MINUTES OF THE THIRTEENTH MEETING

REGIONAL TELECOMMUNICATIONS PLANNING ADVISORY COMMITTEE (Reconstituted)

DATE:	May 23, 2006
TIME:	2:00 P.M.
PLACE:	Commissioners' Conference Room Regional Planning Commission Offices W239 N1812 Rockwood Drive Waukesha, Wisconsin

<u>Members Present</u>

Kurt W. Bauer Chairman	Executive Director Emeritus, SEWRPC
William R. Drew Vice Chairman	Vice-Chairman, SEWRPC; Executive Director, Milwaukee County Research Park
Bob Chernow	Chairman, Regional Telecommunications Commission
Michael Falaschi	President, Wisconsin Internet
Barry Gatz	Network Supervisor, CenturyTel
Michael E. Klasen	Director, Regulatory Affairs, SBC Wisconsin
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
Bennett Schliesman	Director, Kenosha County Emergency Management /Homeland Security
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

<u>Members Absent</u>

David L. DeAngelis	Village Manager, Village of Elm Grove
Roger Caron	President, Racine Area Manufacturers and Commerce
J. Michael Long	Attorney-at-Law, Murn and Martin, SC
Jeff M. Lowney	Vice President/General Manager, Time Warner Telecom
Jeff Mantes	Commissioner of Public Works, City of Milwaukee
Jody McCann	Network Domain Manager, Wisconsin Department of Administration, BadgerNet
Dale R. Shaver	Director, Waukesha County Department of Parks and Land Use

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.

CONSIDERATION OF THE MINUTES OF THE MEETING OF FEBRUARY 28, 2006

Chairman Bauer noted that copies of the minutes of the twelfth meeting of the Reconstituted Regional Telecommunications Planning Advisory Committee held on February 28, 2006, had been distributed to all members of the Committee for review prior to the meeting. He asked the Committee to consider approval.

There being no corrections or additions, on a motion by Mr. Mueller, seconded by Mr. Romlein, and carried unanimously, the minutes of the meeting of February 28, 2006, were approved as submitted.

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

Chairman Bauer recalled that the Committee, at its meeting held on June 29, 2005, had considered a pre-preliminary draft of Chapter V, "Wireless Telecommunications Infrastructure Inventory Findings," of SEWRPC Planning Report No. 51, in effect, a partial draft reporting on the inventory findings for Kenosha County. Chairman Bauer recalled that the Committee had in its review, called attention to a number of errors and omissions in the number, location, characteristics, and service coverage of the wireless telecommunication antennas and antenna sites reported in Kenosha County and had declined to approve the pre-preliminary draft as presented. Chairman Bauer recalled further that it had been agreed that the inadequacies of the inventory findings as observed by the Committee could not be corrected without the cooperation of the private service providers concerned, cooperation which was withheld by those providers.

Chairman Bauer recalled further that with the exception of a brief progress report given at the meeting held on July 27, 2005, the Chapter was next considered at a meeting held on September 20, 2005, at which meeting the Commission Executive Director had indicated that, given the position of some of the Committee members, the staff proposed to complete Chapter V by presenting only the results of the antenna siting inventory utilizing the best information available from the public records. Service coverage maps would not be included in the revised Chapter. In addition, all of the private service providers operating within the Region were to be sent letters asking whether or not they were willing to cooperate in the completion of the wireless antenna sites inventory; and whether or not they were interested in requesting the preparation of an interim 2G-3G stage antenna siting plan. None of the providers responded positively.

Chairman Bauer indicated that the Chapter was next considered by the Committee at its meeting held on December 6, 2005, when a preliminary draft of Chapter V was submitted to the Committee for review. At that meeting the Committee acted unanimously to approve the Chapter with additions of only three paragraphs; those additions being reported in the minutes of the December 6, 2005 meeting.

Chairman Bauer then noted that a copy of the final draft of Chapter V had been provided to all Committee members with the agenda for the meeting. He noted that since the preliminary draft of the Chapter had been approved at the meeting of December 6, 2005, and since the final draft did incorporate the three substantive changes which the Committee requested be made in the preliminary draft, the Chapter was being provided – in effect – for informational purposes only. No further Committee action on this final Chapter was being requested nor was necessary. Chairman Bauer indicated that it was his opinion that the Chapter presented the best wireless antenna siting inventory that it was possible for the Commission to prepare in the absence of the cooperation of the private service providers.

In answer to a question by Mr. Falaschi, Chairman Bauer indicated that the copy of Chapter V provided to the Committee members with the agenda was indeed the final Committee approved version of the Chapter; and that the Chapter would be published by the Commission as presented. In answer to a further question by Mr. Falaschi, Chairman Bauer indicated that Chapter V, having been approved by the Committee at its meeting held on December 6, 2005, was now a public document and copies could be provided to anyone requesting copies. In addition, he said, the Chapter would be available through the Commission's Internet website.

CONSIDERATION OF PRELIMINARY DRAFT OF 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 recalled that the Committee at its meeting held on December 6, 2005, had considered a pre-preliminary draft of Chapter VI, "Wireless Telecommunications Performance Inventory Findings," of SEWRPC Planning Report No. 51. The Committee did not at that meeting act to approve the pre-preliminary draft as submitted, but did make a number of suggestions for consideration by the staff in preparing the actual preliminary draft.

Chairman Bauer noted that a copy of the now completed preliminary draft of Chapter VI, "Wireless Telecommunications Performance Inventory Findings," of SEWRPC Planning Report No. 51 had been distributed to all members of the Committee for review prior to the meeting.

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

In answer to a question by Mr. Chernow, Dr. Schlager indicated that the difficulties which the staff had experienced in monitoring the performance of T-Mobile within the Region was not attributable to the monitoring procedures, nor to the Commission's monitoring hardware and software packages, since these worked well with all of the other service providers; but rather to the unavailability of a competent staff person at T-Mobile to assist the Commission staff in finding the reasons for the dropped monitoring calls. In answer to a further question by Mr. Chernow, Dr. Schlager indicated that the availability data -- as summarized in Tables 1 and 7 -- did not include any monitoring data for T-Mobile; and did indeed accurately reflect the regional level performance of the packet-switched cellular/PCS wireless networks operating within the Region for the monitoring period.

Mr. Klasen, noting that the staff had determined not to monitor the performance of circuit-switched networks within the Region, expressed concern that there may be a need to revise earlier chapters of the report -- and particularly Chapter III dealing with objectives, principles, and standards -- which may contain references to monitoring of the performance of such circuit-switched networks. Chairman Bauer indicated that Mr. Klasen's concern was certainly a valid one, and indicated the Commission staff would accordingly review the earlier chapters of the report as approved by the Committee to identify any links and needed changes.

Secretary's Note: Staff review of the first five chapters of the planning report as approved by the Committee -- including particularly Chapter III, "Objectives, Principles, and Standards" -- indicated that those chapters contained no references to the performance of circuit-switched, as opposed to packet-switched, wireless networks within the Region. The objectives, principles, and standards as approved were intended implicitly to apply to both types of networks.

Staff review also indicated that monitoring of the performance of circuit-switched networks within the Region was originally proposed in Technical Design Study Memorandum No. 7, "Wireless Performance Monitoring Inventory." This Memorandum was considered by the Committee at their meetings held on May 10 and June 29, and was approved at the Committee meeting held on July 27, 2005. That approval was contingent upon further additions or deletions required by the staff's findings relative to the Committee suggested changes in the circuit-switched monitoring system procedure. Technical design memorandums are considered by the Commission to be internal working papers, and-as-such, subject to revision as work proceeds.

Finally, staff investigation indicated that Chapter VI, "Wireless Telecommunications Performance Inventory Findings," as originally drafted and presented to the Committee for review at its meeting held on September 6, 2005, had contained references to monitoring of the performance of the circuit-switched networks within the Region. These references were, however, deleted from the draft of Chapter VI as presented to the Committee for review at this meeting.

In answer to a question by Mr. Chernow, Dr. Schlager indicated that network security provisions prevented the monitoring of download throughput for the Cingular, Nextel, and U.S. Cellular networks. The average values presented in the summary tables concerning download throughput, he said, reflect only the collected data points. Mr. Falaschi agreed with Mr. Chernow's implied concern in that users customarily judge system performance with respect to throughput by download performance. Mr. Klasen suggested, and the Committee agreed, that appropriate footnotes be added to Tables 1 through 8, clarifying the procedure used to determine the average values, thereby properly addressing Mr. Chernow's expressed concern. Chairman Bauer indicated that the footnote should not only indicate the basis for the average values presented, but also the reason why download data could not be obtained for certain providers. Mr. Falaschi indicated that the reasons given for the inability to obtain download throughput data should be specific, indicating for example, if the problem was due to "port blocking."

Secretary's Note: The following footnote was added to Table 1:

1. The download data presented originated only in the Sprint and Verizon wireless networks. The data represent weighted averages of the data for these two providers, with the weighing being based on the number of

data points collected for each provider. Security features -- firewalls -- in place by the other wireless service providers prevented the collection of other download throughput data. Collection of download throughput data, unlike the other monitoring parameters, required initiation of the transaction outside of the service provider's network by a server located at SEWRPC. Such transaction initiations were blocked by firewalls at all service providers except Sprint and Verizon.

The following footnote was added to Tables 2, 3, and 5:

1. Security features -- firewalls -- in place by the wireless service providers prevented collection of download throughput data.

Mr. Chernow suggested, and the Committee concurred, that the first word in the second sentence of the second paragraph on page 9 should be changed from "if" to "when".

Mr. Klasen expressed concern with the conclusion set forth in the last full paragraph on page 9 concerning the inability of the existing network performance within the Region to meet the performance standards established in Chapter III, "Objectives and Standards," of the planning report. He suggested, and the Committee concurred, that text be added indicating that the standards are intended to specify system performance by the design year of the plan – and not existing performance.

Dr. Schlager pointed out that the performance standards of Chapter III as stated in the footnotes on page 3 of that Chapter are for fourth generation (4G) wireless networks at whatever date they are achieved. To support the economic development of the Region, the broadband wireless network plan is intended to encourage early development of 4G capabilities within the Region prior to the design year of the plan if possible.

Secretary's Note: The following sentence was added to the end of the third paragraph on page 9:

"With respect to this finding, it should be noted that the performance standards set forth in Chapter III of this report are intended to specify performance for 4G networks and are not intended to specify the performance of existing networks."

In answer to a concern expressed by Mr. Chernow relating to the possible incompatibility of the Commission's hardware and software with that of the particular provider network being monitored, Dr. Schlager indicated that the problem concerned could not be attributed to the hardware or software comprising the Commission's monitoring system in that the Commission system performed well for all of the providers except for T-Mobile.

There being no further questions or comments, on a motion by Mr. Melcher, seconded by Mr. Wirth, and carried unanimously, Chapter VI, "Wireless Telecommunications Performance Inventory Findings," of SEWRPC Planning Report No. 51, *A Wireless Antenna Siting And Related Infrastructure Plan For Southeastern Wisconsin,* was approved as amended.

CONSIDERATION OF REVISED PRELIMINARY DRAFT OF CHAPTER VII, "A REGIONAL WIRELESS TELECOMMUNICATIONS PLAN FOR SOUTHEASTERN WISCONSIN," OF SEWRPC PLANNING REPORT NO. 51, *A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN FOR SOUTHEASTERN WISCONSIN*.

Chairman Bauer recalled that the Committee at its meeting held on February 28, 2006, had considered a pre-preliminary draft of Chapter VII "A Regional Wireless Telecommunications Plan For Southeastern Wisconsin," of SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin.* The Committee did not, at that meeting, approve the pre-preliminary draft, but did make a number of suggestions for consideration by the staff in preparing the actual preliminary draft.

Chairman Bauer noted that a copy of the now completed preliminary draft of Chapter VII had been distributed to all members of the Committee for review prior to the meeting. He noted that the changes and additions which the Committee had suggested in its review of the pre-preliminary draft were indicated -- as has been the practice -- by strike outs and italic type inserts in the preliminary draft.

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

Mr. Mueller called attention to Figure 1 on page 7 noting that the access point symbol shown for the personal computer connection to the system appeared to differ from the symbol used for the other access points. Chairman Bauer indicated that this was a drafting error and would be corrected.

In answer to a question by Mr. Chernow concerning the proposed locations of backhaul base stations shown on Map 1, page 20, Dr. Schlager indicated that the station locations were selected to provide full service coverage within the Region; and that the locations were not related to population densities within the Region.

Mr. Ulicki noted that the word "isotropic" was misspelled in the penultimate bulleted item under the data for the third class of users on page 16; and that the units given in the last bulleted item for that class of users should be "decibels" and not "decibel milliwatts."

Dr. Schlager indicated that the number of base stations in the plan for the backhaul network as listed on page 19 should be changed from 11 to 10 for Walworth County; 11 to 10 for Washington County, and from 12 to 14 for Waukesha County.

Mr. Falaschi questioned the proposal in the plan that the links between the backhaul base station shown on Map 1, page 20, be operated in the 5.8 gigahertz frequency band. He noted that he was unaware of the technology being available to provide such links. Dr. Schlager demurred, indicating that the standards for this frequency band were currently in the process of being released and that certain manufacturers -- such as Motorola -- were actually manufacturing equipment which could function in this frequency band. Mr. Klasen indicated that the network architecture required for the 4G plan was based on technical standards that are apparently still in the developmental stage within the industry, and this, in his opinion, made the cost data provided questionable. Dr. Schlager disagreed, indicating that cost data for equipment required to operate WiMAX technology in the 5.8 gigahertz frequency band were currently available. Mr. Chernow asked that this be confirmed by the staff.

Secretary's Note: Waveteq Communications, Inc., a WiFi/WiMAX communications equipment manufacturer of British Columbia, Canada, confirmed in a letter (copy appended to these minutes) that they will have WiMAX equipment operating in the 5.8 GHz frequency band. Furthermore, they stated that any manufacturer or competent system installer could modify WiMAX equipment to accommodate different authorized frequency bands.

Mr. Ritt expressed concern with the practicality of locating proposed antennas on existing antenna towers, and with the validity of associated costs in so doing, those costs clearly being incomplete. He also noted that the plan required two antenna heights on a tower, and that a ten foot separation must be maintained between existing carriers on a tower. Tower owners were apt to resist co-location in order to retain the flexibility to add additional equipment for their own use, or are apt to impose a high cost on the co-location.

A lengthy discussion ensued in which, in answer to a question by Mr. Ritt, Dr. Schlager indicated that if co-location on a tower on a preferred site became impractical for whatever reasons, the plan would have to be adjusted to identify a different existing tower; or -- in some cases -- it may become necessary to build a new antenna base station.

Mr. Chernow raised the possibility of potential interference with transmission of other users on the tower. Mr. Ritt agreed and indicated that field studies might be required with respect to any given antenna co-location proposal.

Upon the conclusion of the discussion, it was the consensus of the Committee that both the capital and operating cost estimates given in the chapter were underestimated.

Dr. Schlager, however, challenged this overall conclusion, and opined that a detailed listing of the infrastructure cost elements would substantiate the original estimates. The operating costs for Internet connection and fiber wireline transport rates, he said, were also based on quoted rates from a responsible vendor. As stated, rental fees for antenna base stations were not included in the estimate, but could be included in a revised operating cost estimate. A more detailed infrastructure cost estimate was prepared for inclusion in the report as Appendix I to Chapter VII. These more detailed estimates validate the original estimate as provided in the preliminary draft of Chapter VII.

Mr. Romlein suggested, and the Committee concurred, that given the uncertainties involved in the cost estimates being provided, two summary cost tables be added to the summary section of the chapter setting forth cost ranges for plan implementation, while identifying un-included costs.

Secretary's Note: More detailed infrastructure cost and operation estimates were prepared for inclusion in the report as Appendices I and II to Chapter VII. These more detailed estimates validate the original estimate as provided in the preliminary draft of Chapter VII.

Chairman Bauer suggested that a range of capital costs could be provided, the low end of the range being marked by the values given in the Chapter, and the high end being estimated by assuming the construction of new base stations for each of the backhaul base stations shown on the plan. He noted that system planning level costs generally entail substantial uncertainty -- even in areas of public works supported by a long period of experience -- and that it must be expected that system level planning cost estimates will be subject to revision at the preliminary engineering and final design stages.

Mr. Ritt suggested, and the Committee concurred, that a paragraph be added to the text describing the uncertainties inherent in the systems level planning costs given, the need to revise these costs as plan implementation proceeds, the problems and costs entailed in co-location, and the alternative procedure if co-location at any given base station site is found to be unattainable.

Secretary's Note: The following paragraph was prepared to replace the first two paragraphs on page 22, these paragraphs being set forth in italics in the draft under consideration.

The foregoing estimate of costs includes only the costs of equipment and associated installation. Importantly, these costs do not include operation or maintenance costs; nor such costs as exclusive use license fees, if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental charges, if any, for use of municipal structures to mount antennas; nor legal fees. The capital costs of the antenna base stations and gateway stations set forth on pages 21 and 22, should, therefore, be considered as minimal. These costs will need to be refined as implementation proceeds based upon field tests and inspections, and on site specific analyses. If such further investigations indicate the impracticality of co-location of antenna on any given existing structure identified in the plan, an alternative structure will have to be found for co-location, or a new base station with attendant tower constructed. The capital costs could range up to about $2.9 million if new base station installations had to be constructed for each of the backhaul and gateway base stations shown on the plan. In any case, it must be recognized that the costs provided are based upon a system level of planning; and refinement of those costs should be expected as plan implementation proceeds through the preliminary engineering and final design stages.

Mr. Ulicki pointed out a typographical error in the last sentence of the third full paragraph on page 21, where "megabit" was misspelled as "megabite".

Mr. Richardson expressed concern about the implied public development and ownership of the proposed backhaul and community service networks. He indicated that State law prohibited county and local governments from providing publicly owned and operated telecommunication services in competition with privately provided services. Chairman Bauer suggested that this issue be considered when the Committee considers Chapter VIII dealing with plan implementation.

Mr. Klasen expressed concern about the operating cost savings set forth in the third full paragraph on page 22 and the Committee directed that this paragraph be revised to provide a range in costs similar to the range that is to be provided for capital costs.

Secretary's Note: A more detailed operating cost estimate was prepared for inclusion in the report as Appendix II to Chapter VII. This more detailed estimate validated the original estimate as provided in the preliminary draft of Chapter VII. A letter from Light Point Networks, LLC providing transport rates from the Internet connection is appended to these minutes.

Based upon the revised cost estimates the following paragraph was prepared for insertion as the last paragraph on page 22:

The operational cost savings from such a network would depend on the traffic volume on the network, but if each of the 47 base stations and 7 gateway stations were operating at a capacity of 100 megabits per second, the increased transport volume at each gateway would be approximately 8 times the volume of each base station connecting to the Internet individually. Such an increase in volume would result in a 32.6 percent cost savings based on the Light Point transport rate tables listed in Appendix III. Each base station, therefore, would save 32.6 percent of its monthly transport cost of $7,400 per month or $2,412 per month. The total cost savings for a 54 station network would then be $130,240 per month or $1,562,926 per year. The annual savings would approximate 54 percent of the cost of the original network of $2,855,754. Following the return of the initial investment, an annual savings of $1.56 million would be realized.

Dr. Schlager observed that while the development of the proposed regional backhaul network would effect substantial savings in operating costs, it could – as noted in the text -- also serve as a key infrastructure component of regional economic development initiatives. However, he said, it was likely that community level networks would be developed first, with such networks being connected to the closest available fiber cable interconnection. This probable sequence of development will tend to negate the need for a regional backhaul network. Mr. Mueller suggested, and the Committee concurred, that Dr. Schlager's comments be included in a paragraph to be added to the text.

Secretary's Note: The following text is proposed to be added to the fifth full paragraph on page 23.

, the development of such a regional backhaul network system in a timely manner within the Region is unlikely, since no institutional structure presently exists for the development of such a network. Moreover, it is likely that community level networks will be developed first, with such networks being connected on a case by case basis to the closest available fiber cable interconnection. This probable sequence of development will tend to negate the need for an integrated regional backhaul network.

Mr. Ritt suggested, and the Committee concurred, that a description of the equipment of the access point station be described in the text, including a description of how the equipment would be mounted on necessary structures.

Secretary's Note: The second full paragraph on page 24 was divided into two paragraphs, the first paragraph consisting of the first three sentences of the original paragraph. The second paragraph would consist of the remainder of the third full paragraph, with the following text inserted at its beginning:

The equipment configuration at a typical access point would include:

1. 3 – 802.11g transceivers
2. 1 – 801.11a backhaul transceiver
3. 1 – 120 degree sectorized antenna
4. Electrical and lightning surge protective equipment
5. Power over ethernet (POE) power injector
6. Ethernet and coaxial cabling
7. Weatherproof enclosures for auxiliary equipment
8. Mounting hardware

Plans call for the use of heavy duty wall brackets to mount the communications equipment at each access point. Four equipment modules will be pole-mounted: transceiver modules (2), sectorized antenna (1), and auxiliary equipment enclosure (1).

Dr. Schlager indicated that access point antennas could be mounted on municipal lampposts, or, if necessary, on a pole similar to a lamppost erected for this purpose. He indicated that the use of electric power poles was not contemplated.

Mr. Richardson noted that all street lampposts are not provided with power twenty-four hours per day and the provision of such continuous power might require retrofitting. Dr. Schlager noted that issue had been discussed by City of Waukesha officials considering the installation of a community access system for the City of Waukesha and that City officials had agreed that the service provider selected would be permitted to mount needed antenna on City street lampposts and traffic signal and sign poles, as may be necessary, at no cost to the service provider. The City would presumably make arrangements for the provision of necessary “round-the-clock” power.

Mr. Romlein asked to be excused in order to meet another commitment, and left the meeting at 3:30PM.

In answer to a question by Mr. Ritt concerning the community service network installation to serve the City of Chaska, Minnesota by a private service provider – Tropos, Dr. Schlager indicated that the community paid for and owns the system. Dr. Schlager indicated that this was not the case with the City of Milwaukee or the proposed City of Waukesha systems where the providers are to assume – with the exception of the costs attendant to the use of city poles – the capital investment costs. Mr. Ritt observed that it would appear that the cities of Milwaukee and Waukesha are setting a precedent with respect to the free use of municipal poles to mount telecommunication service antenna.

Mr. Falaschi, referring to Map 2, questioned the ability of the most remote access stations to connect with the proposed base station, the distance involved apparently being about five miles. Dr. Schlager responded that with a backhaul antenna on each access point with a gain of 21dBi and a gateway receiving antenna of 15 dBi supplemented with high gain low noise preamplifiers at both ends, a backhaul link of 5 miles is quite manageable. In any event, this link distance capability will be verified in the pre-installation field test of each network.

There being no further questions or comments, Mr. Drew moved to approve Chapter VII as amended. The motion was seconded by Mr. Chernow.

Mr. Klasen objected to the proposed motion indicating that, in his opinion, the Committee was not ready to approve the chapter in that the Committee had asked for major modifications of a substantive nature, particularly some regarding the validity of the cost estimates presented. Therefore, Mr. Klasen moved to amend Mr. Drew’s motion to indicate that the Committee postpone consideration of the approval of Chapter VII to its next meeting when the Committee would have before it the changes it recommended to be made in the draft presented at this meeting. Mr. Ritt seconded the motion to amend. On a vote of eight to six, with Messrs. Chernow, Falaschi, Gatz, Klasen, Richardson, Ritt, Schleisman, and Ulicki voting “yes,” and with Messrs. Drew, Melcher, Mueller, Winston, Wirth voting “no,” the motion to amend carried.

Chairman Bauer then asked the Committee to consider the original motion as amended, namely, to postpone approval of Chapter VII to the next meeting when the Committee will have before it all of the requested changes to the text as that text was provided for consideration at this meeting. Chairman Bauer noted that it was the consensus of the Committee that the text set forth in italics within the draft of Chapter VII considered at this meeting, can be considered acceptable to the Committee; and that these would be set forth in normal type in the draft of the Chapter, as submitted for Committee review at its next meeting. The changes in the Chapter requested by the Committee at today’s meeting, he said, would -- as usual -- be set forth in italics in the draft to be considered at the next meeting.

CONSIDERATION OF PRELIMINARY DRAFT OF CHAPTER VIII, "FOURTH GENERATION REGIONAL WIRELESS NETWORK PLAN IMPLEMENTATION," 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 preliminary draft of Chapter VIII, "Fourth Generation Regional Wireless Network Plan Implementation," 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 then asked Dr. Schlager to undertake a page by page review of the preliminary draft with the Committee.

Mr. Ritt suggested, and the Committee concurred, that the first sentence of the first full paragraph on page 2 be revised to read as follows:

> "The currently prevailing wireless telecommunication system development process within the United States, as established by Federal law, places the responsibility for system development generally within the private sector, that process being, however, regulated by Federal and State laws and regulations."

In answer to a question by Mr. Klasen, Mr. Evenson indicated that it was his decision as the Commission's Executive Director to respond to county and municipal requests for preparation of telecommunication plans at no cost to the requesting counties or municipalities while the Commission is still in the mode of preparing the regional telecommunications plan, of which the wireless plan is an element. He indicated that, upon completion of the regional plan, whether or not counties and communities requesting assistance in development of telecommunications systems in accordance with completed regional plan would be charged a fee would be a matter of policy to be determined by the Commission.

Mr. Falaschi expressed concern that the Commission would be placing itself in competition with private sector planning services. Mr. Chernow observed that the Commission's work is generally very highly regarded by its constituent counties and municipalities. He observed, that while those counties and municipalities often prefer to obtain county and local planning services from the Commission, as opposed to from private sector establishments, requests for Commission assistance are responded to in the order in which they are received and lengthy delays may be entailed in waiting for the Commission services. He noted, for example, that the Village of River Hills had to wait two years to have the Commission revise its zoning ordinance. Mr. Wirth indicated that it was important for all concerned to understand that the Commission does not solicit work of any kind, but responds only to requests made in writing from its constituent county and municipal governments. Chairman Bauer observed that the State Regional Planning Enabling Act specifically provides for the extension by the Commission of planning services to its constituent governments.

Mr. Klasen then suggested, and the Committee concurred, that the first step in the system planning and development sequence set forth on page 2 be revised to read as follows:

1. At the specific request of a constituent county or municipality, the Commission will prepare a broadband wireless system service plan for areas designated in the request;

Chairman Bauer indicated that this was an appropriate point in the Chapter review to consider Mr. Richardson's comment made earlier in the meeting about State law generally prohibiting the development of public owned telecommunication service networks within the State. Chairman Bauer observed that the nine-step procedure set forth on page 2 was specifically designed to facilitate plan implementation through private sector action. He called attention to steps five and six, seven and eight, and nine, all of which provide for actual system development by private equipment vendors and service providers. Clearly, he said, there is no intent on the part of the Commission to promote the creation of publicly owned telecommunication facilities and services within the Region. He indicated that such public development would, under the plan implementation procedure, occur only if no private sector interests respond to the envisioned requests for proposals. In that instance, he said, it would be perfectly proper, and in accordance with State and Federal law, for a county or a group of counties, or a municipality or a group of municipalities, to proceed with the development and operation of a publicly owned telecommunications system.

There being no further questions or comments, on a motion by Mr. Wirth, seconded by Mr. Melcher, and carried with Messrs. Klasen and Ritt voting no, the revised preliminary draft of Chapter VIII, "Fourth Generation Regional Wireless Network Plan Implementation," of SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin,* was approved as amended.

Mr. Klasen explained his "no" vote, indicating that it was the position of AT&T, formerly SBC, to concur in the technical sound efforts of the Commission to inventory the current telecommunication facilities and services provided within the Region, but to object to Commission preparation of plans for the provision of such facilities and services. Mr. Ritt concurred with Mr. Klasen's explanation.

CONSIDERATION OF PRELIMINARY DRAFT OF CHAPTER IX, "SUMMARY," 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 preliminary draft of Chapter IX, "Summary," 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 noted that Chapter IX contained no new material being, as the Chapter title suggested, a summary of the material presented in the first eight chapters of the report. Chairman Bauer noted further, that if the Committee's action at its next meeting on the revised draft of Chapter VII should require changes in Chapter IX, those will certainly be made.

There being no questions or comments, on a motion by Mr. Wirth, seconded by Mr. Melcher, and carried unanimously, the preliminary draft of Chapter IX, "Summary," of SEWRPC Planning Report No. 51, *A Wireless Antenna Siting and Related Infrastructure Plan for Southeastern Wisconsin* was approved subject to the staff making any necessary modifications to ensure consistency with Committee action on the revisions to Chapter VII.

CORRESPONDENCE

Chairman Bauer noted that the Commission was in receipt of an electronic communication from Committee member Jody McCann, indicating that he was retiring from his position with the Wisconsin Department of Electronic Government effective June 1, 2006 and, therefore, was resigning from membership on the Committee. Chairman Bauer observed that it would be the Commission's decision as to whether or not to replace Mr. McCann on the Committee.

Chairman Bauer indicated that the Commission was appreciative of Mr. McCann's services, noting that he was a very active member of the Committee early in its work, but that a back injury had precluded his active participation lately. Chairman Bauer indicated that the Commission would express this appreciation to Mr. McCann for his services in a letter (copy attached to these minutes.)

DATE AND TIME OF NEXT MEETING

Chairman Bauer then asked the Committee to consider the date and time for the next Committee meeting.

Chairman Bauer indicated that the items of business for the next meeting would include -- possibly among others -- consideration of a revised draft of Chapter VII, “A Regional Wireless Telecommunications Plan for Southeastern Wisconsin;” and an outline of the third and last report to be prepared by this Committee, that report documenting the third element of the Regional telecommunications plan, the wireline service plan that is to be the comparison plan to the wireless plan; and the draft of an Appendix to the wireless plan report – SEWRPC Planning Report No. 51 setting forth an environmental assessment of the plan.

In answer to a question by Mr. Ritt, Chairman Bauer indicated that the Commission, as a matter of long-standing policy, included an environmental assessment in all of its major plan description documents -- and indeed the inclusion of such an assessment is required by Federal and State laws and regulations for some regional plan elements. In answer to a question by Mr. Falaschi, Dr. Schlager indicated that the assessment would not extend to the potential environmental impacts of the location and design of antenna support structures since the safety and potential effects on real property values can only be properly considered on a site specific basis. The proposed assessment, Dr. Schlager said, would be focused on the radiation effects of the wireless antennas.

After some further discussion, it was agreed that the next meeting of the Committee would be held on Monday, July 10, 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. Wirth, seconded by Mr. Chernow, and carried unanimously, the meeting was adjourned at 4:00 PM.

Respectfully Submitted,

Lynn G. Heis
Staff Secretary

KWB/lgh
06/20/06
#117532 V1 - T/C Minutes - 13th Meeting

PRELIMINARY DRAFT

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

Chapter VI

WIRELESS TELECOMMUNICATIONS PERFORMANCE INVENTORY FINDINGS

INTRODUCTION

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

WIRELESS PERFORMANCE MONITORING SYSTEM

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

1. Network Management System (NMS) Server Computer– located at the Commission offices.
2. Supervisory NMS Desktop Computer– located at the Commission offices.

3. Five Laptop Computer Agents - located at various rotating locations throughout the Region.
4. Five Transceiver Interface Access Cards - one for each wireless cellular/PCS service provider and each integrated with one of the five laptop computers.

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

NETWORK MONITORING PARAMETERS – PACKET-SWITCHED

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

Availability

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

Throughput

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

Response Time

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

NETWORKS – PACKET SWITCHED

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

NETWORK – CIRCUIT-SWITCHED

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

CALL DURATION AND VOLUMES

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

MONITORING LOCATION SCHEDULING

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

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

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

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

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

A total of 42 randomly selected monitoring locations were used within the Region. A list of civil divisions within the seven county Southeastern Wisconsin Region together with their code numbers is given in Appendix I. ~~The civil division locations used as monitoring sites together with their code numbers are listed in Appendix I.~~ A map of the~~se~~ civil division*s* ~~locations~~ *together with the locations of the monitoring stations* is ~~included as~~ *given in* Appendix II. The ~~randomly~~ *locations of the* selected monitoring sites in each county ~~for the inventory round of network performance monitoring are tabulated~~ *are given* in Appendix III. The actual *monitoring* deployment dates and times are ~~recorded~~ *given* in Appendix IV. Site assignments for each time period are ~~tabulated~~ *given* in Appendix V. The start date of the initial network monitoring cycle was November 14, 2005.

PERFORMANCE MONITORING REPORTING

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

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

Regional-Level

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

Service Provider Level

- Same categories as regional level

County Level

- Same categories as regional level

Technology Categories

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

CELLULAR/PCS NETWORK PERFORMANCE (November 14, 2005 – March 2, 2006)

Table 1 tabulates the composite performance of all wireless service providers segmented by county and averaged at the regional level. Tables 2 through 6 provides this same performance data for each of the five wireless service providers monitored. Table 7 summarizes regional network performance for each of the three wireless technologies deployed in Southeastern Wisconsin. Table 8 separates out third generation (3G) performance data for the two 3G service providers in the Region.

Table 1

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR ALL PACKET-SWITCHED CELLULAR/PCS WIRELESS NETWORKS: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[1]	Data Points[1]	Total Number of Data Points	Percent Availability
Kenosha	.519	6962	57.23	9113	165.32	6151	18734	85.81
Milwaukee	.255	4318	79.25	4652	347.73	4468	9665	92.81
Ozaukee	.553	8300	69.03	8891	0.00	0	19394	88.64
Racine	.592	7398	67.02	8536	114.83	6622	18070	88.18
Walworth	.645	2140	67.36	2229	76.45	2536	5111	85.48
Washington	.618	4428	65.16	4655	0.00	0	10125	89.71
Waukesha	.558	9377	50.57	9521	0.00	0	20356	92.84
Regionwide:	.537	42923	63.26	47597	178.23	19777	101455	89.22

[1]The download data presented originated only in the Sprint and Verizon wireless networks. The data represent weighted averages of the data for these two providers, with the weighing being based on the number of data points collected for each provider. Security features -- firewalls -- in place by the other wireless service providers prevented the collection of other download throughput data. Collection of download throughput data, unlike the other monitoring parameters, required initiation of the transaction outside of the service provider's network by a server located at SEWRPC. Such transaction initiations were blocked by firewalls at all service providers except Sprint and Verizon.

Source: SEWRPC.

Table 2

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED CINGULAR CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kpbst[1]	Data Points[1]	Total Number of Data Points	Percent Availability
Kenosha	1.242	13	21.95	15	0	0	43	65.12
Milwaukee	0	0	0	0	0	0	0	0
Ozaukee	.968	1296	40.06	1406	0	0	391	87.42
Racine	1.165	13	23.22	16	0	0	45	64.44
Walworth	1.091	14	58.54	16	0	0	53	56.60
Washington	.907	550	38.28	487	0	0	1204	86.13
Waukesha	.688	2240	48.32	2058	0	0	4344	98.94
Regionwide:	.810	4126	44.03	3998	0	0	7870	92.53

[1]*Security features -- firewalls -- in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC.

Table 3

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED NEXTEL COMMUNICATIONS CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[1]	Data Points[1]	Total Number of Data Points	Percent Availability
Kenosha	5.157	61	15.82	1535	0	0	1982	80.52
Milwaukee	4.676	5	29.25	531	0	0	598	89.63
Ozaukee	.725	1189	17.31	1230	0	0	2634	91.84
Racine	3.982	115	15.86	1282	0	0	1662	84.06
Walworth	4.265	40	13.77	33	0	0	102	71.57
Washington	0	0	0	0	0	0	0	0
Waukesha	.773	1687	18.02	1618	0	0	3352	98.60
Regionwide:	1.011	3097	17.83	6229	0	0	10330	90.28

[1]*Security features -- firewalls -- in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC.

Table 4

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED SPRINT PCS WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Kenosha	.356	3262	72.03	3481	223.80	3474	7212	93.50
Milwaukee	.218	1651	93.61	1653	364.55	1729	3517	93.94
Ozaukee	.472	1965	95.47	1885	0.00	0	3911	98.44
Racine	.545	3192	77.27	3104	82.68	3376	6792	92.70
Walworth	.550	992	80.11	1070	75.75	1213	2335	88.31
Washington	.554	401	88.76	351	0.00	0	761	98.82
Waukesha	.409	1195	83.07	1192	0.00	0	2392	99.79
Regionwide:	.430	12658	81.75	12736	181.66	9792	26920	94.33

Source: SEWRPC.

Table 5

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED U.S. CELLULAR - CELLULAR WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps[1]	Data Points[1]	Total Number of Data Points	Percent Availability
Kenosha	.588	1217	52.68	1636	0	0	4111	69.40
Milwaukee	.637	51	51.47	70	0	0	170	71.18
Ozaukee	.601	1094	51.53	1579	0	0	3786	70.60
Racine	.590	1110	53.20	1129	0	0	3027	73.97
Walworth	.589	228	51.30	222	0	0	678	66.37
Washington	.582	531	52.65	869	0	0	1919	72.95
Waukesha	.591	1354	50.51	1921	0	0	4365	75.03
Regionwide:	.592	5585	51.90	7426	0	0	18056	72.06

[1]*Security features -- firewalls -- in place by the wireless service providers prevented collection of the download throughput data.*

Source: SEWRPC.

Table 6

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE PACKET-SWITCHED VERIZON PCS WIRELESS NETWORK: NOVEMBER 14, 2005 TO MARCH 2, 2006

County	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Kenosha	.584	2409	65.40	2446	89.42	2677	5386	90.14
Milwaukee	.262	2611	81.24	2398	337.12	2739	5380	93.10
Ozaukee	.323	2756	98.45	2791	0.00	0	5972	92.88
Racine	.510	2968	83.68	3005	148.26	3246	6544	91.27
Walworth	.595	866	58.17	888	77.08	1323	1943	90.27
Washington	.579	2946	70.48	2948	0.00	0	6241	94.44
Waukesha	.380	2901	57.40	2732	0.00	0	5903	95.43
Regionwide:	.448	17457	75.39	17208	174.86	9985	37369	92.76

Source: SEWRPC.

Table 7

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THE THREE WIRELESS TECHNOLOGIES: NOVEMBER 14, 2005 TO MARCH 2, 2006

Technology	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
CDMA	.464	35700	72.89	37370	178.23	19777	82345	88.74
GSM	.810	4126	44.03	3998	0.00	0	7870	92.53
iDEN	1.011	3097	17.83	6229	0.00	0	10330	90.28

Source: SEWRPC.

Table 8

SUMMARY OF REGIONAL LEVEL PERFORMANCE FOR THIRD GENERATION (3G) CELLULAR/PCS WIRELESS NETWORKS: NOVEMBER 14, 2005 TO MARCH 2, 2006

Provider	Response Time in Seconds	Data Points	Upload Throughput in kbps	Data Points	Download Throughput in kbps	Data Points	Total Number of Data Points	Percent Availability
Sprint	.246	3569	74.33	3746	330.87	3803	7737	94.55
Verizon	.261	3294	84.44	3133	341.05	3445	6830	94.10

Source: SEWRPC.

SUMMARY AND CONCLUSIONS

The initial seven-county regional wireless network performance inventory is based on 90,520 packet-switched total transactions (data points) measuring four performance parameters with individual transaction totals and average performance values as follows:

Response Time	- 537 milliseconds
	- 42,923 transactions
Upload Throughput	- 63.26 kilobits per second
	- 47,597 transactions
Download Throughput	- 178.2 kilobits per second
	- 19,777 transactions
Availability	- 89.22 percent
	- 101,455 transactions

The above performance data summary includes both 2G and 3G transactions, with the majority representing 2G transactions. ~~If~~ *When* the 3G performance data are tabulated separately, a higher level of communications performance is indicated:

Response Time	- 253 milliseconds
	- 6,863 transactions
Upload Throughput	- 78.93 kilobits per second
	- 6,879 transactions
Download Throughput	- 336.0 kilobits per second
	- 7,248 transactions
Availability	- 94.34 percent
	- 14,567 transactions

Even with the upgrade to third generation technology, cellular/PCS wireless network performance does not approach the specified standards established in Chapter III of this planning report except in the response time standard. *With respect to this finding, it should be noted that the performance standards set forth in Chapter III of this report are intended to specify performance for 4G networks and are not intended to specify the performance of existing networks.*

Response Time	- 250 milliseconds
Upload Throughput	- 20 megabits per second
Download Throughput	- 20 megabits per second
Availability	- 99.9 percent

The most critical of the above performance parameters are throughput and availability. These are the parameters that are most deficient in current wireless networks. The asymmetric nature of current wireless networks is also noteworthy. Although current day Internet users typically require more download than upload throughput performance, emerging video applications, such as videoconferencing, require high speed performance in both directions to maintain quality.

Beyond comparisons with 4G standards, other features of this initial wireless performance inventory that should be noted are:

1. Regional Geographic Performance Variability
   - Variability in performance between counties is not significant except for Milwaukee County where the recent introduction of 3G networks by Sprint and Verizon skews results to a higher level of performance.
2. Service Provider Performance Variability
   - Sprint and Verizon Wireless significantly out-performed the other wireless carriers in every performance category including network availability. These two service providers were also the most reliable for monitoring, accounting for 27 percent (Sprint) and 36 percent (Verizon) of all of the transactions. Even if the third generation (3G) transactions are removed, these two carriers led in every performance category. In the critical throughput performance category, Sprint had a slight lead over Verizon.
3. Technology Performance Variability
   - CDMA technology (Sprint, Verizon, U.S. Cellular) out-performed the GSM (Cingular) and iDEN (Nextel) technologies in every performance category.
4. Third Generation (3G) Technology Performance
   - The 3G CDMA technologies introduced by Sprint and Verizon demonstrated throughput performance far below the much heralded theoretical throughput of 2 megabits per second. Average download throughput is still under 350 kilobits per second.
5. Service Provider Cooperation
   - The network monitoring system program could benefit significantly from better cooperation from the wireless service providers. Verizon Wireless was the most helpful in this regard. In many instances, lack of cooperation resulted from the inability of the Commission to find provider personnel with in-depth knowledge of their networks.

Overall, the network monitoring round inventory was considered a success. Potential additional monitoring efforts should emphasize more detailed parameters, such as packet loss rates, that are primary determinants of network performance for both data communications and future multimedia applications.

KWB/KJS/lgh
06/09/06
#113484 V3 - T/C PR51-Chapter VI-Wireless T/C Performance Inventory Findings

Appendix I

CIVIL DIVISION CODES

LIST OF CIVIL DIVISION WITHIN SOUTHEASTERN WISCONSIN AREA
APPENDIX I
CIVIL DIVISION CODES

KENOSHA COUNTY -100

101 Brighton Town
102 Bristol Town
103 Kenosha City
104 Paddock Lake Village
105 Paris Town
106 Pleasant Prairie Village
107 Randall Town
108 Salem Town
109 Silver Lake Village
110 Somers Town
111 Twin Lakes Village
112 Wheatland Town
113 Genoa City Village (Part) See 512

OZAUKEE COUNTY - 200

201 Belgium Town
202 Belgium Village
203 Cedarburg City
204 Cedarburg Town
205 Fredonia Town
206 Fredonia Village
207 Grafton Town
208 Grafton Village
209 Mequon City
210 Port Washington City
211 Port Washington Town
212 Saukville Town
213 Saukville Village
214 Thiensville Village
215 Bayside Village (Part) See 401
216 Newburg Village (Part) See 620

RACINE COUNTY - 300

301 Burlington City (Part) See 529
302 Burlington Town
303 Caledonia Town
304 Dover Town
305 Elmwood Park Village
306 Mt. Pleasant Village
307 North Bay Village
308 Norway Town
309 Wind Lake (U)
310 Racine City
311 Raymond Town
312 Rochester Town
313 Rochester Village
314 Sturtevant Village
315 Union Grove Village
316 Waterford Town
317 Waterford Village
318 Wind Point Village
319 Yorkville Town

MILWAUKEE COUNTY-400

401 Bayside Village (Part) See 215
402 Brown Deer Village
403 Cudahy City

MILWAUKEE COUNTY-400

404 Fox Point Village
405 Franklin City
406 Glendale City
407 Greendale Village
408 Greenfield City
409 Hales Corners Village
410 Milwaukee City (Part) See 621, 739
411 Oak Creek City
412 River Hills Village
413 St. Francis City
414 Shorewood Village
415 South Milwaukee City
416 Wauwatosa City
417 West Allis City
418 West Milwaukee Village
419 Whitefish Bay Village

WALWORTH COUNTY - 500

501 Bloomfield Town
502 Darien Town
503 Darien Village
504 Delavan City
505 Delavan Town
506 Delavan Lake (U)
507 East Troy Town
508 East Troy Village
509 Elkhorn City
510 Fontana on Lake Geneva Village
511 Geneva Town
512 Genoa City Village (Part) See 113
513 LaFayette Town
514 LaGrange Town
515 Lake Geneva City
516 Linn Town
517 Lyons Town
518 Richmond Town
519 Sharon Town
520 Sharon Village
521 Spring Prairie Town
522 Sugar Creek Town
523 Troy Town
524 Walworth Town
525 Walworth Village
526 Whitewater City (Part)*
527 Whitewater Town
528 Williams Bay Village
529 Burlington City (Part) See 301
530 Mukwonago Village (Part)

WASHINGTON COUNTY

601 Addison Town
602 Barton Town
603 Erin Town
604 Farmington Town
605 Germantown Town
606 Germantown Village

WASHINGTON COUNTY - 600

607 Hartford City (Part)*
608 Hartford Town
609 Jackson Town
610 Jackson Village
611 Kewaskum Town
612 Kewaskum Village (Part)*
613 Polk Town
614 Richfield Town
615 Slinger Village
616 Trenton Town
617 Wayne Town
618 West Bend City
619 West Bend Town
620 Newburg Village (Part) See 216
621 Milwaukee City (Part) See 410, 739

WAUKESHA COUNTY - 700

701 Big Bend Village
702 Brookfield City
703 Brookfield Town
704 Butler Village
705 Chenequa Village
706 Delafield City
707 Delafield Town
708 Dousman Village
709 Eagle Town
710 Eagle Village
711 Elm Grove Village
712 Genesee Town
713 Hartland Village
714 Lac La Belle Village (Part)*
715 Lannon Village
716 Lisbon Town
717 Menomonee Falls Village
718 Merton Town
719 Merton Village
720 Mukwonago Town
721 Mukwonago Village (Part)
722 Muskego City
723 Nashotah Village
724 New Berlin City
725 North Prairie Village
726 Oconomowoc City
727 Oconomowoc Town
728 Okauchee (U)
729 Oconomowoc Lake Village
730 Ottawa Town
731 Pewaukee City
732 Pewaukee Village
733 Summit Town
734 Sussex Village
735 Vernon Town
736 Wales Village
737 Waukesha City
738 Waukesha Town
739 Milwaukee City (Part) See 410, 621

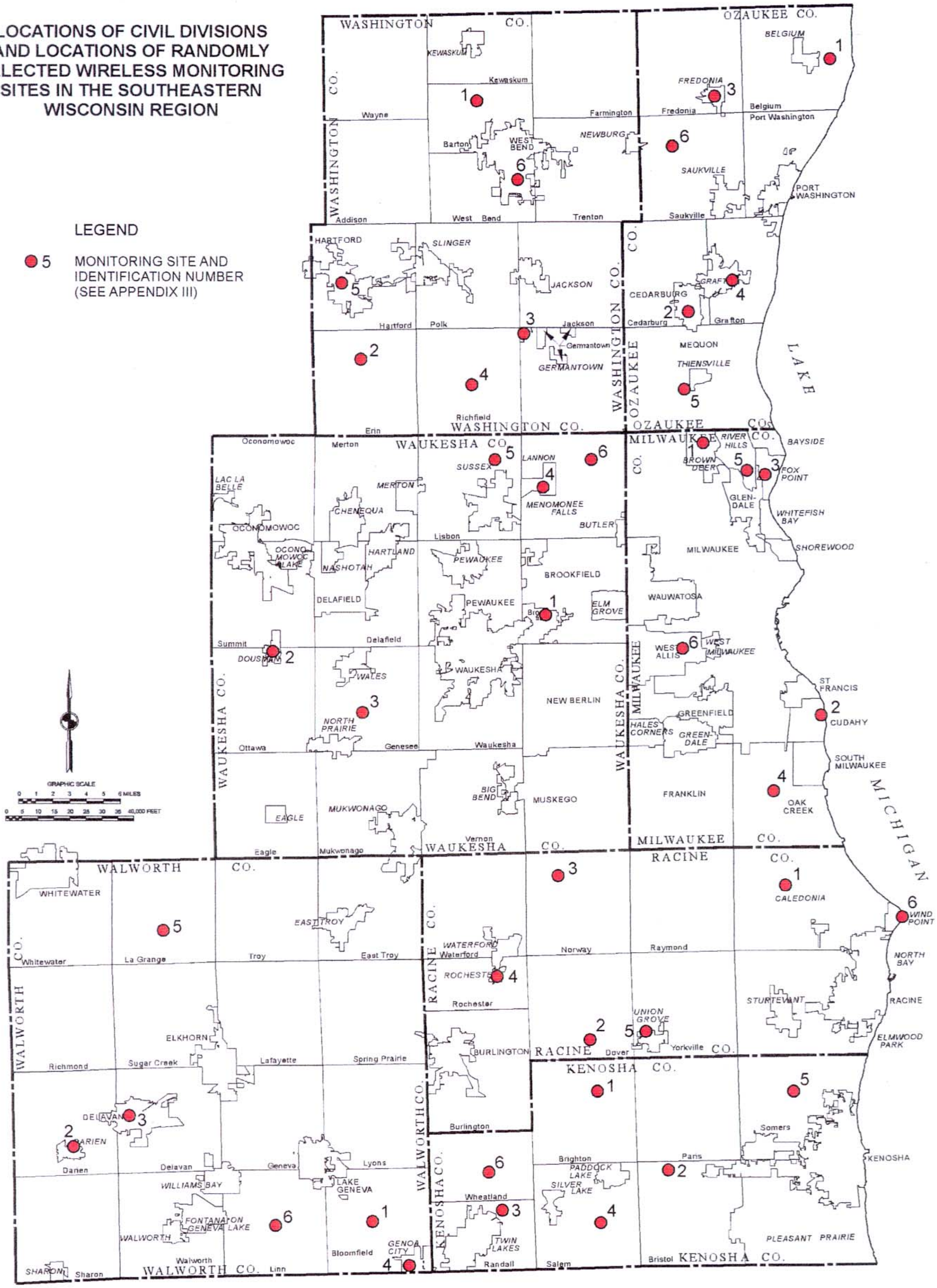
***Partially outside of the Southeastern Wisconsin Region**
U - Unincorporated

Appendix II

LOCATIONS OF CIVIL DIVISIONS AND LOCATIONS OF RANDOMLY SELECTED WIRELESS MONITORING SITES IN THE SOUTHEASTERN WISCONSIN REGION

APPENDIX II

LOCATIONS OF CIVIL DIVISIONS AND LOCATIONS OF RANDOMLY SELECTED WIRELESS MONITORING SITES IN THE SOUTHEASTERN WISCONSIN REGION



Source: SEWRPC.

Addition to Appendix III

RANDOMLY SELECTED WIRELESS MONITORING SITES

APPENDIX III

LOCATIONS AND ADDRESSES OF RANDOMLY SELECTED WIRELESS MONITORING SITES BY COUNTY

KENOSHA COUNTY – 100		
1	Brighton Town	Town Hall 25000 Burlington Rd. Town of Brighton
2	Bristol Town	Kenosha County Department of Public Works 19600 75th St. Town of Bristol
3	Randall Town	Town Hall 34530 Bassett Rd. Town of Randall
4	Salem Town	Town Hall 9814 Antioch Rd. Town of Salem
5	Somers Town	Town Hall 7511 12th St. Town of Somers
6	Wheatland Town	Town Hall 34315 Geneva Rd. Town of Wheatland

OZAUKEE COUNTY - 200		
1	Belgium Town	St. Marys School 675 County Road D Town of Belgium
2	Cedarburg City	Police Department W75 N444 Wauwatosa Rd. City of Cedarburg
3	Fredonia Village	Village Hall 4126 Fredonia Ave. Village of Fredonia
4	Grafton Village	Police Department 1981 Washington Ave Village of Grafton
5	Mequon City	Police Department 11300 N. Buntrock Ave. City of Mequon
6	Saukville Town	Town Hall 3762 Lakeland Rd. Town of Saukville

MILWAUKEE COUNTY – 400		
1	Brown Deer Village	Village Hall 4800 Green Brook Dr. Village of Brown Deer
2	Cudahy City	City Hall 5050 S. Lake Dr. City of Cudahy
3	Fox Point Village	Municipal Building 7200 N Santa Monica Blvd. Village of Fox Point
4	Oak Creek City	City Hall 8640 S. Howell Ave. City of Oak Creek
5	River Hills Village	Village Hall 7650 N. Pheasant Ln. Village of River Hills
6	West Allis City	City Hall 7525 W. Greenfield Ave. City of West Allis

RACINE COUNTY - 300		
1	Caledonia Village	Village Hall 6922 Nicholson Rd. Village of Caledonia
2	Dover Town	Town Hall 4110 S. Beaumount Ave. Town of Dover
3	Norway Town	Municipal Building 6419 Heg Park Rd. Town of Norway
4	Rochester Village	Village and Town Hall 203 W. Main St. Village of Rochester
5	Yorkville Town	Town Hall 720 Main St. Town of Yorkville
6	Wind Point Village	Village Clerk’s Office 215 E. Four Mile Rd. Village of Wind Point

WALWORTH COUNTY – 500

1	Bloomfield Town	Town Hall 1100 Town Hall Rd. Town of Bloomfield
2	Darien Village	Village Hall 24 N. Wisconsin St. Village of Darien
3	Delavan City	City Hall 123 S. 2nd St. City of Delavan
4	Genoa City Village	Village Hall 715 Walworth St. Village of Genoa City
5	LaGrange Town	Town Hall N7899 County Rd. H Town of LaGrange
6	Linn Town	Town Hall W3728 Franklin Walsh St. Town of Linn

WASHINGTON COUNTY – 600

1	Barton Town	Town Hall 3482 Town Hall Rd. Town of Barton
2	Erin Town	Town Hall 1846 STH 83 Town of Erin
3	Germantown Town	Town Clerk's Residence N142 W21825 Marquette Rd. Town of Germantown
4	Richfield Town	Town Hall 4128 Hubertus Rd. Town of Richfield
5	Hartford City	City Hall 109 N. Main St. City of Hartford
6	West Bend City	City Hall 1115 S. Main St. City of West Bend

WAUKESHA COUNTY - 700

1	Brookfield Town	Town Hall 645 North Janacek Rd. Town of Brookfield
2	Dousman Village	Village/Town Hall 118 S. Main St. Village of Dousman
3	Genesee Town	Town Hall S41 W31391 STH 83 Town of Genesee
4	Lannon Village	Village Hall 20399 W. Main St. Village of Lannon
5	Lisbon Town	Town Hall W234 N8676 Woodside Rd. Town of Lisbon
6	Menomonee Falls Village	Village Hall W156 N8480 Pilgrim Rd. Village of Menomonee Falls

Source: SEWRPC

06/09/06
#118220 V1 - T/C - Locations & Addresses Of Wireless Monitoring Sites

Appendix IV

MONITORING SCHEDULE

APPENDIX IV
MONITORING SCHEDULE

All monitoring periods will begin on either Monday or Thursday unless that day conflicts with a holiday. In that case the period will begin on the day before or the day after the holiday, as appropriate. All monitoring periods will follow the following time schedule.

Monday Period:

Installation:	Monday:	0800-1600
Monitoring:	Monday:	1600-2400
	Tuesday:	0000-2400
	Wednesday:	0000-2400
	Thursday:	0000-0800

Thursday Period:

Installation:	Thursday:	0800-1600
Monitoring:	Thursday:	1600-2400
	Friday:	0000-2400
	Saturday:	0000-2400
	Sunday:	0000-2400
	Monday:	0000-0800

The scheduled assignments for each location and test period are indicated in Appendix V that follows.

Appendix V

SITE ASSIGNMENTS

Appendix V

SITE ASSIGNMENTS

OZAUKEE COUNTY-200	November 14, 2005	November 17, 2005	November 21, 2005	November 23, 2005
1 Belgium Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Cedarburg City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Fredonia Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Mequon City	Cingular	Verizon	Sprint	Nextel
5 Grafton Village	T-Mobile	Cingular	Verizon	Sprint
6 Saukville Town	U.S. Cellular	T-Mobile	Cingular	Verizon
WASHINGTON COUNTY-600	November 28, 2005	December 1, 2005	December 5, 2005	December 8, 2005
1 Barton Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Erin Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Germantown Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Richfield Town	Cingular	Verizon	Sprint	Nextel
5 Wayne Town	T-Mobile	Cingular	Verizon	Sprint
6 West Bend City	U.S. Cellular	T-Mobile	Cingular	Verizon
WAUKESHA COUNTY-700	December 12, 2005	December 15, 2005	December 19, 2005	December 22, 2005
1 Brookfield Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Dousman Village	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Genesee Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Lannon Village	Cingular	Verizon	Sprint	Nextel
5 Lisbon Town	T-Mobile	Cingular	Verizon	Sprint
6 Menomonee Falls Village	U.S. Cellular	T-Mobile	Cingular	Verizon
WALWORTH COUNTY-500	December 27, 2005	December 29, 2005	January 3, 2006	January 5, 2006
1 Bloomfield Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Delavan City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Darien Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Genoa City Village (Part)	Cingular	Verizon	Sprint	Nextel
5 LaGrange Town	T-Mobile	Cingular	Verizon	Sprint
6 Linn Town	U.S. Cellular	T-Mobile	Cingular	Verizon
KENOSHA COUNTY-100	January 9, 2006	January 12, 2006	January 16, 2006	January 19, 2006
1 Brighton Town	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Bristol Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Somers Town	Verizon	Sprint	Nextel	U.S. Cellular
4 Randall Town	Cingular	Verizon	Sprint	Nextel
5 Salem Town	T-Mobile	Cingular	Verizon	Sprint
6 Wheatland Town	U.S. Cellular	T-Mobile	Cingular	Verizon
RACINE COUNTY-300	January 23, 2006	January 26, 2006	January 30, 2006	February 2, 2006
1 Caledonia Village	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Dover Town	Sprint	Nextel	U.S. Cellular	T-Mobile
3 North Bay Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Norway Town	Cingular	Verizon	Sprint	Nextel
5 Rochester Village	T-Mobile	Cingular	Verizon	Sprint
6 Yorkville Town	U.S. Cellular	T-Mobile	Cingular	Verizon
MILWAUKEE COUNTY-400	February 6, 2006	February 9, 2006	February 13, 2006	February 16, 2006
1 Brown Deer Village	Nextel	U.S. Cellular	T-Mobile	Cingular
2 Cudahy City	Sprint	Nextel	U.S. Cellular	T-Mobile
3 Fox Point Village	Verizon	Sprint	Nextel	U.S. Cellular
4 Oak Creek City	Cingular	Verizon	Sprint	Nextel
5 River Hills Village	T-Mobile	Cingular	Verizon	Sprint
6 West Allis City	U.S. Cellular	T-Mobile	Cingular	Verizon

Source: SEWRPC.

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 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.

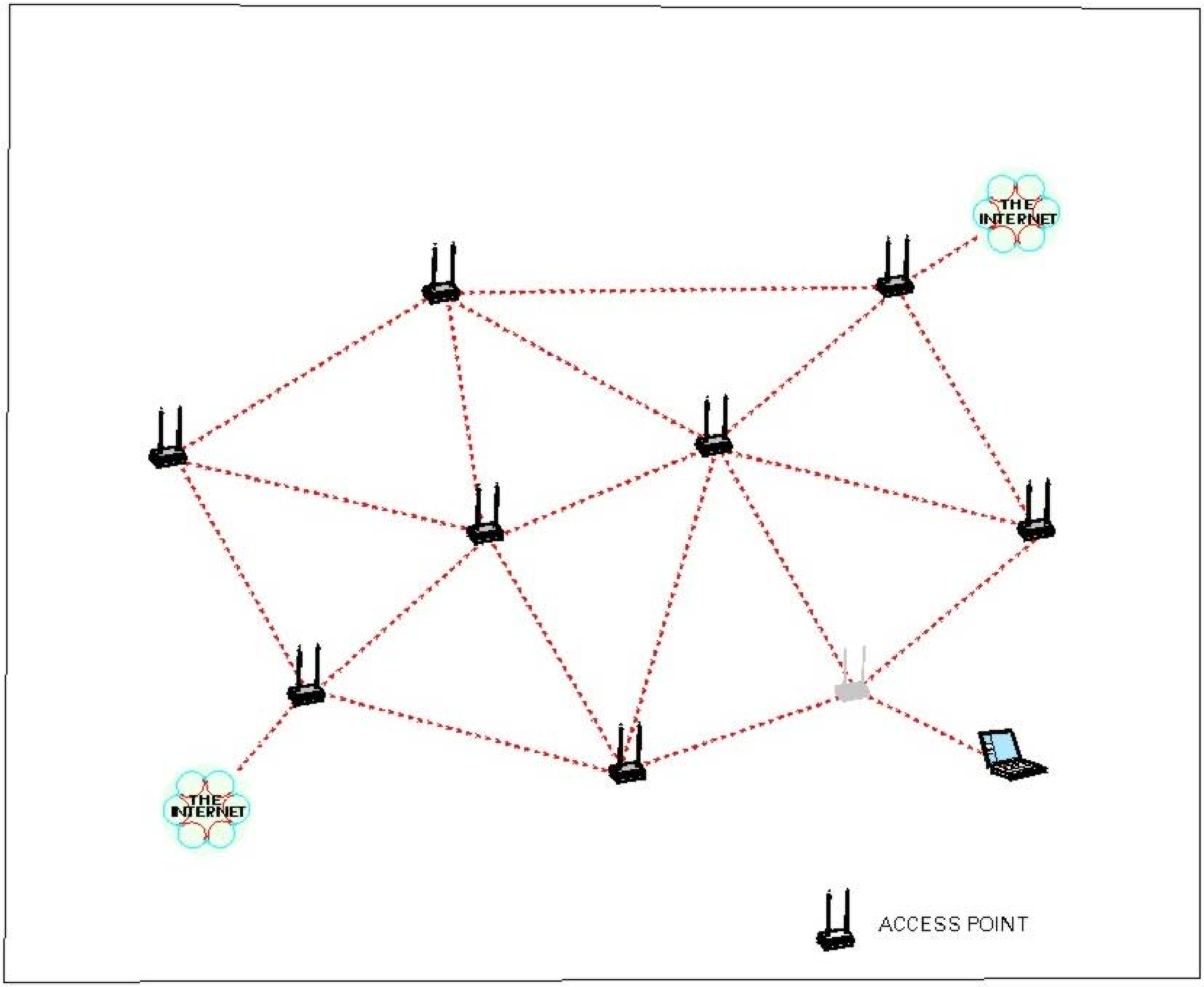
A second stage of WiFi communications development has been the mesh network in which an entire metropolitan area is blanketed with WiFi coverage. A mesh network involves the interconnection of the WiFi access points -- hot spots -- into a mesh topology. In such a network, shown in Figure 1, each access 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. The first known major city to install a citywide wireless mesh network is Taipei, Taiwan, a city of about 2.6 million people. Nortel Networks has been installing the Taipei network over the last few years, and it now covers about half of that city's approximately 106 square mile area and with 3,300 wireless access points, or 63 access points per square mile. Tropos Networks has installed a WiFi mesh network in Chaska, Minnesota, a city of about 18,000 residents with an area of about 16 square miles. Tropos installed 250 access points to cover the City of Chaska for a density of 16 access points per square mile, considerably less than the Nortel experience in Taipei, Taiwan. High density cities generally require higher access point densities for two reasons: (1) to overcome the effects of "clutter" attendant to the presence of numerous high-rise structures; and (2) to provide the needed capacity to serve higher user density and demand.

Mesh networking has brought new applications and continuing growth to 802.11 WiFi technologies. The scope and capabilities of 802.11 also continue to grow and expand with new versions of the technology in process for later release. An example is standard 802.11n which will extend the range and increase the throughput of WiFi using phased array multiple input multiple output (MIMO) antennas. A second example is 802.11s which concern WiFi networks using mesh network topologies. A third that is very pertinent to the regional plan and its impact on

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
6. - The most demanding applications relate to video communications with transmission data rate requirements up to 200 megabits per second.Network Infrastructure Cost Minimization Standard
   - The sum total of capital investment and discounted operating costs should be minimized. Full use should be made of existing site facilities.
7. Antenna Site Aesthetics and Safety
   - Independent of technology selection
8. Public Safety Emergence Preference Standard
   - Independent of technology selection

Based upon the foregoing review, technology selection was based upon the performance, most demanding application, and cost minimization standards. All of the above technologies are being improved to meet higher performance standards particularly for the throughput standard beyond the current 3G standard peak transmission rate of 2 megabits per second. It is not clear, however, that either of the proprietary wireless technologies -- GSM and CDMA -- in their advanced versions are even specifying throughput rates as high as 100 megabits per second. In fact, both technologies envision eventually switching to Orthogonal Frequency Division Multiplexing (OFDM) technology, the same radio technology currently employed in both WiFi and WiMAX.

Even if the specifications for GSM/HSDPA and CDMA/ED-DO were revised upward to comply with the throughput standards, they would fail to qualify under standard number six for cost minimization. A major justification for the development of standards technologies has been cost minimization. The past history of Ethernet and WiFi both testify to the ability of standards based technologies to drastically reduce user costs. Such a cost minimization history inevitably moves the technology selection toward standards-based technologies-WiFi and WiMAX. Aside from standards compliance, the proprietary technologies also suffer from the disadvantage of favoring the mobile user. The 4G regional wireless plan must provide for both fixed and mobile users. Selecting a mobile-alone wireless technology inevitably compromises performance for the fixed user. The technology choice is thus reduced to a selection between WiFi (IEEE 802.11) and WiMAX (IEEE 802.16).

WiFi technology has the advantage of proven performance particularly relating to access networks. Its disadvantage is typically stated in terms of its limited range -- about 300 feet -- but this limitation is a function of the network topology and the equipment employed not of the technology itself. WiFi, has also been lacking in important aspects related to security and quality of service, but almost every current limitation of the technology is being addressed by an IEEE subcommittee with the goal of upgrading future versions of the standard.

WiMAX technology was originally introduced as a longer range higher quality version of WiFi (IEEE 802.11). As previously stated, there is nothing inherent in WiMAX technology that extends the range of operation. Given the same antenna with the same power output transmitting to the same class of receiver, WiFi and WiMAX will have identical range performance. A number of desirable features have been introduced into the WiMAX technology that will make WiMAX networks more secure with a better quality of service. The design viewpoint inherent in WiMAX is one of a wide area network, and the technology has many design features that make it well suited for use in regional wireless backhaul networks.

An important consideration with WiMAX, however, is its higher costs. As a new technology being introduced in 2006, the costs of WiMAX network elements may be expected to exceed the cost of equivalent WiFi elements for some time to come. For that reason alone, WiFi technology must be favored for access networks restricting WiMAX for those applications where its features most apply.

Weighing the advantages and disadvantages of the two potential technologies, WiFi is the preferred choice for access networks, with WiMAX providing the regional wireless backhaul network. WiMAX would also be a possible choice for the provision of direct access in rural areas of the Region. Thus, WiFi networks would be the preferred choice for access except in rural areas where the deployment of a community WiFi network would not be cost effective. A WiFi-WiMAX combination would build upon the strengths of both technologies and should provide for minimal capital costs as called for in Standard Number Six.

This hybrid set of technologies would also allow for early buildup of WiFi-based community networks which will inevitably be part of any regional telecommunications plan, and allow for later cost benefit comparisons between wireless and fiber wireline backhaul networks. Since WiMAX wireless technology is in its initial application stage, the preferred choice for regional backhaul can be evaluated prior to the ready availability of WiMAX equipment.

Having identified the combination of technologies deemed to be best suited to achieving the performance objectives and standards set forth in Chapter III, it is important to identify some shortcomings of these technologies that must be overcome if the plan design standards are to be achieved. Certain technical argumentations in both equipment performance and network protocols will be necessary to fully meet the standards previously specified.

Accessory Technologies for Standards Compliance

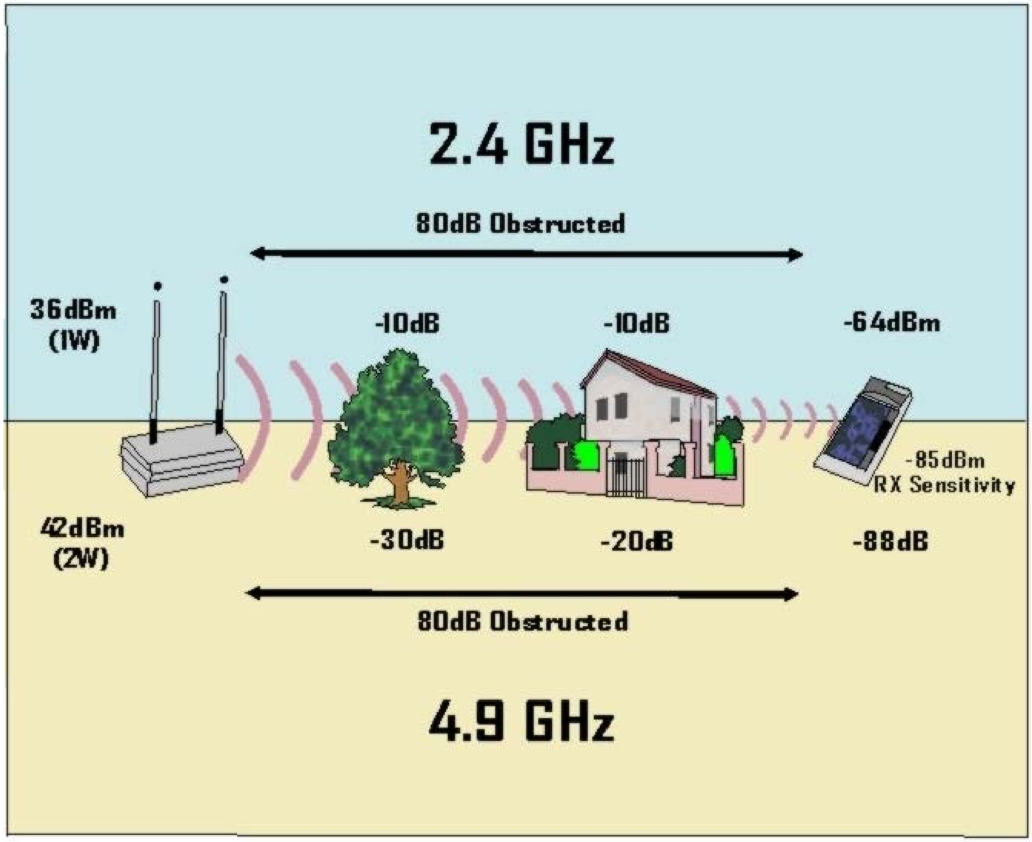
Recent experience with mesh networks in smaller cities such as Chaska, Minnesota (Tropos Networks) and Buffalo, Minnesota (Motorola) have demonstrated that WiFi technology in its current state (802.11g, 802.11a) will not achieve the performance standards for both throughput -- 20 megabits per second -- and associated packet loss rate -- 10 percent -- specified in Chapter III. Two shortcomings of these technologies combine to limit system performance. The first relates to signal levels achievable given the FCC specified power output levels and the signal attenuations caused by natural foliage and man-made structures. This “clutter” problem is illustrated in Figure 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:

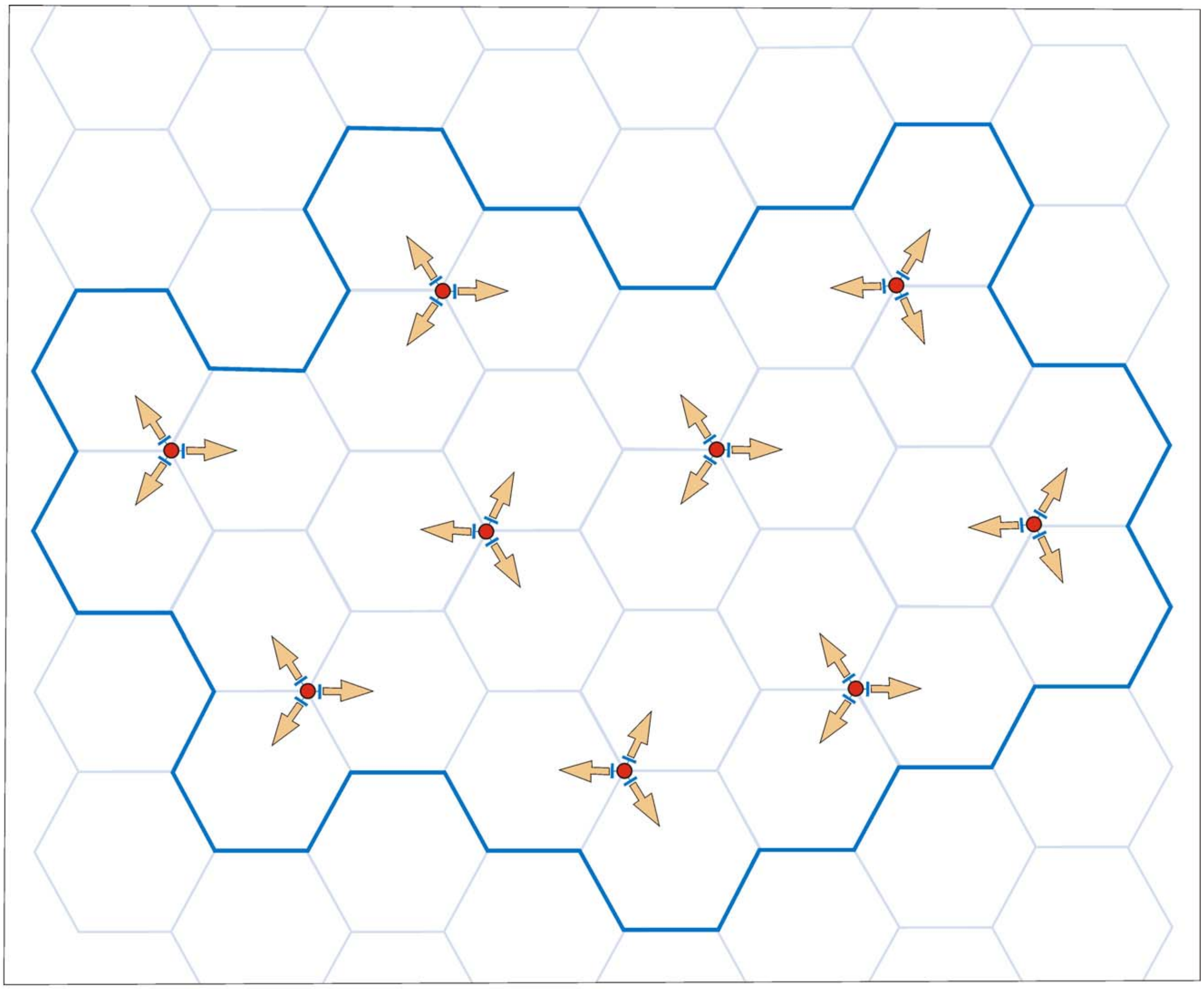
1. The nomadic laptop user
    - Transmit power – 200 milliwatts = 23 decibel-milliwatts
    - Receiver sensitivity – (-82 decibel-milliwatts) @ 6 megabits per second
    - Antenna gain – 5 dBi (decibels isotropic)
2. The mobile WiFi phone user
    - Transmit power – 100 milliwatts = 20 decibel-milliwatts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

Network Topology

A basic consideration in any wireless network system design is the network topology -- or interconnection structure -- of the network layout. Two major classes of network topologies are currently employed in wireless communications: network cellular topologies and mesh topologies. In cellular networks, as shown in Figure 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 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~~*10*
Washington	~~11~~*10*
Waukesha	~~12~~*14*

The plan was prepared using a combination of radio propagation modeling and a SEWPRC mathematical programming model that minimizes the number of base stations required to provide backhaul coverage throughout the Region. Radio propagation modeling operates in conjunction with a "clutter" data base that records the topographic terrain along with natural (wooded areas) and artificial (buildings) features that obstruct and attenuate radio signals. Based on antenna height, transmit power, and receiver sensitivity, the radio propagation model estimates the geographic coverage of each potential antenna base station. This coverage data provide 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:

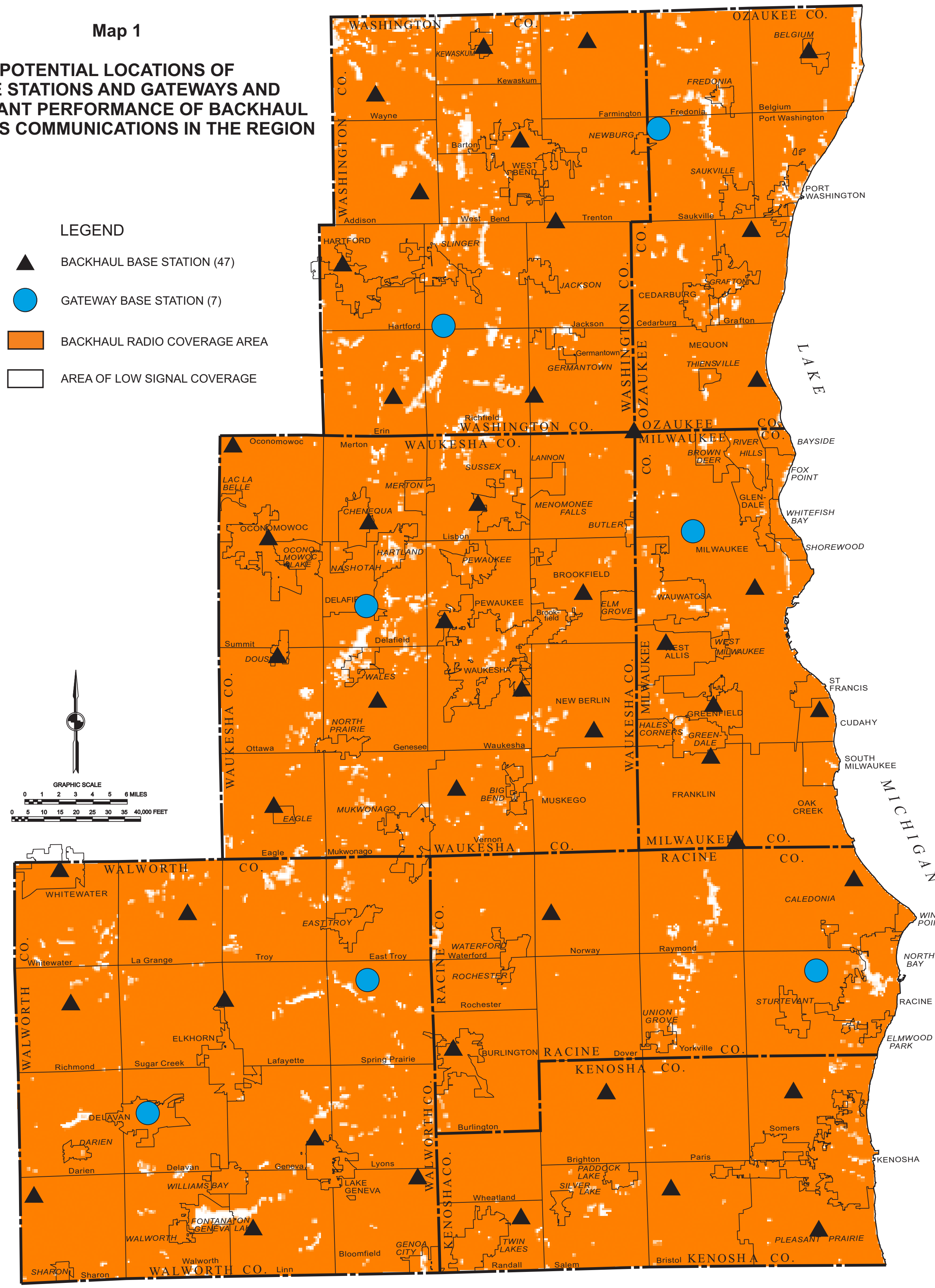
1. Antennas
   4 – 16 dBi 90 degree sectorals (802.11a)
   1 – 21 dBi directional (802.16d)

Map 1

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

LEGEND

- ▲ BACKHAUL BASE STATION (47)
- ● GATEWAY BASE STATION (7)
- BACKHAUL RADIO COVERAGE AREA
- AREA OF LOW SIGNAL COVERAGE



Source: SEWRPC.

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 megabit/second unit of bandwidth declines by about 32 percent for a 8:1 ratio of gateways to base stations.

Based on a regional backhaul network of 54 base stations, 7 of which provide gateways, the following initial infrastructure costs are estimated: *A detailed support listing of the components of these estimated costs are included in Appendix I.*

Backhaul Network with Co-located Sites

1. *Forty-Seven Backhaul* ~~Antenna~~ Base Stations*: approximately $1.10 million*

   ~~54 at 25,000~~ = ~~$1,350,000~~

2. *Seven* Gateway Stations*: approximately 640,000*

   ~~7 at 100,000~~ = ~~700,000~~

3. Project Management and Engineering*: approximately* 350,000

   Total: approximately $ 2.09 million

   ~~$2,400,000~~

Backhaul Network Costs with New Tower Sites

1. Forty-Seven Backhaul Base Stations:	*approximately*	*$1.80 million*
2. Seven Gateway Stations:	*approximately*	*740,000*
3. Project Management and Engineering:	*approximately*	*350,000*
Total:	*approximately*	*$2.90 million*

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

The foregoing estimate of costs includes only the costs of equipment and associated installation. Importantly, these costs do not include operation or maintenance costs; nor such costs as exclusive use license fees, if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental charges, if any, for use of municipal structures to mount antennas; nor legal fees. The capital costs of the antenna base stations and gateway stations set forth on pages 21 and 22, should, therefore, be considered as minimal. These costs will need to be refined as implementation proceeds based upon field tests and inspections, and on site specific analyses. If such further investigations indicate the impracticality of co-location of antenna on any given existing structure identified in the plan, an alternative structure will have to be found for co-location, or a new base station with attendant tower constructed. The capital costs could range up to about $2.9 million if new base station installations had to be constructed for each of the backhaul and gateway base stations shown on the plan. In any case, it must be recognized that the costs provided are based upon a system level of planning; and refinement of those costs should be expected as plan implementation proceeds through the preliminary engineering and final design stages.

~~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.~~

The operational cost savings from such a network would depend on the traffic volume on the network, but if each of the 47 base stations and 7 gateway stations were operating at a capacity of 100 megabits per second, the increased transport volume at each gateway would be approximately 8 times the volume of each base station connecting to the Internet individually. Such an increase in volume would result in a 32.6 percent cost savings *based on the Light Point transport rate tables listed in Appendix III. Each base station, therefore, would save 32.6 percent of its monthly transport cost of $7,400 per month or $2,412 per month. The total cost savings for a 54 station network would then be $130,240 per month or $1,562,926 per year . The annual savings would approximate 54 percent of the cost of the original network of $2,855,754. Following the return of the initial investment, an annual savings of $1.56 million would be realized.*

These same antenna base station sites could be used to implement a 4.9 GHz broadband public safety communications system throughout the Region. Such a network would provide full regional interoperability first for high speed data transfer and later for voice traffic. A preliminary analysis of radio coverage for public safety vehicles indicates that such a co-located system network is feasible although preparation of a plan for such a network is not within the scope of this planning report.

The estimated cost of the Regional Wireless Backhaul Network was based upon equipment cost quotations from a WiFi/WiMAX equipment manufacturer. The costs of WiMAX equipment are less certain than WiFi equipment since the first WiMAX equipment will enter the market only this year. WiFi equipment costs are well established in a competitive marketplace.

Part of the project engineering costs quoted would support field testing to verify the performance of the backhaul network. These field tests would result in signal level coverage maps of the Region. Such coverage maps verify the placement of the base stations and help to insure successful operation of the network. The pre-startup engineering effort would also establish a network monitoring system that provide the tools for ongoing network monitoring and management.

Two alternative business models are proposed as alternatives for plan implementation. The first and preferred alternative would involve a private investor-operator who would finance, install, and operate the regional backhaul network. The second option would involve multi-county ownership and operation of the system, if an acceptable and qualified investor-operator firm does not receive approval of a multi-county regional consortium. Both models provide this critical component of the regional telecommunication plan. Both models also call for an experienced network operator 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.

Although the deployment and operation of the proposed regional wireless backhaul network system could serve as the key infrastructure component of the regional economic development initiatives, *the development of such a regional backhaul network system in a timely manner within the Region is unlikely, since no institutional structure presently exists for the development of such a network. Moreover, it is likely that community level networks will be developed first, with such network being connected on a case by case basis to the closest* *available fiber cable interconnection. This probable sequence of development will tend to negate the need for an integrated regional backhaul network.*

Sectoral Cellular Cedarburg-Grafton Wireless Network Plan

The sectoral cellular wireless plan for the Cedarburg-Grafton area is shown in Maps 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.

The equipment configuration at a typical access point would include:

1. *3 – 802.11g transceivers*
2. *1 – 801.11a backhaul transceiver*
3. *1 – 120 degree sectorized antenna*
4. *Electrical and lightning surge protective equipment*
5. *Power over ethernet (POE) power injector*
6. *Ethernet and coaxial cabling*
7. *Weatherproof enclosures for auxiliary equipment*
8. *Mounting hardware*

Plans call for the use of heavy duty wall brackets to mount the communications equipment at each access point. Four equipment modules will be pole-mounted: transceiver modules (2), sectorized antenna (1), and auxiliary equipment enclosure (1).

It is also assumed that the access point equipment generally will not employ preamplifiers. Such preamplifiers will be required, however, in low density rural areas of the Region. Without such preamplifiers, rural broadband communications to the agreed upon throughput standards would not be possible. All access point equipment is assumed to be mounted on street lampposts or equivalent structures at an assumed height of about 20 feet. Small variations in heights should not significantly alter the structure of the network. Variations in geographic position within a range of 100 feet also should not significantly alter the network structure. User to access point communication would employ IEEE standard 802.11g equipment. All access points would backhaul to a single WiMAX base station as shown on Maps 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~~ *$353,336*, expressed in year 2006 real dollars. This total cost included the cost of the equipment and equipment installation for each access point estimated at ~~$5,250~~ *$6,196* each or ~~$212,250~~ *$254,036*; Internet access equipment – in the form of a WiMAX or fiber connection - ~~$17,300~~ *$34,600*; a network monitoring system - $10,000; and project management and engineering costs of $55,000. The foregoing estimate of costs include only the costs of equipment and equipment installation.

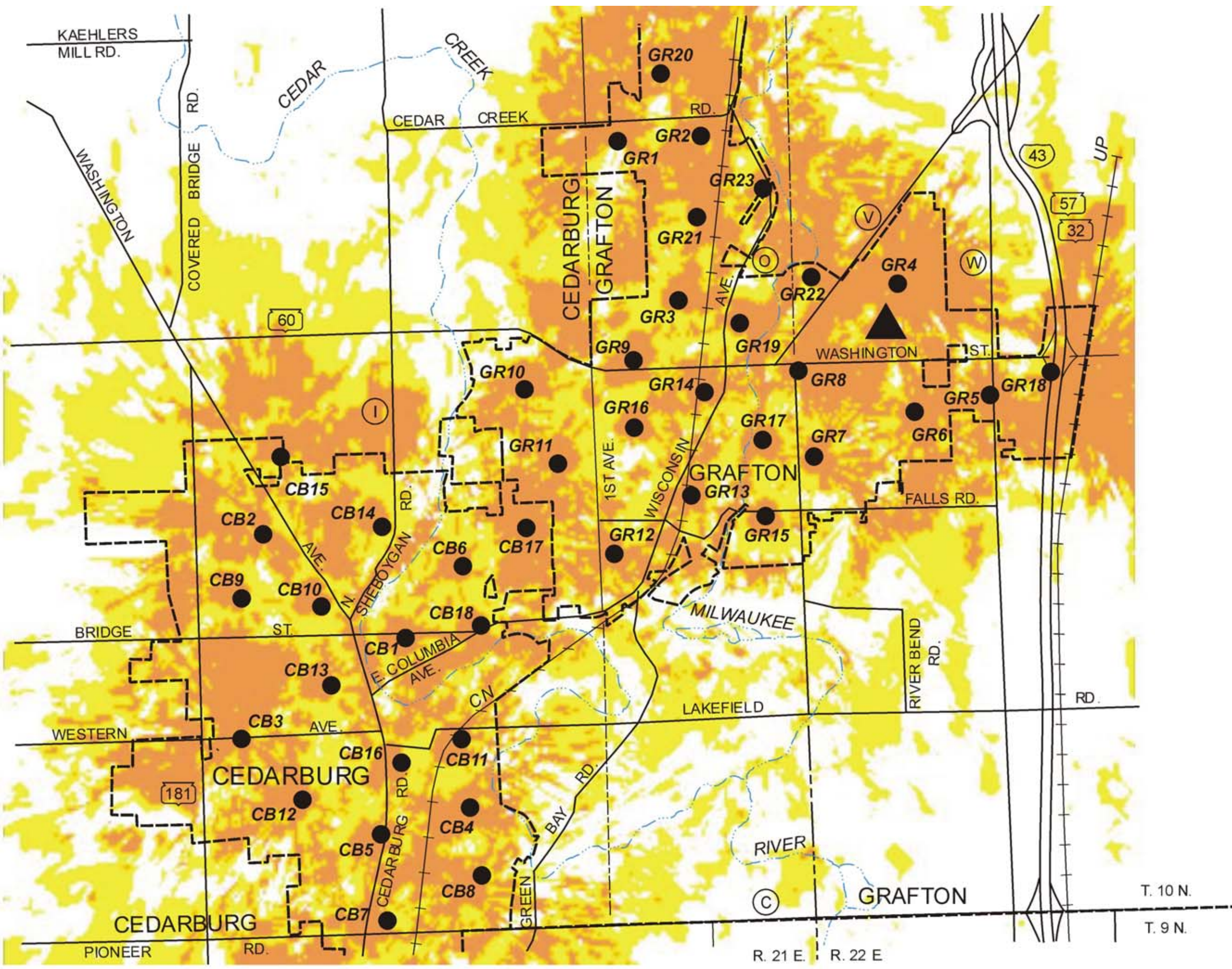
~~These costs do not include operation or maintenance costs, nor such potential additional costs as exclusive use license fees if the provider deems such exclusive use desirable or essential; municipal permit fees, if any; municipal rental fees, if any, for use of municipal structures to mount antennas;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

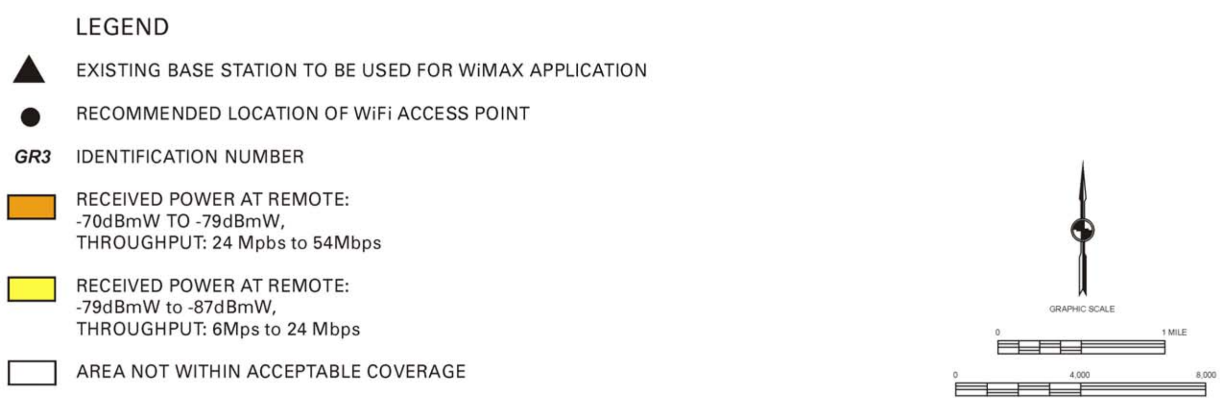
Operating and maintenance costs including network management and utility pole rental costs are detailed in Appendix II. Total continuing costs are estimated at $112 per month for each access point.

Part of the project engineering cost would support field testing to verify the performance of the access point locations in providing specified signal levels throughout their individual coverage areas. The cost estimate encompasses only the network infrastructure and does not include the cost of user equipment which would be purchased by individual users.

Map 2

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR NOMADIC USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO USER

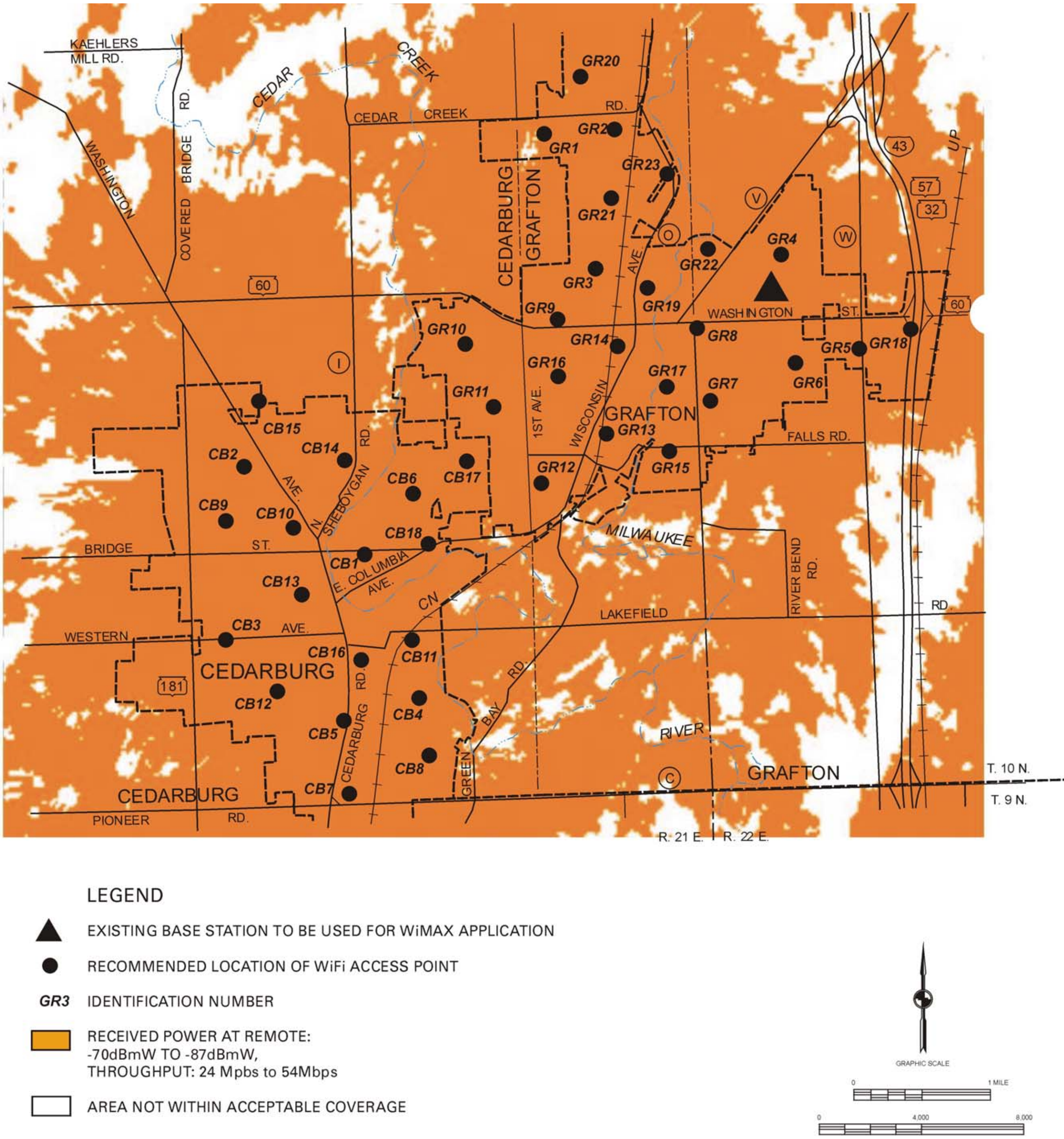




Source: SEWRPC.

Map 3

POTENTIAL LOCATIONS OF WiFi ACCESS POINTS AND ATTENDANT PERFORMANCE OF ACCESS NETWORK FOR FIXED USERS IN THE CEDARBURG-GRAFTON AREA: BASE STATION TO REMOTE



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.

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.

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.

ENVIRONMENTAL ASSESSMENT

Commission policy as well as Federal and State regulations require the Commission to prepare an environmental assessment in connection with the development of any elements of the Commission's comprehensive plan for the physical development of the Region. Such an assessment, focusing on radiation hazards, is included in Appendix I.

SUMMARY

A five-step plan development sequence has been presented for a fourth generation (4G) wireless network plan for Southeastern Wisconsin. This sequence includes the following work activities:

1. Selecting a basic wireless communications technology
2. Supporting this basic technology with accessory technologies required to achieve performance standards
3. Identifying and defining equipment requirements for various classes of network users to be serviced by the new wireless network
4. Planning an optimized WiMAX-based regional wireless backhaul network to service multiple community WiFi networks
5. Formulating a community-level WiFi network plan for a sample community -- the Cedarburg-Grafton area in Ozaukee County

A standards-based WiFi-WiMAX wireless communications technology was selected as the foundation for the regional wireless network plan. WiFi would serve as the access network for individual local communities, and WiMAX would provide the backhaul connection to other WiFi networks and the Internet. Competing proprietary wireless technologies are more costly and less likely to achieve 4G performance standards.

Achieving throughput and other 4G performance standards required an improvement in receiver sensitivity performance. An approach to achieving this higher level receiver performance was described in some detail.

Two classes of current users were defined – the nomadic laptop computer user and the fixed location user. A plan objective was to support the laptop user as the defining measure for plan design with a strong broadband communications capability. The fixed location user could then benefit with higher data rate performance because of enhanced equipment capabilities.

Pilot system plans were prepared for both a WiMAX-based Regional Wireless Backhaul network and a community-based WiFi network. The regional wireless backhaul network would result in both infrastructure and operation savings that allow for an investment pay-back period of less than one year. A sectoral cellular network plan was generated based on radio propagation modeling for the Cedarburg-Grafton area that provided high speed data transmission rates of 24 to 54 megabits/second to all fixed location users at a system infrastructure cost of approximately $295,000 compared with approximately $456,000 for an equivalent Tropos mesh network that does not achieve the performance standards.

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Appendix I

INFRASTRUCTURE,

COST ESTIMATE TABULATIONS

COMMUNITY WiFi NETWORK (802.11)

ACCESS POINT EQUIPMENT

WiFi (802.11 a,g) Access Point

1.	Transceiver Modules	
	2 at $1,500 =	$3,000
2.	Sectorized Antenna	995
3.	Auxiliary Equipment	841
4.	Installation and Testing	
	17 hours at $80	1,360
	Total	$6,196

For rural wireless network, add:

Three sets of preamplifiers, connectors and power injectors - $645

WiFi Network Cost Summary - Cedarburg-Grafton

1.	Access Points	
	41 at $6,196 =	$254,036
2.	Gateway Stations	
	2 at $17,300 =	34,600
3.	Network Monitoring System	10,000
4.	Project Management and Engineering	55,000
	Total	$353,336

BACKHAUL WiMAX/WiFi NETWORK (802.11, 802.16)

BASE STATION EQUIPMENT

Co-located Site

1.	Site Preparation and Cleanup	$ 1,000
2.	Shelters and Buildings	200
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	21 dBi Antenna	150
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Installation and Testing	
	40 hours at $80	3,200
9.	Miscellaneous	
	(Freight, cabling and travel)	2,250
	Total	$23,024

New Site

1.	Items 1-9 of co-located site above		$23,024
2.	Town Erection		
	100 foot tower	$7,200	
	Foundation	4,100	
	Labor	2,200	
	Climb Shield	1,000	14,500
	Total		$37,524

Gateway Station

1.	Site Preparation and Cleanup	$ 1,000
2.	Shelters and Building	10,850
3.	Utility Connection	2,000
4.	Power Conditioning and Backup	7,020
5.	31.2 dBi Antenna	3,874
6.	16 dBi Sectorized Antenna	1,404
7.	Transceiver Modules	
	WiFi (802.11) (2)	2,800
	WiMAX (802.16) (1)	3,000
8.	Internet Interconnection	
	MPLS Router	30,420
	Fiber Interconnect Equipment	20,000
9.	Installation and Testing	
	80 hours at $80	6,400
10.	Miscellaneous	
	(Freight, cabling and travel)	2,750
	Total	$91,518
	If new tower required	14,500
		$106,018

Backhaul Network Cost Summary – Co-Location

1.	Antenna Base Stations	
	47 at $23,024 =	$1,082,128
2.	Gateway Stations	
	7 at $91,518 =	640,626
3.	Project Management and	
	Engineering	350,000
	Total	$2,072,754

Backhaul Network Cost Summary – New Tower Sites

1.	Antenna Base Stations	
	47 at $37,524 =	$1,763,628
2.	Gateway Stations	
	7 at $106,018 =	742,126
3.	Project Management and	
	Engineering	350,000
	Total	$2,855,754

Appendix II

OPERATING COST
ESTIMATE TABULATIONS

Access Point

Community WiFi Network

1.	Electric Power 50 watts at $0.05/kwh	$1.80/month
2.	Maintenance and Network Management	25.00/month
3.	Pole Rental	10.00/month
	Total	$ 36.80/month

Backhaul Base Station

WiFi/WiMAX Network – Co-location

1.	Electric Power 20 watts at $0.05/kwh	$7.20/month
2.	Maintenance and Network Management	100.00/month
3.	Base Station Rental $4/foot/month 100 foot tower	400.00/month
4.	Transport Costs (100 Mbps) 74 x 100 =	7,400.00/month
	Total	$7,907.20/month

Backhaul Base Station

WiFi/WiMAX Network – New Towers

1.	Electric Power 200 watts at $0.05/kwh	$7.20/month
2.	Maintenance and Network Management	100.00/month
3.	Land usage fee	1,060.00/month
4.	Transport Costs (100 Mbps) 74 x 100 =	$7,400.00/month
		$8,507.20/month

Note:

Base station operators are often required to have liability insurance in the range of $1-3 million for each base station site. Less often they are required to post performance bands for the contingency of tower abandonment. Neither of these costs are included here.

PRELIMINARY DRAFT

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FOR SOUTHEASTERN WISCONSIN

Chapter VIII

REGIONAL WIRELESS NETWORK PLAN IMPLEMENTATION

INTRODUCTION

In order for a publicly prepared wireless telecommunications plan to fully achieve its potential benefits, the plan must be implemented through actual network development. Given the predominance of the private sector in wireless network development, a specific well-defined procedure for plan implementation is an important element of the plan itself. This chapter will describe such a plan implementation procedure for both the regional wireless backhaul network element of the wireless telecommunications plan, and for a community-level access network plan.

Plan implementation as presented here extends beyond the physical and technical development of the network to the business and operational models required to effectively finance, market, and operate the networks concerned. The business model addresses the economics of a wireless communications system in terms of the user charge rates required for economically viable operation and the marketing activities needed to establish and operate the services envisioned in the plan. The operational model is concerned with network management and an associated network monitoring system necessary to supervise network operation.

Although a presentation of the regional wireless backhaul network plan implementation process followed by a presentation of the community access networks plan implementation process would seem the logical sequence, this order will be reversed here since the community access networks may be expected to be developed earlier than the regional backhaul network. This may be expected because:

1. The regional backhaul network is based on WiMAX technology which is a new standards technology scheduled for release in 2006. The community access networks are based on WiFi technology which is well established with ready equipment availability.

2. There is no regional institutional framework for regional wireless backhaul system plan implementation. Individual counties or a consortium of counties may be required for such a deployment even if a private service provider installs and operates the system.
3. Local units of governments provide a strong institutional structure for community access networks, and this implementation process is already underway.

COMMUNITY LEVEL WIFI NETWORKS PLAN IMPLEMENTATION

~~The currently prevailing wireless telecommunication system development process within the United States places the responsibility for system development largely within the private sector.~~ *The currently prevailing wireless telecommunication system development process within the United States, as established by Federal law, places the responsibility for system development generally within the private sector, that process being, however, regulated by Federal and State laws and regulations.* Therefore, the system development process is driven by decisions made within national corporate structures in response to competitive market forces. Public telecommunication service planning efforts, such as that conducted by the Southeastern Wisconsin Regional Planning Commission, are intended not to replace, but rather to influence this competitive, market driven process in the public interest. To be effective, the introduction of public planning requires some changes in the current entirely private development process. The modified system development process, then, consists of the following sequence of steps:

1. ~~Public preparation of a broadband wireless system plan for designated service areas;~~ *At the specific request of a constituent county or municipality, the Commission will prepare a broadband wireless system service plan for areas designated in the request;*
2. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;
3. Field studies to verify or modify the preliminary plan as may be found necessary;
4. Final review and approval of system plan by the municipalities comprising each service area concerned;
5. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;
6. Selection of infrastructure development vendor;
7. Issuance of a request for proposals to operate system;
8. Selection of an internet service provider to operate the system; and
9. System operation

Plan preparation using radio propagation modeling and design optimization model tools would take place as previously described in Chapter VII, and would be initiated by the Commission upon request of the community.

Each community level wireless plan would then be presented to the appropriate local governing body and advisory committees to that body for review and approval. Upon approval, the community would submit a letter requesting the Commission to move to step 3 – field study verification of the community wireless plan.

Field study plan verification involves an extensive series of radio frequency signal intensity measurements using temporarily located access point equipment, equivalent to that planned for use in the network infrastructure. A truck-mounted antenna mast is employed for a series of temporary access point locations. For each temporary access point location, a signal-level coverage map is prepared based on a large number of radio frequency signal level measurements collected in a moving vehicle equipped with a WiFi-enabled laptop computer with a professional site survey software package. A variety of network performance measures will be recorded including signal level, noise level, throughput (packet speed) and packet retry and loss rates. In small networks with a few access points as in rural areas, all of the access points can be coverage and performance verified. In larger networks, a randomly selected set of access points can be used to statistically verify network coverage and performance. The field survey will identify weak coverage or performance areas which may require additional or relocated access points to achieve network coverage and performance objectives.

Following the completion of the field survey studies, the adjusted plan is resubmitted to the community for final review and approval. Upon approval, the plan implementation process would move to the final five stages which involve various aspects of vendor selection and system startup. The manner in which these final stages are approached depends on the general business model selected. If private service providers are asked and respond to a formal request for proposal, then steps 5 through 8 would be accomplished as a continuous final single stage process. If an alternative government ownership model is chosen, then infrastructure deployment and ISP (Internet Service Provider) selection would be executed as a two-stage process.

Whether the private or public version of a business model is selected, this business model plan must detail the marketing, training, financial and general business aspects of the proposed network operation in order to generate confidence in the economic viability of the new venture in a competitive environment.

Operational management of the new wireless system would be based on a network management system that employs real-time network monitoring to measure network performance in order to provide information for rapid trouble-shooting of network outages, and early identification and correction of network bottlenecks or areas of weak signal coverage.

The end result of the community-based WiFi network plan implementation process would be an operating broadband wireless network system that achieves the agreed upon performance objectives and is able to grow and adapt to an expanding network clientele. A wireless communications network system can be well managed only through constant observation of its dynamic nature as it grows its user base and adapts to changing traffic patterns.

REGIONAL WIMAX WIRELESS BACKHAUL NETWORK PLAN IMPLEMENTATION

The technical and operational aspects of a regional wireless backhaul network are similar to community-level WiFi network only on a larger scale. A backhaul network operates as an interconnection service to a multitude of community-level access networks linking their access points to fiber-based core networks that provide the regional and national backbone of the Internet.

The eight step plan implementation process just presented for community-level access networks can be applied in a modified form for the regional backhaul network. The initial regional wireless backhaul network plan has already been prepared and is documented in Chapter VII of this report. Identification of the review agency concerned would be either a county or a consortium of two or more counties – desirably of the seven counties comprising the planning region. Lacking a multi-county consortium, sequential review on a county-by-county basis provides the only alternative. If a favorable response is received from the first few county presentations, the climate may be improved for a more desirable region-wide initiative.

The step 3 field studies phase of backhaul network verification introduces challenges much greater than those encountered in a community access network. Antenna heights on backhaul base stations approximate 100 feet, while access points on community networks average around 20 feet. The latter height is suitable for truck mounting of antennae and rapid field testing. The former antenna base station situation does not lend itself to such truck mounting. At the same time, the need for field test verification for a backhaul network prior to deployment is even more compelling than for a lower cost access network. Needed is an approach capable of temporarily elevating two antenna fixtures at heights in the 100 feet range. Lower heights would be acceptable where two locations concerned provided line-of-sight connection. As long as a line-of-sight wireless link connection is established above the "clutter level," field test conditions will emulate future backhaul network operation. One possible approach would utilize a pair of traveling cranes in which the antennas would be crane-mounted at sufficient height to create a clean line-of-sight connection between the two base station locations being tested. Although increased costs would be encountered with such an approach, the size of the infrastructure investment for a wireless regional backhaul network justifies such testing costs.

Following a final review and approval of the verified network, the remaining steps of regional backhaul plan implementation would depend upon the network ownership model selected. If private ownership, infrastructure deployment, and network operation is the choice, then a multi-county consortium would probably be required as the institutional framework for issuing requests for proposals, reviewing, proposals and selecting a provider. It is questionable whether private service providers would be interested in a county-by-county implementation since the economic justification for the wireless backhaul relates primarily to lower cost data transmission rates achieved mainly through region-wide implementation. With a multi-county consortium, it would be possible to follow the same review and selection process previously presented for community access networks. Lacking a multi-county consortium, a county-by-county plan implementation approach may be necessary, with emphasis on public ownership.

SUMMARY

This Chapter has set forth a procedure for implementation of a 4th generation regional wireless network plan for the seven county Southeastern Wisconsin Region. As noted in the body of the Chapter, the currently prevailing wireless telecommunications system development process within the United States places the responsibility for system development largely within the private sector. Therefore, the system development process is defined by decisions made within the national corporate structure in response to competitive market forces. Public telecommunication service planning efforts, such as that conducted by the Southeastern Regional Planning Commission, are intended, not to respond, but to influence this competitive market defining process in the public interest. To be effective, the introduction of public planning requires some changes in the current entirely private development process. The modified system development process consists of the following sequence of steps:

1. Public preparation of a broadband wireless system plan for designated service areas;
2. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;
3. Field studies to verify or modify the preliminary plan as may be found necessary;
4. Final review and approval of system plan by the municipalities comprising each service area concerned;
5. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;
6. Selection of infrastructure development vendor;
7. Issuance of a request for proposals to operate system;
8. Selection of an internet service provider to operate the system; and
9. System operation

With respect to the development of community level WiFi networks, the plan implementation process would be initiated through requests from a local community, or group of communities, to the Commission and would be directed through the nine steps by a community level advisory committee created for this purpose. Infrastructure development and system operation would desirably take place in the private sector, that sector responding to requests for proposals issued by the community or communities concerned based upon the approved plan. Failure of the private sector to respond to such requests would require consideration of public system development and operation.

With respect to the regional WiMAX wireless backhaul network plan implementation, the same nine step process would be followed. The initiation and directing agencies, however, would consist of a county or a consortium of two or more counties – preferably of all seven counties comprising the Southeastern Wisconsin Planning Region.

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A WIRELESS ANTENNA SITING AND RELATED INFRASTRUCTURE PLAN
FOR SOUTHEASTERN WISCONSIN

Chapter IX

SUMMARY

SUMMARY

This planning report documents the findings and recommendations of the planning process conducted by the Southeastern Wisconsin Regional Planning Commission to develop a wireless telecommunications system plan for the seven-county Southeastern Wisconsin Region. The planning process concerned was initiated in August 2004. The wireless telecommunications element of the planning process was completed in May 2006. The findings and recommendations are presented in the eight chapters which together with this summary comprise the report.

Chapter I presents background information about the Regional Planning Commission, the regional planning concept in Southeastern Wisconsin, and about the seven-county planning Region; including basic information on the size, resident population, employment, real property valuation, and governmental structure of the Region. The Chapter also contains a brief description of the work programs undertaken by the Commission from its creation in 1960 through 2004. Importantly, the Chapter describes the importance of telecommunications to the continued sound social and economic development of the Region, and the need for regional telecommunications planning. The Chapter notes that the regional telecommunications planning effort was being conducted in accordance with a Prospectus adopted by the Commission in December 2003. This Prospectus envisioned the regional telecommunications plan to be comprised of two principal elements: a wireless antenna siting and related infrastructure plan, and an overall telecommunications network plan.

Chapter II sets forth the basic principles and concepts underlying the regional telecommunications planning process; describes that process; and, importantly, describes the technologies involved including mobile and fixed wireless networks.

Chapter III sets forth a set of eight objectives that should be met by the regional telecommunications system, together with their supporting principles and standards. These objectives relate to system performance, as measured by data transmission rate, availability, quality of voice transmission, error rate, and packet loss; universality of service; redundancy; antenna site number optimization; application to be served; cost minimization; antenna site aesthetics and safety; and use in public safety emergencies. The objectives and supporting quantitative standards were intended to be used in plan design and evaluation of alternative plans and the selection of a recommended plan.

Chapter IV presents inventory findings relating to pertinent background within the Region, conditions including information on the demographic and economic base, land use, and supporting transportation facilities and services.

Chapter V catalogues the locations and certain technical characteristics of the 755 mobile – cellular - PCS and fixed wireless antenna sites within the seven-county planning area. These antenna sites not only provide the infrastructure for the existing mobile and fixed wireless networks within the Region, but also serve as potential co-location sites for new advanced wireless network antennas. Such co-located sites reduce new infrastructure costs and minimize environmental impact.

Chapter VI documents the findings of the Commission inventory and the performance of the existing cellular – PCS mobile wireless networks operating within the Region. The performance of five service providers are evaluated in terms of network availability, upload and down load, throughput, and response time. Significant performance differences were observed between both the individual service provider networks and the technologies used in these networks. Performance data for both second generation (2G) and third generation (3G) packet-switched networks were acquired. Although the 3G networks demonstrated considerable improvement over the 2G networks, performance was still far below the theoretical target for throughput performance of 2 megabits per second, and far below the agreed upon service objectives for the Region.

Chapter VII describes the recommended wireless telecommunications plan for the seven-county Southeastern Wisconsin Region. The recommended plan consists of two levels of wireless networks – a wireless backhaul network plan, and a pilot, community level, wireless access network plan. The proposed backhaul network would service a multitude of community level access points that would forward data to the backhaul network for cost effective Internet connection. The higher volumes of data that would be processed through the envisioned regional network may be expected to lead to significantly lower Internet charge rates and would allow for recovery of the backhaul infrastructure capital costs in approximately one year. An illustrative pilot community level access network plan was prepared and presented for the Cedarburg-Grafton area of Ozaukee County. A sectoral cellular network structure served as the framework for the plan design which provided for 4G-level performance, with data transmission rates above 20 megabits per second. The illustrative pilot plan is compliant with the objectives and performance standards specified in Chapter III. An alternative community access plan based upon a mesh topology was also designed and was found to be more costly than the cellular network structure plan. Moreover, the mesh network plan did not achieve the specified objective and performance standards.

Chapter VIII sets forth an approach to implementation for both the community level wireless access network plans and for the regional wireless backhaul network. The proposed plan implementation process is intended not to replace, but rather to influence the extant competitive market driven, private sector planning in order to promote the public interest within the Region. The proposed modified system development process consists of the following sequence of steps:

1. Public preparation of a broadband wireless system plan for designated service areas;
2. Preliminary review and approval of system plan by the municipalities comprising each service area concerned;
3. Field studies to verify or modify the preliminary plan as may be found necessary;
4. Final review and approval of system plan by the municipalities comprising each service area concerned;
5. Issuance of a request for proposals to deploy infrastructure in accordance with approved plan;
6. Selection of infrastructure development vendor;
7. Issuance of a request for proposals to operate system;
8. Selection of an internet service provider to operate the system; and
9. System operation

With respect to the development of the community level access network plans, the plan implementation process would be initiated through requests from a local community, or group of communities to the Commission, and would be directed through the nine steps by a community level advisory committee created for this purpose. Infrastructure development and system operation would desirably take place in the private sector, that sector responding for requests for proposals issued by the community or communities concerned based upon the above plan. The same nine-step plan implementation process would be followed with respect to the regional backhaul network plan. The initiating and directing agencies, however, would consist of a county or consortium of two or more counties -- desirably of all seven counties -- comprising the planning Region.

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