications plan for Southeastern Wisconsin.

The environmental assessment focuses on the potential effects on human health of radio frequency transmissions, considering to the extent possible given the current state of the art both the thermal and athermal effect of such transmissions. The assessment does not concern itself with the potential impacts of the location of transmitting and receiving structures on surrounding land uses and on property values. Such impacts are highly site specific and can only be properly considered in the preliminary engineering stage of plan implementation when specific station locations together with their surrounding environments have been identified.

Background Information

Wireless communications systems are usually based on transfers of radio frequency electromagnetic energy between users with antenna base stations or network access points as intermediaries. Some wireless networks such as amateur radio and citizen band radio also allow for direct communications between users without the need for base station or access point intermediaries. The radio frequency signals used in these wireless networks are typically of low power, with transmitting powers ranging from about 100 milliwatts to as high as 1,000 watts. To put these power levels in perspective, most commercial AM radio broadcasting stations transmit at power levels of 50,000 watts. The Voice of America broadcasts at power levels of 500 kilowatts, with directional power levels as high as 100 megawatts. The typical cellular wireless network base station transmits at about 150 watts, far below the levels of radio and television broadcasting stations, and also far below the levels of shortwave radio broadcasting stations and many amateur radio stations.

Whatever the power level, the function of wireless radiowave communications is to convey information, not to transfer power or energy. Whether the media is voice, data, or video, radio frequency signal performance is based on the transfer rate of information and not the watts of power. To transfer information, however, an adequate level of radio frequency power is required, the power required depending on the frequency of the signal transmitted, the distance, the nature of the propagation path traversed, and the sensitivity of the receiver processing these signals. Although the primary function in telecommunications is information transfer, various levels of radio frequency power may have secondary effects. These secondary effects may affect the health of persons in the path of radio frequency radiation. The purpose of this assessment is to evaluate the potential health effects of radio frequency radiation created by wireless telecommunications networks particularly those existing and proposed networks comprising a part of the broadband wireless telecommunications system plan for Southeastern Wisconsin.

The two types of radio frequency health effects to be examined are thermal effects and athermal effects. The thermal effects of radio frequency energy on the human body are fairly well understood, and maximum permissible exposure limits as a function of frequency are specified by the Federal Communications Commission (FCC). Wireless telecommunications networks are prohibited by law from violating these exposure limits in their network operations. Athermal effects, in contrast, are not well understood, and are currently very controversial with conflicting results from controlled lab-oratory and epidemiological studies.

The findings of this assessment of potential environmental impacts indicate that the FCC maximum permissible exposure limits for radio frequency thermal exposure are not being violated by cellular/PCS or other wireless systems currently deployed within the Region. The Commission planned broadband WiFi/WiMAX based systems with their very low transmitting power are even farther below these thermal exposure limits, and pose no thermal health hazards for citizens of Southeastern Wisconsin.

Athermal effects present a more ambiguous picture with conflicting results in different controlled studies. A recent major study sponsored by the European Union (EU 2004), which aggregated the results of many RF-EMF (radio frequency electromagnetic fields) studies, did indicate that there were valid concerns about athermal effects on human DNA strands and various body tissues at lower than published FCC thermal effect exposure levels. These studies, all based on *in vitro* laboratory investigations, however, were not directly related to human health effects; and, therefore, were not considered conclusive with respect to use in establishing new maximum permissible exposure (MPE) limits for athermal radio frequency radiation.

Given the uncertainty of radio frequency radiation athermal health effects, prudence would require that a low power telecommunications approach be used in the preparation of Commission broadband wireless communications plans. Radio frequency radiation effects, whether thermal or athermal, are a function of radio frequency power density. Low power telecommunications facilities may be defined as facilities with transmitting powers limited to a maximum power of 5 watts. Use of such relatively low power requires significantly increased receiver sensitivities to compensate for reduced transmitting power. Such enhanced receiver sensitivities, are well within the current state of telecommunications technologies. Use of low power transmitters not only reduces the risks of radio frequency exposure, but also provides an improved radio frequency environment. Radio frequency interference (RFI) has become one of the major obstacles to wireless telecommunications, and universal adaptation of low power standards would do much to alleviate this obstacle. Environmentally, low power transmission also allows for the use of solar panels on access points, taking wireless off the electric power grid for more reliable and environmentally-friendly telecommunications.

Radio Frequency Radiation

Radio frequency (RF) radiation, for the purposes of this study is defined as radiation in the spectral range of 50 MHz to 18 GHz. Such a frequency range encompasses all known current commercial and public wireless communications networks. Most existing and planned commercial and public wireless networks are, and may be expected to remain in the 800 MHz to 6 GHz range. The only major exceptions are satellite broadband transmissions which operate in the 12 to 18 GHz band. Some public safety telecommunications networks still operate in the 50 or 150 MHz bands.

Radio frequency radiation is classified as a non-ionizing form of radiation in contrast with x-rays, gamma rays, and even some ultra-violet fields which are designated as ionizing radiation. Ionizing radiators have enough energy to dislodge electrons from their atoms. When this happens, positive and negative ions are formed with well-documented potential damage to human health. At sufficiently high power densities, however, radio frequency radiation can pose health hazards. Experience since the early days of radio has shown that radio frequency energy can cause injury by heating body tissue. Radio frequency burns can be extremely painful, but even lower level tissue heating can be damaging to internal body organs. Radio frequency induced heating of the eye can result in cataracts or even cause blindness. These heat-related hazards of radio frequency radiation are called thermal effects.

Extensive research has also been conducted on changes in physiological function in the presence of radio frequency energy that is too low to cause heating. These athermal effects are more subtle than thermal heating and involve changes in function at the cellular level that may produce breakages in DNA strands. The conflicting results of laboratory studies relating to this concern make it difficult to establish exposure guidelines. The alternative approach is to adopt a policy requiring low power telecommunications.

Thermal Effects of Radio Frequency Energy

Body tissues exposed to very high levels of radio frequency energy may suffer serious heat damage.[1] These effects depend upon the frequency of the energy, and the power density of the radio frequency field striking the body, together with other factors such as the polarization of the radio wave.

Radio frequency energy is absorbed more efficiently at frequencies near the body's natural frequency which is about 35 MHz for a grounded person, and 70 MHz for a person insulated from ground. Various parts of the body have different resonant frequencies such as the adult head of about 400 MHz and the infant head of about 700 MHz. As the frequency moves away from body resonance, less radio frequency heating is experienced. The specific absorption rate, (SAR) defines the rate at which radio frequency energy is absorbed in tissue.

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[1] *Hare E.* Radio Frequency Exposure and You, *American Radio Relay League, 2003-Chapter 3.*

Based on power density levels specified by the IEEE/FCC in the latest releases, there is no evidence to support a conclusion that existing or planned wireless base stations, or access points, exceed the thermal radio frequency exposure limits. On October 3, 2005, the Standards board of the IEEE Standards Association approved a new "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3kHz to 300 GHz"[2,3] The maximum permissible exposure standard for the frequency range of interest is between 2 watts per square meter and 10 watts per square meter in the band from 400 to 2000 MHz, and 10 watts per square meter for frequencies above 2000 MHz.

Three particular frequencies of interest related to existing cellular/PCS or planned WiFi/WiMAX networks are:

Cellular – 800 to 900 MHz
PCS – 1900 MHz
WiFi/MAX – 2.4 to 5.8 GHz

The maximum permissible exposure (MPE) for these three frequency bands are:

800-900 MHz: 4.0 to 4.5 W/m^2
1900 MHz: 9.5 W/m^2
2.4 to 5.8 GHz: 10.0 W/m^2

The above MPEs are all for so-called "uncontrolled environments" in which the people involved are unaware of radio frequency radiation. Such limits generally are about 20 percent of the limits for controlled environments where technical personnel are aware of radio frequency radiation.

[2] *Lin, James,* A New Standards for Safety Levels with Respect to Human Exposure to Radio Frequency Radiation *IEEE Antennas and Propagation Magazine, 48, 1, February 2006.*

[3] *IEEE International Committee on Electromagnetic Safety (SCC39), IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE Std C95.1TM-2005 (Revision of IEEE Std C95.1-1991).*

The formula for radio frequency power flux density in free space is:

$$S = p_t/4\pi r^2$$

Where
S – power flux density – watts per square meter
p_t – transmit power – kilowatts
r – distance – kilometers

Using logarithmic ratios and practical units:

$$S = -41 + P_t - 20 \log d$$

Where
S – power flux density in dBW – decibels relative to watt per square meter
P_t –power dBKW decibels relative to 1 kilowatt
d – distance – kilometers

The above formula represents radio propagation in free space. In terrestrial application, the presence of natural foliage and structural interferences will attenuate the radio signal below free space levels. Therefore, free space presents a worst case scenario.

Based on the above formula, a typical 100 watt cellular transmitter in the 800 MHz frequency band produces a power density of 0.00079 watts per square meter at 100 meters from the site and 0.079 watts per square meter at 10 meters from the site. The largest regional cellular transmitter radiating at 1,000 watts would result in 0.0079 watts per square meter at 100 meters, and 0.79 watts per square meter at 10 meters from the site. A low power—4 watt—WiFi transmitter creates power densities of only 0.0003 watts per square meter at 100 meters from an access point and 0.003 watts per square meter at 10 meters from the access point.

From the above, it is apparent that none of the three classes of wireless radio frequency radiation violate the latest IEEE/FCC MPE limits. These limits are based upon thermal effects testing involving heating tissue with radiation of two watts per kilogram of body weight. Although none of the above examples violate the latest IEEE/FCC MPE restrictions; the 1,000 watt transmitter at 800 MHz does approach the limit—0.79 watts per square meter versus 4.00 watts per square meter—and the question of cumulative effects arises. The averaging time used to determine the above MPE standards is 30 minutes; the radio frequency temperature effects on human tissue and organs having been studied during 30 minute periods. Varying levels of radio frequency radiation were evaluated, and the level of radio frequency radiation that produced sustained temperature rise in human tissue was established. MPE limits were then set at two percent of these thresholds, providing a safety factor of 50 to one for uncontrolled environments. The MPE for controlled environments was set five times higher at 10 percent of the sustained temperature threshold.

The official IEEE/FCC position on cumulative effects is that such effects do not exist below the MPE limits. Restated, if the radio frequency radiation level is below the MPE limit for the frequency of interest, the exposure time whether continuous or intermittent is irrelevant. The rationale for this stated position is clear. If the radio frequency radiation level does not produce sustained heating of human tissue, then exposure time does not matter.

In summary, investigation of the potential thermal effects of radio frequency radiation on human health from wireless communications systems in Southeastern Wisconsin indicates that all current and planned systems should be operating within the latest IEEE/FCC standards. Since the investigation was based entirely on theoretical radio propagation in free space, it is important to confirm this analysis with propagation modeling and some field measurements.

Radio Propagation Modeling

Radio propagation modeling estimates radio frequency radiation levels in a given terrestrial environment. Such radiation levels will be lower in value than those estimated by the free space propagation power density formulas because of signal attenuation from buildings and terrestrial vegetation. To determine the effects of terrestrial attenuation on radio frequency radiation exposure, a series of radio propagation modeling plots were prepared for both cellular (800-900 MegaHertz) and WiFi/WiMAX (2400 MHz) frequency bands. Because available modeling software produced results only in terms of field strength, it was first necessary to convert the IEEE/FCC standard into field strengths limits. To utilize the standard FCC formula for field strength conversion set forth in FCC DET Bulletin 65, Edition 97-01, it is necessary to convert from watts per square meter to milliwatt per square centimeter.

By dimensional analysis:

10 watts per square meter = one milliwatt per square centimeter

The conversion formula in FCC Bulletin 65 states:

$E^2 = 3770S$

where E = electric field strength in volts per meter

and S = power density of one milliwatt per square centimeter

Solving

$E = 61.4$ volts per meter

$E = 61.4 \times 10^6$ microvolts per meter

$= 20 \log_{10} 61.4 \times 10^6$

$= 155.8$ decibels microvolts per meter (dB μV/m)

The lower two watts per square meter standard for the 800 MHz band is[4]

$E = 27.4$ volts per meter

$= 148.7$ dB μV/m

Observing the two radio propagation plots shown on Maps I-1 and I-2, the highest field strength category for a 100 watt, 891 MHz site is represented by the yellow colored area, representing a field strength of only one volt per meter, well below the 27.4 volt per meter standard. The highest field strength level predominant near the base station is indicated by the brown colored area which represents about 0.1 volts per meter – again well below the MPE standard.

In Map I-2, for a four watt WiFi access point, the highest field strength level is indicated by the purple colored area representing 75 dB μV/m which is three orders of magnitude below a field strength of about 0.001 to 0.002 volts per meter.

From the above field strength plots shown in Maps I-1 and I-2, it is clear that both the existing cellular/PCS base stations should operate well within the IEEE/FCC MPE standards. Future WiFi/WiMAX networks may be expected to be at least three orders of magnitude below these same standards.

[4] *Barclay, Les,* Propagation of Radio Waves, *The Institution of Electrical Engineers, United Kingdom, 2003.*

The field strength plots shown on Maps I-1 and I-2 are based upon one transceiver-antenna unit mounted on a station structure. For multiple unit installations the radiation output will be a multiple of the transceiver-antenna units. The maximum number of co-located antennas in the Region was five. Even the power radiated by this collection of antennas would still be a very small percentage of the standard for the worst case in the 800 MHz band.

Field Testing

Thermal radiation effects based on free space formulas and radio propagation modeling were supplemented by field measurements taken with a Spectran HF spectrum analyzer instrument manufactured by Aaronica AG of Germany. Measurements were made of both a 55 watt, 1,932 MHz base station (Sprint) and a 4 watt 2.4 GHz access point. The following power density and field strength levels were recorded.

1. 1,932 MHz base station at a distance of 300 feet from the base of the antenna tower
   S = 120.14 microwatts per square meter
   E = 0.213 volts per meter

2. 2.4 GHz access point at a distance of 300 feet from the base of the utility pole.
   S = 51.4 microwatts per square meter
   E =0.139 volts per meter

A comparison of the RF radiation standards compliance for thermal effect is summarized in Table I-1. It is apparent from the table that whether radio propagation formulas or field measurements are applied that both cellular/PCS and WiFi/ WiMAX networks are well below FCC/IEEE exposure standards.

Athermal Effects

Athermal effects of radio frequency radiation are caused by low-level energy fields insufficient to cause either ionization or heating effects. Research investigations in this area relating to possible health effects of radio frequency radiation exposure has been of two types: epidemiological research and laboratory research. Epidemiologists observe health patterns of large groups of people using statistical methods. These studies look for associations between environmental factors and an observed pattern of illness. Some epidemiological studies have identified an exposure to radio frequency radiation and malignancies such as leukemia and brain cancer. A large number of equally well designed and performed studies have shown no such association.

Laboratory studies of radio frequency radiation have a similar history. Some studies have indicated the ability of low levels of radio frequency radiation to alter the human body's circular rhythms and weaken the immune system. Attempts to replicate these studies have also had mixed results.

The overall conclusion at this time regarding athermal effects of radio frequency radiation must be that adverse health effects have not been demonstrated sufficiently to establish maximum permissible exposure (MPE) limits lower than those specified for thermal affects. One factor, however, is certain lower power communication is beneficial for all effects of radio frequency radiation. For this reason, the Commission's planning efforts have continually emphasized low power transmission supported by high sensitivity reception as the key to minimizing the environmental impact of wireless communications.

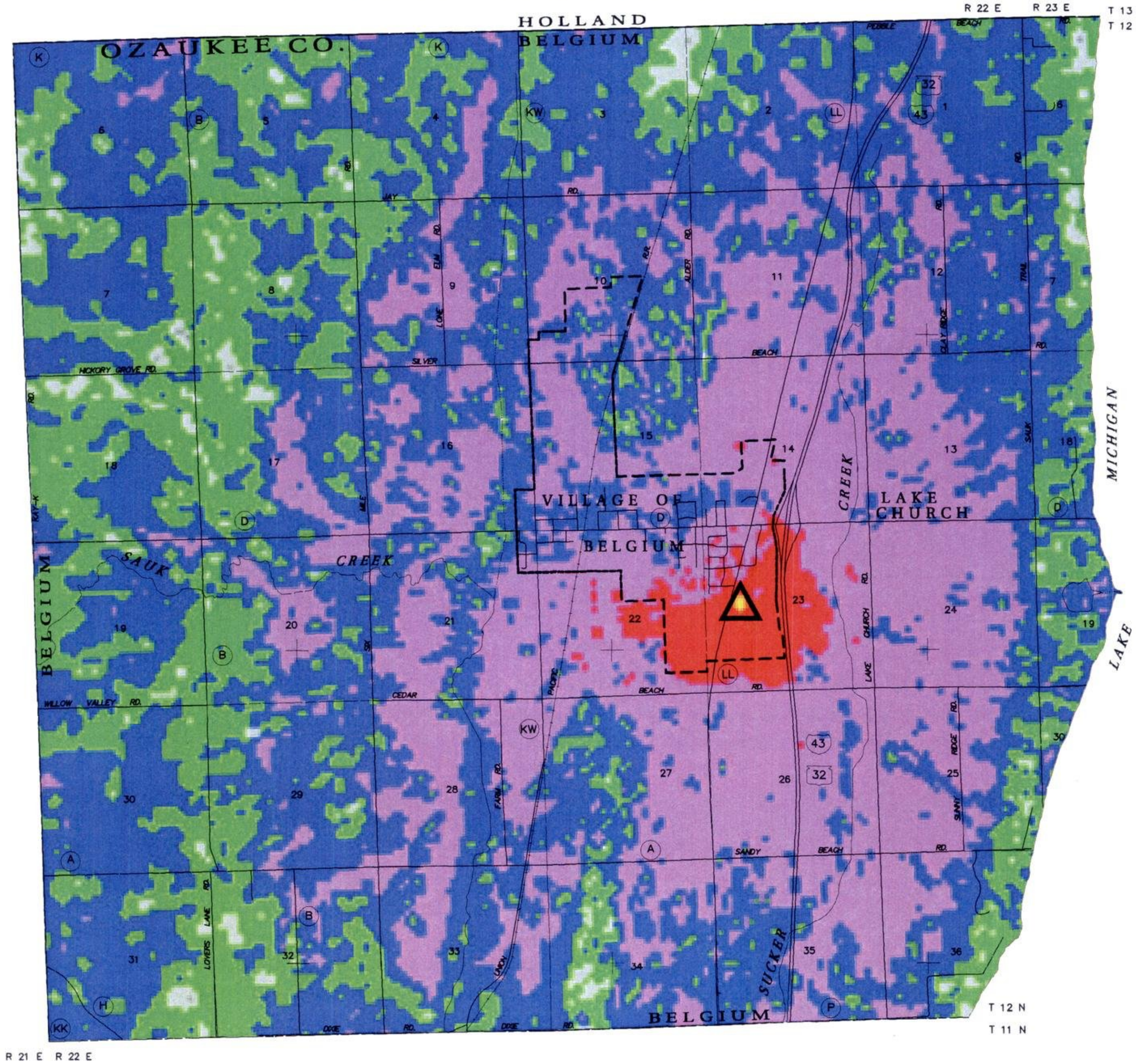
Other Environmental Impacts

This review of the environmental effects of radio frequency radiation has concentrated exclusively on human health impacts. There are however, two other environmental consequences of radio frequency radiation that should be noted.

A major consequence of the growth of cellular wireless communications and the proliferation of cell phone users and WiFi "hot spot" locations has been radio frequency interference. The 2.4 GHz unlicensed frequency band used in WiFi networks is also used by microwave ovens and many cordless phones. WiFi systems operate in unlicensed bands which are open to all users, so that interference becomes a major issue. Private cellular networks typically employ licensed frequency bands that are exclusive for the licensed operator. These systems, because they operate at higher transmit power levels, can also be a source of interference to other frequency bands based on the harmonic signals they generate. Harmonics are integer multiples of the base frequency that are generated and transmitted along with the base frequency. For example, a 800 MHz transmitter could generate harmonics at 1600 MHz and 2400 MHz. The second harmonic at 2400

Map I-1

FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA USING EXISTING FREQUENCY OF 891 Mhz AND 100 WATTS OF POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



LEGEND

△ EXISTING ANTENNA

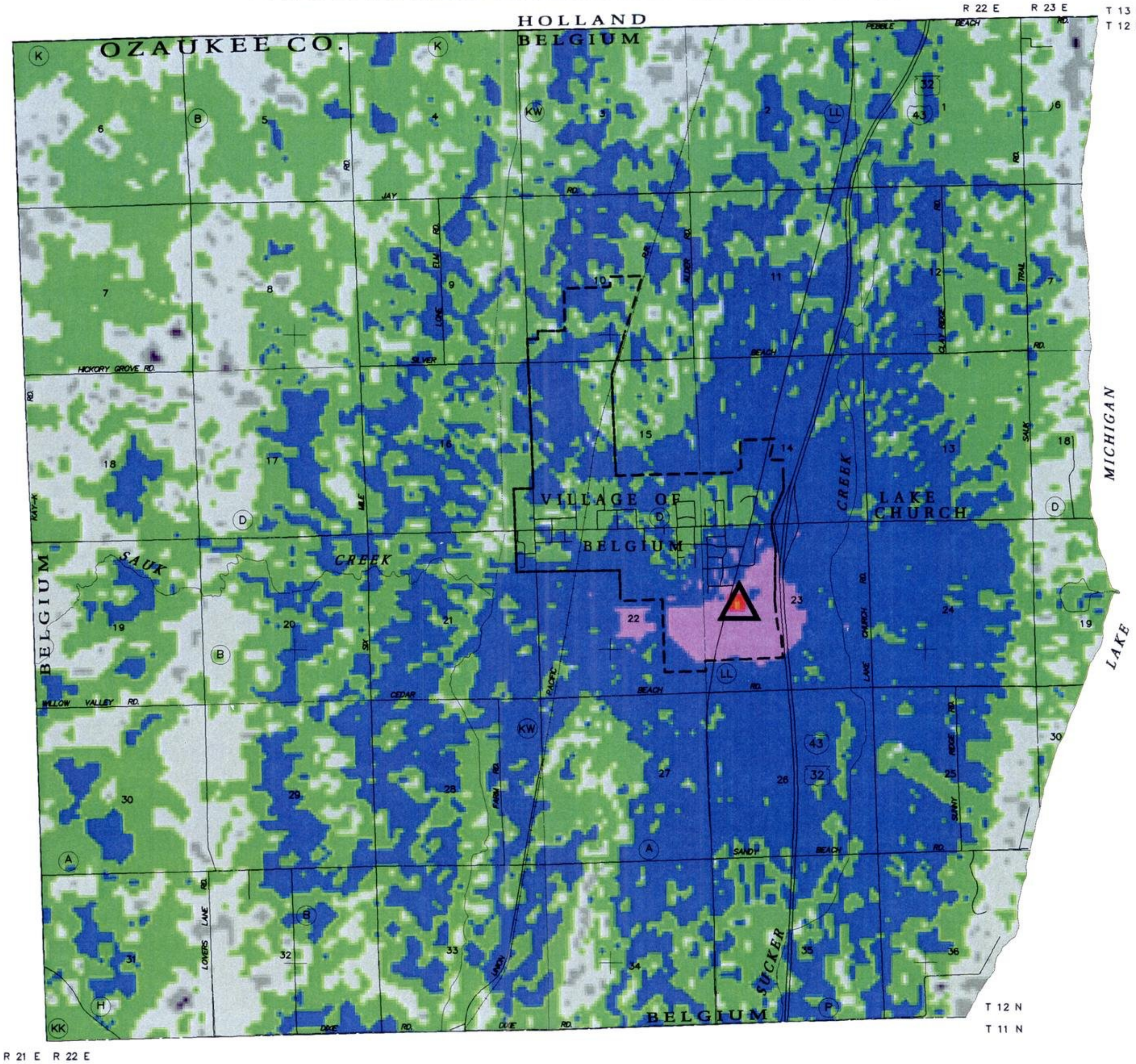
- GREATER THAN 120 dBuV/m
- 105 dBuV/m TO 120 dBuV/m
- 90 dBuV/m TO 105 dBuV/m
- 75 dBuV/m TO 90 dBuV/m
- 60 dBuV/m TO 75 dBuV/m
- 45 dBuV/m TO 60 dBuV/m
- 30 dBuV/m TO 45 dBuV/m
- 15 dBuV/m TO 30 dBuV/m
- 0 dBuV/m TO 15 dBuV/m
- LESS THAN 0 dBuV/m

GRAPHIC SCALE
0 1/2 1 MILE
0 2,000 4,000 6,000 FEET

Source: SEWRPC.

Map I-2

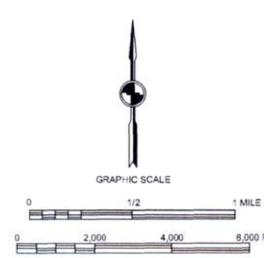
FIELD STRENGTH OF SIGNAL AT REMOTE ANTENNA USING PROPOSED FREQUENCY OF 2400 Mhz AND 4 WATTS OF POWER IN THE VILLAGE OF BELGIUM AND THE TOWN OF BELGIUM



LEGEND

△ EXISTING ANTENNA

- GREATER THAN 120 dBuV/m
- 105 dBuV/m TO 120 dBuV/m
- 90 dBuV/m TO 105 dBuV/m
- 75 dBuV/m TO 90 dBuV/m
- 60 dBuV/m TO 75 dBuV/m
- 45 dBuV/m TO 60 dBuV/m
- 30 dBuV/m TO 45 dBuV/m
- 15 dBuV/m TO 30 dBuV/m
- 0 dBuV/m TO 15 dBuV/m
- LESS THAN 0 dBuV/m



Source: SEWRPC.

Table I-1

COMPARISON OF RADIATION EXPOSURE LIMITS, COMPUTED VALUES AND MEASURED VALUES: SEPTEMBER 2006

Type	Frequency (Megahertz)	Standard		Computed		Measured	
		Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)	Power Density (watts per meter^2)	Field Strength (volts per meter)
Cellular/PCS	1,932	9.5	59.8	0.00079	0.54	0.000120	0.213
WiFi/WiMAX	2,400	10.0	61.4	0.00030	0.34	0.000051	0.139

Note: Radio propagation computations and field measurements are based on radiation levels 100 meters from the antenna location.

Source: SEWRPC.

MHz could interfere with WiFi communications. Responsible communications practices recommend the conservation of transmit power in the interest of other users. The golden rule of wireless communications is to utilize only the transmit power necessary to reliably serve the network. Excess transmit power contributes to the electronic pollution of the airwaves. Radio interference is currently the limiting factor in most wireless communications systems. The low power wireless systems advocated in this plan serve to free up the airwaves for higher communication performance.

Another environmental benefit of low power communications relates to its potential use of renewable power sources. Solar panels and their associated photovoltaic cells and rechargeable batteries are particularly attractive low power sources for network access points. Small solar power units have been developed that are capable of operating in overcast weather for very extended periods. Use of solar power also provides for a lower cost, more reliable and robust network.

Summary

A combined theoretical and experimental investtigation of the environmental impact of radio frequency (RF) radiation generated by existing and planned wireless communications systems in Southeastern Wisconsin confirms that all are in compliance with maximum permissible exposure (MPE) limit standards published by the Federal Communications Commission. These standards are based on the thermal effects of radio frequency on the human body. Some epidemiological and laboratory investigations of athermal effects of radio frequency radiation have indicated possible adverse effects on human health, but the results of these studies have not been sufficiently confirmed to allow for standards lower than those already established for thermal effects. In the absence of conclusive recommendations on athermal effects, the Commission staff recommends the deployment of low power wireless communications systems that will not only tend to minimize radio frequency radiation effects on human health, but also reduce electronic pollution of the airwaves and allow for low power renewable energy sources such as solar cells.

Appendix J

GLOSSARY

GLOSSARY

Term	Definition
1G	First generation wireless technology: Analog technology, introduced circa 1983.
2G	Second generation wireless technology: Digital technology, introduced circa 1992.
2.5G	Second and a half generation wireless – 2G digital technology plus added feature of GPRS (General Packet Radio Service).
3G	Third generation wireless technology: Broadband, high speed, digital technology, currently being introduced.
4G	Fourth generation wireless technology: Advanced broadband, high speed, digital technology, anticipated to be introduced circa 2007.
Access Network	The fiber connection and associated electronic equipment that link a core network to Points of Presence (POPs) and on to Points of Interconnect (POIs) switch locations.
Advanced Broadband	The FCC defines advanced broadband as service providing data transmission at a rate of at least 200 kilobits per second in both directions.
AMPS	Advanced Mobile Phone Service. Another word for the North American analog cellular phone system.
Antenna Site	A geographic location used for an antenna structure.
Antenna Structure	The tower, mast or other support on which antenna are mounted together with the radiation system and attendant appurtenances.
Antenna	A device for transmitting, receiving or transmitting and receiving radio frequency signals.
AT&T	American Telephone & Telegraph Company: Prior to 1984, AT&T was the major telephone service provider and equipment manufacturer in the U.S. Broken up by court decree in 1984, the Company became a long distance service provider and eventually spun off its manufacturing arm in a series of divestitures. Today, it is a major long distance and wireless service provider and a CLEC in many areas of the country.
ATM	Asynchronous Transfer Mode: ATM service was developed to allow one communication medium (high speed packet data) to provide for voice, data and video service. During the 1990s, ATM became a standard for high-speed digital backbone networks. ATM networks are widely used by large telecommunications service providers to interconnect their network parts (e.g., DSLAMs and Routers). ATM aggregators operate networks that consolidate data traffic from multiple feeders (such as DSL lines and ISP links) to transport different types of media (voice, data and video).

Term	Definition
Base Station	A fixed station used for communicating with mobile stations most commonly handsets. Fixed stations usually consist of an antenna site, antenna structure, antennae and supporting electronic and electric power facilities.
Backhaul Network	A wireless communications network that transports data access point to point of presence (POP) gateways for Internet interconnection
Bluetooth	A standard for short range wireless personal area networks (IEEE 802.15.1). Operates in the 2.45 GHz unlicensed frequency band.
Broadband	In general, any telecommunications connection to a user providing transmission at a rate of at least of 256 kilobits per second or more is considered broadband Internet. The official International Telecommunications Union Standardization Section (ITU-T recommendation I.113 has defined broadband as a transmission capacity that is faster than ISDN, at 1.5 to 2 megabits per second. It should be noted, however, that there is no international uniformity with respect to the definition of the term "Broadband," for example, the United States FCC definition of broadband is 200 kilobits per second in one direction, while the country of South Korea defines as broadband a telecommunication connection providing a transmission rate of over 50 megabits per second."
CDMA	Code Division Multiple Access.
CLEC	Competitive Local Exchange Carriers: The term was coined by the Telecommunications Act of 1996 and refers to an organization that competes with the incumbent, i.e., a former monopoly local phone company.
CO	Central Office: The CO is the location which houses a switch to serve local telephone subscribers.
Core Network	A combination of high-capacity switches and transmission facilities which form the backbone of a carrier network. End users gain access to the core of the network from the Edge Nctwork.
dBi	Decibals isotropic. A unit of gain applied to antennas, both directional and omnidirectional.
dBmW	Decibel Milliwatts
DNS	Domain Name Service.
DSL	Digital Subscriber Line: A generic name for a family of digital lines (also called xDSL) being provided by CLECs and local telephone companies for high speed data services.
DSSS	Direct Sequence Spread Spectrum. RF modulation technique that uses algorithms to code transmissions in sequential channels and then decodes them in the receiving end.

Term	Definition
DWDM	Dense Wave-Length Division Multiplexing: A version of fiberoptic communication that combines many optical channels on a single fiber to increase the data transmission capacity of the fiber. Dense wave division multiplexing provides a significant increase to wave division multiplexing (WDM) that combines up to four different optical channels (different wavelengths) on a single fiber. As of 2001, DWDM systems provided for 8 to 80 different wavelengths with the capability of transferring over 1 trillion bits of data per second (Tbps).
EHF	Extremely High Frequency: The band of microwave frequencies between the limits of 30 GHz and 300 GHz (wavelengths between 1 cm and 1 mm).
Ethernet	An access control method based on IEEE standard 802.3.
EV-DO	Evolutionary Data Optimized.
FAA	Federal Aviation Administration
FCC	Federal Communications Commission: The federal organization set up by the Communication Act of 1934 to regulate all interstate (but not intrastate) communications in the U.S.
FHSS	Frequency Hopping Spread Spectrum. A technique used in spread spectrum radio transmission systems, such as Wireless LANs and some PCS cellular systems. FHSS involves the conversion of a data stream into a stream of packets, each of which is prepended by an ID contained in the packet header.
FSO	Free Space Optical: FSO refers to wireless telecommunications transmission in the infrared frequency bands in the 800-1600 nanometer range.
FTTC	Fiber to the Curb: A hybrid transmission system which involves fiber optic links to the curb and either twisted pair or coaxial cable to the premises.
FTTH	Fiber to the Home: A transmission system in which optical fiber is carried all the way to the customer's premises.
FTTN	Fiber to the Neighborhood: A hybrid transmission system involving optical fiber from the carrier network to a neighborhood node. The connection from the neighborhood node to individual homes may be wireless or involve legacy twisted pair or coaxial cable.
Gateway Base Station	Base station with an Internet connection.
GHz	Gigahertz: A unit of frequency denoting one billion Hertz (Hz) or one billion cycles per second.
GIS	Geographic Information System: Computer applications involving the storage and manipulation of maps and related data in electronic format.

Term	Definition
GSM	Global System for Mobile Communications. The standard digital cellular phone service found in Europe, Japan, Australia and elsewhere – a total of 85 countries.
GPRS	General Packet Radio Service
Hertz	Cycles per second named after German physicist, Heinrich Hertz.
HFC	Hybrid Coax-Fiber Optic Cable: An advanced CATV (cable television) transmission system that uses fiber optic cable for the head end and feeder distribution system and coaxial cable for the customer's end connection. HFC are the 2nd generation of CATV systems. They offer high-speed backbone data interconnection lines (the fiber portion) to interconnect end user video and data equipment. Many cable system operators anticipating deregulation and in preparation for competition began to upgrade their systems to HFC systems in the early 1990s. As of late 2000, over 35 percent of the total cable lines in the United States had been converted to HFC technology.
HSDPA	High Speed Downlink Packet Access
HSUPA	High Speed Uplink Packet Access
HTTP	Hyper Text Transfer Protocol – text or graphic.
HTTPS	The secure version of HTTP.
iDEN	Integrated Dispatches Enhanced Network
IEEE	Institute of Electrical and Electronic Engineers: Founded in 1884 as the AIEE (American Institute of Electrical Engineers), it later merged (circa 1960s) with the Institute of Radio Engineers (IRE) to become the world's largest technical professional society renamed the IEEE. It sponsors technical symposia, conferences and local meetings and publishes technical papers. In telecommunications, it is best known for the publication of standards such as the 802 series for local area networks.
ILEC	Incumbent Local Exchange Carrier: A telephone carrier (service provider) that was operating a local telephone system prior to the divestiture of the AT&T Bell system. Also specifically defined in the Telecommunications Act of 1996 as a carrier providing local exchange service to a specific area as of the date of the enactment of the Act.
IP	Internet Protocol: The IP is a protocol describing software used on the Internet that routes outgoing messages, recognizes incoming messages, and keeps track of addresses for different nodes.
ISO/FCAPS	International Standards Organization/Fault Configuration Accounting Performance Security: ISO is a voluntary organization chartered by the United Nations in 1947 that develops and publishes international standards in many technical areas. FCAPS is a standard for the management of telecommunications networks. The standard embraces performance management which is the function of the proposed network monitoring system in Southeastern Wisconsin.

Term	Definition
ISP	Internet Service Provider: A company that provides an end user with data communications service that allows them to connect to the Internet. An ISP purchases a high-speed link to the Internet and divides up the data transmission to allow many more users to connect to the Internet.
ITS	Intelligent Transportation System: A technology that employs computers, sensors and communications networks to improve the operation of transportation systems.
ITU	International Telecommunications Union: An organization based in Geneva, Switzerland, the most important telecom standards setting body in the world.
LAN	Local Area Network: A LAN is a communications network connecting computers, work stations, printers, file servers and other devices inside a building or campus.
LATA	Local Access Transport Area: An area served by a local telephone company in which it may offer both local and toll services.
MAC-Media	Media Access Control. Protocol for network access at layer 2 of OSI.
MC-CDMA	Advanced 4th generation version of CDMA
Mesh Network	A network in which each is connected to multiple neighbor nodes.
MHz	Megahertz: A unit of frequency denoting one million Hertz (Hz) or one million cycles per second.
MIB	Management Information Base: A database of network management information used by CMIP (common management information protocol) and SNMP (simple network management protocol).
MIMO	Multiple Input - Multiple Output: Involves the employment of phased array antennas for increased range of data transfer rates.
MMDS	Microwave Multipoint Distribution System: A method of distributing television signals through microwave from a single transmission point to multiple receiving points.
MOS	Mean Opinion Score.
MPLS	Multiple Protocol Label Switching: MPLS is a widely supported method of speeding up IP-based communications over ATM or Ethernet networks.
MSC	Mobile Switching Center.
Network Architecture	The philosophy and organizational concept for enabling communications between multiple locations and multiple organizational units. Network architecture is a structural statement of the terminal devices, switching elements and the protocols and procedures to be used for the establishment effective telecommunications.
OC	Optical Carrier: OC is a term used to designate transmission rates in fiber transmission systems using the SONET protocol.

Term	Definition
OFDM	Orthogonal Frequency Division Multiplexing. A modulation technique for wireless communications.
OFDMA	Advanced version of OFDM using more frequency bands.
OSI	Open System Interconnection: A reference model developed by the ISO that defines the seven layers used in communication network protocols.
PCS	Personal Communication System: A low-powered, high frequency alternative to traditional wireless cellular communications systems.
POP	Point of Presence: A physical location that allows an interexchange carrier (IXC) to connect to a local exchange company (LEC) within a LATA. The point of presence (POP) equipment is usually located in a building that houses switching and/or transmission equipment for the LEC.
POTS	Plain Old Telephone Service: The basic service supplying standard telephone single line telephones and access to the public switched network.
PSC-WI	Public Service Commission of Wisconsin: The agency that regulates public utilities in Wisconsin.
PSTN	Public-Switched Telephone Network: The local, long distance, and international phone system.
QoS	Quality of Service: A measure of the quality of telephone service provided to a subscriber. It embraces a wide range of specific definitions depending on the type of service provided.
RF	Radio Frequency: Electromagnetic waves operating between 10 kHz and 30 GHz in either cables or free space.
RTM	Regional Traffic Matrix: A data matrix that defines the origins and destinations of voice, data, or multimedia communications in a geographic region.
SCADA	Supervisory Control and Data Acquisition Systems used by electric power, gas, water, wastewater and other utilities to monitor and manage the operation of geographically dispersed facilities.
Sectoral Cellular Network	A cellular network with 3 or 4 sectors at each access point.
SHF	Super High Frequency: The frequencies ranging from 3 GHz to 30 GHz (wavelengths between 10 cm and 1 cm).
SNMP	Simple Network Management Protocol: A standard communication protocol that is used to setup, test, and manage network equipment. By conforming to this protocol, equipment assemblies that are produced by different manufacturers can be managed by a single program. SNMP protocol can operate via Internet protocol.
SNR	Signal to Noise Ratio.

Term	Definition
SONET/SDH	Synchronous Optical Network/Synchronous Digital Hierarchy: The current leading optical transmission protocols used in North America (SONET) and internationally (SDH).
T/DS	Transmission-Digital Signal: The T and DS define levels of digital transmission speed capabilities of digital lines and trunks. The T-1 line has a signaling speed of 1,544,000 bits per second.
TCP/IP	Transmission Control Protocol/Internet Protocol: TCP/IP is standard set (suite) of protocols that define the transmission of Internet messages. The Transmission Control Protocol (TCP) portion ensures message delivery between two points and the Internet Protocol (IP) defines the routing of physical packets of data.
TDMA	Time Division Multiple Access. One of several technologies used to separate multiple conversation transmissions over a finite frequency allocation of through-the-air bandwidth.
TIA	Telecommunications Industry Association: An association of telecommunications equipment manufacturers.
UHF	Ultra High Frequency. The frequency range from 300 MHz to 3000 MHz (3GHz).
UMTS	Universal Mobile Telecommunications System. Advanced version of GSM.
UNE	Unbundled Network Element: Network elements owned by ILECs that must be available to CLECs in accordance with the Telecommunications Act of 1996.
VA	Vulnerability Assessment: Methods used to determine the security of a network.
VHF	Very High Frequency: The band of frequencies between the limits of 30MHz and 300 MHz (wavelengths between 10 cm and 1 cm).
VoIP	Voice Over Internet Protocol: A process of sending voice telephone signals over the Internet. If the telephone signal is in analog form (voice or fax), the signal is first converted to a digital form. Packet routing information is then added to the digital voice signal so it can be routed through the Internet.
WAVE	Wireless Access In Vehicular Environments.
WCDMA	Wideband CDMA.
WiFi	Wireless Fidelity: A popular term for wireless local area networks operating under IEEE Standard 802.11b or 802.11g in the 2.4 GHz range.
WiFi5	A faster, higher frequency version of WiFi defined under IEEE Standard 802.11a operating in the 5 GHz frequency band.
WiMAX	(Worldwide Interoperability Microwave Access) Wireless Technology serving Metropolitan Area Networks under IEEE Standard 802.16.
WLANS	Wireless Local Area Network. A LAN without wires.

Term	Definition
WNMS	Wireless Network Monitoring System.
ZigBee	A standard for short range wireless sensor networks (IEEE 802.15.4). Operates in the 2.40 GHz band. Emphasizes small size, low power and low cost.

CORRIGENDUM

SEWRPC Planning Report No. 51
A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN

September 2006

The paragraph numbered 3 and entitled "Analyses and Forecasts" on page 14, indicates that the plan presented in the report was based upon spatial forecasts of potential subscribers and attendant call generation characteristics based upon future land use plans. This is an error and the paragraph concerned should be replaced in its entirety with the following paragraphs:

Analyses and Forecasts
In the classic approach to systems planning, forecasts are made of those factors that affect the structure of the system plan concerned, but which lie outside of the scope of the system being planned. Thus, public infrastructure systems planning typically involves the preparation of forecasts of probable future system demand—expressed in terms of such parameters as person trips, per capita sewage contribution, or per capita water demand—derived from population, household, employment, and land use forecasts for the plan design year. The forecast period is determined by the physical and economic life of the facilities concerned—for most types of public works facilities this period approximates 20 years. Procedures for developing such forecasts are well established and widely used for transportation, sanitary sewerage, storm water drainage and flood control, and water supply system planning. In transportation system planning, for example, population, household, employment, and land use forecasts are used to estimate future travel demand by mode. This demand is then used in the simulation of the performance of the arterial street and highway and transit systems through mathematical modeling. This permits quantitative analyses of the performance of alternative system plans considered, and facilitates the selection and more detailed design of a recommended system plan.

This classic approach to systems planning was originally intended to be applied in the regional telecommunications planning effort. The formulation and calibration of the necessary mathematical simulation models, however, required detailed information about the configuration, capacity and utilization of the existing telecommunications facilities within the Region that would permit the correlation of such utilization with socioeconomic and land use data for use in forecasting probable future demand. The necessary information was available only from the existing service providers, which refused to provide the information to the Commission. Therefore, the classic approach to systems planning could not be applied in the regional telecommunications process.

Consequently, a different approach to the plan design process was taken. Telecommunication supply and demand are known to be greatly influenced by the rate of new technology adoption and user acceptance. User acceptance is typically measured by a "take rate" which may vary widely, perhaps from 2 to 50 percent, or by a ratio of 25 to 1. This uncertainty of demand for a new broadband telecommunication service creates a need for system designs that may be expected to be profitable at the lowest expected take rate, but which have the capacity to accommodate much higher take rates at the desired levels of service. Thus, in the absence of being able to base alternative plan designs on long term forecasts and performance simulation, alternative plans were designed so that "break even" operation would be possible at low take rates, but which possessed capacities able to serve much higher take rates at the desired level of service.

In the planning process, the ability to achieve break even operation at low take rates was assessed on the basis of analyses of the capital costs involved. The adequacies of the system capacity were assessed on the basis of analyses of the level at which subscriber arrival rates and message sizes would become unacceptable with respect to the level of throughput desired. The alternative plans were, moreover, designed to permit the ready expansion of the initially available capacity through simple changes in the software and hardware concerned, without changes in the basic structure of the system plan. These analyses were based on modified versions of traffic engineering formulas originated by the Danish mathematician, A. K. Erlang, and used for many years by the Bell System in determining the capacity of circuit-switched telephone systems. The probability distributions involved—Poisson and Erlang—and their supporting algorithms were converted from circuit-switched to packet-switched network form for application to the network system plans developed under the regional telecommunications plan program.