MINUTES OF THE TWELFTH MEETING

REGIONAL TELECOMMUNICATIONS PLANNING ADVISORY COMMITTEE (Reconstituted)

DATE:	February 28, 2006
TIME:	2:00 P.M.
PLACE:	Commissioners' Conference Room Regional Planning Commission Offices W239 N1812 Rockwood Drive Waukesha, Wisconsin

Members Present

Kurt W. Bauer Chairman	Executive Director Emeritus, SEWRPC
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
Michael E. Klasen	Director, Regulatory Affairs, SBC Wisconsin
Jeff M. Lowney	Vice President/General Manager, Time Warner Telecom
George E. Melcher	Director, Office of Planning and Development, Kenosha County
Paul E. Mueller	Administrator, Washington County Planning and Parks Department
Rob N. Richardson	Director, Racine County Information Systems
Steven L. Ritt	Attorney at Law, Michael Best & Friedrich
James W. Romlein	Managing Director, MVLabs, LLC
Gustav W. Wirth, Jr.	SEWRPC Commissioner

Members Absent

William R. Drew Vice Chairman	Vice-Chairman, SEWRPC; Executive Director, Milwaukee County Research Park
Roger Caron	President, Racine Area Manufacturers and Commerce
J. Michael Long	Attorney-at-Law, Murn and Martin, SC
Jeff Mantes	Commissioner of Public Works, City of Milwaukee
Jody McCann	Network Domain Manager, Wisconsin Department of Administration, BadgerNet
Bennett Schliesman	Director, Kenosha County Emergency Management /Homeland Security
Dale R. Shaver	Director, Waukesha County Department of Parks and Land Use
Michael Ulicki	Vice President and Chief Technology Officer, Norlight Telecommunications
Darryl Winston	Director of Data Services, City of Milwaukee Police Department

Staff

Philip C. Evenson	Executive Director, SEWRPC
Kenneth J. Schlager, PhD	Chief Telecommunications Engineer, SEWRPC
Lynn G. Heis	Staff Secretary, SEWRPC

CALL TO ORDER AND ROLL CALL

Chairman Bauer called the meeting to order at 2:00P.M. Roll call was taken by circulating an attendance signature sheet, and a quorum was declared present.

Chairman Bauer noted that there was a new member of the Committee present – Mr. Rob N. Richardson, Director, Racine County Information Systems, replacing Mr. Paul R. Schumacher. He welcomed Mr. Richardson to the Committee, and indicated that the Commission looked forward to his active participation in the work of the Committee.

CONSIDERATION OF THE MINUTES OF THE MEETING OF DECEMBER 6, 2005

Chairman Bauer noted that copies of the minutes of the eleventh meeting of the Reconstituted Regional Telecommunications Planning Advisory Committee held on December 6, 2005, had been distributed to all members of the Committee for review prior to the meeting, and asked that the Committee consider approval of those minutes.

Mr. Ritt called attention to the first two sentences of the Secretary's Note on page 10 of the Minutes, noting that Verizon Wireless had not acquired any of the wireless provider companies involved in the base station inventory discrepancies concerned. He suggested, and the Committee concurred, that these two sentences be revised to read as follows:

> "Investigation of the discrepancies noted in the meeting found that the missing Verizon Wireless antenna sites in Ozaukee County, were the result of a failure on the part of the Commission staff to recognize that Verizon Wireless and PrimeCo are, in fact, the same entities."

There being no further corrections or additions, on a motion by Mr. Wirth, seconded by Mr. Chernow, and carried unanimously, the minutes of the meeting of December 6, 2005, were approved as corrected.

CONSIDERATION OF PRE-PRELIMINARY DRAFT OF CHAPTER VII, "FOURTH GENERATION (4G) REGIONAL WIRELESS NETWORK PLAN," OF SEWRPC PLANNING REPORT NO. 51, *A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN*.

Chairman Bauer noted that a copy of the pre-preliminary draft of Chapter VII, "Fourth Generation (4G) Regional Wireless Network Plan," of SEWRPC, Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin*, had been distributed to all members of the Committee for review prior to the meeting.

Chairman Bauer indicated that the draft of Chapter VII was intended as a "pre-preliminary" draft for initial Advisory Committee review and comment. The Chapter included, in addition to text describing the technological alternatives considered, a description of a pilot plan consisting of cellular network plans for Ozaukee County and the Cedarburg-Grafton area of Ozaukee County. Based upon the Advisory Committee's review comments, a revised Chapter VII will be prepared setting forth a proposed wireless telecommunication plan for the entire seven county planning region, such plan to consist of a regional "backhaul" network together with selected examples of community level access plans to illustrate the potential application of the plan recommendations in urban and rural areas.

Chairman Bauer then asked Dr. Schlager to undertake a page by page review of the preliminary draft with the Committee.

Mr. Ritt observed that the Chapter set forth a proposed wireless telecommunication plan for the Region and that such plans are normally prepared by the private service providers who then implement their plans. How, he asked, was it envisioned that the Commission's plan would be implemented? A lengthy discussion ensued.

Mr. Evenson observed that the plan was intended to set forth the Commission's vision for the type of wireless telecommunication network that could be put in place to provide the level of service that the Commission believes is necessary to maintain the economic competitiveness of this Region with other regions of the United States and the world. He indicated that it was hoped that there may be several private providers who would choose to deploy the technology that becomes available to move toward a level of service envisioned in the plan.

Mr. Klasen suggested that a paragraph be inserted after the first paragraph of the introductory section of the Chapter on page 1, indicating that the plan, as set forth in the Chapter, represents one means of achieving the desired level of service. It should be stated, he said, that the plan should not preclude consideration of other plans for providing improved levels of telecommunication service within the Region that the private providers might bring forward and want to implement in a given sub-area of the Region. It was important, he said, that the plan not be used by any county or municipality to attempt to -- for example -- block access to rights-of-way required for the implementation of such private plans, or to place restrictions on the private plan implementation proposals. The document, he said, should stress that there may be other plans coming forward to provide improved service within the Region and the Commission's plan should not be used to impede implementation of such plans prepared by private service providers, even though the latter plans may not provide the service level specified in the Commission's plan. Mr. Chernow agreed that such a paragraph should be added to the text, but indicated that the paragraph should state that the Commission's plan was not intended to be used to block not only alternative plan proposals devised by private providers, but also alternative plan proposals put forth by any sources, including public sources.

Mr. Wirth agreed that the intent of the paragraph should be to indicate that it was the Commission's desire to broaden, and not restrict, planning efforts to provide improved telecommunication service to the Region; and that the Commission did encourage the putting forth of other plans to meet the agreed upon objectives and standards; or at least to move existing level of service toward the eventual attainment of such objectives and standards.

Mr. Romlein also agreed on the desirability of adding the proposed paragraph to the text, indicating that the term "point of departure" could be used in the paragraph to characterize the intended function of the Commission plan.

Chairman Bauer indicated that the Minutes would show that it was the consensus of the Committee to add a paragraph to the introductory section of the Chapter that addressed the concerns raised in the Committee discussion.

Secretary's Note: The following paragraph was prepared as an insert to page 1 of the introductory section of the Chapter immediately following the first paragraph of that section:

"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."

Mr. Falaschi called attention to the first sentence of the third full paragraph on page 5, indicating that the sentence, in his opinion, left the reader with the impression that "frequency hopping" was still characteristic of WiFi service. Mr. Falaschi suggested, and the Committee concurred, that the following sentence be inserted after the second sentence of the third full paragraph on page 5.

> "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."

Mr. Falaschi noted, and the Committee concurred, that the term "digital subscriber level" in the eleventh line of the third full paragraph on page 5 should be changed to "digital subscriber line".

Mr. Klasen called attention to the first sentence in the second full paragraph on page 6, which implied that cities were installing WiFi mesh networks when, in fact, the networks were being installed by private providers in the cities listed. He suggested, and the Committee concurred, that this be clarified.

Secretary's Note: The first sentence of the second full paragraph on page 6 was rewritten to read as follows:

"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."

Mr. Chernow called attention to the last sentence in the second full paragraph on page 6 concerning the relationship of the number of access points in a wireless network to density and clutter, and asked that the issues concerned be clarified, particularly with respect as to whether or not existing urban development within Southeastern Wisconsin may constitute a problem.

Mr. Schlager indicated that in highly developed areas of the Region -- such as the central business district of Milwaukee -- the presence of high-rise buildings did indeed constitute a problem for WiFi transmissions, which problem would have to be addressed in any planning effort. He indicated further, that experience to date elsewhere indicated that the required density of mesh network WiFi access points may be expected to range from approximately 16 per square mile to approximately 62 per square mile, depending upon the characteristics of the urban areas concerned.

Mr. Falaschi agreed that clutter related to buildings and other structures -- such as billboards -- and trees, would indeed be a problem within parts of the Region.

In answer to a further question by Mr. Chernow, Mr. Schlager indicated that in addition to clutter, another important consideration was involved in the design of WiFi access networks, namely, the density of users and the related traffic demand on the access points and backhaul network. He indicated that more access points per square mile were needed in an area of high user density than in an area of relatively low user density.

Upon the conclusion of the discussion, it was the consensus of the Committee that the last sentence of the second full paragraph on page 6 be revised, and if necessary, additional sentences be added to clarify that two issues were involved in the density of the required cellular WiFi antenna networks: clutter and the density of demand as related to capacity of the access point.

Secretary's Note: The last sentence of the second full paragraph on page 6 was rewritten to read as follows:

> "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."

In answer to a question by Mr. Wirth, Mr. Schlager indicated that the IEEE standards 802.16d had indeed been approved, and equipment to meet that standard was being produced. Moreover, he said, IEEE standard 802.16e, the mobile version, is expected to be issued by 2007 and equipment manufacturers -- like Motorola -- were working to design and produce equipment that would meet this standard.

Mr. Falaschi noted that the issue of mobile public safety telecommunication networks operating in the 4.9GHz range was introduced in the first full paragraph on page 9 and indicated that this introduction seemed out of context. A brief discussion ensued upon the conclusion of which it was agreed that the following sentence would be added to the first full paragraph on page 9 immediately following the third sentence.

> "This report does not address planning for the mobile public safety networks, which networks will be addressed in a separate Commission planning effort and the results documented in a separate Commission planning report."

Mr. Falaschi questioned the statement made in the third sentence of the second full paragraph on page 11 that WiFi ranges of up to 30 miles have been demonstrated. A brief discussion ensued and it was agreed that this sentence should be struck as irrelevant within the context of the paragraph.

Mr. Klasen called attention to the penultimate sentence of the first paragraph on page 18, which sentence indicated that mesh networks are "self-healing" and that the failure of a single access point in such networks does not disable the network. He noted that this statement implied that the loss of a single access point in cellular networks did disable the entire network which was clearly not true. He indicated that such loss in a cellular network might lead to a loss of service in a small such subarea of the total system service area, but not to failure of the total system. A brief discussion ensued at the conclusion of which it was agreed that the staff would rewrite the last three sentences of the first paragraph on page 18 to clarify the discussed advantages and disadvantages of mesh networks.

Secretary's Note: The last three sentences of the first paragraph on page 18 were rewritten to read as follows:

"Mesh networks are sometimes seen to provide an advantage over cellular network with respect to redundancy and reliability. The mesh network 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."

Mr. Mueller called attention to Figure 3 on page 17, noting that the boundary of the cellular network service area as shown was in error with respect to the northwesterly boundary configuration in that the boundary as shown included a cell within the service area boundary that was not served by the network. Chairman Bauer agreed and indicated that the figure would be corrected.

Chairman Bauer noted that at this point in the Committee's review, the text set forth on the first eighteen pages of the chapter had been carefully reviewed and revisions had been directed to be made as necessary. He indicated that he hoped that these eighteen pages of text, with the corrections and additions, could be considered essentially approved by the Committee. Although, he stressed, the Committee would see directed changes and additions in the Minutes of the meeting, and would through consideration of those Minutes, be able to make further changes. He then noted that a pilot plan had been prepared and was described beginning on pages 18 and that this pilot plan, in his opinion, was in a much more elementary state than was the work on technology selection described in the first eighteen pages.

Mr. Ritt indicated that before turning to consideration of the pilot plan, he would suggest that consideration be given to adding in an appropriate location somewhere in the first seventeen pages of the Chapter, a paragraph that would acknowledge that the private service providers that had built wireless telecommunication networks within the Region had acquired -- at substantial cost -- the exclusive right to use portions of the broadcast spectrum, and that these providers were, therefore, licensed to the exclusive use of the acquired bandwidths concerned. He noted that the text was silent as to whether the proposed network plan was intended to use a licensed portion of the radio frequency spectrum, or whether the proposed network was assumed to operate in the unlicensed band spectrum. A brief discussion ensued in which it was agreed that Mr. Ritt had raised an important issue and that the staff should prepare an insert at an appropriate place in the text preceding the actual plan description addressing this issue.

Secretary's Note: The following paragraph was prepared for insertion as the third full paragraph on page 18.

"**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 networks, acquired -- at often 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."

Mr. Wirth indicated that, in his opinion, in the graphic presentation of the proposed plan, Maps 1 through Map 4, were actually presented in reverse order and this may be expected to be confusing to some readers. He suggested, and the Committee concurred, that the order of the maps graphically presenting the plan be reversed so that Map 4 becomes Map 1, Map 3 becomes Map 2, Map 2 becomes Map 3, and Map 1 becomes Map 4. Chairman Bauer noted that the text -- which would in any case have to be revised as the pilot plan presented is recast as a regional plan -- the proposed changes in the graphic presentation would require attendant changes in the text. These, he said, would be made when the plan description section beginning on page 18 is totally rewritten to produce a description of a regional plan.

Mr. Mueller suggested, and the Committee agreed, that the titles of the maps concerned be changed to read, in accordance with the revised order agreed to: Map 1, "Potential Locations of Base Stations and Attendant Performance of Access Network (WiMAX) for Backhaul: Remote to Base Station"; Map 2, "Potential Locations of Base Stations and Attendant Performance of Access Network (WiMAX) for Rural Fixed Users: Base Station to Remote"; Map 3, "Potential Locations of WiFi Access Points and Attendant Performance of Access Network for Fixed Users: Base Station to Remote"; Map 4, "Potential Locations of WiFi Access Points and Attendant Performance of Access Network for Nomadic Users: Base Station to User".[1]

Mr. Klasen reiterated his concerns about the potential use of the Commission recommended plan to delay or block proposed actions by private providers based on the providers' own network development plans, and asked how it was envisioned that the plan would be used in this respect. Mr. Evenson indicated that the issues concerning the way in which the Commission plan – if adopted – was to be used would be addressed in a chapter of the report on plan implementation, and that it was premature to discuss any of these issues in detail at this time. Chairman Bauer agreed, but indicated that in an effort to be helpful to Mr. Klasen, an example of a situation that might arise and how it would be addressed might be in order. He indicated that, if for example, a private provider approached the City of Cedarburg and proposed the development of a WiFi access network in the City – as is currently the case in the City of Milwaukee – and the City approved the proposal, the development of the network would proceed, and the Commission would be entirely "out of the picture." If, however, he said, the City approached the Commission and asked the Commission to review and comment on the proposal being made by the private provider, then the Commission would become involved, and would review the proposal in light of the adopted plan -- using that plan -- as Mr. Romlein has suggested -- as a point of departure for the review and analysis. The Commission's comments would then be advisory to the City. Mr. Klasen indicated that this hypothetical example was helpful.

Mr. Ritt referred to Maps 1 and 4, noting that the base station identified on Map 4 as 05 was apparently the base station shown on Map 1 in the easterly part of the service area. He noted that another base station, identified on Map 4 as 04, was not shown on Map 1 and asked why not. Chairman Bauer indicated that this was because base station 04 was presently located outside of the corporate limits of the City of Cedarburg. Mr. Ritt then asked what would happen to the plan if either the corporate limits were

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[1] The map numbers and titles in this paragraph of the minutes were changed in the final draft as attached with Map 4 having been eliminated.

expanded to incorporate another base station such as 04, or a private provider constructed a new base station within the existing city limits. Chairman Bauer replied by indicating that the Commission's plans, like any long-range plan, were dynamic, and subject to change over time as might be found necessary to reflect changing conditions in the planning area. Such changes might require a reanalysis of the Commission's adopted plan and perhaps a change in the plan. Such plan reanalysis and changes, he said, have always been a part of the Commission's continuing planning operations.

In answer to a question by Mr. Falaschi, Mr. Schlager indicated that the location of the access points shown on Map 1 were identified in terms of the State Plane Coordinates set forth in Table 2. In any plan implementation process, field inspections would have to be conducted of the coordinate locations to determine the availability of a suitable structure or structures on which to mount the antenna in the vicinity of the desired State Plane Coordinate location. In answer to a question by Mr. Klasen, Mr. Schlager indicated that in the same manner, plan implementation would require further analysis to determine the availability of the existing base stations for use in the proposed backhaul network.

Mr. DeAngelis called attention to the first full paragraph on page 24. He indicated that the presentation of the costs in that paragraph were confusing since the incremental figures given apparently did not add up to the total cost. He suggested, and the Committee agreed, that this paragraph should be revised to remove the ambiguity. Accordingly, the first paragraph on page 24 was revised to read as follows:

> "Based on the 41 access points deployed - 18 for Cedarburg and 23 for Grafton – the infrastructure deployment cost was estimated at $294,550, expressed in year 2006 real dollars. This total cost included the cost of the equipment and equipment installation for each access point estimated at $5,250 each or $212,250; Internet access equipment – in the form of a WiMAX or fiber connection - $17,300; a network monitoring system - $10,000; and project management and engineering costs of $55,000."

Mr. Ritt suggested, and the Committee concurred, that a section be added to the first full paragraph on page 31 referencing potential costs of the network that were not included in the estimate given.

> Secretary's Note: The following paragraph was added after the first partial paragraph on page 24.
>
> "The foregoing estimate of costs include only the costs of equipment and equipment installation.
>
> These costs do not include operation or maintenance costs, nor such potential additional costs as exclusive use license fees if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental fees, if any, for use of municipal structures to mount antennas; or legal fees."

There being no further questions or comments, Chairman Bauer indicated that the staff would now prepare a preliminary draft of Chapter VII, "A Fourth Generation (4G) Regional Wireless Network Plan," of SEWRPC, Planning Report No. 51, A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin, incorporating the changes made by the Committee for further review by, and approval of, the Advisory Committee. Chairman Bauer indicated that the new preliminary draft would reflect all of the changes made by the Committee through its review of the pre-preliminary draft and these changes would be indicated – as has been the practice – by strikes out and italic type inserts. He indicated further that an annotated copy of the pre-preliminary draft would not be attached to the minutes of the meeting and that the new preliminary draft would be provided to the Committee for review with the agenda for the next meeting.

WORK PROGRESS REPORT ON CHAPTER V, "WIRELESS TELECOMMUNICATIONS INFRASTRUCTURE INVENTORY FINDINGS," OF SEWRPC PLANNING REPORT NO. 51, *A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN.*

Chairman Bauer then asked Mr. Evenson to review with the Committee the progress toward the completion of Chapter V of SEWRPC Planning Report No. 51.

Mr. Evenson recalled that at the Committee meeting held on September 20, 2005, he had indicated that the Commission staff would contact all of the private wireless telecommunication service providers operating within the Region to ascertain their interest in cooperating with the Commission in the preparation of 2G-3G wireless plans. It had been determined, he said, that the Commission would, prepare such plans for those individual providers indicating an interest, and any such plans would be documented in separate Commission reports. The Commission would, in any case, he said, proceed with the preparation of a 4G wireless telecommunication service plan for the Region.

Mr. Evenson indicated that, in accordance with the commitment made at the September meeting, he had sent letters to all of the private wireless telecommunication service providers operating within the Region, asking whether or not the service provider concerned would be interested in cooperating with the Commission in the preparation of a 2G-3G wireless telecommunications plan for that provider. Mr. Evenson then distributed a list of the addressees of the letters sent, together with the dates of transmission; copies of each letter; and a copy of the staff memorandum enclosed with each letter (copy of packet attached as Appendix I to these minutes).

Mr. Evenson noted that the letters requested a response within thirty days concerning the willingness of the addressed service provider to cooperate with the Commission in the regional planning program. He noted that the thirty day time period had now expired for all of the providers concerned. Accordingly, the Commission is proceeding with the preparation of the 4G wireless telecommunication plan for the Region. He indicated that the revised copy of Chapter V should be available for Committee review and approval at the next meeting of the Committee. Transitional 2G-3G plans would not be prepared for any of the individual providers. The revised Chapter would consist of a documentation of the findings of the Commission's wireless base station inventory without the inclusion of service coverage maps and with appropriate documentation relative to the unwillingness of the service providers to help verify the wireless infrastructure inventory findings set forth in the Chapter.

In answer to a question by Mr. Chernow, Mr. Evenson indicated that as of this date no written replies have been received from any of the addressees.

There being no further questions or comments, it was the consensus of the Committee that the report be accepted and placed on file via the minutes of the meeting.

WORK PROGRESS REPORT ON CHAPTER VI, "WIRELESS TELECOMMUNICATIONS PERFORMANCE INVENTORY FINDINGS," OF SEWRPC PLANNING REPORT NO. 51, *A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN.*

Chairman Bauer then asked Dr. Schlager to undertake a review of the work progress with the Committee.

Dr. Schlager indicated the initial round of performance monitoring should be completed on March 2, 2006. In that initial effort, a provider dedicated monitoring station was operated for a period of three to four days at each of four locations within each County of the Region. He indicated that this initial monitoring effort would be the basis for the completion of Chapter VI of SEWRPC Planning Report No. 51. Dr. Schlager recalled that a preliminary version of this Chapter had been reviewed by the Committee at the meeting held on December 6, 2005. A revised draft, he said, should be ready for Committee review and approval at its next meeting.

There being no questions or comments, it was the consensus of the Committee that the report be accepted and placed on file via the minutes of the meeting.

CORRESPONDENCE

Chairman Bauer reported that there was no other correspondence to be brought to attention of the Committee.

DATE AND TIME OF NEXT MEETING

Chairman Bauer then asked the Committee to consider the date and time for the next Committee meeting. After a brief discussion it was agreed that the next meeting of the Committee would be held on May 23, 2006, at the Commission offices beginning at 2:00PM.

ADJOURNMENT

There being no further business to come before the Committee, on a motion by Mr. Melcher, seconded by Mr. Chernow, and carried unanimously, the meeting was adjourned at 4:00 P.M.

Respectfully Submitted,

Lynn G. Heis
Staff Secretary

KWB/lgh
05/03/06
#115684 V1 - T/C Minutes - 12th Meeting

PRELIMINARY DRAFT

SEWRPC Planning Report No. 51
A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN
FOR SOUTHEASTERN WISCONSIN

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 1 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.

Table 1

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.

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 megabit per second range and maximum packet loss of ten 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 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 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 ~~level~~ *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.

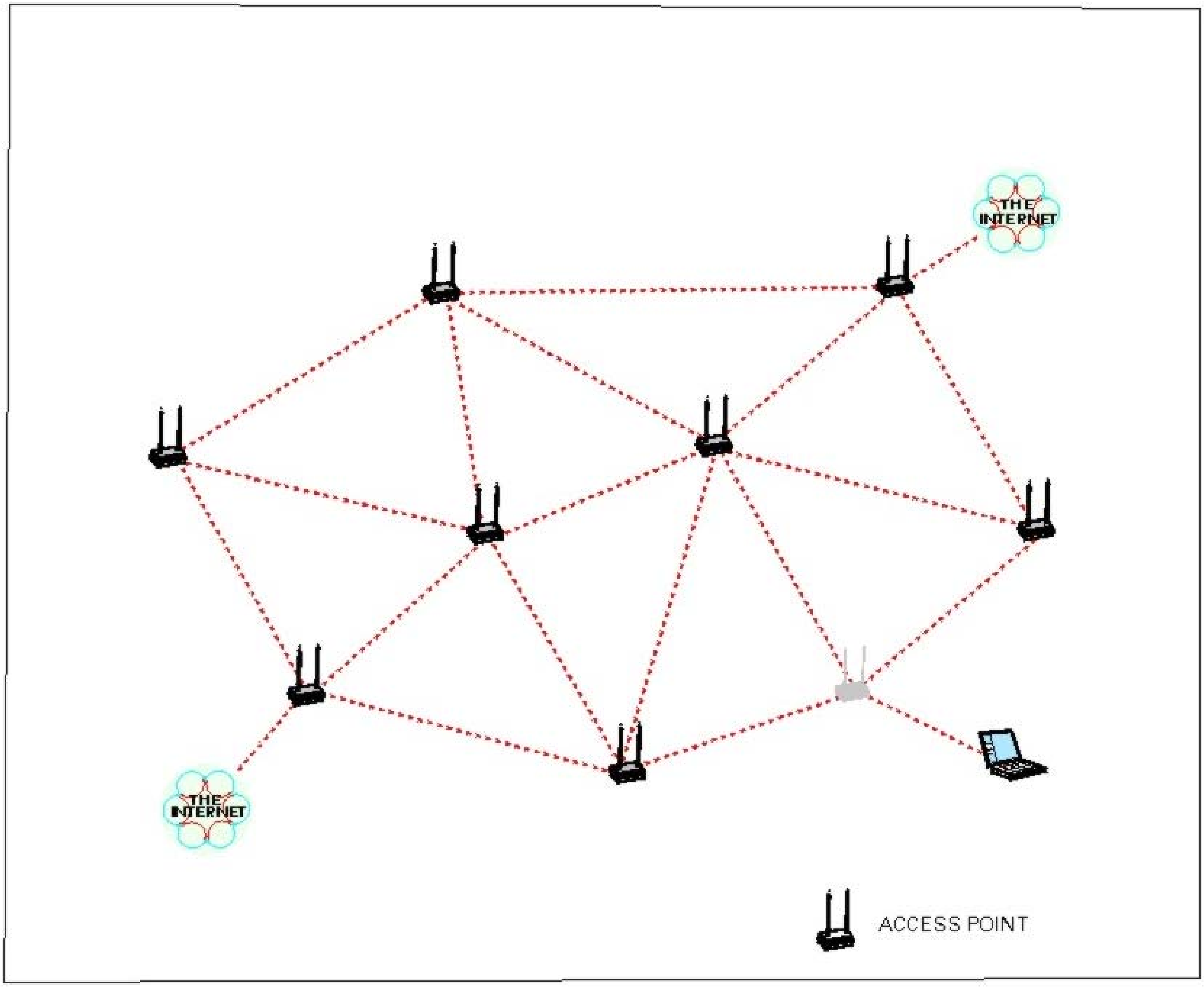
A second stage of WiFi communications development has been the mesh network in which an entire metropolitan area is blanketed with WiFi coverage. A mesh network involves the interconnection of the WiFi access points -- hot spots -- into a mesh topology. In such a network, shown in Figure 1, each access 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. ~~A number of American cities are presently installing WiFi mesh networks including 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 of larger size generally require higher access point densities to overcome the "clutter" attendant to the numerous structures comprising such cities.~~ *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

Figure 1

CONCEPTUAL MESH NETWORK



Source: Tropos and SEWRPC.

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 simalar 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
   - The most demanding applications relate to video communications with transmission data rate requirements up to 200 megabits per second.
6. 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 ranges up to 30 miles have been demonstrated in point-to-point applications while still operating within FCC transmission power limitations~~. 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

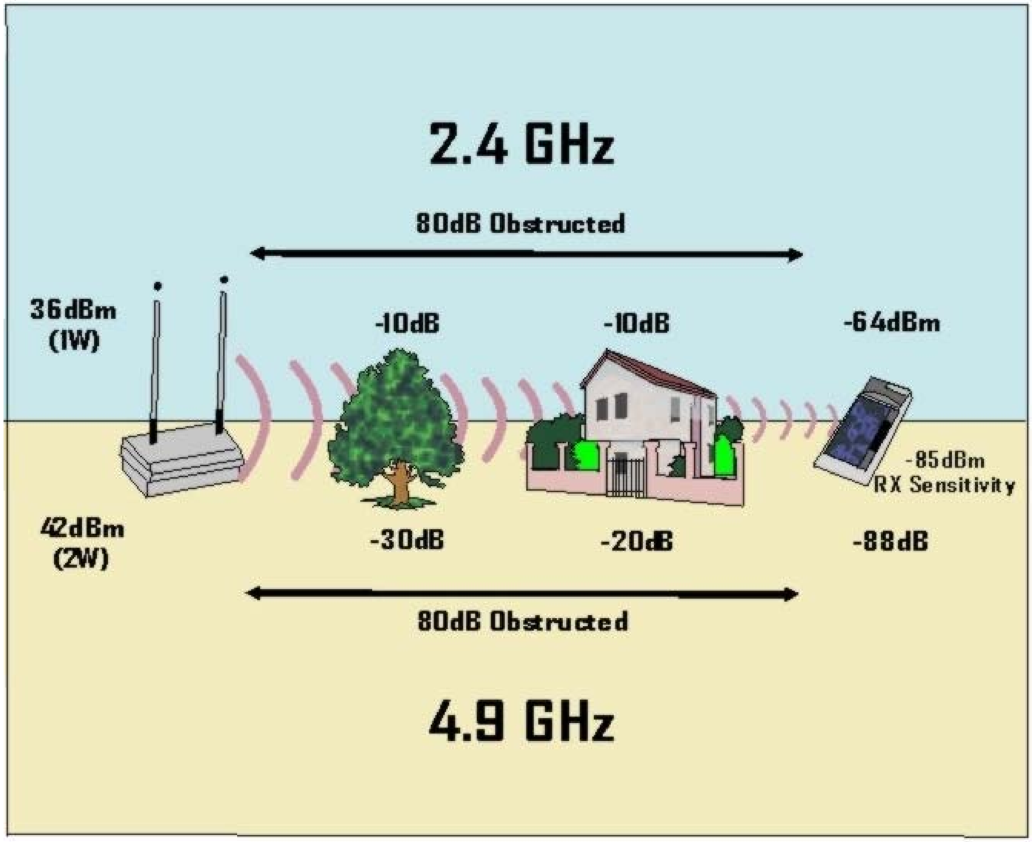
Recent experience with mesh networks in smaller cities such as Chaska, Minnesota (Tropos Networks) and Buffalo, Minnesota (Motorola) have demonstrated that WiFi technology in its current state (802.11g, 802.11a) will not achieve the performance standards for both throughput -- 20 megabits per second -- 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 2 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.

These technology shortcomings concerned are best understood by reference to Shannon’s Law which defines the channel capacity -- maximum transmission 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.

Figure 2

RADIO PROPAGATION CLUTTER LOSSES



Source: Tropos 2004.

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, than 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 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 one 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:

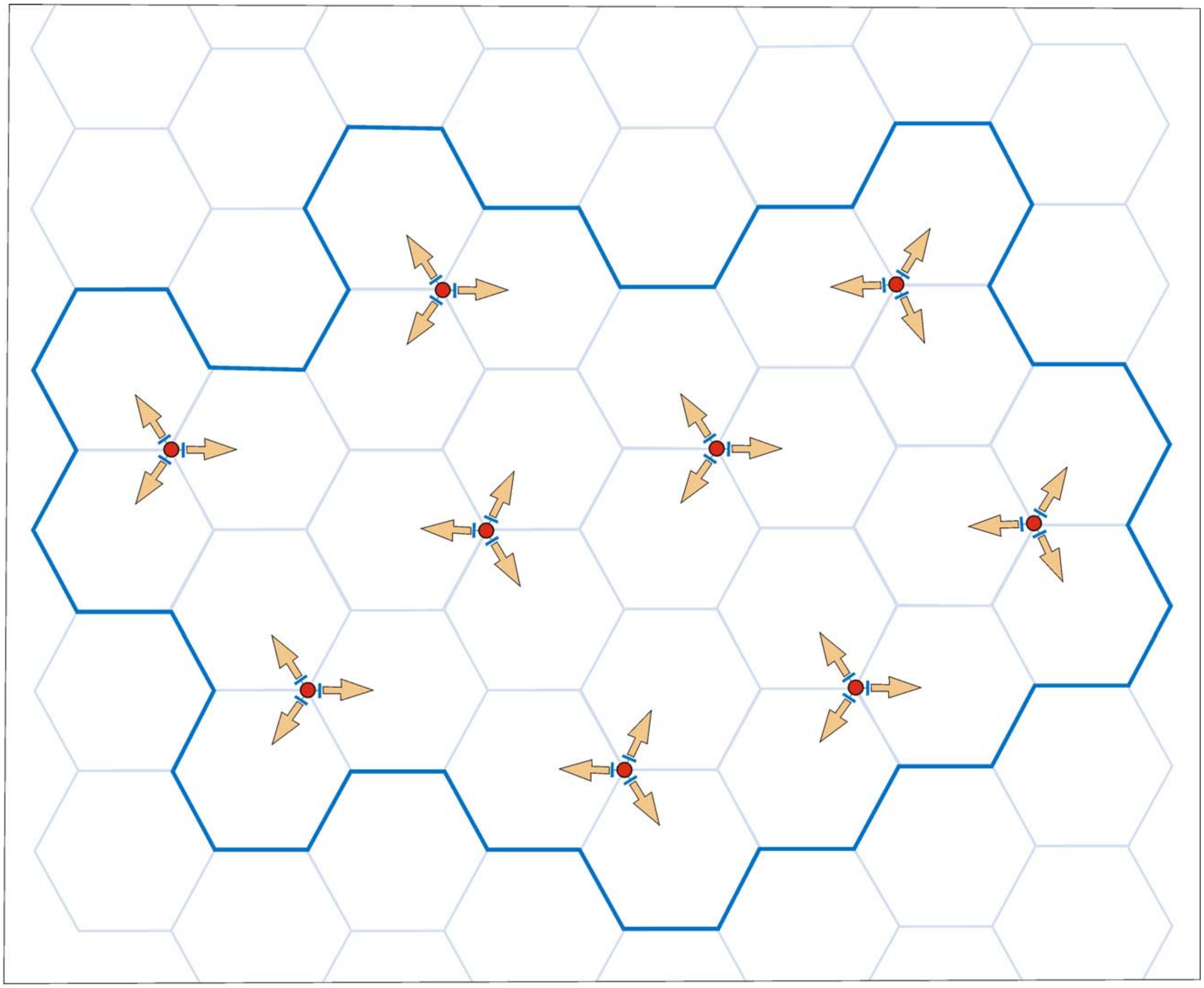
1. The nomadic laptop user
    - Transmit power – 200 milliwatts = 23 decibel-milliwatts
    - Receiver sensitivity – (-82 decibel-milliwatts) @ 6 megabits per second
    - Antenna gain – 5 dBi (decibels isotropic)
2. The mobile WiFi phone user
    - Transmit power – 100 milliwatts = 20 decibel-milliwatts
    - Receiver sensitivity – (-82 decibel-milliwatts) @ 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
    - Receiver sensitivity – (-74 decibel-milliwatts) @ 24 megabits per second
    - Antenna gain – 13 dbi (decibels-sotropic)
    - Preamplifier gain – 22 decibel-milliwatts

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 3, the service areas 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 1, 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

Figure 3

CONCEPTUAL SECTORAL CELLULAR NETWORK



LEGEND

ACCESS POINT WITH 120 DEGREE SECTORAL ANTENNAS

CELL SERVED BY SECTORAL ANTENNA

technologies. WiFi networks, however, evolving from a network of isolated "hot spots" have generally employed the mesh network topology. ~~Mesh networks provide a number of advantages particularly relating to redundancy and reliability. The mesh network is largely "self-healing" in that the failure of a single access point does not disable the network. Mesh networks also suffer from two major disadvantages that are critical to their adoption in this regional wireless network plan: higher infrastructure costs and reduced network performance.~~ *Mesh networks are sometimes seen to provide an advantage over cellular network with respect to redundancy and reliability. The mesh network 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.

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 Wi-MAX-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 1 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	11
Washington	11
Waukesha	12

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 inputs 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 the 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 will 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

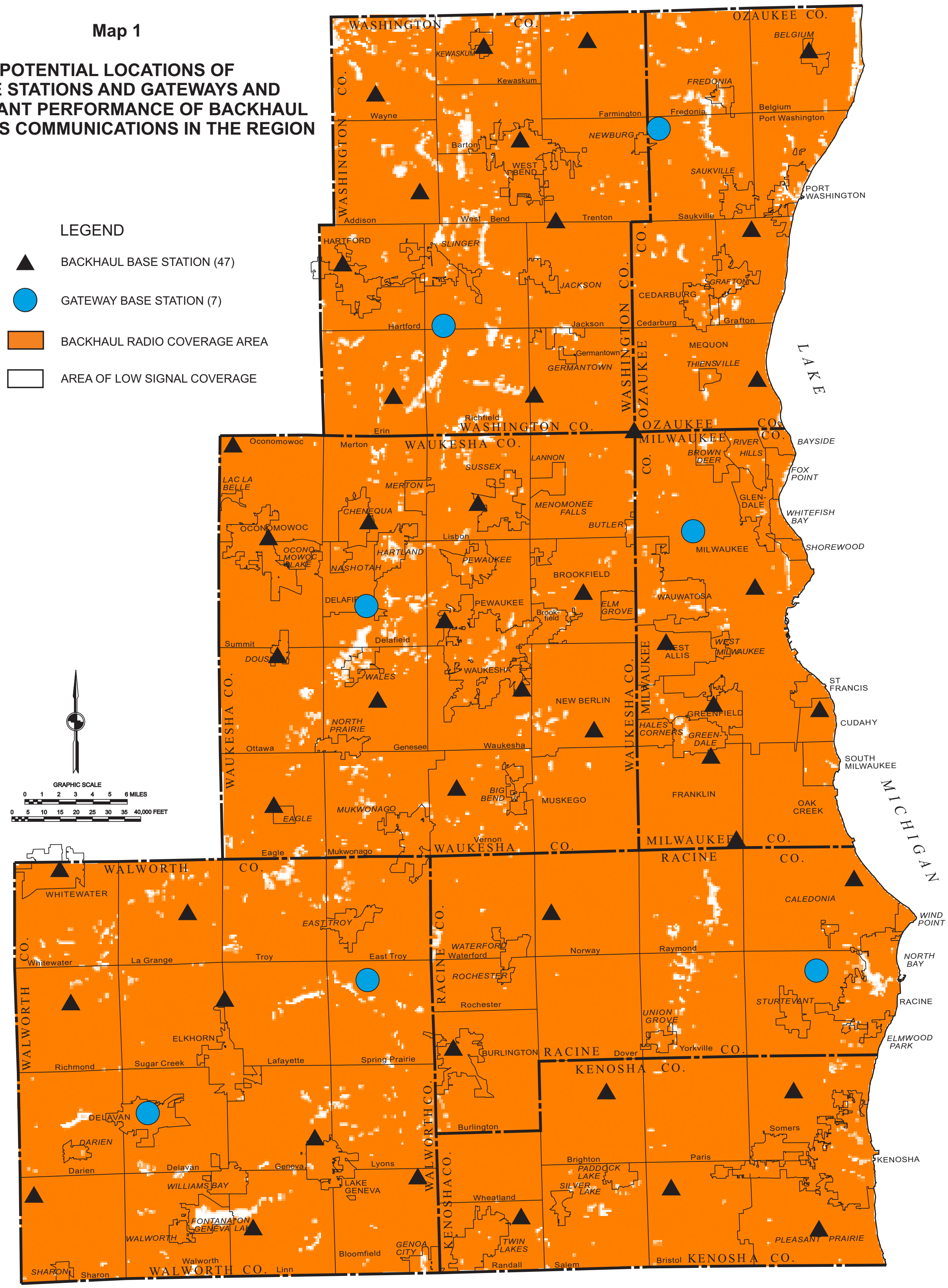
Following the optimal selection of a backhaul station set, a second stage of mathematical optimization was used to select the minimal number of gateway stations needed to service the backhaul network. Minimizing the number of backhaul gateway stations is important not only to minimize the additional investment that each of these gateways requires, but also to minimize ongoing network operating costs. The cost of a megabite/second unit of bandwidth declines by about 32% 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:

1.	Antenna Base Stations	
	54 at 25,000 =	$1,350,000
2.	Gateway Stations	
	7 at 100,000 =	700,000
3.	Project Management and Engineering	350,000
		$2,400,000

Map 1

POTENTIAL LOCATIONS OF BASE STATIONS AND GATEWAYS AND ATTENDANT PERFORMANCE OF BACKHAUL WIRELESS COMMUNICATIONS IN THE REGION



Source: SEWRPC.

The foregoing estimate of costs include only the costs of equipment installation.

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 fees, if any, for use of municipal structures to mount antennas, or legal fees.

The operational cost savings from such a network would depend on the traffic volume on the network, but if the network were operating at a capacity of 100 megabits per second for each base station then the regional traffic volume should be 54 gigabits per second. At a unit cost of $100 per megabit per second per month, the monthly transmission costs would be $540,000 per month. A 32 percent savings rate would then yield a cost reduction of $172,800/month or $2.07 million per year. Following the return of the initial investment, an annual savings of $2.07 million less operating and maintenance costs could 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 with 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.

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.

Sectoral Cellular Cedarburg-Grafton Wireless Network Plan

The sectoral cellular wireless plan for the Cedarburg-Grafton area is shown in Maps 2 and 3. 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 2. The two color coverage pattern in Map 2 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 3 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. It is also assumed that the access point equipment 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 2 and 3. 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 1 would also serve to provide alternate backhaul base stations as may be required.

The estimated cost of cellular infrastructure deployment for Cedarburg-Grafton 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.

Based on the 41 access points deployed - 18 for Cedarburg and 23 for Grafton – the infrastructure deployment cost was estimated at $294,550, expressed in year 2006 real dollars. This total cost included the cost of the equipment and equipment installation for each access point estimated at $5,250 each or $212,250; Internet access equipment – in the form of a WiMAX or fiber connection - $17,300; 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.

These costs do not include operation or maintenance costs, nor such potential additional costs as exclusive use license fees if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental fees, if any, for use of municipal structures to mount antennas; or legal fees.

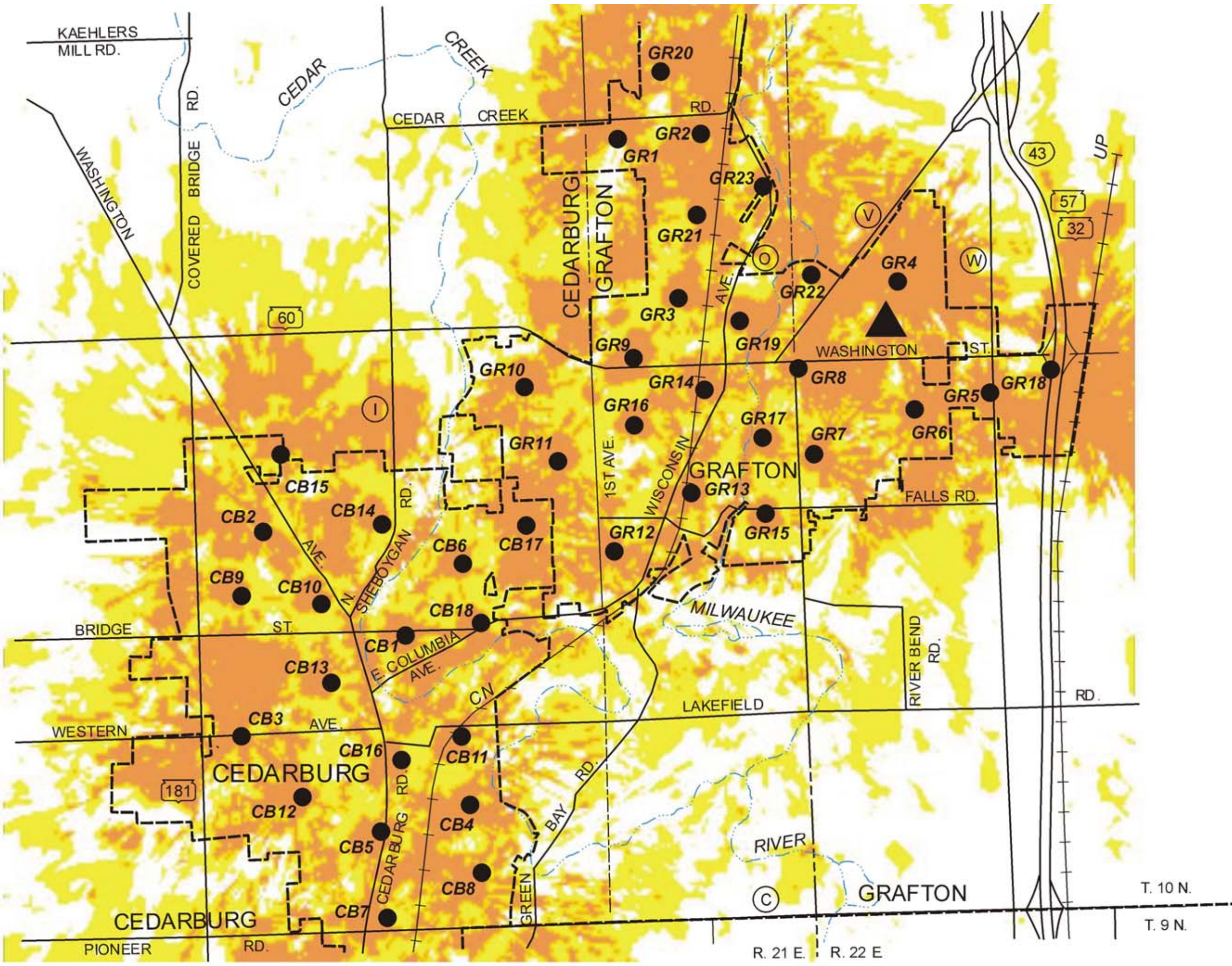
Part of the project engineering cost would support field testing to verify the performance of the access point locations in providing specified signal levels throughout their individual coverage areas. The cost estimate encompasses only the network infrastructure and does not include the cost of user 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 provided the fixed location user in the recommended cellular plan.

Map 2



LEGEND

EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION

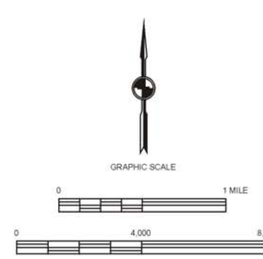
RECOMMENDED LOCATION OF WiFi ACCESS POINT

GR3 IDENTIFICATION NUMBER

RECEIVED POWER AT REMOTE:
-70dBmW TO -79dBmW,
THROUGHPUT: 24 Mpbs to 54Mbps

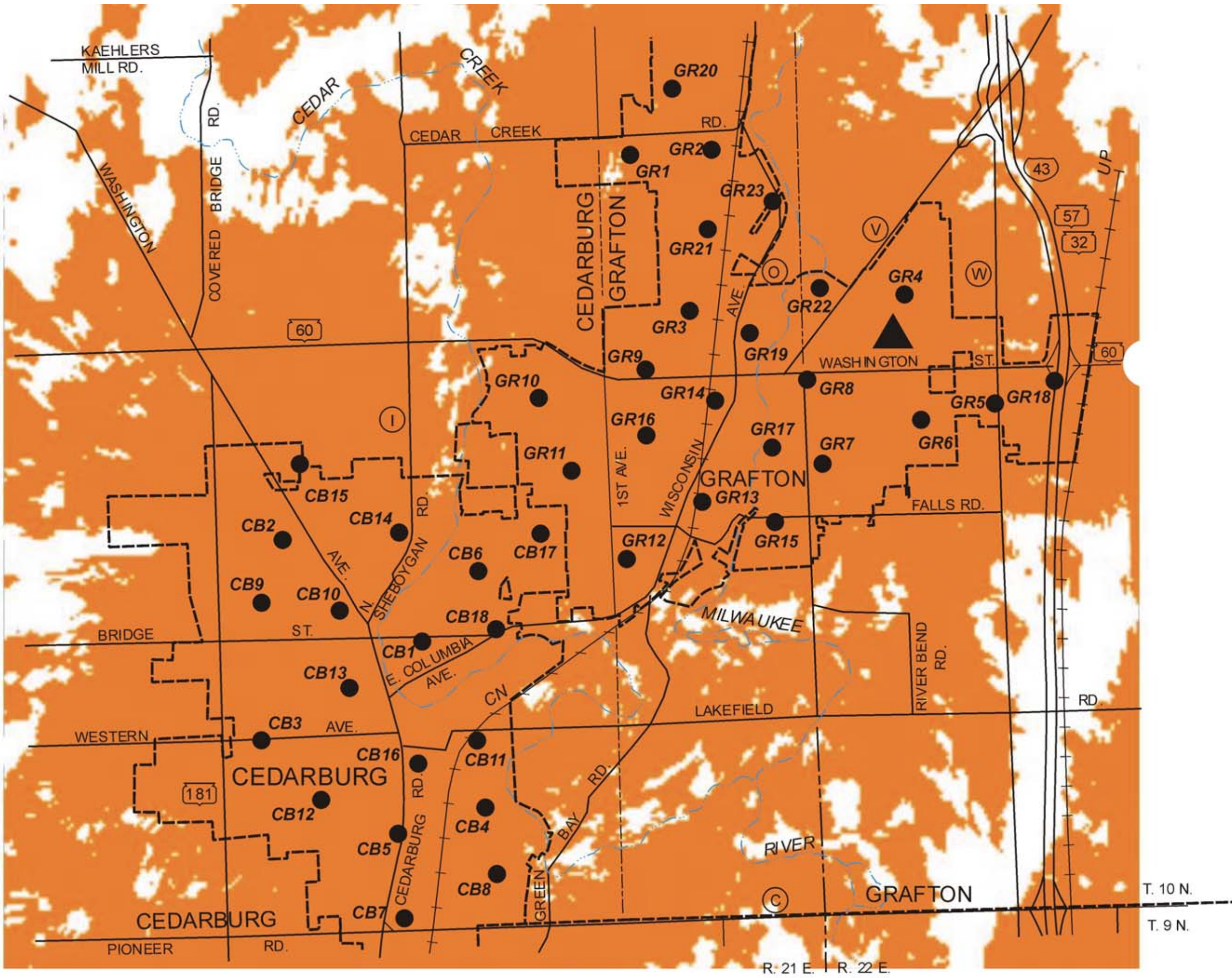
RECEIVED POWER AT REMOTE:
-79dBmW to -87dBmW,
THROUGHPUT: 6Mps to 24 Mbps

AREA NOT WITHIN ACCEPTABLE COVERAGE



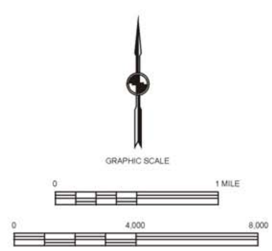
Source: SEWRPC.

Map 3



LEGEND

- ▲ EXISTING BASE STATION TO BE USED FOR WiMAX APPLICATION
- ● RECOMMENDED LOCATION OF WiFi ACCESS POINT
- *GR3* IDENTIFICATION NUMBER
- RECEIVED POWER AT REMOTE: -70dBmW TO -87dBmW, THROUGHPUT: 24 Mpbs to 54Mbps
- AREA NOT WITHIN ACCEPTABLE COVERAGE



Source: SEWRPC.

Table 2

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 2 and 3)	0Location			
	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	2,46,826	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. 100 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

Table 2 continued

Site Number (See Maps 2 and 3)	Location			
	State Plane Coordinates[a]		U.S. Public Land Survey Township-Range-Section	Civil Division
	North	East		
GR23	492,355	2,546,028	T. 10 N., R. 21 E. Sec. 13	Village of Grafton
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.

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 non-standard 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.

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 Cedarbury-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 only $294,550 compared with $456,300 for an equivalent Tropos mesh network that does not achieve the performance standards.

KJS/KWB/lgh
05/10/06
#115251 V4 - T/C - PR No. 51-Chapter VII

Appendix I

LETTERS TO TELECOMMUNICATION SERVICE PROVIDERS

LETTERS TO PROVIDERS

January 16, 2006	Ms. Shannon Nichols Project Manager, Site Development Sprint/Nextel 5600 N. River Road Rosemont, IL 60018
January 11, 2006	Verizon Wireless c/o Mr. Steven L. Ritt Michael Best & Friedrich, LLP One South Pinckney Street, Suite 700 Madison, WI 53703
January 11, 2006	Ms. Terry Kyne Executive Director-Network Services Cingular Wireless 115 S. 84th Street, Suite #101 Milwaukee, WI 53214
January 9, 2006	Mr. Eric M. Engen Development Manager-Central T-Mobile N19 W24075 Riverwood Drive #100 Waukesha, WI 53188-1170
January 6, 2006	Ms. Sandra Peters Regional Construction Manager U.S. Cellular 5117 West Terrace Drive Madison, WI 53718

KWB/lgh
02/06/06
#115604 V1 - Provider Letter

COPY

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Serving the Counties of: KENOSHA MILWAUKEE OZAUKEE RACINE WALWORTH WASHINGTON WAUKESHA

January 16, 2006

Ms. Shannon Nichols
Project Manager, Site Development
Sprint/Nextel
5600 N. River Road
Rosemont, IL 60018

Dear Ms. Nichols:

Following up conversations you have had with staff members in the Commission's Telecommunications Planning Division, I am sending the enclosed memorandum that proposes a partnership program to develop an antenna site and related infrastructure plan for all of the cellular/PC wireless networks in Southeastern Wisconsin. Background material on the Southeastern Wisconsin Regional Planning Commission, its geographic area, and the need for the regional antenna site inventory are all contained in the memorandum. This memorandum should assist you in answering questions in your organization relating to the need for or the procedures of this inventory.

Recent contacts with local governments in the region indicate strong support for the cooperative partnership approach outlined in the memorandum. These governments historically have looked to the Commission for guidance in matters involving physical infrastructure. A cooperative approach between wireless service providers and the Commission telecommunications staff has the potential to greatly expedite the new antenna site applications process, eliminating extended delays for the mutual benefit of wireless service providers and their customers in Southeastern Wisconsin.

Please review the enclosed memorandum. A response within 30 days on your willingness to cooperate with the Commission on this important program would be very much appreciated. Time is of the essence for the proposed partnership program. A timely reply to this letter and the partnership program would greatly expedite the Commission's telecommunications planning program.

Both Sprint PCS and Nextel have previously demonstrated a spirit of cooperation with the Commission's antenna site inventory program. Sprint has furnished the required antenna site for six of the seven counties in the Southeastern Wisconsin Region. The data for Kenosha County were not furnished since it was not part of Sprint's Milwaukee region. The Commission has also, upon the request of the Town of Oconomowoc, prepared radio coverage maps that supported Sprint's application for a new antenna site in that community.

Nextel has previously furnished the Commission with antenna site data for all of the seven counties of the Region except for antenna power and antenna pattern parameters.

Based on data previously furnished, Sprint/Nextel could become a cooperative partner on the antenna site inventories project by:

1. Sprint
   - furnishing the Commission with the same data for Kenosha County that it has already furnished for the other six counties.

2. Nextel
   - Furnishing antenna site power and pattern data for the seven counties in the Region.

Thank you for your attention to this matter.

Sincerely,

Philip C. Evenson
Executive Director

PCE/KWB/KJS/lgh
#114989 V1 - T/C Partnership Ltr-Site Development

Enclosure

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January 11, 2006

Verizon Wireless
c/o Mr. Steven L. Ritt
Michael Best & Friedrich, LLP
One South Pinckney Street, Suite 700
Madison, WI 53703

Dear Mr. Ritt:

Following up conversations you have had with staff members in the Commission's Telecommunications Planning Division, I am sending the enclosed memorandum that proposes a partnership program to develop an antenna site and related infrastructure plan for all of the cellular/PC wireless networks in Southeastern Wisconsin. Background material on the Southeastern Wisconsin Regional Planning Commission, its geographic area, and the need for the regional antenna site inventory are all contained in the memorandum. This memorandum should assist you in answering questions in your organization relating to the need for or the procedures of this inventory.

Recent contacts with local governments in the region indicate strong support for the cooperative partnership approach outlined in the memorandum. These governments historically have looked to the Commission for guidance in matters involving physical infrastructure. A cooperative approach between wireless service providers and the Commission telecommunications staff has the potential to greatly expedite the new antenna site applications process, eliminating extended delays for the mutual benefit of wireless service providers and their customers in Southeastern Wisconsin.

Please review the enclosed memorandum. A response within 30 days on your willingness to cooperate with the Commission on this important program would be very much appreciated. Time is of the essence for the proposed partnership program. A timely reply to this letter and the partnership program would greatly expedite the Commission's telecommunications planning program.

Thank you for your attention to this matter.

Sincerely,

Philip C. Evenson
Executive Director

PCE/KWB/KJS/lgh
#114852 V1 - T/C Partnership Ltr-Verizon

Enclosure

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January 11, 2006

Ms. Terry Kyne
Executive Director-Network Services
Cingular Wireless
115 S. 84th Street, Suite #101
Milwaukee, WI 53214

Dear Ms. Kyne:

Following up conversations you have had with staff members in the Commission's Telecommunications Planning Division, I am sending the enclosed memorandum that proposes a partnership program to develop an antenna site and related infrastructure plan for all of the cellular/PC wireless networks in Southeastern Wisconsin. Background material on the Southeastern Wisconsin Regional Planning Commission, its geographic area, and the need for the regional antenna site inventory are all contained in the memorandum. This memorandum should assist you in answering questions in your organization relating to the need for or the procedures of this inventory.

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Please review the enclosed memorandum. A response within 30 days on your willingness to cooperate with the Commission on this important program would be very much appreciated. Time is of the essence for the proposed partnership program. A timely reply to this letter and the partnership program would greatly expedite the Commission's telecommunications planning program.

Thank you for your attention to this matter.

Sincerely,

Philip C. Evenson
Executive Director

PCE/KWB/KJS/lgh
#114854 V1 - T/C Partnership Ltr-Cingular Wireless

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FAX (262) 547-1103

Serving the Counties of: KENOSHA MILWAUKEE OZAUKEE RACINE WALWORTH WASHINGTON WAUKESHA

January 9, 2006

Mr. Eric M. Engen
Development Manager-Central
T-Mobile
N19 W24075 Riverwood Drive #100
Waukesha, WI 53188-1170

Dear Mr. Engen:

Following up conversations you have had with staff members in the Commission's Telecommunications Planning Division, I am sending the enclosed memorandum that proposes a partnership program to develop an antenna site and related infrastructure plan for all of the cellular/PC wireless networks in Southeastern Wisconsin. Background material on the Southeastern Wisconsin Regional Planning Commission, its geographic area, and the need for the regional antenna site inventory are all contained in the memorandum. This memorandum should assist you in answering questions in your organization relating to the need for or the procedures of this inventory.

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Please review the enclosed memorandum. A response within 30 days on your willingness to cooperate with the Commission on this important program would be very much appreciated. Time is of the essence for the proposed partnership program. A timely reply to this letter and the partnership program would greatly expedite the Commission's telecommunications planning program.

Thank you for your attention to this matter.

Sincerely,

Philip C. Evenson
Executive Director

PCE/KWB/KJS/lgh
#114792 V1 - T/C Partnership Ltr-T-Mobile

Enclosure

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January 6, 2006

Ms. Sandra Peters
Regional Construction Manager
U.S. Cellular
5117 West Terrace Drive
Madison, WI 53718

Dear Ms. Peters:

Following up conversations you have had with staff members in the Commission's Telecommunications Planning Division, I am sending the enclosed memorandum that proposes a partnership program to develop an antenna site and related infrastructure plan for all of the cellular/PC wireless networks in Southeastern Wisconsin. Background material on the Southeastern Wisconsin Regional Planning Commission, its geographic area, and the need for the regional antenna site inventory are all contained in the memorandum. This memorandum should assist you in answering questions in your organization relating to the need for or the procedures of this inventory.

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Please review the enclosed memorandum. A response within 30 days on your willingness to cooperate with the Commission on this important program would be very much appreciated. Time is of the essence for the proposed partnership program. A timely reply to this letter and the partnership program would greatly expedite the Commission's telecommunications planning program.

Thank you for your attention to this matter.

Sincerely,

Philip C. Evenson
Executive Director

PCE/KWB/KJS/lgh
#114759 V1 - T/C Partnership Letter

Enclosure

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MEMORANDUM

TO: Regional Wireless Cellular/PCS Service Providers

FROM: Philip C. Evenson, Executive Director, SEWRPC

DATE: January 4, 2006

SUBJECT: WIRELESS SERVICE PROVIDERS IN SOUTHEASTERN WISCONSIN – A PROPOSAL FOR PARTNERSHIP

This memorandum will provide the background, rationale, and procedure for the creation of a partnership between regional wireless service providers in Southeastern Wisconsin and the Southeastern Wisconsin Regional Planning Commission to cooperate in the planning for and development of cellular/PCS networks in the seven-county Southeastern Wisconsin Region. Such a partnership would be an integral part of the Commission's ongoing telecommunications planning program, a program that recognizes the central role of private sector service providers in developing wireless communications networks within the planning Region.

BACKGROUND

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 Commission's regional telecommunications planning is also strongly linked to the regional land use plan based upon 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 regional telecommunications planning process. To that end, the following briefly 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 addressing areawide problems and, working with private sector interests 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 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 1.93 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 1.18 million jobs, or about 36 percent of the total employment of the State. The Region contains real property valued at about $133.5 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.

THE REGIONAL TELECOMMUNICATIONS PLANNING PROGRAM

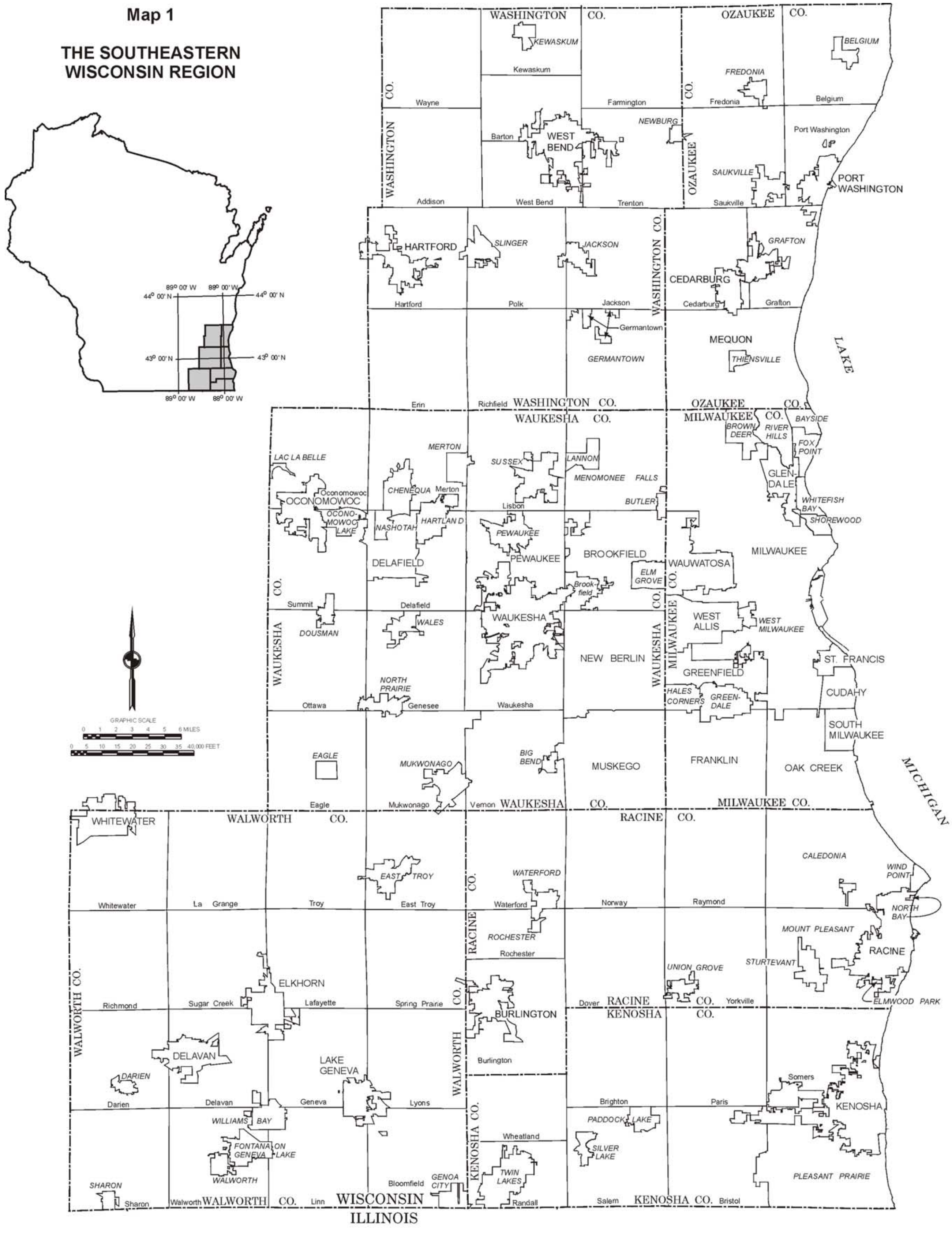
In Fall 2004, the Commission initiated the conduct of a regional telecommunications planning program. The first stage of this planning program has emphasized wireless communications networks, both commercial cellular networks and governmental public safety networks. The primary objective of the wireless communications work activity is to produce a regional wireless communications system plan for both current second and third generation technologies and future fourth generation technologies. To develop such plans, it is important first to compile an inventory of all antenna sites and their related infrastructure in the Region. This inventory, along with a network performance evaluation, is important not only in terms of understanding current networks, but as a resource for future networks. Minimization of the number of antenna sites in any network consistent with quality service is a major goal of the cooperative wireless network planning program. The foundation of any regional wireless communications plan is a knowledge of the current state of the system as reflected in network infrastructure and network performance inventories.

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 is drawn, as appropriate, to include knowledgeable and concerned representatives of the constituent communities and municipalities, all concerned state and federal agencies, the academic community and all concerned private business and industries. Accordingly, an Advisory Committee of 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, and Executive Director, Milwaukee County Research Park
Roger Caron .... President, Racine Area Manufactures 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
Michael E. Klasen .... Director of Regulatory Affairs, SBC
J. Michael Long .... Attorney at Law, Murn and Martin, SC
Jeff Lowney .... Vice President/General Manager Time Warner Telcom
Jeff Mantes .... Commissioner of Public Works, City of Milwaukee
Jody McCann .... Network Domain Manager, Wisconsin Department of Administration, BadgerNet
George E. Melcher .... Director, Office of Planning and Development, Kenosha County
Paul E. Mueller .... Administrator, Washington County Planning and Parks Department

Map 1

THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Steven L. Ritt .... Attorney at Law, Michael Best & Friedrich
James W. Romlein .... Managing Director, MVLabs, LLC
Bennett Schliesman .... Director, Kenosha County Emergency Management/Homeland Security
Dale R. Shaver .... Director, Waukesha County Department of Parks and Land Use
Michael Ulicki .... Vice President and Chief Technology Officer, Norlight Telecommunications
Darryl Winston .... Director of Data Services, City of Milwaukee Police Department
Gustav W. Wirth, Jr. .... SEWRPC Commissioner

THE REGIONAL WIRELESS NETWORK INVENTORIES

The state of a wireless telecommunications system is to be represented by two inventories:

1. An infrastructure inventory that defines the antenna site locations and the technical parameters of the base station but also estimates the geographic coverage of the network determined from radio propagation modeling and terrestrial databases.

2. A performance inventory based on a regional network monitoring system that monitors circuit-switched networks for availability and voice quality, and that monitors packet-switched networks for availability, throughput, response time, and accuracy.

THE REGIONAL WIRELESS INFRASTRUCTURE INVENTORY

Developing a comprehensive and accurate antenna site inventory has been a challenging task. There are basically three data sources for antenna site data: the Federal Communications Commission (FCC) databanks, local units of government use permit files, and the wireless service providers. The FCC data files are incomplete and frequently outdated. Local governmental data are generally reliable relative to geographic location and structural detail, but lacking technical data on antenna power and patterns. These shortcomings dictate that a complete antenna site inventory is possible only with the cooperation of the wireless service providers.

The Planning Commission has recently completed an extensive antenna site inventory data acquisition program based on FCC data and permit file data from local units of government. It also has acquired a complete set of infrastructure data for six of the seven counties from one wireless service provider (Sprint PCS) and one partial set of infrastructure data from another provider (Nextel) for all seven of the regional counties. To complete the infrastructure inventory, however, service provider cooperation is needed from all six of the regional wireless carriers. From a corporate ownership standpoint, there are only five wireless cellular/PCS networks in the Region, with Sprint and Nextel operating as separate networks under common ownership.

In working with each regional wireless service provider, the following procedure is proposed to be followed:

1. The wireless service provider would first provide to the Commission staff the antenna site data listed in Appendix I. Please note the need for antenna power output and other technical parameters, as well as geographic position and height data.

2. Commission staff would then reconcile the service provider’s data with antenna site data collected by the Commission from FCC files and the county and municipal governments. The reconciled data file would then form an error-free antenna site inventory by provider. A copy of the reconciled data file would be provided to the service provider concerned. The reconciled data file would be annotated to identify any proposed adjustments.

3. These antenna site data would be used by the Commission to generate a preliminary coverage map for the Region using radio propagation modeling. This preliminary coverage map would be provided to the service provider and in consultation with the service provider adjusted as may be necessary to create a mutually-agreed upon coverage map of the Region. The mutually-agreed coverage map would allow the Commission to support providers in any new antenna site permits that they apply for within the Region. Because of the Commission's long-standing, good working relationships with the counties and municipalities within the Region, the cooperative planning effort should significantly expedite the approval of such permit applications.

   The reason that the Commission cannot work on a site-by-site basis in reviewing proposed antenna site location permit applications is that the county and municipalities look to the Commission to verify that any current antenna site application fits into an overall plan that is best for their community and the Region as a whole. A site-by-site approach would preclude the Commission from performing its primary function in this regard: regional planning.

REGIONAL WIRELESS NETWORK MONITORING SYSTEM

The regional wireless network monitoring system is based on a set of laptop and cell phone assemblies that are randomly located at pre-selected sites throughout the seven county Region. There is one equipment assembly for each of the six wireless service providers operating in the Region. All of these remote agent stations are in continual communication with a sever computer and a supervisory computer located at the Commission offices in Pewaukee. Performance data are collected on both circuit-switched (availability, voice quality) and packet-switched (availability, throughput and response time) networks. Received signal level data are also recorded to allow for verification of geographic coverage maps. Remote agent stations are moved twice weekly on a regular basis. The initial inventory is based on a 14-week rotation cycle covering all seven counties. The first rotation cycle is now in its 7th week of the 14-week cycle. After completion in February 2006, the inventory is expected to include over 20,000 packet-switched transactions and over 5,000 circuit-switched calls. Monitoring will continue on a cyclical rotation throughout 2006 in order to eventually provide performance information for all cities, villages and towns in the Region. Larger cities such as Milwaukee, Racine and Kenosha will be monitored at multiple points throughout the municipality.

The purpose of the wireless network performance inventory is to determine the status of mobile wireless communications in Southeastern Wisconsin. Unlike the infrastructure inventory, it was not necessary to initially obtain the close cooperation of the regional wireless service providers. The output results of the performance inventory, however, provide an excellent vehicle for cooperation between the Commission and the service providers in further developing the coverage and quality of mobile wireless communication in the Region.

ACTION PROPOSAL

The Commission would urge all service providers to pursue the cooperative wireless inventory program outlined above. We are confident that this would significantly facilitate the setup of additional antenna locations within the Region. Please contact us via:

Kenneth J. Schlager, P.E.
Chief Telecommunications Engineer
Southeastern Wisconsin Regional Planning Commission
W239 N1812 Rockwood Drive
Waukesha, WI 53187-1607
Phone: (262) 547-6721 (X280)
E-Mail: Kschlager@sewrpc.org

* * *

Appendix I

County:

Community: ___________________________________

Structure Information

Latitude:

Degrees: _____________

Minutes: _____________

Seconds: _____________

Longitude:

Degrees: _____________

Minutes: _____________

Seconds: _____________

Street Address: ____

Tax Key Number: ____

Structure Type: **Church / Guyed / Monopole / Self-Supporting / Watertower**

Other: _____________________________

Antenna Information

Antenna Height (meters): ____

Number of Sectors: ____

Sector 1

Azmuth Orientation: ____

Beam Tilt: ____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): ________________________________

Sector 2

Azmuth Orientation: ____

Beam Tilt: ____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): ________________________________

Sector 3

Azmuth Orientation: ____

Beam Tilt: ____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): ________________________________

Sector 4

Azmuth Orientation:____

Beam Tilt:____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): _______________________________

Sector 5

Azmuth Orientation:____

Beam Tilt:____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): _______________________________

Sector 6

Azmuth Orientation:____

Beam Tilt:____

Antenna Pattern: ____

Highest Frequency (Mhz): ____

Effective Radiated Power - ERP (Watts): _______________________________

KWB/KJS//lgh
01/05/06
#114550 v1 - memo to wireless providers