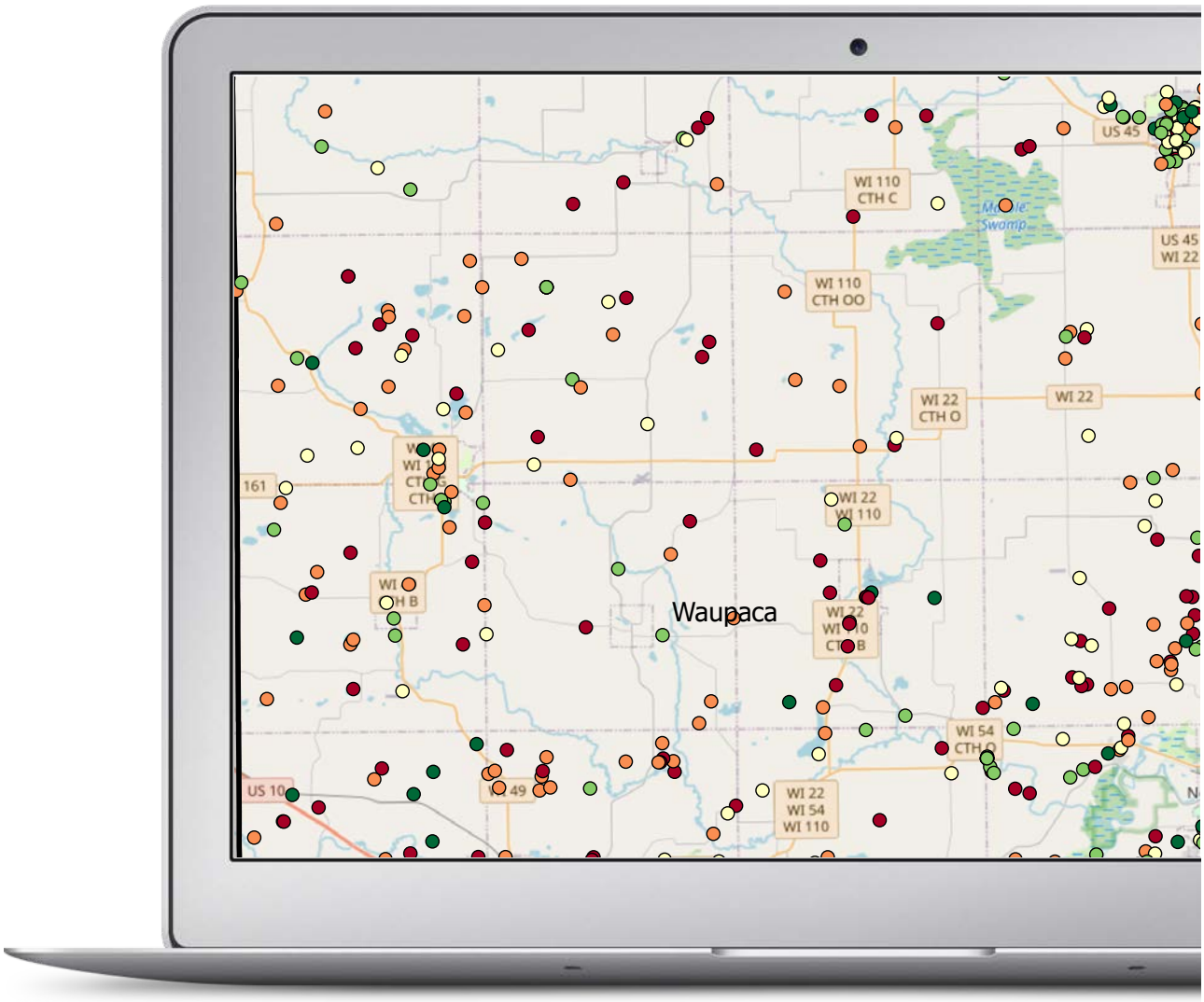
BROADBAND STUDY REPORT

Waupaca County, Wisconsin



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1 OVERVIEW OF THE WORK

A broadband study of Waupaca County began in early fall of 2021 and was completed in December, 2021. The study included meetings with stakeholders and interested parties in the county, interviews and meetings with businesses, meetings with county officials, and residential and business broadband surveys. The report has several key sections:

- **Asset Assessment** – Demographic data, tower and fiber assets in the county, underserved and unserved areas of the county, and geo-coded survey results.
- **Service Provider Analysis** – A review of current service provider service offerings, speeds, and prices for those services and what bandwidth is available.
- **Broadband Surveys** – In Waupaca County, both a residential broadband survey and a business broadband survey was distributed. A strong response was received.
- **Market and Gap Analysis** – How much bandwidth is enough for residential and business use, now and in the future?
- **Connectivity Solutions** – This section provides an overview of various technologies, including both broadband wireless and broadband fiber.
- **Planning for Broadband** – Design and estimates of a middle mile project to assist ISPs and WISPS with lower capital costs and faster deployment of high performance broadband in rural areas of the county.
- **Infrastructure Funding and Grant Opportunities** – A discussion of a variety of grant and funding strategies.

The survey data collected as part of this study indicates that residents and businesses are anxious for better Internet service. Because a very large number of comments were received, they have been included in a separate document.

- 92% of respondents are interested in faster and more reliable Internet service.
- 98% believe that local government should help facilitate better Internet access.
- 37% of residents report the quality of Internet service is affecting where they choose to live.
- Most businesses indicated that the Internet is important to the success of their business.
- Most businesses reported that they need employees able to work from home.

1.1 FUTURE-ORIENTED INFRASTRUCTURE

Affordable high speed Internet is essential to the future growth and prosperity of Waupaca County. Over the past twenty years, Internet access has evolved from a luxury to a necessity. School students need Internet access to complete homework and to study. Online shopping can save energy and make it easier for the elderly and homebound to obtain the needs of every day life. Telemedicine and telehealth services and applications is revolutionizing health care, reducing costs, and allowing older citizens to live independently longer.

More and more workers and business people are working from home, either on a part time or a full time basis, and the Covid crisis has highlighted the critical need for reliable high performance Internet service for work, learning, and access to health services. New work from home job

opportunities are growing rapidly, but most of those jobs require reliable, symmetric Internet service to qualify.

Many business employees are already trying to work more from home more often (e.g. one or two days per week) to reduce travel costs. Some major businesses in other parts of the U.S. are actively planning to have 20% of their workforce work full time from home to reduce employee travel costs and office energy costs. Corporate employees working from home require high bandwidth services to be connected to the office network and to use corporate videoconferencing systems. These corporate network services often require 10-50 Megabit ***symmetric*** connections.

Broadband has become essential infrastructure.

Just as communities had to take on the task of building and maintaining roads in the early twentieth century, communities now need digital road systems as a matter of community and economic development.

The communities of Waupaca County, with the right broadband infrastructure, can be attractive to an emerging new group of businesspeople and entrepreneurs that typically are well-educated, own their own businesses or work for large global corporations, and are making choices about where they lived based on family needs and interests, rather than business interests. This new breed of entrepreneurs and workers place a high value on the kinds of amenities that contribute to a good quality of life–traditional neighborhoods, vibrant downtown areas, a wide range of cultural and recreation opportunities, good schools, and a sense of place. These businesspeople and their families make relocation decisions based on quality of life only where there is abundant and affordable broadband, because broadband is the enabler of this new approach to personal and work life.

The Governor's Task Force on Broadband Access has set aggressive goals for the state:

- By 2025, all homes and businesses should have access to 25 Mbps download and 3 Mbps upload speeds.
- By 2028, all homes and businesses should have access to 50 Mbps download and 10 Mbps upload speeds.
- By 2031, all homes and businesses in the state should have access to 100 Mbps download and 50 Mbps upload.

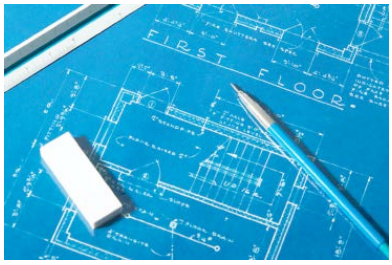
Given that the Covid crisis has created increased attention to fiber Internet service, these goals are modest. If Waupaca County can use ARPA funds, other grant opportunities, and some local funds to make carefully targeted passive infrastructure investments and to develop constructive public/private partnerships, most homes and businesses in Waupaca County could have Gigabit fiber service within the next four to six years.

1.2 RECOMMENDATIONS

Recommendation	Description	Expected Outcomes
County-wide broadband strategy	A long term strategic plan is needed to bring affordable high performance broadband to all homes and businesses.	This will require a multi-year effort, using a variety of funding resources. While increased funding will be available in 2022, it will take several years to permanently address needs in unserved and underserved areas of the county.
Public/private partnerships	Telecom is inherently a public/private partnership when telecom firms use public funding and/or right of way.	Faster expansion of high performance broadband services when local governments provide funding and support.
Dig Once policies	The County should encourage joint trenching and and shared conduit construction where feasible and practical.	Better use of public right of way (a scarce resource). Lower costs for construction for new broadband infrastructure.
Grant funding	2022 represents a significant one time opportunity for Waupaca County to leverage ARPA, BEAD, and other state and Federal funds for broadband.	Well-planned public/private partnerships and broadband infrastructure expenditures should provide substantial improvements in broadband service in under-served and unserved parts of the county.
Distributed ownership	Some county or regional ownership of broadband infrastructure.	Some public ownership of broadband infrastructure (e.g. fiber middle mile) will lower capital costs for ISPs and WISPs, create more competition, and lower the cost Internet service.
Regional collaboration	Networks span political boundaries and require a regional approach to maximize use of grant funds to create maximally efficient networks.	A shared vision of broadband in the New North region will lead to universal access to high performance broadband at affordable prices. Regional collaboration will also be a key driver of economic growth and jobs creation.

County-wide Broadband Strategy

Use the findings and recommendations in this report to develop a multi-year set of goals that can be realistically achieved using a basket of local, state, and Federal funding. Commit to providing the grant writing resources needed to pursue every possible grant opportunity.



The County government should not become an Internet provider. Instead, it should focus on developing public/private partnerships by making targeted investments in passive broadband infrastructure like towers and dark fiber. These assets have long life spans of fifty years or more.

Ownership of those assets can be retained by the County and can be leased out to private sector ISPs (passive infrastructure leasing is not a telecommunications service), or ownership can be gradually transferred to the private sector partner over a period of several years. While the revenue from the lease agreements will be modest, the funds generated can be used to support maintenance of this infrastructure.

Many residents and businesses rely heavily on poor DSL Internet access and need an alternative. Improving service provider access to more towers in the rural and underserved areas of the county will support improved Internet service. Expanded fixed point broadband wireless service is a critical strategic short term goal in the county, but widespread access to high performance fiber connections to homes and businesses–throughout the entire county–is critical to the long term economic growth of Waupaca County.

Managing expectations will be an important part of the county's broadband strategy. The current deficiencies in Internet access in the county took decades to develop, and planned improvements should be approached as a multi-year process, with an expectation of some improvements in affordability and availability in twelve to eighteen months.

Recommendation: The County should convene a permanent broadband committee of County staff, grant writers, K12 and higher education representatives, and health care representatives to provide guidance on broadband strategy and to assist with grant proposals. ISPs and WISPs should participate only in a non-voting or adjunct capacity. The County should continue to participate in the State of Wisconsin Broadband Forward! program.

Recommendation: County staff from Planning, GIS, Planning Commission, and Engineering departments should evaluate how and where County policies should be adapted to better support broadband infrastructure improvements. These activities could include Dig Once formal or informal policies, putting all broadband infrastructure (e.g. underground conduit/fiber cable, towers) into the County GIS system, annual allocations to the Capital Improvement Fund, and broadband infrastructure updates to the County Comprehensive Plan.

Public/Private Partnerships

Telecom has always been a public/private partnership; in the twentieth century, local governments gave private companies access to right of way to deploy telecom infrastructure. Throughout the U.S., many ISPs and WISPs are aggressively pursuing Public-Private Partnerships (PPPs) with county governments. Ideally, a public/private partnership combines government oversight, some public funding, and private sector expertise to improve broadband infrastructure in a locality.

A typical partnership is a long term contract between a government entity (e.g. Waupaca County) and a private sector telecom firm, in which the private partner assumes much of the business risk and management responsibility in return for public funding.

The advantage of a PPP is that the ISP or WISP typically is responsible for most of the day-to-day management of the network assets, as opposed to county or regional responsibility for assets.

These partnerships may include a variety of strategies:

- Collaboration on a grant opportunity,
- Shared costs of developing a new tower site,
- Revenue sharing,
- Fee waivers, and other kinds of cost and revenue sharing.

Selected providers should be evaluated carefully. Prospective partners must be able to show technical competency and have a demonstrable track record of managing substantial fiber and/or wireless builds on time and within budget.

It will also be important for any public/private partnership agreement have a claw-back agreement. When public funds are transferred to a private company, the County should have the ability to "claw back" the built infrastructure for a minimum of five to ten years.

Conditions for a claw back could include bankruptcy of the ISP, sale to a third party (where substantial profit taking leverages the public funds), poor service, unreasonably high cost of service, and/or poor service reliability.

Recommendation: Waupaca County can pursue public/private partnerships with technically qualified and financially stable ISPs and WISPs. Where appropriate, the County can channel grant funds to providers who will use the funds to build and manage new broadband infrastructure.

Recommendation: Any public/private partnership agreement should have a well-defined claw back section that provides protection of the public funds from mis-use, business failure, or early asset sale.

Dig Once Policies

According to the Federal Highway Administration, "90 percent of the cost of deploying broadband is when the work requires significant excavation of the roadway."

The National Broadband Plan has recommended that Congress consider creating "dig once" legislation applying to all future federally funded projects along rights-of-way (including sewers, power transmission facilities, rail, pipelines, bridges, tunnels and roads).

Deploying a mile of fiber can easily cost more than $100,000. The largest portion of construction costs is not the fiber cable itself, but the labor costs associated with burying the fiber in the ground (or attaching it to poles in an aerial network design). These construction costs can account for up to 75% of the total cost of fiber deployment.

Local governments improve the efficient use of public rights-of-way by creating Dig Once ordinances and/or encouraging shared trenching and shared conduit. Running a fiber cable through an existing conduit is 3–4 times cheaper than constructing a new aerial build.

Similarly, it can be extremely expensive to add telecom conduit to a bridge after it has been built. It is much less costly to plan to install a conduit bank on a new or refurbished bridge project, with enough conduit installed to support access and use by multiple broadband providers.

Dig Once ordinances facilitate the laying of necessary infrastructure, namely fiber and conduit, to expand broadband service. On the local level, Dig Once would work as follows: whenever there is street construction planned on locally owned roads and/or highways, the county would inform all private providers in the area in an effort to coordinate the laying of fiber and conduit as part of the construction project. That is, once there is a plan for street construction, there would be a second plan to incorporate the laying of fiber and conduit before the construction begins.

In addition to reducing the cost of broadband deployment, the strategic investment in broadband infrastructure at the time of construction also reduces the damage and disruption to rights-of-way in the future.

Recommendation: County Engineering and Planning departments should receive training and information on telecom conduit and fiber installation and management best practices.

Recommendation: County Engineering and Planning departments should be directed to evaluate all new road and road improvement projects for suitability for coordinated installation of telecom conduit.

Grant Funding

The Federal government has been steadily increasing the amount of grant funding available for broadband infrastructure, with USDA and HUD both having programs that are designed to help underserved and unserved areas construct new broadband infrastructure.

Some Federal grant applications will be due in mid-spring of 2022, so planning for submitting grant proposals should begin in early January 2022. Covid relief funding (ARPA, American Rescue Plan Act) should also become available in early 2022.

Because ARPA funding is expected to exceed the previous Covid funding program (CARES), Waupaca County's share of ARPA funds should be substantial and a portion of it could cover a large part of the needed broadband infrastructure improvements via public/private partnerships with ISPs and WISPs. The NTIA IIJA BEAD (Broadband Equity Access Deployment) program represents an additional and substantial funding opportunity.

Grants may not provide sufficient funds to reach the County's long-term goals. Evaluate longer term funding strategies, like using a special assessment, or implementing a very small increase in property taxes. Revenue would be earmarked exclusively for broadband improvements. Expansion of broadband in Waupaca County will be most successful by recognizing that funding will come from a range of funding sources rather than a single source. Grants, public/private partnerships, some local funds, and other sources may all be needed to achieve success.

Grants can be extremely important in the early stages of an effort to support planning activities and/or to fund a first-phase build-out initiative. However, grants rarely allow spending on operational expenses. Grants should be used carefully as one-time cash injections to support very specific goals. Communities that have relied too heavily on "the next grant" as a key source of expansion or operational funding usually experience severe financial problems.

Recommendation: Assemble a broadband grant team. Some grants, like the USDA ReConnect program, require a significant effort to assemble the required forms, letters, and supporting information needed for the grant application. All grants will require a well-structured technical and operational plan. Team members should have grant-writing experience and should also have a good understanding of the basics of broadband infrastructure.

Recommendation: For grant requests that are focused on public/private partnerships, coordination with the private sector partner is critical. While the private partner may be responsible for developing some or most of the technical detail, many ISPs and WISPs have little or no experience writing grant applications and managing the paperwork required by a grant program. The broadband grant team should be careful not to delegate too much responsibility for developing the grant application to the private partner.

Distributed Ownership

Where cable Internet service is available in the county, download speeds are generally considered adequate, although upload speeds tend to be much lower (as much as 10x to 20x slower). In more rural areas of the county, homes and businesses are struggling with inadequate service, including mediocre DSL, expensive satellite service, and fixed point wireless broadband Internet service.

This bifurcation of service has perpetuated the digital divide. At one time, people usually discussed the digital divide in terms of who could afford broadband location. Some areas of the county have adequate broadband and internet access, and other areas do not. This new digital divide is leading to unanticipated consequences. The availability of broadband (or the lack of it) is beginning to drive land use decisions, including where people want to work and where they want to live in the county.

Regardless of where broadband is deployed, both fiber and wireless providers are carving up service areas to create mini-monopolies. In the fiber business, the rule of thumb is that whoever builds fiber into an area first "wins" because building two fully duplicated fiber networks to compete for the same customers is simply not economical.

The effect could be called the balkanization of American broadband. The main effect of telecom deregulation has been to break up large service area monopolies into many smaller service area monopolies. Though there has been some limited progress in terms of competition, the on-the-ground reality for many broadband users, both residential and business, is a continued lack of service alternatives and ever-increasing prices.

Distributed ownership helps level the playing field in telecom by giving communities, residents, and businesses more control over their community and economic development future. When incumbent and competitive providers do not own all of the infrastructure, everyone benefits, even providers—regional or county-owned broadband infrastructure—leased at fair prices to providers, lowers their capital costs and allows them to expand their service territories more rapidly. ISP and WISP access to shared infrastructure also creates more opportunities for true competition for customers, lower prices, and better service.

Recommendation: Evaluate the potential for some regional and/or county-owned infrastructure, especially in underserved and unserved areas of the county, where public investments would allow faster expansion of fiber to the home and fixed point wireless services by ISPs and WISPs.

Regional Collaboration

Networks do not recognize political boundaries. Indeed, the fundamental design of the Internet was driven by the principle that any computing device, no matter where it was located, could be connected to the larger network of networks. Inter-networking, or the Internet for short, has collaboration baked into it.

Because networks do not stop at political boundaries, regional networks, designed and developed specifically to connect multiple local government and political sub-divisions (e.g. towns, cities, counties) have much greater utility than networks isolated to a single political entity.

While many Federal and state funding opportunities are disbursed to a single locality, many grant programs will rank multi-jurisdictional grant applications higher than single locality applications, precisely because of the recognition that a wide area network can more effectively leverage grant funds.

Regional collaboration can take many forms:

- Public/private partnerships with ISPs and WISPS that offer service in more than one county in the New North region.
- Collaboration on shared meet-me points and collocation facilities to help lower costs for private sector service providers.
- Shared infrastructure, including networks of fixed point wireless towers, shared conduit and fiber middle mile routes, and other telecom facilities.
- Regional digital literacy and training programs for low and moderate income families and the elderly.
- Shared procurement of certain kinds of computing equipment (e.g. laptops, tablets, desktop computers, etc.) that can lower the cost of those items to individual localities.

Recommendation: The local governments continue to work with New North (thenewnorth.com) to provide a long term regional broadband strategy.

2 ASSET ASSESSMENT

A wide variety of assets in Waupaca County are identified in the following pages.

The included maps provide detail on the following:

Points of Interest – This information is used to identify key users of Internet services that could benefit from improved broadband infrastructure in the county. K12 schools, public safety facilities, fire and rescue locations, health facilities, and county facilities are included.

LMI/HUD Areas – Low and Moderate Income (LMI) and HUD-eligible areas often qualify for certain kinds of grants not available to other areas.

Towers – Of particular importance are towers, which can be divided approximately into two categories: publicly owned towers and privately owned towers. As a general rule, WISPs (Wireless Internet Service Providers) have found that the lease fees to obtain space on cellular towers is too high to justify the expected revenue from broadband Internet customers in the area around that tower. To improve broadband Internet coverage in rural areas of the county, some new towers are going to be needed, with very modest lease fees–to attract WISPs onto those towers.

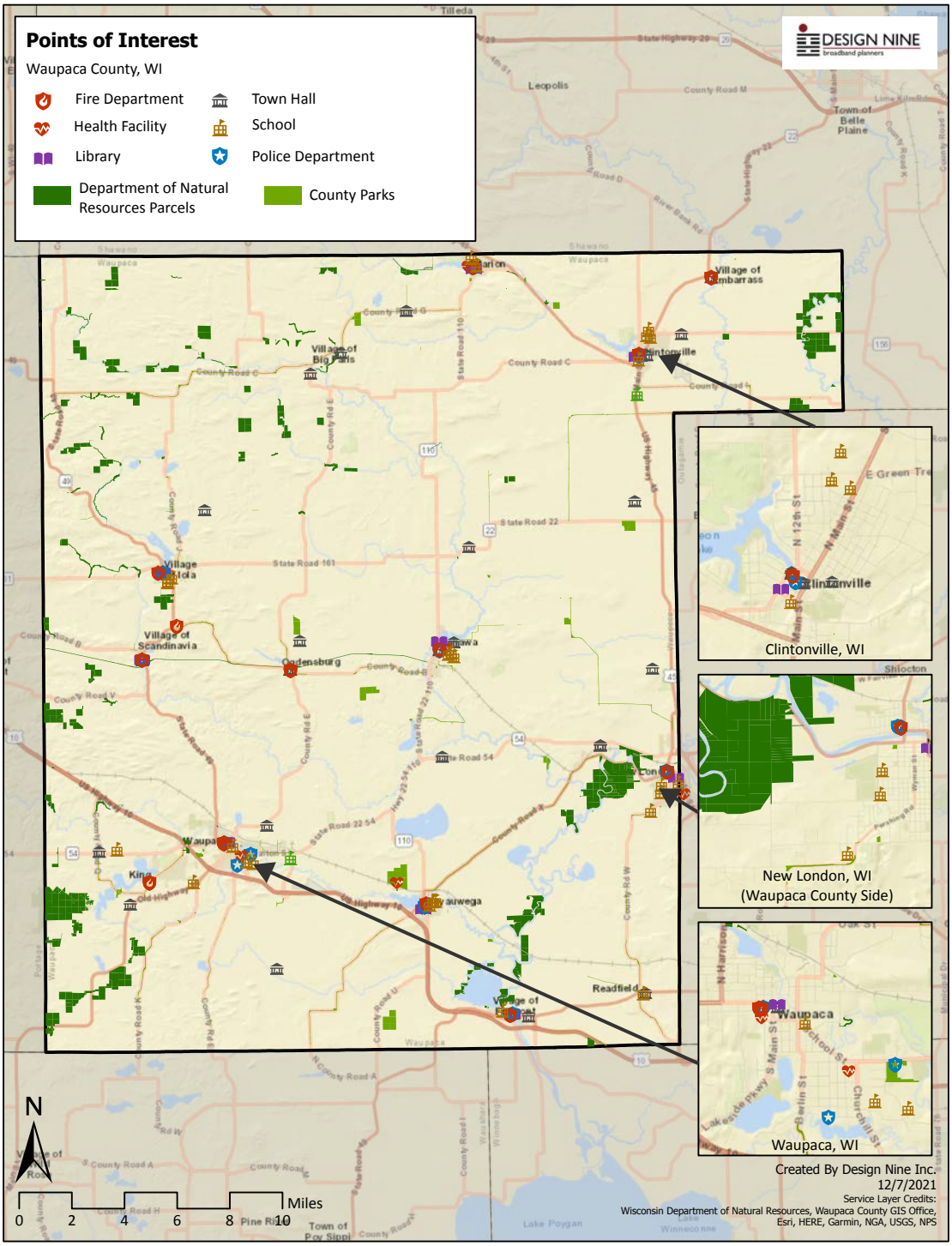
Fiber Routes – In most areas of the county, fiber routes are typically long haul routes passing through the county to other major metro areas and/or connecting only a few institutional and enterprise customers.

Service Levels – This map illustrates information on served, underserved, and unserved areas in the county obtained from FCC 477 reports. The data is self-reported by the service providers.

Wireless and Wireline Coverage in the County – This data has been developed using data provided to the state of Wisconsin and the FCC by the cellular carriers, incumbents, WISPs, and ISPs.

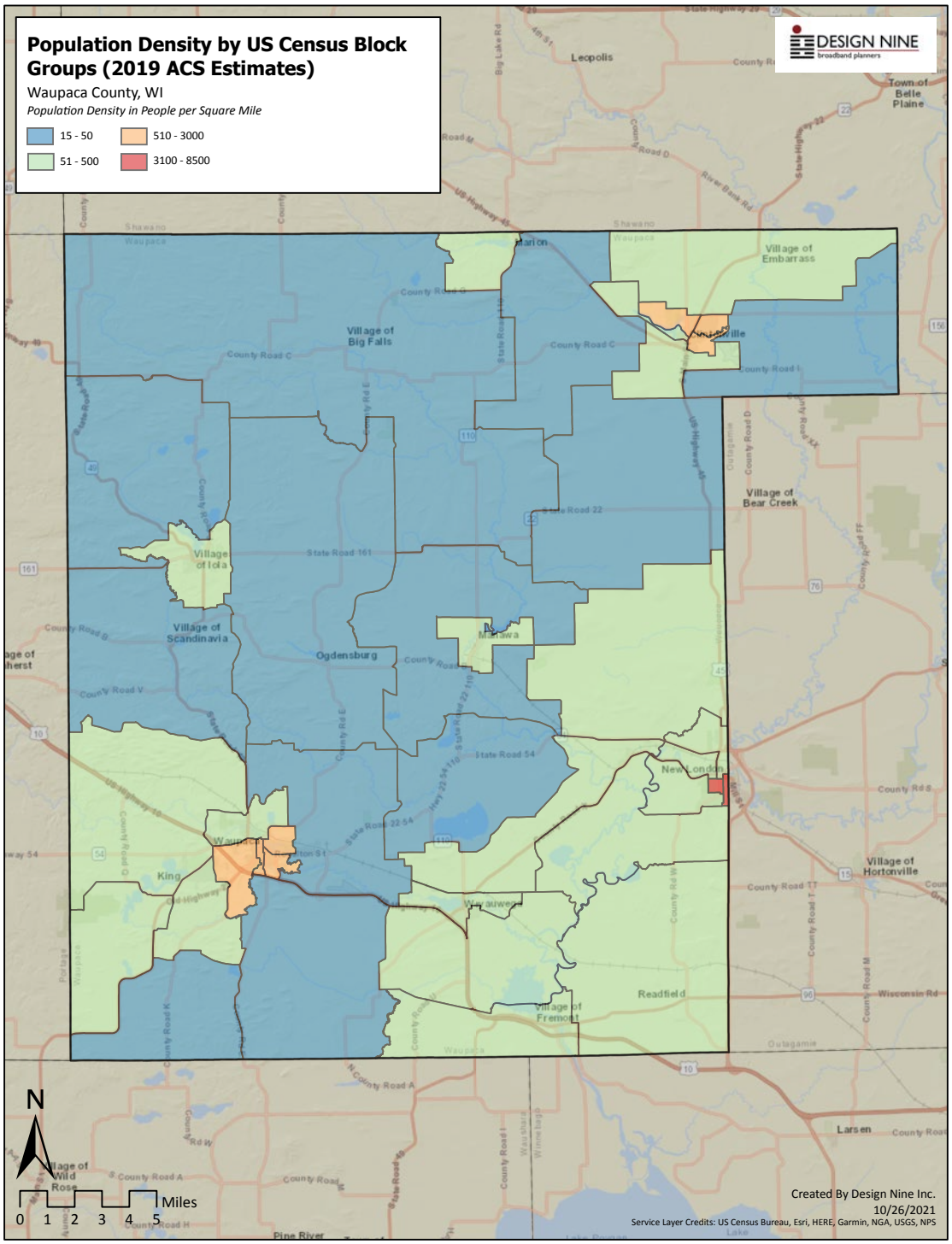
2.1 POINTS OF INTEREST

County facilities, municipal facilities, libraries, K12 and higher education facilities, fire and rescue stations, and public safety locations are all candidates to be anchor tenants for fixed point wireless and/or fiber services.



2.2 POPULATION AND DENSITY DISTRIBUTION

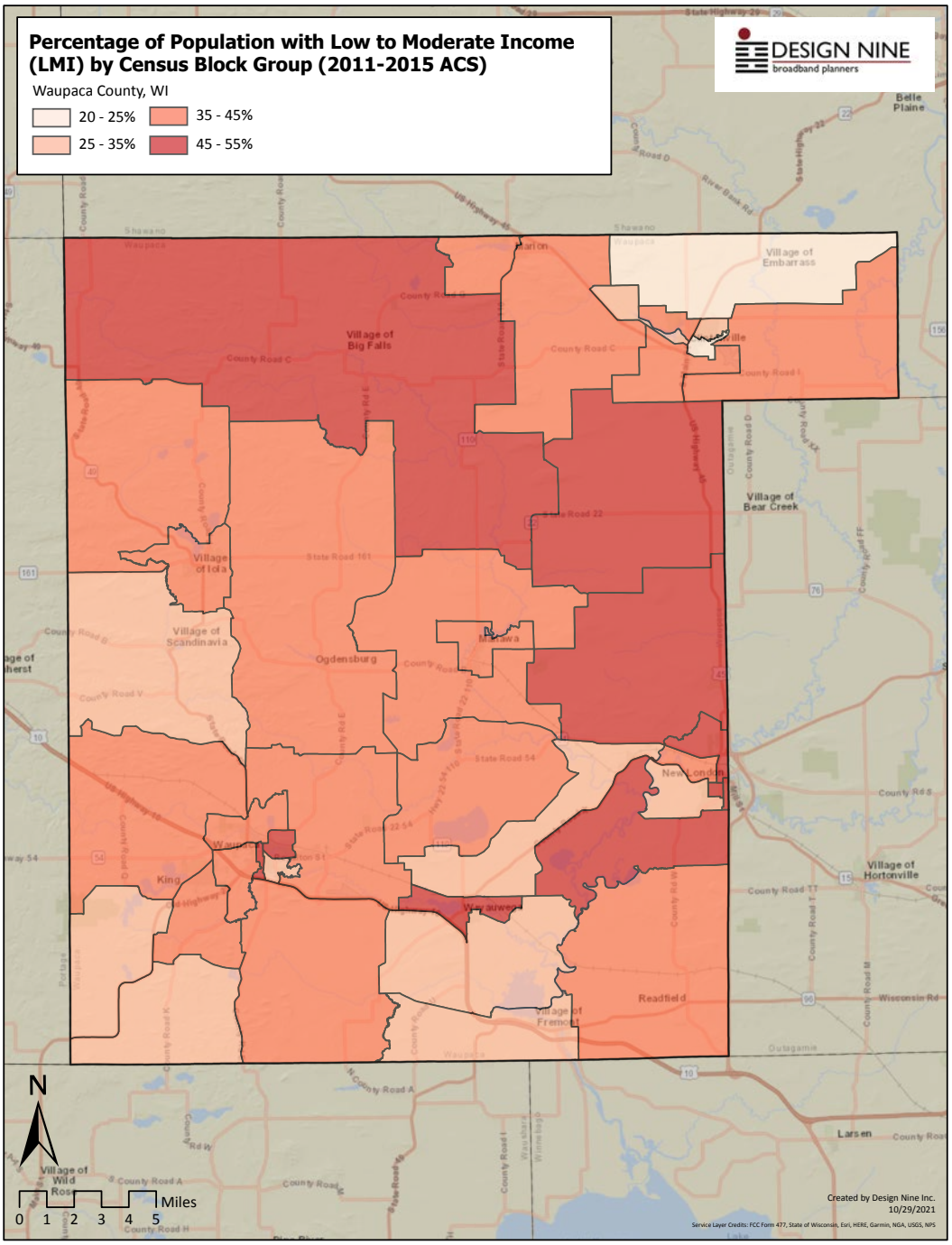
This map shows the population and density distribution in the county, by census block. This information can be helpful when working with service providers and when trying to identify what technologies are most appropriate for various areas of the county.

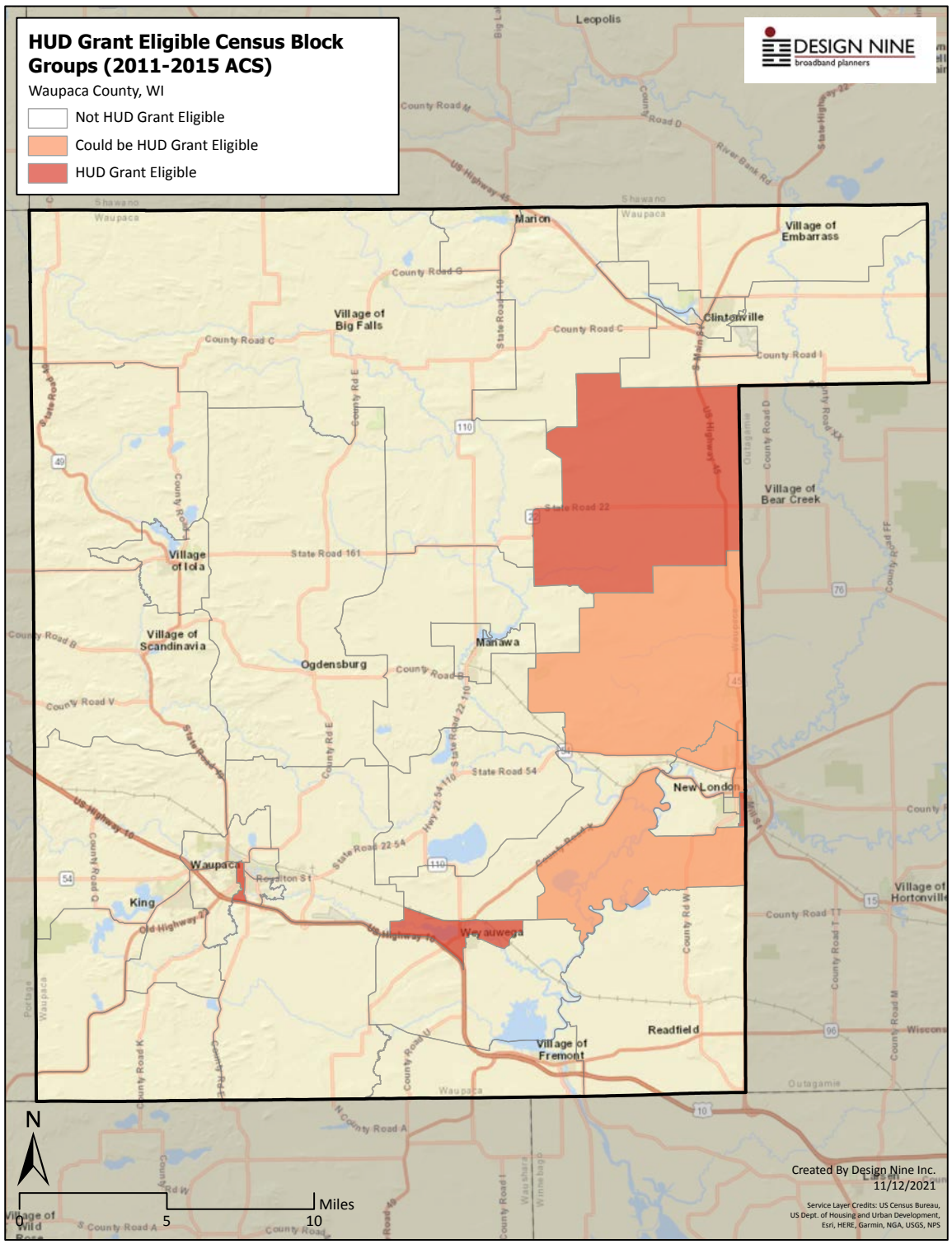


2.3 LMI AND HUD ELIGIBLE AREAS

HUD-eligible areas are determined by LMI (Low and Moderate Income) statistics—but can be different from census blocks in the county that meet LMI thresholds.

HUD-eligible census blocks can qualify for CDBG funding for telecom infrastructure projects.




HUD Grant Eligible Census Block Groups (2011-2015 ACS)
Waupaca County, WI
Not HUD Grant Eligible
Could be HUD Grant Eligible
HUD Grant Eligible
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broadband planners
Leopolis
Marion
Village of Embarrass
Village of Big Falls
Clintonville
Village of Bear Creek
Village of Iola
Village of Scandinavia
Ogdensburg
Manawa
New London
Waupaca
King
Weyauwega
Village of Fremont
Readfield
Village of Hortonville
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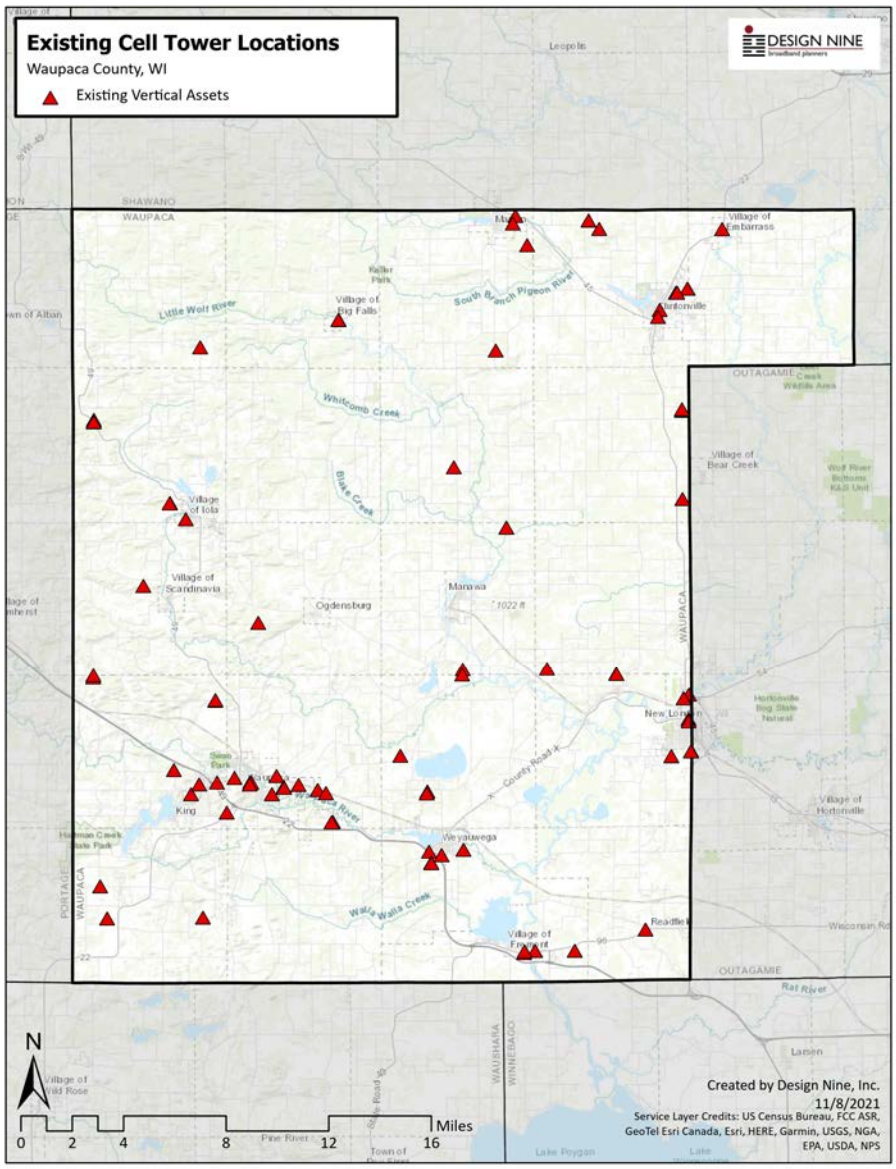
Service Layer Credits: US Census Bureau, US Dept. of Housing and Urban Development, Esri, HERE, Garmin, NGA, USGS, NPS

2.4 TOWERS IN THE COUNTY

A variety of publicly-owned and privately owned towers are shown here. Tower data is collected from an FCC database, County data, and other publicly available sources. The FCC database usually includes most towers that are in a locality, and generally includes all or nearly all cellular towers. Tower ownership data is not always updated in a timely manner in the FCC database.



Towers can be divided approximately into two categories: publicly owned towers and privately owned towers. Publicly owned towers can be owned by local government, by regional authorities, or by the state. In the county, privately owned cellular towers are the most common type of tower, and are generally clustered along major roadways and higher density population areas.

Many commercial towers, especially cellular towers, may have tower lease fees that are too high for a WISP (Wireless Internet Service Provider) to make a business case for putting fixed point broadband equipment on the tower. The cost to a WISP for getting on a privately owned tower often has to be checked on a case by case (tower by tower) basis.

To improve broadband Internet coverage in rural areas of the county, some new towers are going to be needed, with very modest lease fees—to attract WISPs onto those towers.

A second consideration for placing WISP equipment on a cellular tower is where space is available –that is, at what height? Space may be available at an affordable price, but the location on the tower may not be high enough to cover an area large enough for a decent number of customers.

This table below lists towers in the county, using data contained in the FCC database and other sources.

FCC Registration Number	Tower Owner	Height	Street Address	Latitude	Longitude
1206045	WAUPACA, COUNTY OF	76.2	100 Main St, Freemont Wi, 54940	44.2608	-88.8615
1241908	WAUPACA, CITY OF	11	Waaupaca Municipal Airport, Waupaca Wi, 54981	44.3343	-89.0208
1247322	WAUPACA, CITY OF	11	Waupaca Municipal Airport, Waupaca Wi, 54981	44.3343	-89.0208
1247321	WAUPACA, CITY OF	12.2	Waupaca Municipal Airport (Brunner Field), Waupaca Wi, 54981	44.3344	-89.0197
1206046	WAUPACA, COUNTY OF	77.7	1402 E. Royalton St, Waupaca Wi, 54981	44.3503	-89.0676
1276988	WISCONSIN CENTRAL	71.3	Half Mile West Of Hwy 110 On White Lake Rd, Weyauwega Wi, 54983	44.3503	-88.9458
1050115	WISCONSIN ELECTRIC POWER COMPANY	97.5	Scandinavia, Scandinavia Wi, 54977	44.4181	-89.2078
1206044	WAUPACA, COUNTY OF	97.5	Lw 324 Hillside Rd, Manawa Wi, 54949	44.5008	-88.8818
1038767	BRUCE GRASSMAN	55.5	Twr 1 - Deer Creek Rd 1.2 Km E Of Hwy 45, Clintonville Wi, 54929	44.5667	-88.7425
1038768	BRUCE GRASSMAN	55.5	Twr 2 - Deer Creek Rd 1.2 Km E Of Hwy 45, Clintonville Wi, 54929	44.5667	-88.7425
1038769	BRUCE GRASSMAN	102	Twr 3 - Deer Creek Rd 1.2 Km E Of Hwy 45, Clintonville Wi, 54929	44.5667	-88.7425
1305797	BRT GROUP	60.7	401 Jefferson St / Us-Wi-5245, Fremont Wi, 54940	44.2596	-88.8701
1270753	WAUPACA COUNTY	82.3	Nw Of Intersection Of Jefferson & Fillmore Sts, Fremont Wi, 54940	44.2606	-88.8697
1256658	UNITED STATES CELLULAR CORPORATION	60.6	E7901 Hwy 96, Fremont Wi, 54940	44.2607	-88.8303
1227404	SBA STRUCTURES	60.6	Highway 10, Readfield Wi, 54940	44.2724	-88.7746
1258261	VB-S1 ASSETS	60.7	Suhs Rd, Waupaca, Wi, Waupaca Wi, 54981	44.2803	-89.1975
1268184	TV6 HOLDINGS	58.8	N1027 East Rd. (Wi17222-A), Dayton Wi, 54981	44.2806	-89.1222
1263833	MADDAM AERIALS CORP	82.3	Stratton Lake Rd, Wild Rose Wi, 54981	44.2985	-89.2029
1061798	CENTURYTEL OF THE MIDWEST-WISCONSIN	32.9	1997 Anklam Rd, Weyauwega Wi, 54983	44.3108	-88.9425
1034491	AIRADIGM COMMUNICATIONS	33.5	711 S. Mill St, Weyauwega Wi, 54983	44.3153	-88.9344
1231180	SBA STRUCTURES	74.7	721 E. Alfrewd St, Weyauwega Wi, 54983	44.3183	-88.9172

FCC Registration Number	Tower Owner	Height	Street Address	Latitude	Longitude
1231180	UNITED STATES CELLULAR OPERATING COMPANY LLC	71.6	721 E. Alfred Street, Weyauwega WI	44.3183	-88.9172
1296846	UNITED STATES CELLULAR CORPORATION	57.9	N2770 Hill St, Waupaca Wi, 54981	44.3400	-89.1032
1300761	WISCONSIN CENTRAL	20	.2 Mi Se Of Int Hwy 22 And Wc Rail Crossing, Weyauwega Wi, 54981	44.3508	-89.0251
1245562	WISCONSIN CENTRAL SYSTEM	54.8	White Lake Rd West Of Hwy 110, Weyauwega Wi	44.3514	-88.9453
1298936	WISCONSIN CENTRAL	20	Entering 1830 .13 Mile Nw Of Intersection Hwy22 And Rail Crossing, Waupaca Wi, 54981	44.3526	-89.0316
1035450	LAIRD BROADCASTING COMPANY	81.4	Twr 2 200 Tower Rd Off Hwy 54, Waupaca Wi, 54981	44.3539	-89.0581
1035449	LAIRD BROADCASTING COMPANY	81.4	Twr 2 - 200 Tower Rd, Off Hwy 54, Waupaca Wi, 54981	44.3542	-89.0581
1298937	WISCONSIN CENTRAL	20	Entering 21910 215Ft W Of Intersection Industrial Dr And Rail Crossing, Waupaca Wi, 54981	44.3555	-89.0466
1221417	SBA STRUCTURES	60.7	Highway 10, Waupuca Wi, 54981	44.3560	-89.1248
1249720	SBA TOWERS	61	250 Bailey St (Wi11418-A), Waupaca Wi, 54981	44.3596	-89.0970
1036871	CHARTER VIDEO ELECTRONICS	60.9	1625 Shambeau Rd, Waupaca Wi, 54981	44.3606	-89.0639
1007862	UNITED STATES CELLULAR OPERATING COMPANY LLC	106.7	NORTH OF INTERSECTION OF ERICKSON ROAD & BUTTS DRIVE, WAUPACA WI	44.3641	-89.1448
1007862	UNITED STATES CELLULAR CORPORATION	106.7	N Of Int Erickson Rd & Butts Dr, Waupaca Wi, 54981	44.3642	-89.1447
1256518	VB-S1 ASSETS	60.7	West Beckert Rd, New London Wi, 54961	44.3704	-88.7532
1286350	SBA TOWERS	60.7	E5231 State Hwy 54 (Wi15195-B), Weyauwega Wi, 54983	44.3717	-88.9664
1239714	ANR PIPELINE COMPANY	128	.4 Miles South Of (Waupaca County), New London Wi, 54961	44.3730	-88.7377
1042521	ANR PIPELINE COMPANY	91.5	0.5 Km S, New London Wi, 54961	44.3733	-88.7375
1035028	SUBCARRIER COMMUNICATIONS	90.2	Nelson Rd 3.1 Mi Nw, Waupaca Wi, 54981	44.4037	-89.1118

FCC Registration Number	Tower Owner	Height	Street Address	Latitude	Longitude
1222228	SPECTRASITE COMMUNICATIONS	112.8	Henry St, New London Wi, 54961	44.4052	-88.7389
1033895	LAKE MOBILITY	127.4	Sheridan Site: E402 Grenlie Rd, Waupaca Wi, 54981	44.4168	-89.2079
1034836	Lake Mobility LLC	121.9	N4935 TANK RD (103662), NEW LONDON WI	44.4172	-88.7958
1034836	MADDAM AERIALS CORP	128	N4936 Tank Rd, New London Wi, 54961	44.4174	-88.7960
1103482	UNITED STATES CELLULAR OPERATING COMPANY LLC	155.4	1 MI N OF HWY 54 IN; TOWN OF UNION, 3 MI S MANAWA WI 9.0 MILES NORTHEAST OF, WAUPACA WI	44.4175	-88.9176
1034826	AMERICAN TOWER	152.1	E6200 Bear Lake Rd, New London Wi, 54961	44.4175	-88.9173
1285127	LAKE MOBILITY	61	E7401 Stage Rd, New London Wi, 54961	44.4206	-88.8505
1285127	Lake Mobility LLC	59.7	E7401 Stage Road (158163), New London WI	44.4206	-88.8505
1037866	AMERICAN TOWER	79	640' N Of Poverty Hill Sec 20, Ogdensburg Wi, 54962	44.4478	-89.0778
1280027	WISCONSIN DEPT OF TRANSPORTATION	97.5	E1293 Nottleston Rd, Scandanavia Wi, 54977	44.4689	-89.1682
1252286	VB-S1 ASSETS	60.6	West Iola St, Iola Wi, 54945	44.5065	-89.1346
1055623	LAKE MOBILITY	83.2	E1649 Johnson Rd (Iola), Iola Wi, 54945	44.5155	-89.1472
1055623	Lake Mobility LLC	76.2	E1649 Johnson Road (158151), IOLA WI	44.5155	-89.1473
1055623	UNITED STATES CELLULAR OPERATING COMPANY LLC	82.3	IOLA CELL SITE, IOLA WI	44.5156	-89.1475
1247310	Lake Mobility LLC	54.9	E9655 Blueberry Road (158147), Bear Creek WI	44.5162	-88.7427
1247310	LAKE MOBILITY	60.3	E9577 Blueberry Rd(Bear Creek), Bear Creek Wi, 54922	44.5162	-88.7427
1256309	VB-S1 ASSETS	60.7	1.8 Miles Nw Of Symco, Wi, Sycmo Wi, 54949	44.5351	-88.9229
1257390	VB-S1 ASSETS	60.7	N8873 Highway 49, Iloa, Wi, Northland Wi, 54945	44.5616	-89.2071
1055584	UNITED STATES CELLULAR CORPORATION	105.2	Hwy 49 North, Iola Wi, 54945	44.5628	-89.2069

FCC Registration Number	Tower Owner	Height	Street Address	Latitude	Longitude
0	UNITED STATES CELLULAR OPERATING COMPANY LLC	45.4	8 miles SW of, Clintonville WI	44.5694	-88.8779
1036138	AMERICAN TOWER	99	N 9998 Quarterline Rd. (Marion 88001), Marion Wi, 54950	44.6009	-88.8892
1268530	WAUPACA, COUNTY OF	54.8	Near Waupaca County Rds C & J 4.25 Miles Ne Of Northland Wi, Northland Wi, 54945	44.6036	-89.1227
1256710	VB-S1 ASSETS	97.5	Highway G And Ankien Rd, Big Falls Wi, 54486	44.6187	-89.0134
1258316	LAKE MOBILITY	48.5	Memorial Circle (Clintonville Dt - 196425553), Clintonville Wi, 54929	44.6192	-88.7608
1258316	Lake Mobility LLC	46.9	10A Memorial Circle (158157), Clintonville WI	44.6192	-88.7608
1283286	CHARTER CABLE PARTNERS	42.6	100 Industrial Court, Clintonville Wi	44.6328	-88.7455
1249686	VB-S1 ASSETS	50.3	396 Enterprise Ave., Clintonville, Wi, Clintonville Wi, 54929	44.6350	-88.7374
1272163	WAUPACA, COUNTY OF	85.3	Shauger Rd, 1.44 Miles Southeast Of Marion, Marion Wi, 54950	44.6603	-88.8638
1273693	HORVATH TOWERS	58	Corner Of Church & Bellevue (Hv483 - Embarrass Village), Clintonville Wi, 54933	44.6685	-88.7095
1061360	NORTHWAY COMMUNICATIONS	60.6	N11886 Conradt Rd, Clintonville Wi, 54929	44.6692	-88.8067
1260869	AMERICAN TOWER	97.5	111 Slaughterhouse Rd, Marion Wi, 54950	44.6726	-88.8750
1033897	LAKE MOBILITY	104.5	N11984 Graetz Rd (Clintonville - 120009835), Marion Wi, 54929	44.6740	-88.8151
1033897	Lake Mobility LLC	103.3	N 1384 Graetz Road (158150), MARION WI	44.6740	-88.8151
1261479	WISCONSIN RSA #7 LIMITED PARTNERSHIP DBA ALLTEL	60.6	E7022 Highway 45 (Marion Repeater - 196502597), Marion Wi, 54950	44.6769	-88.8729

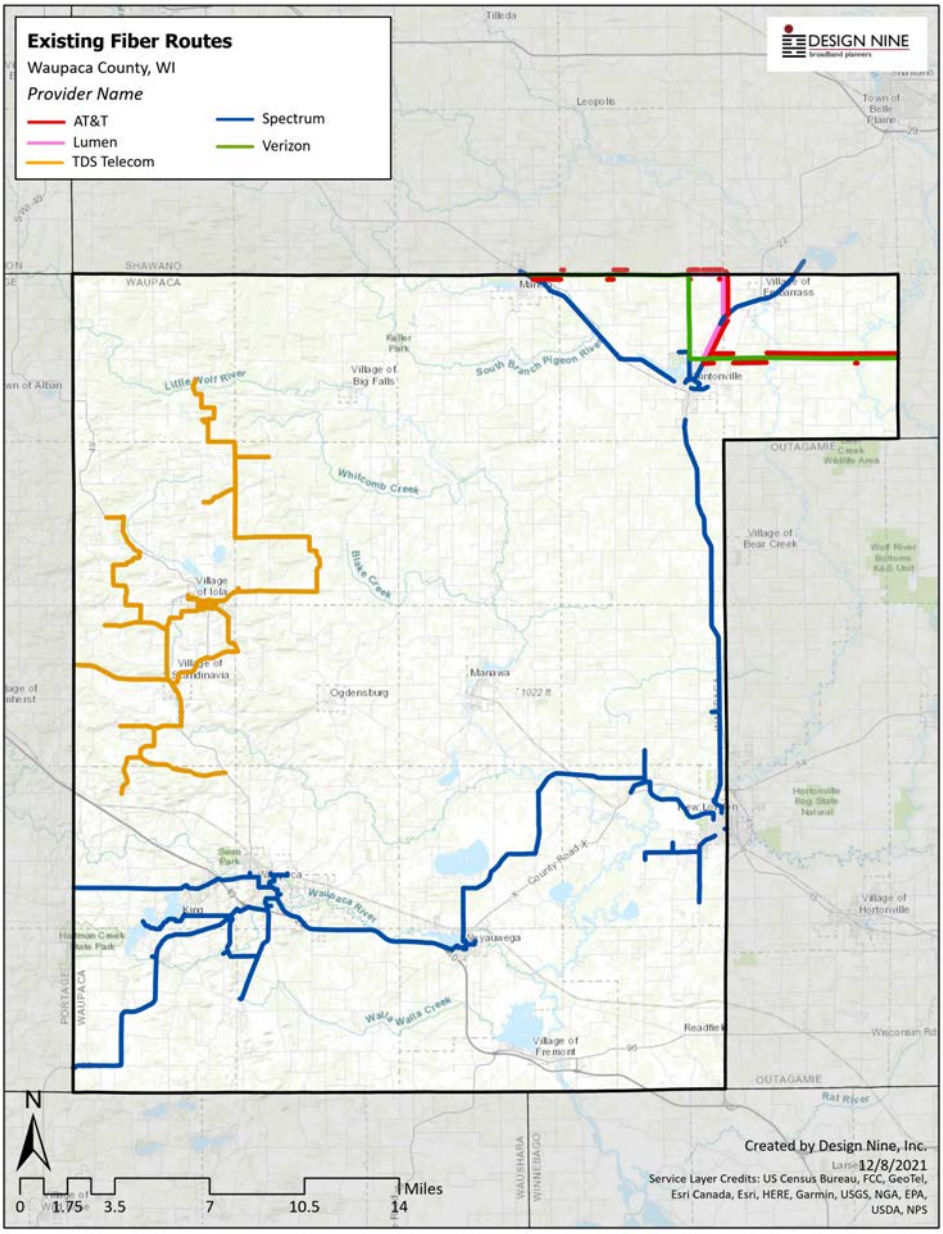
2.5 FIBER ROUTES IN THE COUNTY

Fiber route data is compiled from publicly available sources. Some telecom providers do not share their route data.

Most fiber routes, not only in the county but throughout the country have been designed as long haul point to point fiber routes between population centers. This means that even if a fiber cable passes down a rural road or a residential area, it has not been designed for residential or small business fiber to the premises.

Most of the existing fiber in the county is incumbent fiber, and is usually reserved by the companies to support their DSL or cable Internet networks.

Large areas of the county have no long haul or third party fiber availability, which creates a challenge for local and regional WISPs (wireless Internet providers) who need affordable transport and Internet backhaul fees.



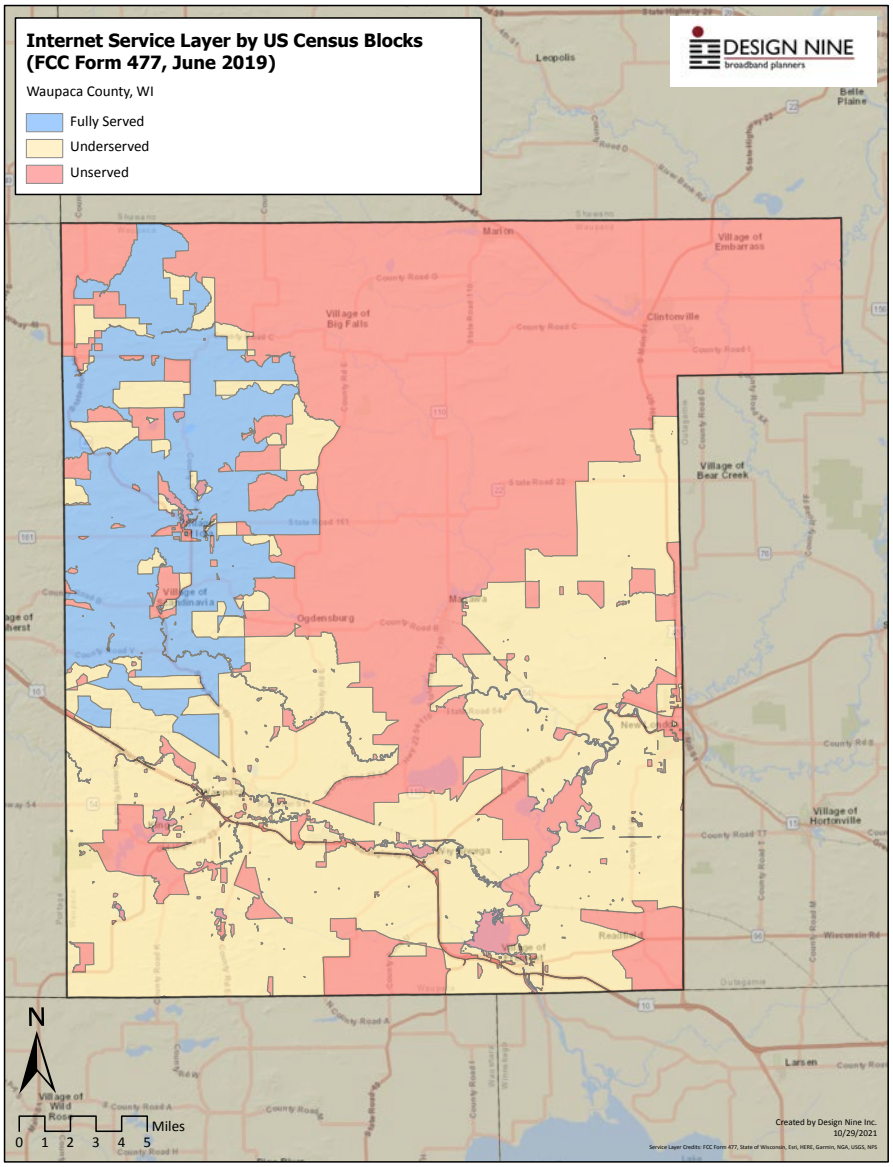
2.6 SERVED, UNDERSERVED, AND UNSERVED AREAS

The areas on the map below have been identified using FCC (Federal Communications Commission) 477 data. The map also shows the three areas (outlined in red) where fiber pilot studies were done as part of this work (see Section 7). Service providers, including incumbent telephone and cable companies, file a 477 report with the FCC to identify where their service is available and at what speed, using the FCC designations :

Unserved – Less than 10 Megabits down/1 Megabit up

Underserved – At least 10 Megabits down/ 1 Megabit up and less than 25 Megabits down/ 3 Megabits up

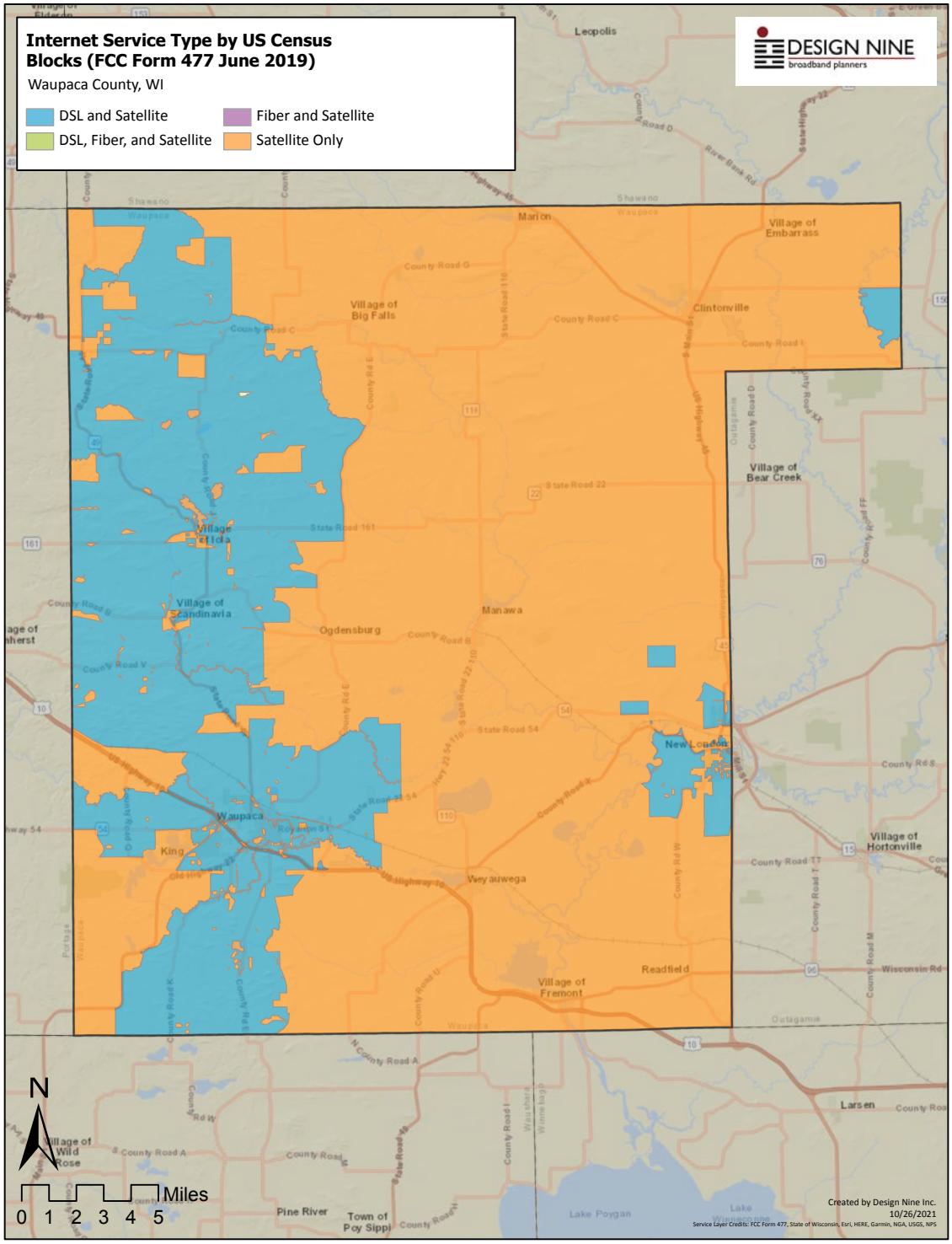
Served – Equal to or better than 25 Megabits down / 3 Megabits up



There are two problems with the 477 data:

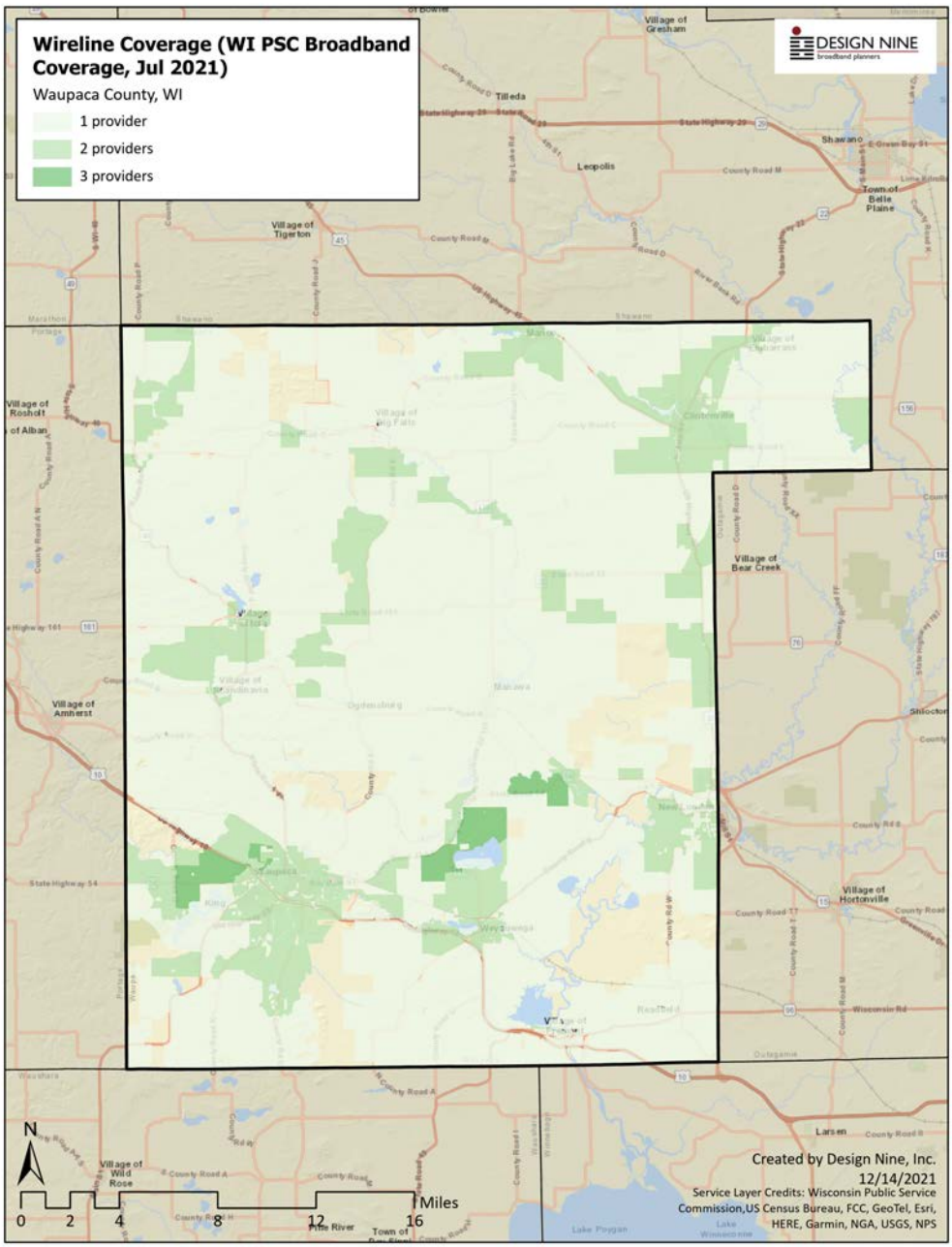
- The data is self-reported by the providers, who typically report their most optimistic Internet speeds. In practice, customers may not always get the reported speeds.
- A single customer receiving service in a census block means that the provider can indicate that the entire census block is counted. So if one household receives 25/3 service, all households in that census block are counted as receiving that level of service.

While the FCC data indicates that the entire county is fully served, there is wide variance in the kind and type of service available to households in the county. Fixed point wireless Internet is widely available, and in most areas with wireless service, DSL is also available.



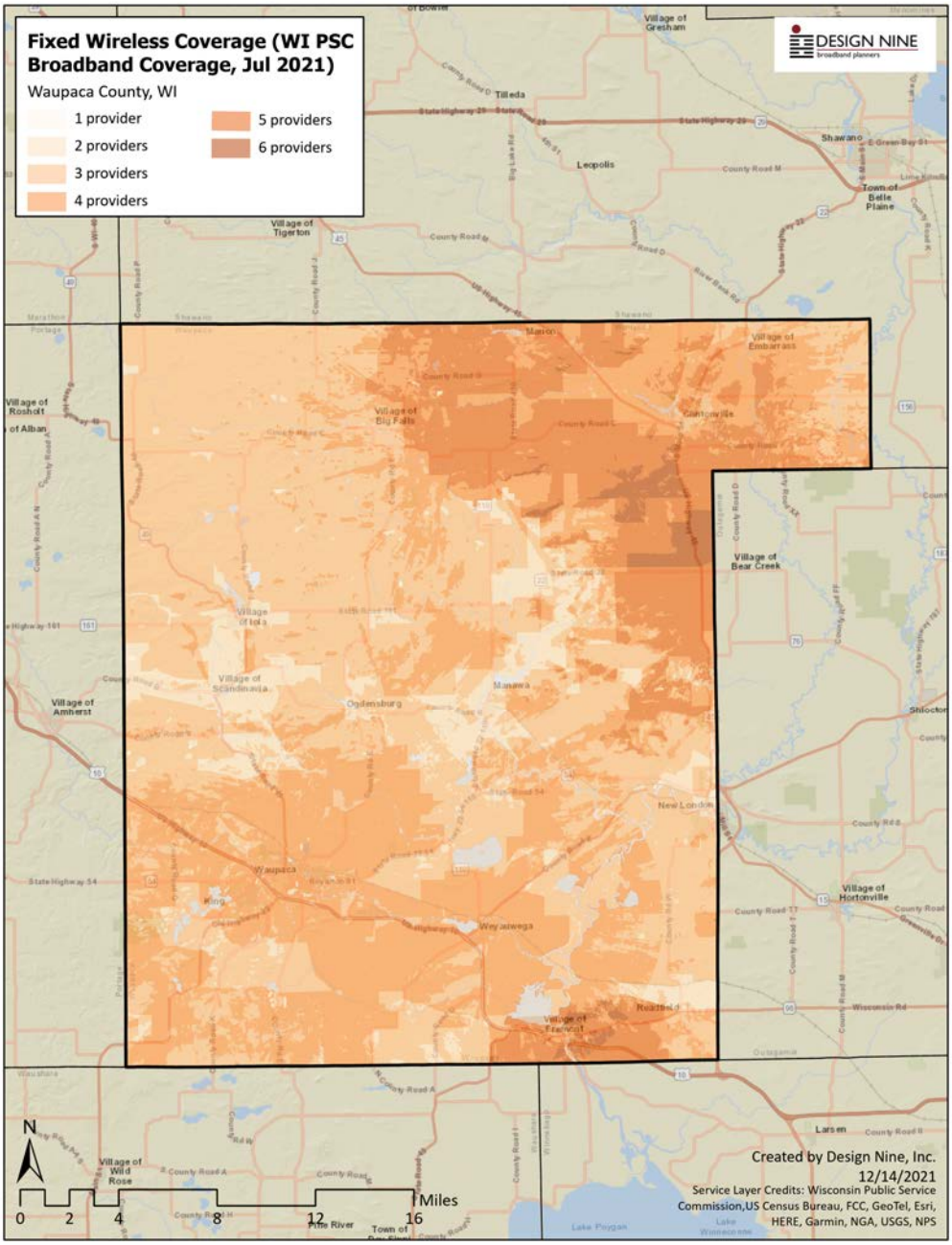
2.7 WIRELINE COVERAGE IN THE COUNTY

The map below shows estimated wireline coverage (i.e. fiber, cable Internet, DSL) in the county. The wireline providers are required to report their service area coverage to the state of Wisconsin on a regular basis. Some providers tend to be optimistic about both the areas they cover and the upload and download speeds they offer. These maps provide a snapshot of existing conditions, and some households and businesses may not be receiving the services as reported by the data collected by the state of Wisconsin.



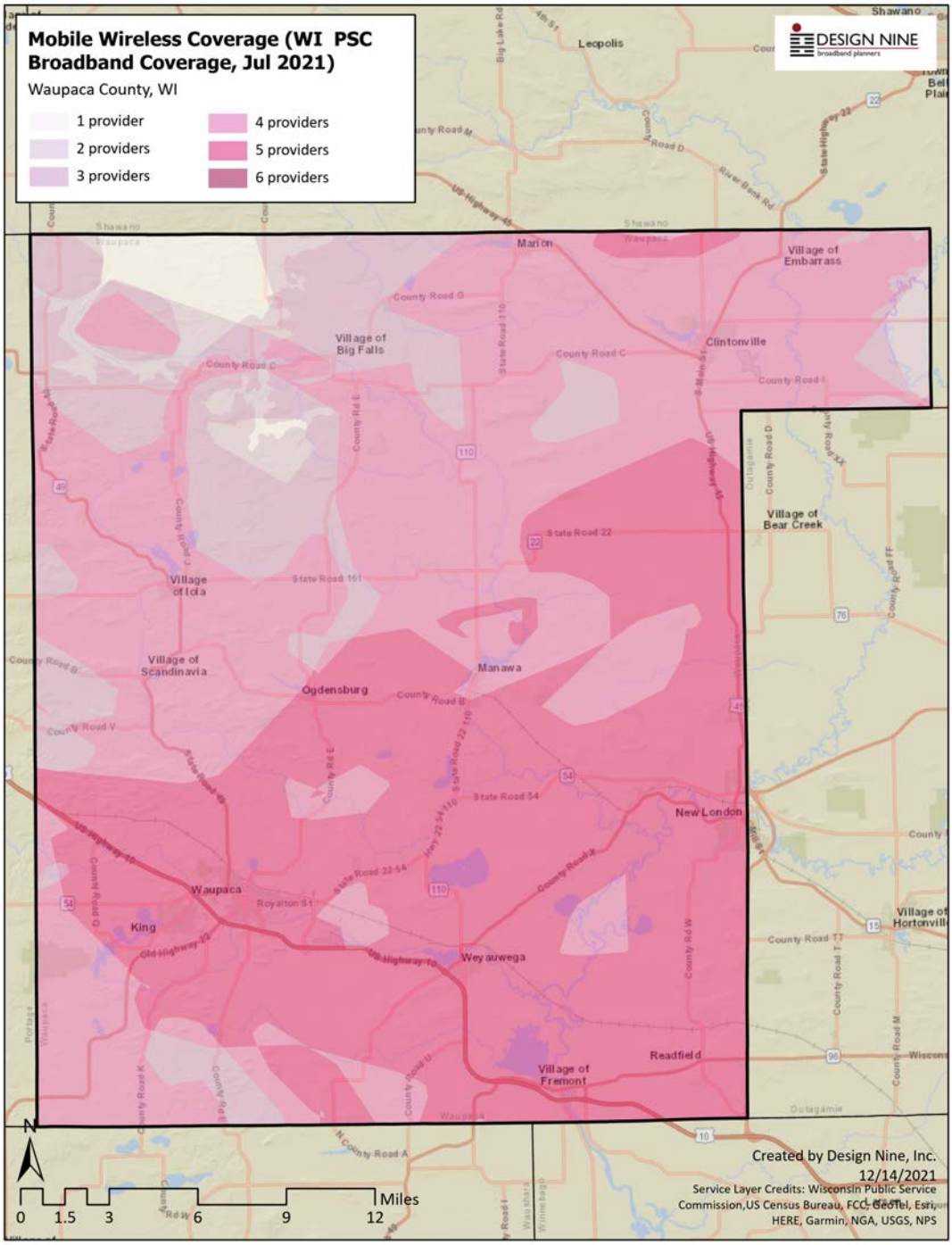
2.8 FIXED WIRELESS COVERAGE IN THE COUNTY

The map below shows estimated fixed point broadband wireless coverage in the county. The wireless providers are required to report their service area coverage to the state of Wisconsin on a regular basis. Some providers tend to be optimistic about both the areas they cover and the upload and download speeds they offer. These maps provide a snapshot of existing conditions, and some households and businesses may not be receiving the services as reported by the data collected by the state of Wisconsin.



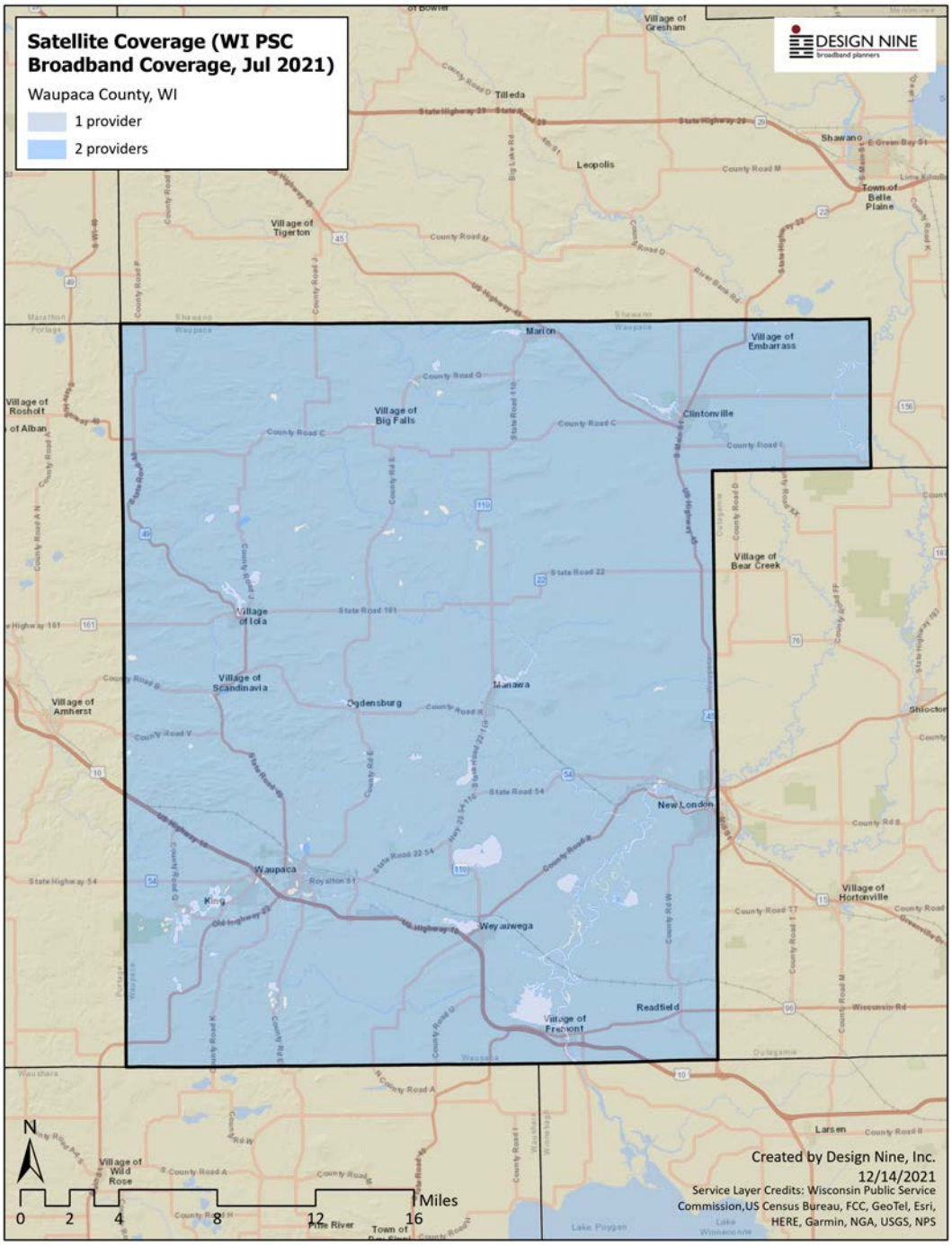
2.9 MOBILE WIRELESS COVERAGE IN THE COUNTY

The map below shows estimated mobile (i.e.cellular providers) broadband wireless coverage in the county. The cellular providers are required to report their service area coverage to the state of Wisconsin on a regular basis.



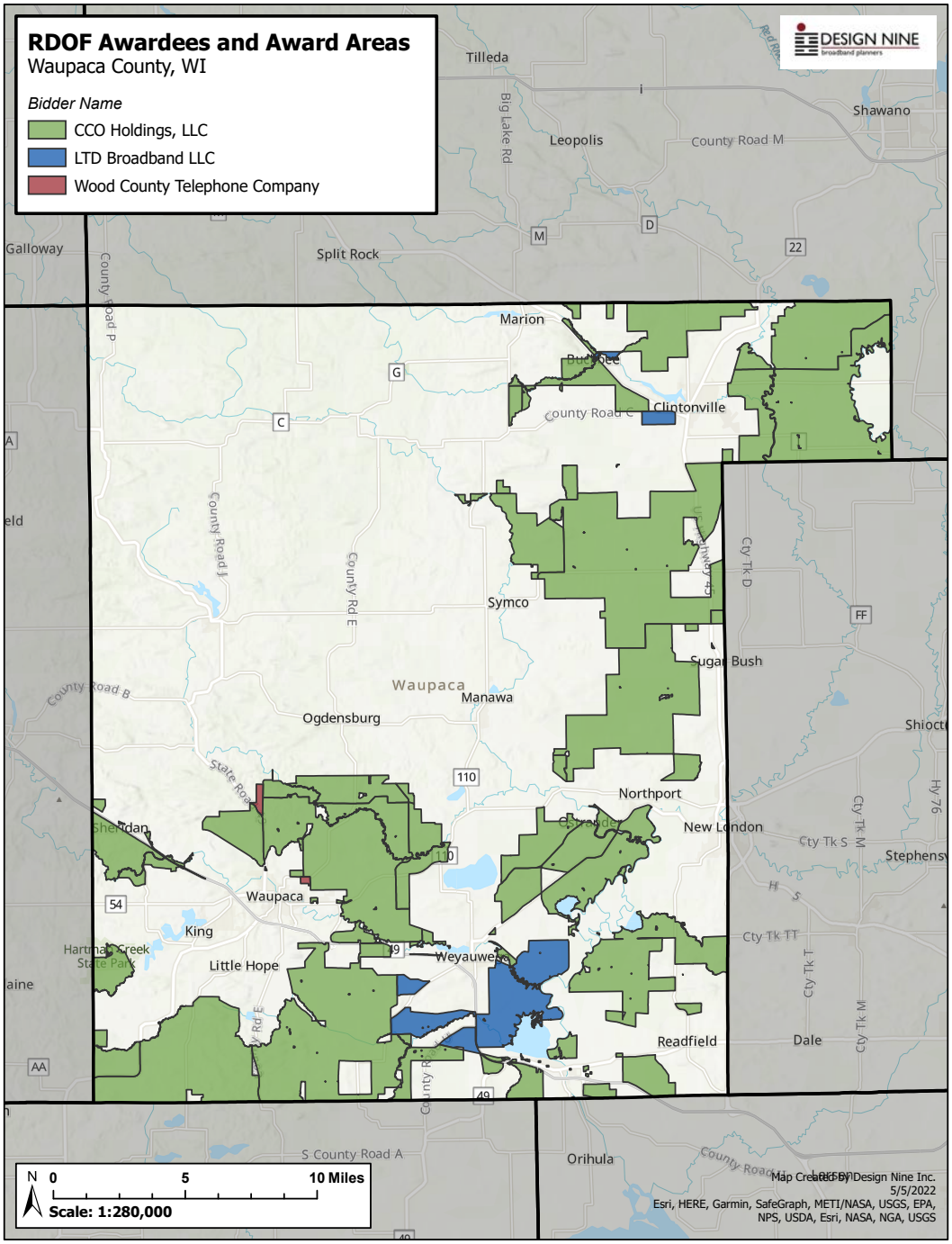
2.10 SATELLITE BROADBAND COVERAGE IN THE COUNTY

The map below shows satellite broadband coverage in the county. Satellite Internet service is generally available everywhere in the continental U.S. HughesNet and Viasat are the two most common geosynchronous satellite broadband providers. Starlink is the only LEO (Low Earth Orbit) broadband provider offering service.



2.11 RDOF AWARD AREAS

CCO Holdings, LTD Broadband, and Wood County Telephone Company were granted RDOF auction funds to serve the areas show on the map below.



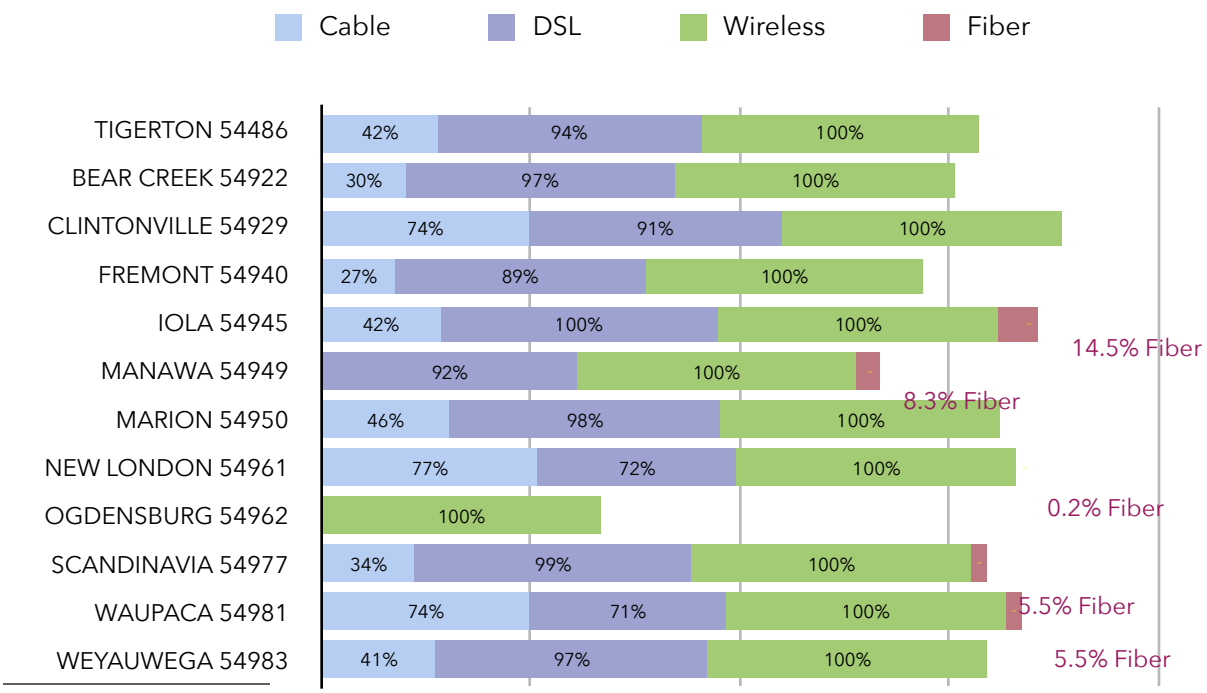
3 SERVICE PROVIDER ANALYSIS

In a February 2021, Consumer Reports Survey, 75% of Americans said they need uninterrupted access to the Internet seven days a week[1]. Pew Reach Center recently reported that during the pandemic, "connection quality has been important for school assignments, meetings and virtual social encounters alike. The new survey highlights difficulties for some: Roughly half of those who have a high-speed internet connection at home (48%) say they have problems with the speed, reliability or quality of their home connection often or sometimes."[2]

Nationally, Consumer Reports found in their Summer 2021 Broadband Survey, "Fifteen percent of American households only have access to the internet through their smartphone data plan and one in 20 use DSL or dial-up to access the internet. Three percent of Americans say their household does not have access to the internet."[3]

The first chart shows ***estimates*** of available broadband technology types in Waupaca County. Note that these estimates are aggregated from several commercial and public sources, and that providers are often very optimistic about their service areas. Additional information shows how much Waupaca County citizens pay for those services. Pricing information is often deliberately difficult to obtain because many providers do not want consumers doing comparison shopping. Real pricing is often hidden behind promotional pricing that is hard to decipher.

Estimates of available broadband technology type in the county



[1] Consumer Reports- Research Snapshot February 2021, The Importance of Broadband Internet

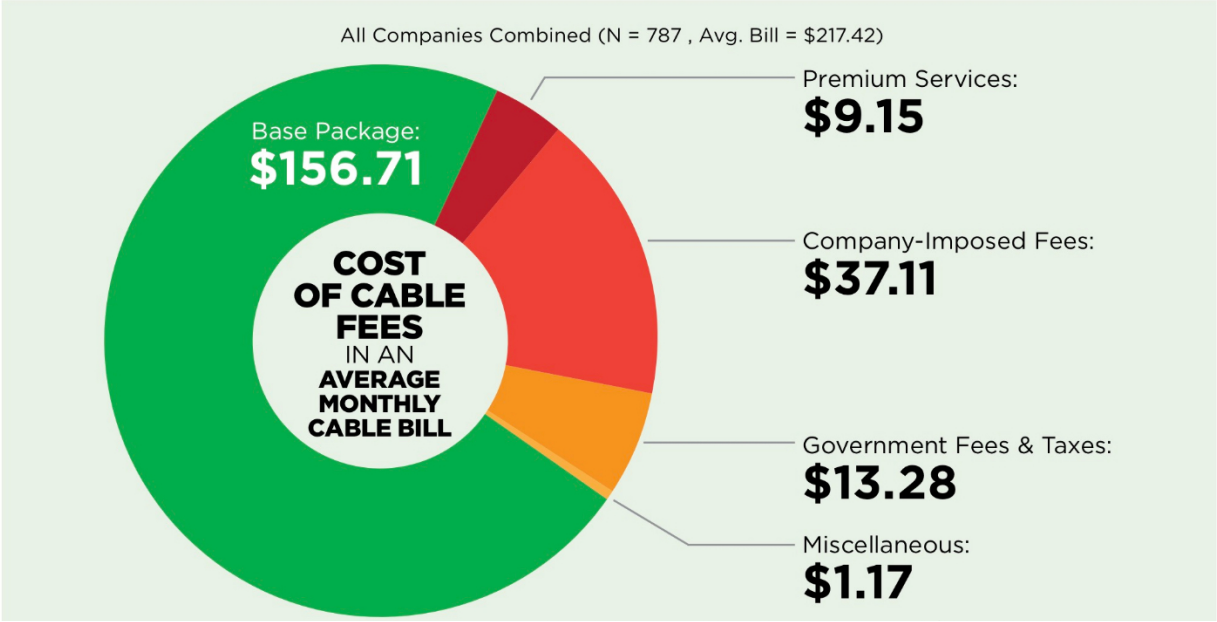
[2] The Internet and the Pandemic, Page 1 https://www.pewresearch.org/internet/2021/09/01/the-internet-and-the-pandemic/

[3] Broadband Survey, Consumer Reports, July 2021

Our data is assembled from several public sources that provide data on Internet use, including FCC data, data from social media, and commercial Web sites that provide Internet use data. Zip code boundaries are not aligned with local government jurisdictions, and some zip code data may include areas outside the county. The information in these charts and tables is current as of October 2021.

Percentages of customers receiving different kinds of service can change. Our pricing information includes all the service providers that have been discovered with services to 1% or more residents living in zip codes with at least 5% or more of their population in Waupaca County.

Figure A: Cost of Cable Fees in an Average Monthly Cable Bill (2018)



According to a 2019 Consumer Reports study[4], the national average advertised price for standard triple play services of Internet, television, and telephone across the country is $156.17. Because of fees and taxes, the actual national average bill is $217.42. Nationally, consumers get an average of 24% added to their bill. Data caps which were turned off early in the pandemic are back[5] and will increase prices for heavy users. Hidden fees are spreading across many broadband services.

It has become normal to find a statement such as this in fine print terms and conditions, "Equipment, installation, taxes and fees, including regulatory recovery fees, Broadcast TV Fee (up to $19.45/mo.), Regional Sports Fee (up to $14.45/mo.) and other applicable charges extra, and subject to change during and after the term agreement."[6] The Broadcast TV Fee was $14.95 a year ago. The Regional Sports Fee was $8.75 per month at the same time.

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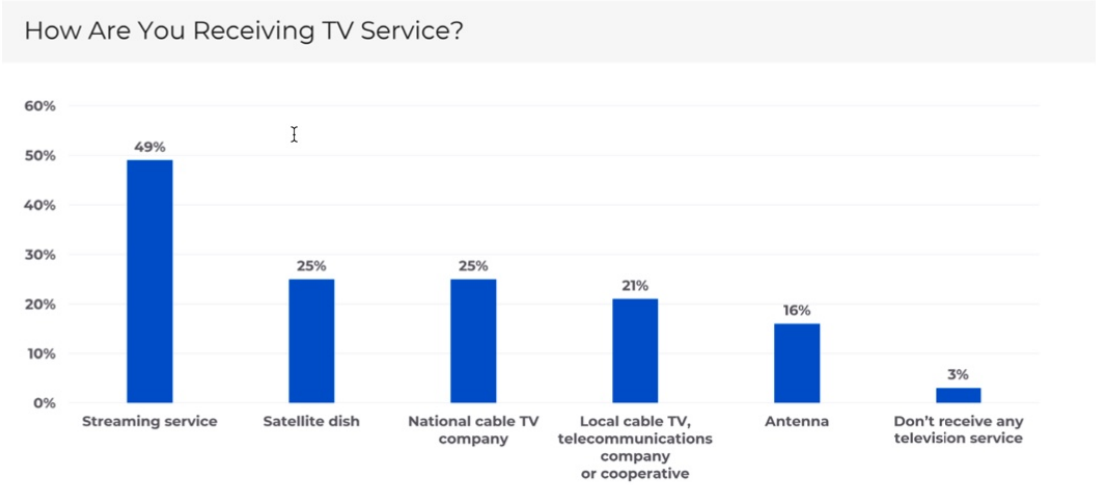
[4] Cord Cutting Continues, Fueled By High Cable Pricing, Consumer Reports' Survey Finds 9/17/2019

[5] Consumer Reports -Get Ready for Cable TV and Internet Price Hikes and Data Caps in the New Year 12/21/20

[6] Xfinity terms and conditions- Manitowoc County, WI, 10/21/21

"Nearly half (47 percent) of U.S. TV viewers state they do not subscribe to "traditional cable," and among those that do, 44 percent are planning to drop cable or cut back services over the next year."

This chart from Innovative Systems' study of rural broadband users[7] shows how streaming is becoming an important delivery mechanism even in rural areas. Streaming is just one of the factors that increases the demand for greater bandwidth across the full spectrum of broadband users.



- **Just about half of rural residents identify streaming as a source for video.**
- **DBS satellite accounts for 25% of rural TV subscribers, and another 25% subscribe to a national cable TV provider.**
- **Just about 1 in 5 households (21%) get TV from a local provider or cooperative.**
- **Local broadcast television via an antenna reaches 16% of rural residents.**

OpenVault recently reported in their Q3 Report on Broadband Insights that "was 434.9 GB up 13% over Q3 2020 and up slightly from Q2 2021. Year-over-year average monthly usage growth of 13% in 3Q21 versus 3Q20 confirms that there is no going back to pre-pandemic levels.[8]"

The Pandemic has also had a major impact on the amount of work done from home even in rural areas.[9] See chart on the next page.

Recent survey results presented by Kyle Rosner, Deputy Broadband Advisor for the Commonwealth of Virginia indicate that the number of people working from home (among those who can) has jumped from a pre-pandemic level of 20% to 71% who are currently working from home. Those who would like to work from home after the pandemic now standard at 54%.[10]

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[7] Rural Video and Broadband Industry Study - 2021, page 4, by Innovative Systems

[8] OpenVault, Broadband Insights Report (OVBI) 3Q21, page 4. Nove mber 20, 2021

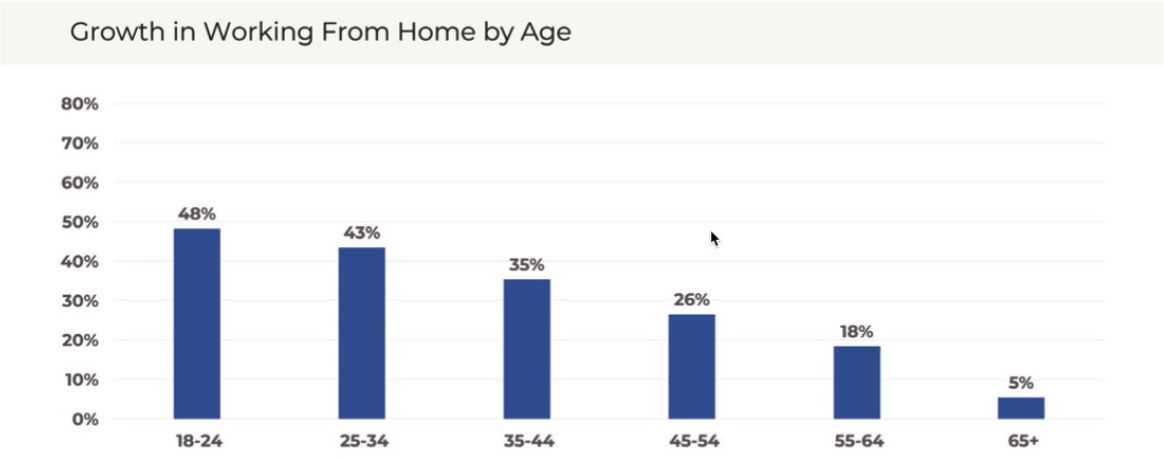
[9] Rural Video and Broadband Industry Study - 2021, page 13, by Innovative Systems

[10] Connect Commonwealth Presentation by Kyle Rosner to NC Broadband Matters, November 15, 2021, slide 16

Pandemic Impact

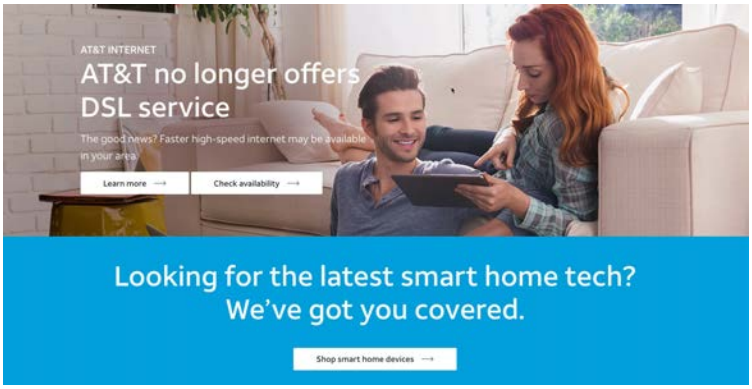
The pandemic impacted just about every aspect of life, including video and internet usage. The following data reveals some of that impact on rural consumers.

Does someone in your household work from home who did not prior to the pandemic? (n=726)
Note: Represents those answering yes.



- **For rural consumers, the younger you are, the more apt you are to have been working from home as a direct result of the pandemic.**

Fiber is increasingly a popular delivery vehicle for broadband services in rural areas across the country[11]. Four zip codes in Waupaca County showed significant residential fiber. One, 54961, had a minor amount (0.2%) of fiber available. There were two zip codes, 54949 and 54962 with no cable availability. Seven other zip codes had less than 50% cable availability. Gamewood Technology Group showed in one of our data sources, but it could be not be verified. The reference indicated fixed wireless service to 2.33% of customers in zip code 54981. All twelve zip codes had 100% wireless availability. DSL continues to lose favor with consumers and companies. While reports show that DSL by AT&T is available in Waupaca County, a trip to the AT&T website indicates otherwise.



[11] Rural Video and Broadband Industry Study - 2021, page 10, by Innovative Systems

The table below illustrates the estimated telecom expenditures, public and private, over the next thirty years. Over that time period, **over $1.65 Billion** in envelopes every month and much of it leaves both the county and the state. Redirecting as little as 5% of those funds could build fiber to every home and business in Waupaca County.

Telecom Expenditures - Waupaca County, WI

Total Households	22,305			
Businesses	1,185			
Estimated Internet Access Type	Households using Cell Phone for Internet	Households with "little" broadband DSL	Households with Cable Modems	Households with no Internet
Household Percentage	9%	42%	32%	17%
Number of households	2,007	9,368	7,138	3,792
Average monthly telecom expenditures	Cell Phone for Voice/Internet $90 Cable/satellite TV: $65 bundle	Cell Phone $70 Phone: $13 Satellite TV: $60 Broadband Internet: $45	Cell Phone $70 Phone $15 TV $43 Broadband Internet $45	Cell Phone, no Internet, $70 Cable/satellite TV: $65
Monthly Cost of Services	$155	$188	$173	$135
Annual household cost	$1,860	$2,256	$2,076	$1,620
Annual cost all households	$3,733,857	$21,134,434	$14,817,658	$6,142,797
30 year expenditure	$112,015,710	$634,033,008	$444,529,728	$184,283,910
Total residential expenditures	$1,374,862,356			
Total Estimated Cost of Hidden Fees	$202,683,394			
Total Business Costs	$73,588,500			
Total expenditures	**$1,651,134,250**			

3.1 LOCAL PRICING DATA

This information provides pricing data and services available from providers in Waupaca County. Prices, availability and promotional offers change frequently and sometimes vary depending on street address. Exact availability often requires customer names and specific street addresses. Pricing for Internet Service Providers showing less than 1% coverage or ones that cannot be verified are not shown in the following data

Summary of Service Provider Data - Waupaca County, WI

	Least Expensive Internet Only Service	Least Expensive Internet Only Service Meeting 25/3	Least Expensive Triple Pay Package Meeting
AT&T DSL	$65	Website Indicates AT&T no longer provides DSL- Legacy AT&T DSL accounts do exist	N/A
Amherst Telephone Company DSL	$74.99	N/A	N/A
CenturyLink DSL	$50	N/A	N/A
Cellcom DSL	No information available		
Cirrinity (Wittenberg Telephone) DSL	$53.63	$93.63	N/A
Frontier DSL	$37.99	$44.99	$129.98
Northern Telephone and Data DSL	$29.95	N/A	N/A
Solarus DSL	$49.95	N/A	N/A
TDS Telecom DSL	$67.95	$67.95	$162.03
Mediacom Cable	$29.99	$29.99	$189.99
Spectrum Cable	$74.95	$74.95	$176.96
Amherst Telephone Company Fiber	$74.99	$74.99	$169.85
Cirrinity (Wittenberg Telephone) Fiber	$60.63	$60.63	Pricing Unavailable
Solarus Fiber	$49.99	$49.99	$183.99
Bertram Wireless	$59.95	$149.95	N/A

	Least Expensive Internet Only Service	Least Expensive Internet Only Service Meeting 25/3	Least Expensive Triple Pay Package Meeting
Bertram Wireless 50 Mbps	No pricing available without exact address		
Bug Tussel Wireless	$59.99	$89.99	N/A
Cellcom Wireless	$10	N/A	N/A
Cirrinity (Wittenberg Cable) Wireless	No information without exact address		
King Street Wireless	No information available	N/A	N/A
Northern Telephone and Data Wireless	N/A	N/A	N/A
TDS TELECOM (Bend Broadband) Wireless	No information available	N/A	N/A
Waupaca Online Wireless City	$25	$75	N/A
Waupaca Online Wireless Rural	$45	$95	N/A
Waupaca Online Wireless Extended	$50	$100	N/A
HughesNet	$59.99	$59.99	N/A
Viasat	$84.99	$119.99	N/A
Starlink	$99	$99	N/A

All the information available at the time of the report is included in this table. If a table cell has no information, that information was not found. However, if there is no information in the "One-time Fees," it does not necessarily mean there are no one-time fees. It just means that information on the one-time fees could not be found on the company's public website.

NOTE: Many ISPs do not provide upload speeds. This table indicates that no upload speed was discoverable by the abbreviation 'NA' (Not Available)

Wireline Internet service provider comparison for Waupaca County, WI

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Amherst Telephone Company DSL	$74.99			10/1			Includes Phone with domestic long distance
	AT&T's website notes that it no longer provides DSL service- Legacy accounts likely exist						
AT&T DSL	$65	$55 for 12 months	$10 Equipment Fee	Varies 10 & 100 Mbps down and 1 and 20 Mbps up			$10 discount for auto pay and paperless billing
CenturyLink DSL	$50		Modem $15	10/NA	None		Internet Only
Cellcom DSL	No Information Available						
Cirrinity (Wittenberg Telecom) DSL	$53.63		Optional Router $10.54	10/NA		$80 Connection Fee	Internet Only
Cirrinity (Wittenberg Telecom) DSL	$73.63		Optional Router $10.54	20/NA		$80 Connection Fee	Internet Only
Cirrinity (Wittenberg Telecom) DSL	$93.63		Optional Router $10.54	30/NA		$80 Connection Fee	Internet Only
Frontier DSL	$37.99	Price good for 1 year. May go up $10 after first year. No contract		3-9/NA	None	$85 Activation Fee	Can be bundled with Dish TV for $64.99/ month. $5 discount for auto pay
Frontier DSL	$44.99	Price good for 1 year. May go up $10 after first year. No contract		12-25/NA	None	$85 Activation Fee	Can be bundled with Dish TV for $64.99/ month. $5 discount for auto pay

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Frontier DSL	$54.99	Price good for 1 year. May go up $10 after first year. No contract		45-115/NA	None	$85 Activation Fee	Can be bundled with Dish TV for $64.99/ month. $5 discount for auto pay
Frontier DSL	$54.99	Price good for 1 year. May go up $10 after first year. No contract		3-9/NA	None	$85 Activation Fee	Can be bundled with Dish TV for $64.99/ month. Unlimited Nationwide Calling $5 discount for auto pay
Frontier DSL	$64.99	Price good for 1 year. May go up $10 after first year. No contract		12-25/NA	None	$85 Activation Fee	Can be bundled with Dish TV for $64.99/ month. Unlimited Nationwide Calling $5 discount for auto pay
Northern Telephone & Data DSL	$29.95			N/A			Information only available by email request on specific addresses
Solarus (Manawa Telephone) DSL	$49.95			3/NA			
Solarus (Manawa Telephone) DS	$58.95			6/NA			
Solarus (Manawa Telephone) DS	$83.95			10/NA			
Solarus (Manawa Telephone) DS	$103.95			20/NA			
TDS Telecom DSL	$67.95	$29.95 for 12 months	Modem $10 monthly	36-50/1.5-10			Internet only $49.95 Installation fee waived
TDS Telecom DSL	$67.95	$39.95 for 12 months	Modem $10 monthly	75-100/7-15			Internet only 49.95 Installation fee waived
	TDS- Broadcast fee of $19.40 and Regional Sports Fee of $7 included in monthly prices						

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
TDS Telecom DSL	$162.03	$30 discount for TV for 1 year, $20 off TV for 2 years. $6 discount for 1 year on TV receiver	1 TV receiver $6 Monthly, Modem $10 monthly	75-100/7-15			Internet Explore TV Package 60 Channels- 30 minutes Long Distance unlimited local
TDS Telecom DSL	$177.03	$30 discount for TV for 1 year, $20 off TV for 2 years. $6 discount for 1 year on TV receiver	1 TV receiver $6 Monthly, Modem $10 monthly	75-100/7-15			Internet Explore TV Package 60 Channels- 30 minutes Long Distance unlimited local
TDS Telecom DSL		$30 discount for TV for 1 year, $20 off TV for 2 years. $6 discount for 1 year on TV receiver	1 TV receiver $6 Monthly, Modem $10 monthly	75-100/7-15			Internet - Journey TV Package 80+ Channels- unlimited Long Distance and local
TDS Telecom DSL	$192.03	$30 discount for TV for 1 year, $20 off TV for 2 years. $6 discount for 1 year on TV receiver	1 TV receiver $6 Monthly, Modem $10 monthly	75-100/7-15			Internet - Voyage TV Package 110+ Channels- unlimited Long Distance and local
	Spectrum: Taxes, fees and surcharges extra and subject to change during and after the promotional period; installation/network activation, equipment and additional services are extra.						

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Mediacom Cable	$29.99	$19.99 For 1 year	$12 Modem fee $10 WiFi Fee after first three months	60/5	200 $10 for every increment of up to 50 additional	$10 Activation	Internet Only
Mediacom Cable	$79.99	$49.99 For 1 year	$12 Modem fee $10 WiFi Fee after first three months	100/10	1,000 $10 for every increment of up to 50 additional	$10 Activation	Internet Only
Mediacom Cable	$139.99	$79.99 For 1 year	$12 Modem fee $10 WiFi Fee after first three months	1000/50	6,000 $10 for every increment of up to 50 additional	$10 Activation	Internet Only
	Each Mediacom Cable Package Includes a statement similar to the one below. An extensive effort was unable to verify Medicom cable bundle prices in both zip code 59540 and 59545. We have chosen the most expensive of the range given as the likely non-promo price.						
	Advertised price is for the promotional period stated. Thereafter, the monthly price increases by $30 each year until the fourth year, when each service will begin to be billed at the standard rate (currently ranges between $152.45 and $229.94 and varies by location)						
Mediacom Cable*	$73.44	$29.99 for one year	$12 Modem fee $10 WiFi Fee after first three months	60/5	200 $10 for every increment of up to 50 additional	$10 Activation	Internet and local TV with 50+ Channels

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Mediacom Cable*	$113.44	$59.99 for one year	$12 Modem fee $10 WiFi Fee after first three months	60/5	200 $10 for every increment of up to 50 additional	$10 Activation	Internet and local TV with 125+ Channels
Mediacom Cable*	$189.99 (Does not vary by location)	$109.99 for one year	$12 Modem fee $10 WiFi Fee after first three months	60/5	200 $10 for every increment of up to 50 additional	$10 Activation	Internet and local TV with 170+ Channels and home phone
Spectrum Cable	$74.95	$49.95 12 months		200/NA	None		Internet Only TV essentials $19.99 month- Stream 60 channels Telephone $12.99 a month
Spectrum Cable	$95.99	$69.99 12 months		400/NA	None		Internet Only TV essentials $19.99 month- Stream 60 channels Telephone $12.99 a month
Spectrum Cable	$134.99	$109.99 12 Months		1000/NA	None		Internet Only TV essentials $19.99 month- Stream 60 channels Telephone $12.99 a month
Spectrum Cable	$176.96	$120.96 12 Months	Other fees may be charged	200/NA	None		Internet 125 Channels Telephone Included
Spectrum Cable	$196.96	$140.96 12 Months	Other fees may be charged	400/NA	None		Internet 125 Channels Telephone Included

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Spectrum Cable	$236.96	$180.96 12 Months	Other fees may be charged	1000/NA	None		Internet 125 Channels Telephone Included
Amherst Communications Fiber	$74.99			50/5			Internet, WiFi included Unlimited Data Phone, Long Distance
Amherst Communications Fiber	$84.99			100/10			Internet, WiFi included Unlimited Data Phone, Long Distance
Amherst Communications Fiber	$99.99			200/20			Internet, WiFi included Unlimited Data Phone, Long Distance
Amherst Communications Fiber	$129			400/80			Internet, WiFi included Unlimited Data Phone, Long Distance
Amherst Communications Fiber	$169.85			50/5			Internet, WiFi included, Unlimited Data, Basic TV with 70+ channels, Phone, Long Distance
Amherst Communications Fiber	$207.3			200/20			Internet, WiFi included, Unlimited Data, Expanded TV with 120+ channels, Phone, Long Distance
Amherst Communications Fiber	$224.85			400/80			Internet, WiFi included, Unlimited Data, Basic TV with 70+ channels, Phone, Long Distance
Cirrinity (Wittenberg Telecom) Fiber	$60.63			100/100		$80 Connection Fee	Internet Only
Cirrinity (Wittenberg Telecom) Fiber	$100.63			500/500		$80 Connection Fee	Internet Only

Provider	Monthly Cost	Promo Rate & Contract Length	Other Monthly Fees	Download/ Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Services & Incentives
Cirrinity (Wittenberg Telecom) Fiber	$140.63			1000/1000		$80 Connectio n Fee	Internet Only
Solarus (Manawa Telephone) Fiber	$49.99			150/150			Internet Only
Solarus (Manawa Telephone) Fiber	$64.99			250/250			Internet Only
Solarus (Manawa Telephone) Fiber	$79.99			400/400			Internet Only
Solarus (Manawa Telephone) Fiber	$114.99			600/600			Internet Only
Solarus (Manawa Telephone) Fiber	$183.99			150/150			Internet, TV, and unlimited phone. Prices is for 1-3 TVs. Additional TVs $3.99 each
Solarus (Manawa Telephone) Fiber	$198.99			250/250			Internet, TV, and unlimited phone. Prices is for 1-3 TVs. Additional TVs $3.99 each
Solarus (Manawa Telephone) Fiber	$213.99			400/400			Internet, TV, and unlimited phone. Prices is for 1-3 TVs. Additional TVs $3.99 each
Solarus (Manawa Telephone) Fiber	$198.99			600/600			Internet, TV, and unlimited phone. Prices is for 1-3 TVs. Additional TVs $3.99 each

Wireless Internet service provider comparison for Waupaca County, WI

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Download /Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Incentives & Notes
Bertram Wireless	$59.95			5/NA	Unlimited		
Bertram Wireless	$74.95			10/NA	Unlimited		
Bertram Wireless	$89.95			15/NA	Unlimited		
Bertram Wireless	$149.95			25/NA	Unlimited		
Bertram Wireless	Requires phone call and exactly location for pricing			50/NA	Unlimited		
Bug Tussel Wireless	$59.99			8/2			
Bug Tussel Wireless	$69.99			12/3			
Bug Tussel Wireless	$89.99			25/5			
Cellcom Wireless	$10			5-12 Mbps/NA	2GB $15/GB 0verage		
Cellcom Wireless	$15			5-12 Mbps/NA	4GB $15/GB 0verage		
Cirrinity (Wittenberg Cable) Wireless	No information without exact address						
ethoplex Wireless	$50			10/1			
ethoplex Wireless	$75			25/5			
ethoplex Wireless	$100			50/5			
King Street Wireless	No Info available						

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Download /Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Incentives & Notes
Northern Telephone & Data	N/A						Information only available by email request on specific addresses
TDS Wireless	No information available						
City of Waupaca Residential	$25			5/3		$95 Installation Router $65	
City of Waupaca Residential	$40			10/4		$95 Installation	
City of Waupaca Residential	$55			15/4		Router $65	
City of Waupaca Residential	$65			20/5		$95 Installation	
City of Waupaca Residential	$75			25/5		Router $65	
Waupaca Area Rural Residential	$45			5/3		$95 Installation Router $65	
Waupaca Area Rural Residential	$60			10/4		$95 Installation Router $65	
Waupaca Area Rural Residential	$75			15/4		$95 Installation Router $65	
Waupaca Area Rural Residential	$85			20/5		$95 Installation Router $65	
Waupaca Area Rural Residential	$95			25/5		$95 Installation Router $65	
Waupaca Extended Residential	$50			5/3		$95 Installation Router $65	

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Download /Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees	Incentives & Notes
Waupaca Extended Residential	$65			10/4		$95 Installation Router $65	
Waupaca Extended Residential	$80			15/4		$95 Installation Router $65	
Waupaca Extended Residential	$90			20/5		$95 Installation Router $65	
Waupaca Extended Residential	$100			25/5		$95 Installation Router $65	

Satellite Internet service provider comparison for Waupaca County, WI

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Downloa d/Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees
HughesNet	$59.99	$39.99 for first six months. 24 month commitment required. Up to $400 ETF	$14.99 equipment lease it you don't purchase	25/3	After 10 GB (speeds drop to 1-3 Mbps)	Purchase pricing is $249.99 to purchase or $99 lease activation- instant lease savings of $99- limited time $100 instant savings if equipment Is purchased
HughesNet	$69.99	$49.99 for first six months. 24 month commitment required. Up to $400 ETF	$14.99 equipment lease it you don't purchase	25/3	After 20 GB (speeds drop to 1-3 Mbps)	Purchase pricing is $249.99 to purchase or $99 lease activation- instant lease savings of $99- limited time $100 instant savings if equipment Is purchased
HughesNet	$99.99	$79.99 for first six months. 24 month commitment required. Up to $400 ETF	$14.99 equipment lease it you don't purchase	25/3	After 30 GB (speeds drop to 1-3 Mbps)	Purchase pricing is $249.99 to purchase or $99 lease activation- instant lease savings of $99- limited time $ $100 instant savings if equipment Is purchased

Provider	Monthly Cost	Promo & Contract Length	Other Monthly Fees	Download/Upload Speed (Mbps)	Data Cap (GB/ Month)	One-Time Fees
HughesNet	$149.99	$129.99 for first six months. 24 month commitment required. Up to $400 ETF	$14.99 equipment lease it you don't purchase	25/3	After 50 GB (speeds drop to 1-3 Mbps)	Purchase pricing is $249.99 to purchase or $99 lease activation- instant lease savings of $99- limited time $100 instant savings if equipment Is purchased
Viasat	$84.99	$64.99 for first three months 24 month contract	$12.99/ month (modem)	12/3	40 GB priority data	Setup Fee- Unknown- equipment purchase instead of lease $299.99- Setup Fee- Unknown
Viasat	$119.99	$84.99 for first three months 24 month contract	$12.99/ month (modem)	25/3	60 GB priority data	Setup Fee- Unknown- equipment purchase instead of lease $299.99- Setup Fee- Unknown
Viasat	$169.99	$99.99 for first three months 24 month contract	$12.99/ month (modem)	30/3	100 GB priority data	Setup Fee- Unknown- equipment purchase instead of lease $299.99- Setup Fee- Unknown
Viasat	$249.99	$169.99 for first three months 24 month contract	$12.99/ month (modem)	30/3	150 GB priority data	Setup Fee- Unknown- equipment purchase instead of lease $299.99- Setup Fee- Unknown
Starlink*	$99	Waupaca County targeted for service in mid to late 2021	Unknown but has $50 shipping cost and $30.20 estimated tax for	100/40	None	

* Starlink service is still by address only so Starlink may not be available in all areas. Early reports from beta testers have been generally positive. Reported speed test results vary, but many users are reporting 10 to 50 Megabit download speeds and upload speeds of 5 to 20 Megabits. Some users have seen higher speed test results. Latency is much lower than traditional geostationary satellite services like HughesNet and Viasat, but latency is still much higher than terrestrial fiber Internet connections. If pricing remains similar to what is being charged for early users, Starlink could be a very significant improvement for rural residents and businesses. It is targeted for the Waupaca County area in mid 2022. In early fall of 2021, Starlink indicated it would be moving the service out of "beta" status and that they would be taking customers nationwide in early 2022. Some Starlink customers we are tracking have been waiting over a year for their orders to be filled.

* Mediacom Terms and Conditions, Waupaca County, November 16, 2021: Advertised monthly price is good for one year. Thereafter, the monthly price increases by $30 in the second year and

then $20 in the third year until the fourth year, when each service will begin to be billed at the standard rate (currently, $189.99). Price does not include standard installation fee (currently free online unless special work needed); a one-time $10 activation fee; or other one-time fees that may apply because of options you select. Price also does not include the following recurring monthly charges: (i) modem fee, currently, $12.00; (ii) regional sports network surcharge, (iii) local broadcast station surcharge, (iv) taxes, franchise fees and other amounts required by law to be collected or paid; or (v) fees for optional services or equipment you may want. All these monthly charges may increase from time to time; surcharges vary depending on location and may increase due to programming cost increases. If you cancel any of the services in the package, standard rates will be charged for any continuing services. After the first year, if our standard rate for any service in your package that is not free increases, or we institute a new fee for service subscribers generally, we can pass that increase or new fee along to you. Internet Service Usage Allowance & Speed: Internet 100: 1,000 GB per monthly billing period. Excess usage will be billed at $10 for every increment of up to 50 additional gigabytes used. For example, if usage exceeded the allowance by 51 gigabytes, the additional charge would be $20. Usage allowances and excess usage charges are subject to change at any time

4 COUNTY RESIDENTIAL SURVEY RESULTS

During the fall of 2021, a broadband survey was conducted in Waupaca County as part of a county wide study in broadband needs. The online (Web) version of the survey was publicized on social media, the County Web site, and a Postal Service mailing to all households. Residents were encouraged to complete the survey online or fill out and return the paper version by surface mail. Businesses were encouraged to complete a separate business-focused survey, and the results of that are included later in this report.

A total of 823 responses were collected in the residential survey—roughly 4% of all households in Waupaca County responded to the survey. Not all responders answered every question. Note that because of rounding, not all percentages sum exactly to 100%. Many comments were received and are included in the appendices.

Some of the key findings from the results are listed below.

88% of respondents are interested in faster and more reliable Internet service

55% of residents are "dissatisfied" or "very dissatisfied" with current Internet speeds

97% of respondents said that they believe the County government should help facilitate better broadband

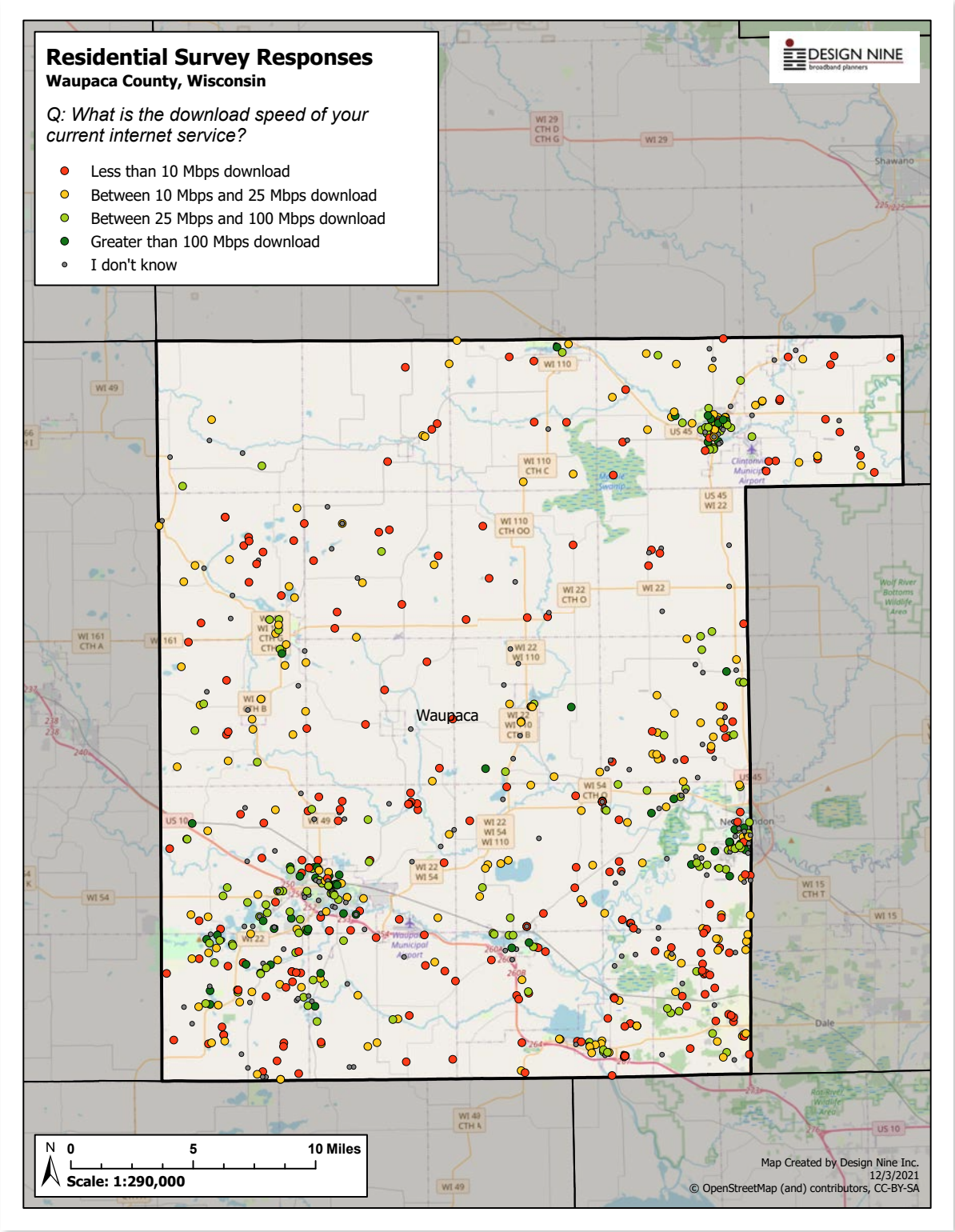
29% of residents have 9 or more Internet-connected devices in their home

59% of respondents report they have trouble using common Internet services

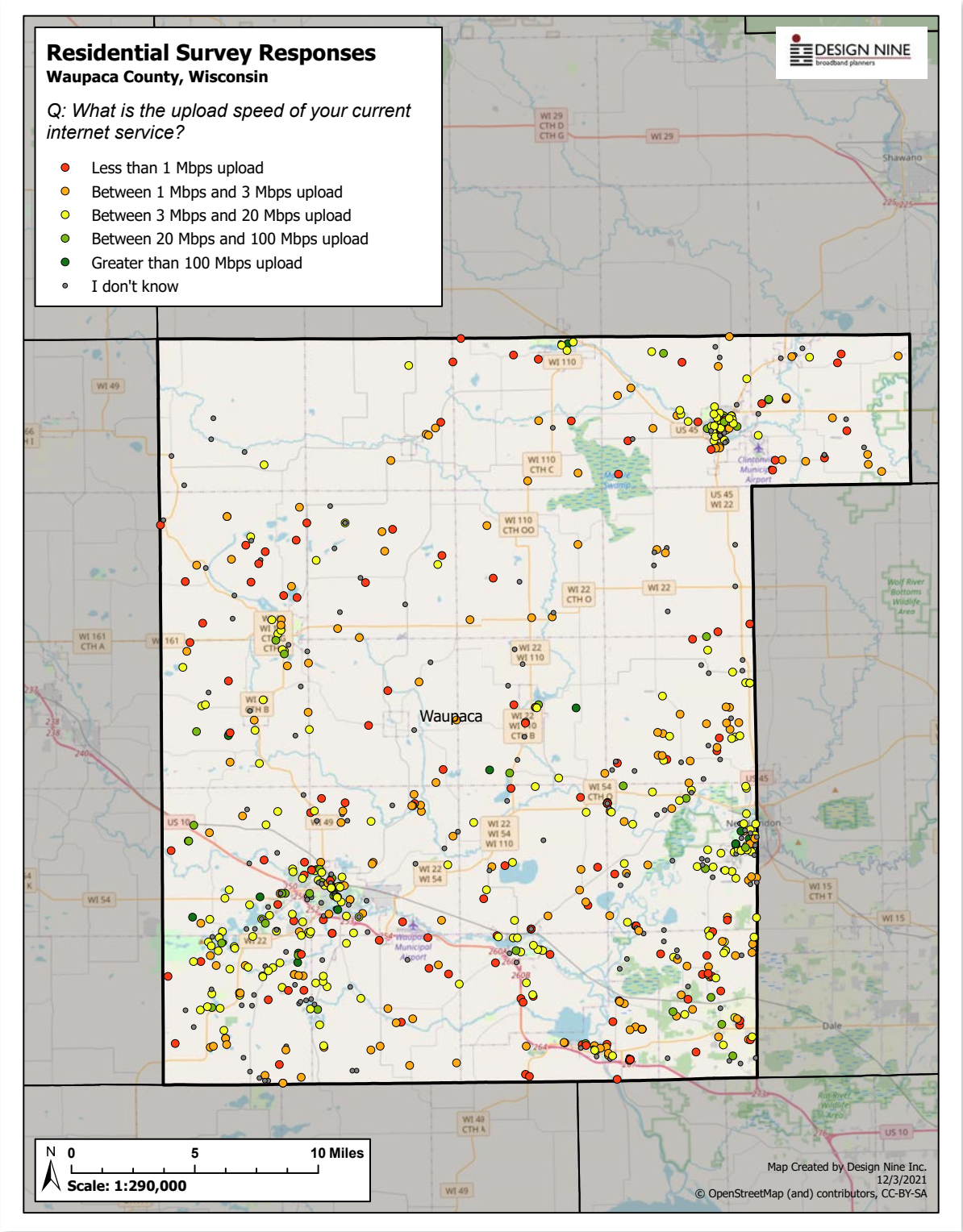
31% indicate that availability of broadband Internet is affecting where they choose to live

4.1 DISTRIBUTION OF RESIDENTIAL SURVEY RESPONSES

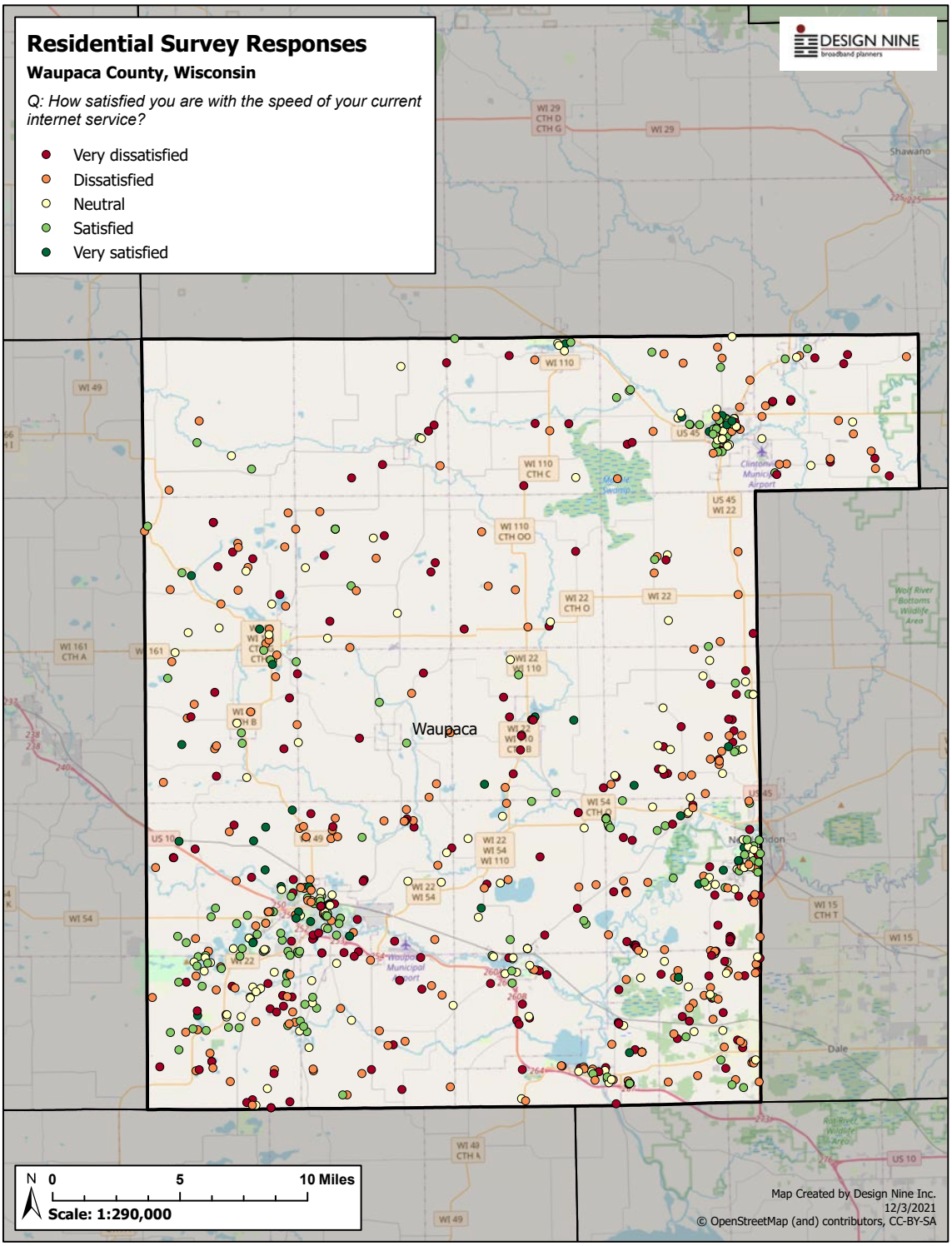
The map below shows the geographic distribution of responses to the residential survey, coded according to the *download speed* of their Internet connection (Question 9).



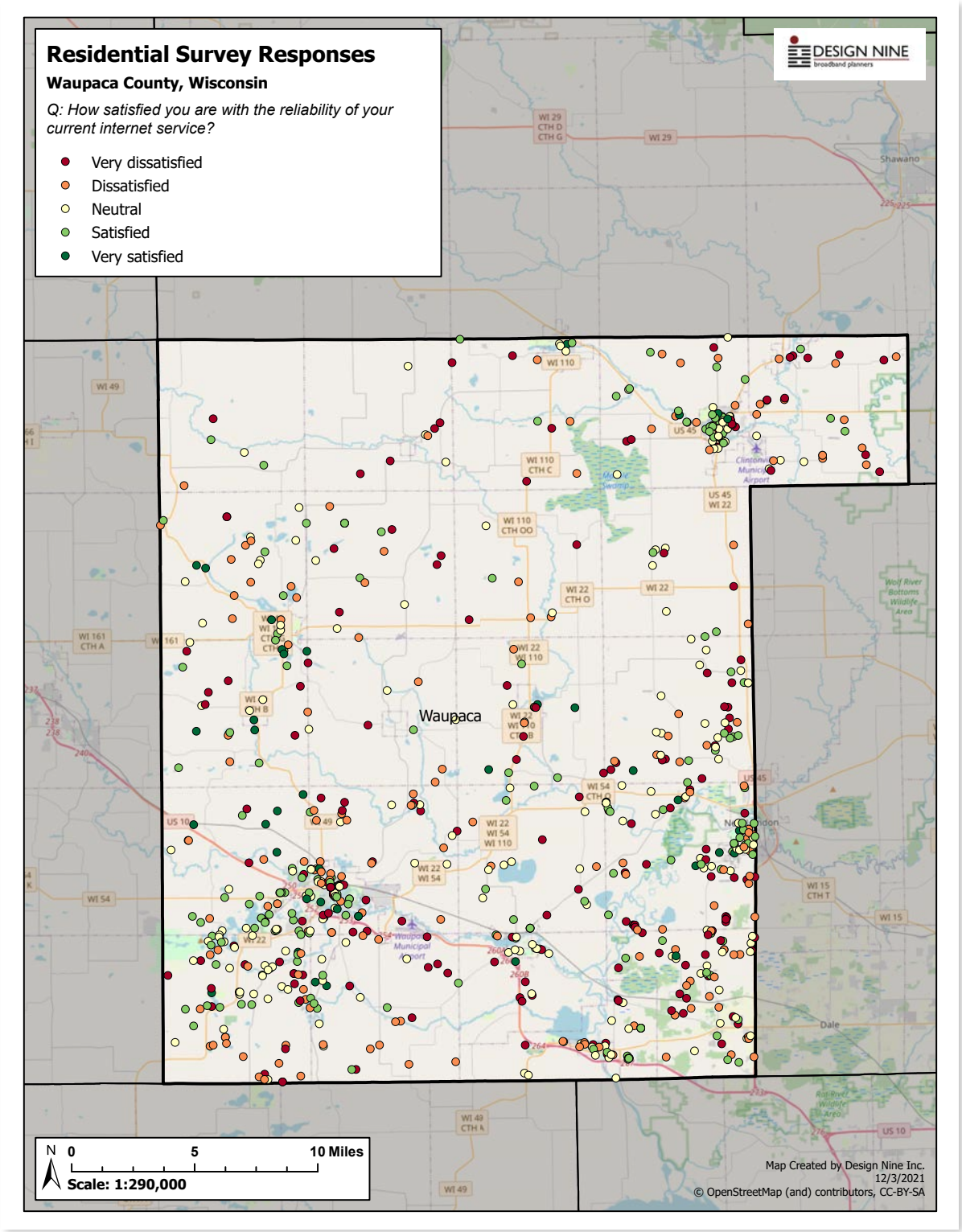
The map below shows the geographic distribution of responses to the residential survey, coded according to the *upload speed* of their Internet connection (Question 10).



The map below shows the geographic distribution of responses to the residential survey, coded according to their satisfaction with the *speed* of their existing Internet service (Question 12).

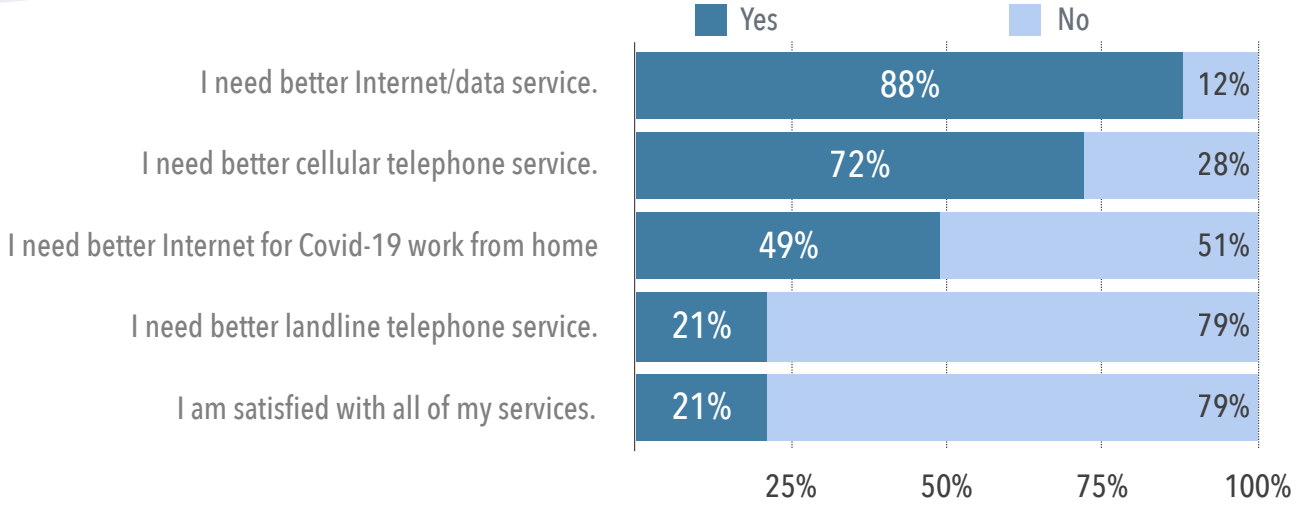


The map below shows the geographic distribution of responses to the residential survey, coded according to their satisfaction with the *reliability* of their existing Internet service (Question 13).



4.2 RESIDENTIAL SURVEY SUMMARY DATA

1. Select the items you agree with below



2a. Total number of adults in household

None	1	2	3	4	5	6	7+
2	105	602	79	18	8	1	2
0%	13%	74%	10%	2%	1%	0%	0%

2b. Total number of K-12 Students in the house hold

None	1	2	3	4	5	6	7+
573	87	78	26	13	4	0	2
73%	11%	10%	3%	2%	1%	0%	0%

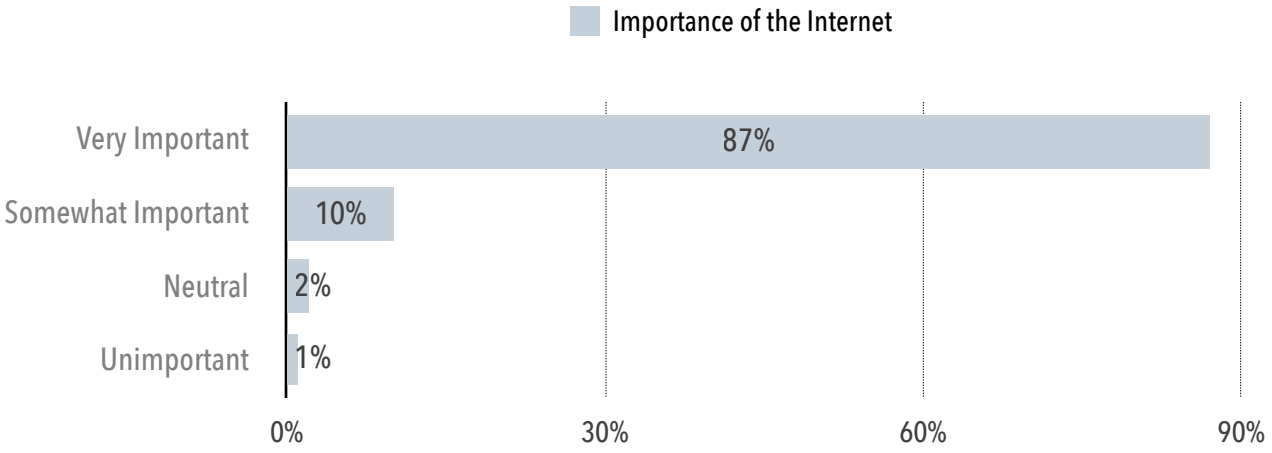
2c. Total number of college students in household

None	1	2	3	4	5	6	7+
695	65	13	2	0	0	1	0
90%	8%	2%	0%	0%	0%	0%	0%

2d. How many total Internet users in household

None	1	2	3	4	5	6	7+
12	99	396	121	100	33	12	11
2%	13%	51%	15%	13%	4%	2%	1%

3. How important is Internet access to you or your household?



4. How much do you spend each month for ALL telecom services? This would include any fees for services like phone, TV, and Internet. Do not include cellphones.

$50 or less	$50 to $75	$75 to $100	$100 to $150	$150 to $200	More than $200/month
66	79	155	162	154	195
8%	10%	19%	20%	19%	24%

5. How much do you pay just for Internet access each month?

No Internet	I only use free hotspots	$10 to $20	$21 to $40	$41 to $60	$61 to $80	More than $80/ month	I don't know
94	38	32	111	530	983	737	95
4%	1%	1%	4%	20%	38%	28%	4%

6. What type of Internet do you have at home?

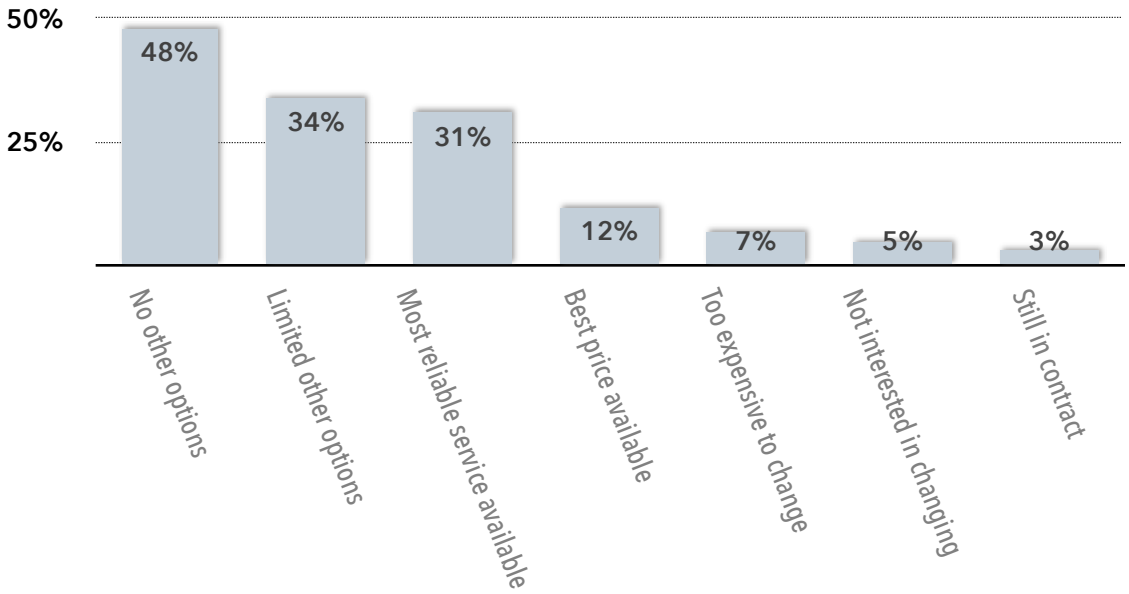
Cable Modem	231	28%
DSL Line	159	20%
Satellite	131	16%
Cellular wireless	90	11%
I Don't Know	60	7%
Wireless ISP	59	7%
Fiber	29	4%
No Internet	28	3%
Other	24	3%

Other internet types responses:

Many comments were received. Because of the volume of replies, these comments can be found in the New North Residential Broadband Survey Comments document.

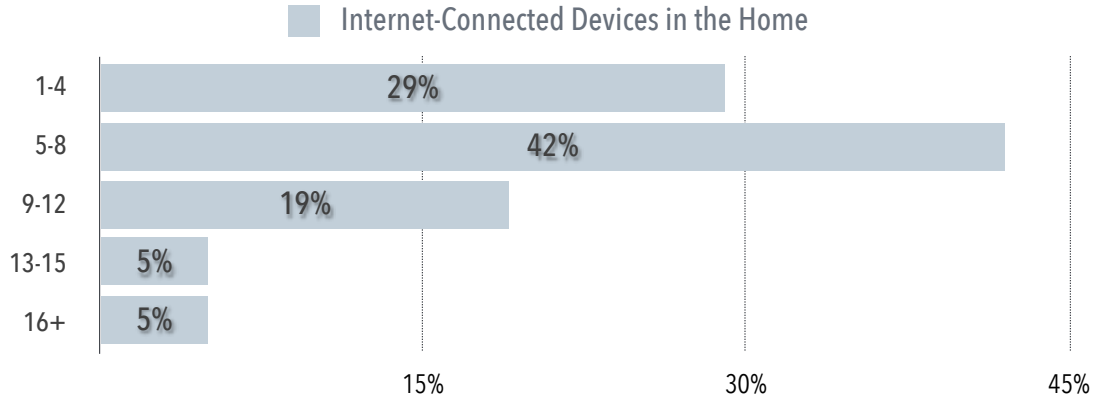
7. Based on the type of Internet connection you selected above, why do you still have it? (select all that apply)

48% of respondents indicated they have no alternative to their current Internet provider



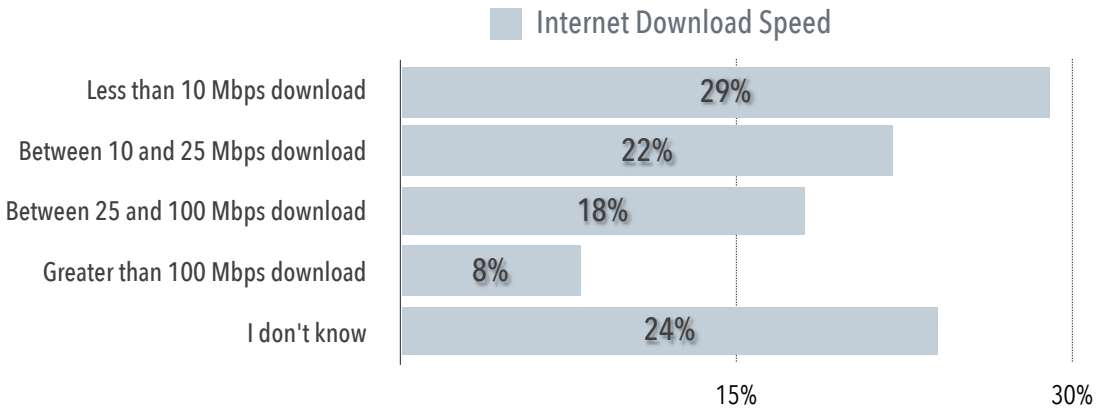
8. How many devices (for example computers, cellphones, smart TVs) connect to the Internet in your household?

29% of residents have 9 or more Internet-connected devices in their home



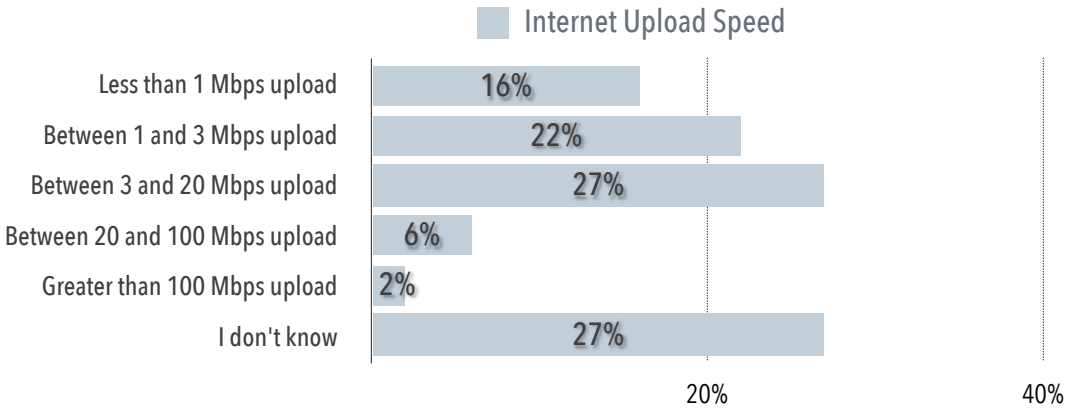
9. What is the download speed of your Internet Connection?

Only 26% of residents can confirm that they have Internet service that meets the FCC definition of adequate broadband service (25 Meg down). It is not unusual that many respondents do not know their exact Internet speeds.



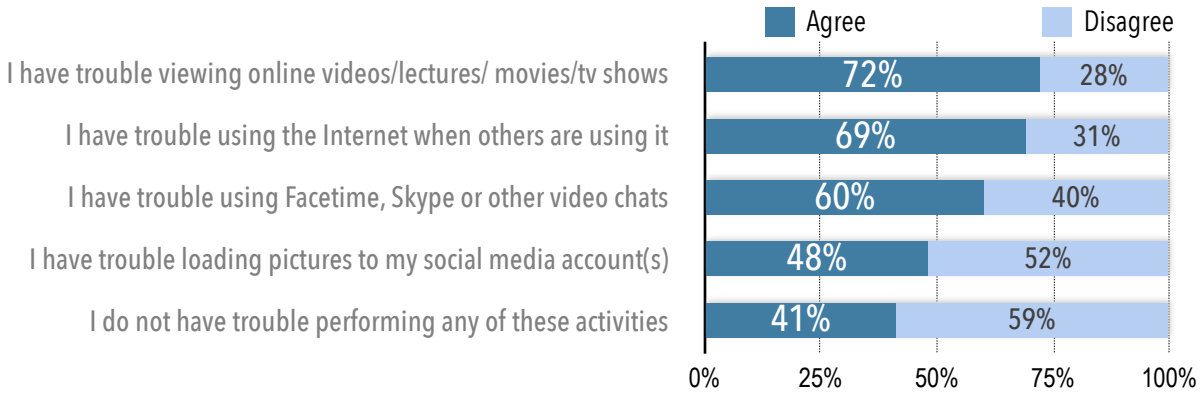
10. What is the upload speed of your Internet Connection?

Only 35% of residents have Internet service that meets the FCC definition of adequate broadband service (3 Meg up). It is not unusual that many respondents do not know their exact Internet speeds.

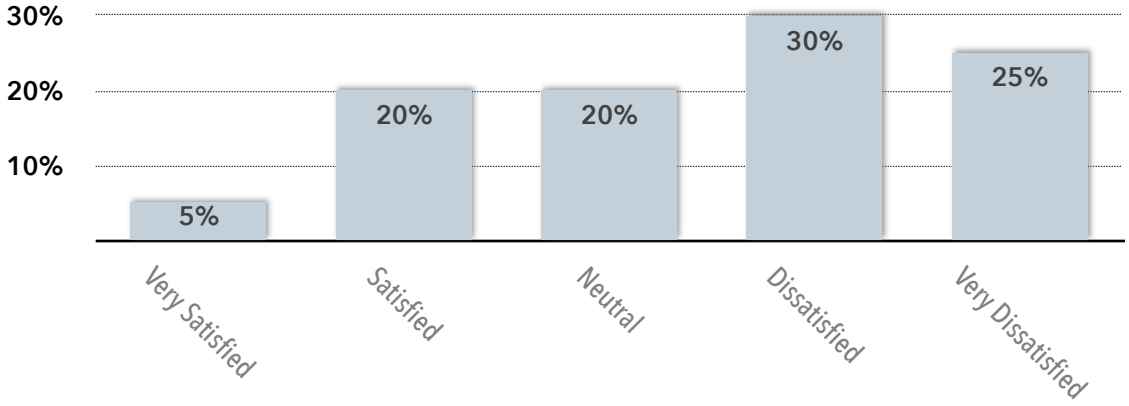


11. Select the items you agree with below

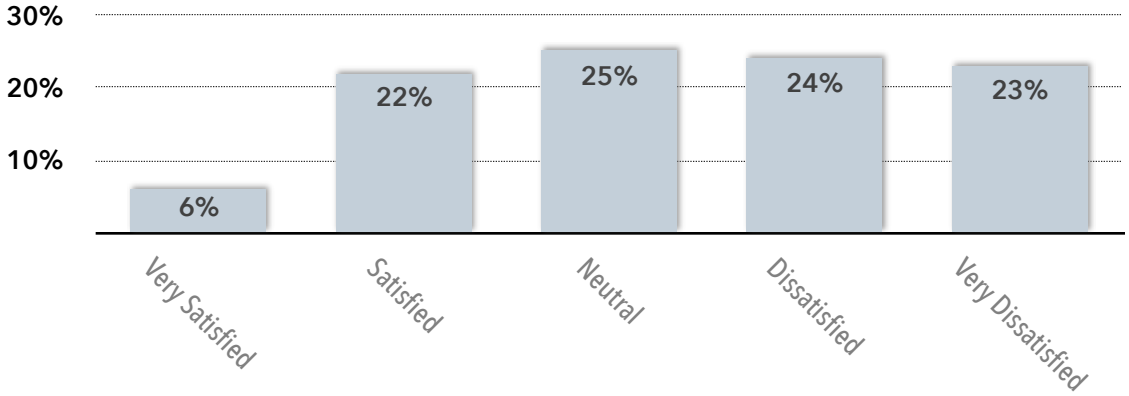
More than 50% of respondents report they have trouble using common Internet services



12. How satisfied are you with the speed of your internet service?



13. How satisfied are you with the reliability of your internet service?



14. Select all items you use the Internet for now

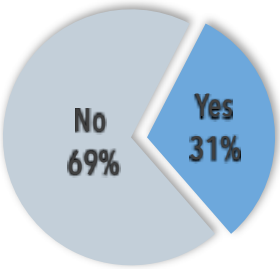
Streaming video services (Netflix, Hulu, Prime, etc)	614	75%
Online Backup (files, photos, music)	494	60%
VoIP Internet phone (Vonage, Skype, FaceTime, etc.)	369	45%
Work from home during Covid-19 pandemic	356	43%
Learn about Covid-19 pandemic issues and information	345	42%
Homework/Schoolwork/Distance learning	318	39%
Telemedicine or tele-health	294	36%
Smart speakers (Alexa, Echo Dot, Google Assistant, etc.)	294	36%
Online gaming	224	27%
Home security (cameras, video doorbells, etc.)	210	26%
Other	112	14%

Other internet types responses:

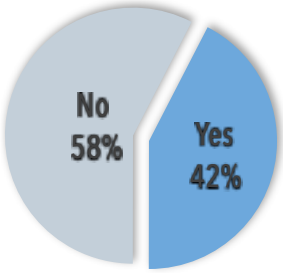
Many comments were received. Because of the volume of replies, these comments can be found in the New North Residential Broadband Survey Comments document.

15. High speed, affordable Internet influences where I choose to live?

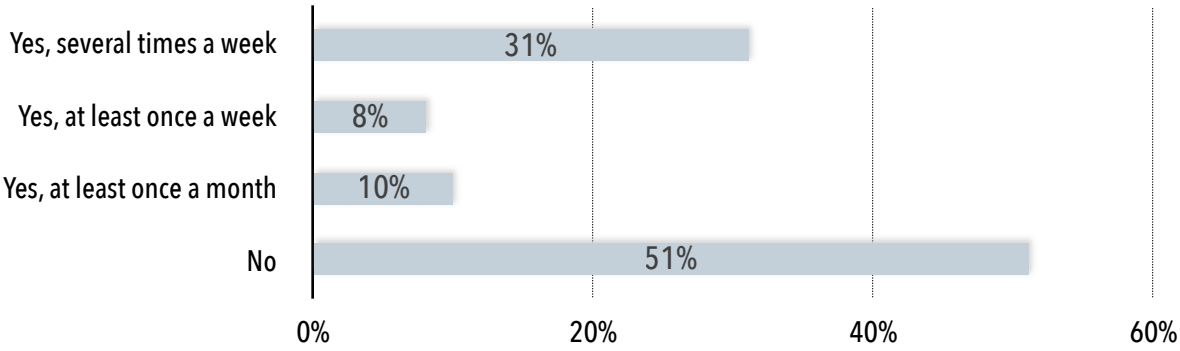
Availability of broadband Internet is affecting where people choose to live. The response of of 31% is typical of many communities. Internet availability can impact home prices and community development.



16. Has the Covid-19 crisis had a negative economic impact on your household?



17. Does anyone in your household use / need the Internet to complete school assignments, participate in distance learning, or receive job training course work?

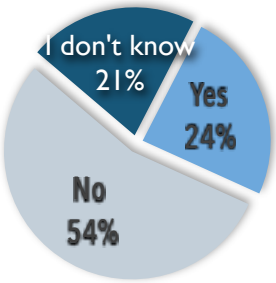


18. Who is your Internet Service provider?

Some responses included more than one provider.

Spectrum	244	35%
CenturyLink	85	12%
TDS	62	9%
Satellite Internet	62	9%
AT&T	56	8%
Frontier	41	6%
Verizon	34	5%
US Cellular	29	4%
Star Comm	25	4%
Waupaca Online	22	3%
Cellphone Hotspot	22	3%
Cellcom	11	2%
Comcast	4	1%
Bug Tussel	4	1%
Wireless Internet	4	1%
Bertram	1	0%

19. Do you have data limits (caps) on your current Internet service?

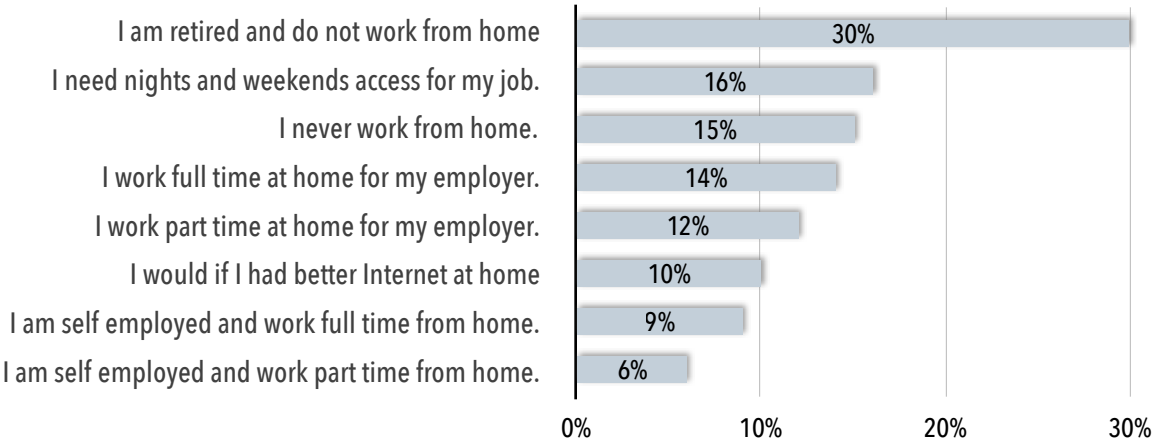


20. If you have data caps, have you exceeded those caps?

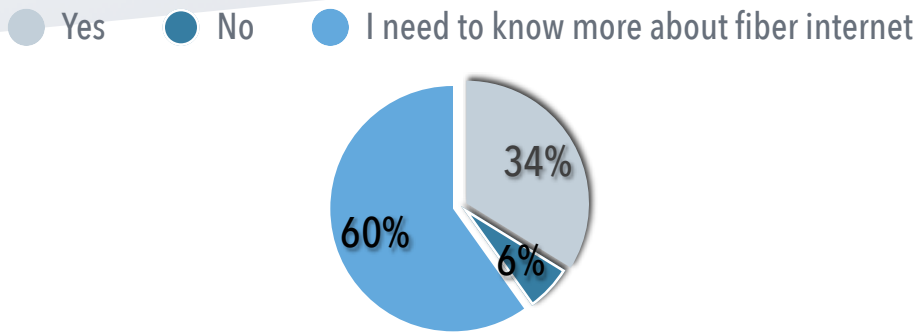
Yes	19%
No	18%
I do not have data caps	20%
I don't know	43%

21. Do you work from home?

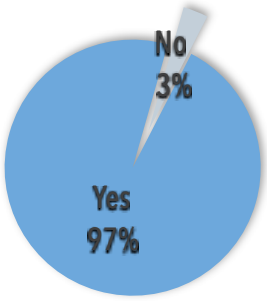
41% report working from home part or full time—the Internet has made residential neighborhoods into business districts. Home-based jobs and businesses reduce traffic congestion and reduce road maintenance. This is also a high number relative to past surveys we have conducted, and undoubtedly the Covid crisis has caused this number to rise.



22. Are you Interested in Gigabit fiber Internet Service?



23. Should New North and/or your county government facilitate better broadband services and more affordable services?



24. Any Other Comments

Many comments were received. Because of the volume of replies, these comments can be found in the New North Residential Broadband Survey Comments document.

5 COUNTY BUSINESS SURVEY RESULTS

A separate and unique business survey was run concurrently with the residential survey. Only 15 responses were collected from Waupaca County Businesses. The small number of responses invalidates the need for a detailed breakdown like that which the residential responses received. A few of the key findings from the businesses who did participate are listed below.

12 out of 15 business respondents need better internet service	15 out of 15 respondents say that County government should facilitate better broadband	6 out of 15 business respondents are home-based businesses	9 out of 15 business pay more than $100/ month for their internet
Business respondents have DSL, Cable, Satellite, and Wireless Internet connection	6 out of 15 business respondents have download speeds below 25 Mbps	Half of the respondents say that they have no other options for internet service	11 of 15 businesses state there is need for employees to be able to work from home
8 out of 15 business are "Dissatisfied" with their current internet speeds	10 out of 15 business are "Dissatisfied" with their current internet reliability	The providers of business respondents include Spectrum, Star Comm, CenturyLink, and Waupaca Online	9 out of 15 business respondents say they are interested in fiber internet

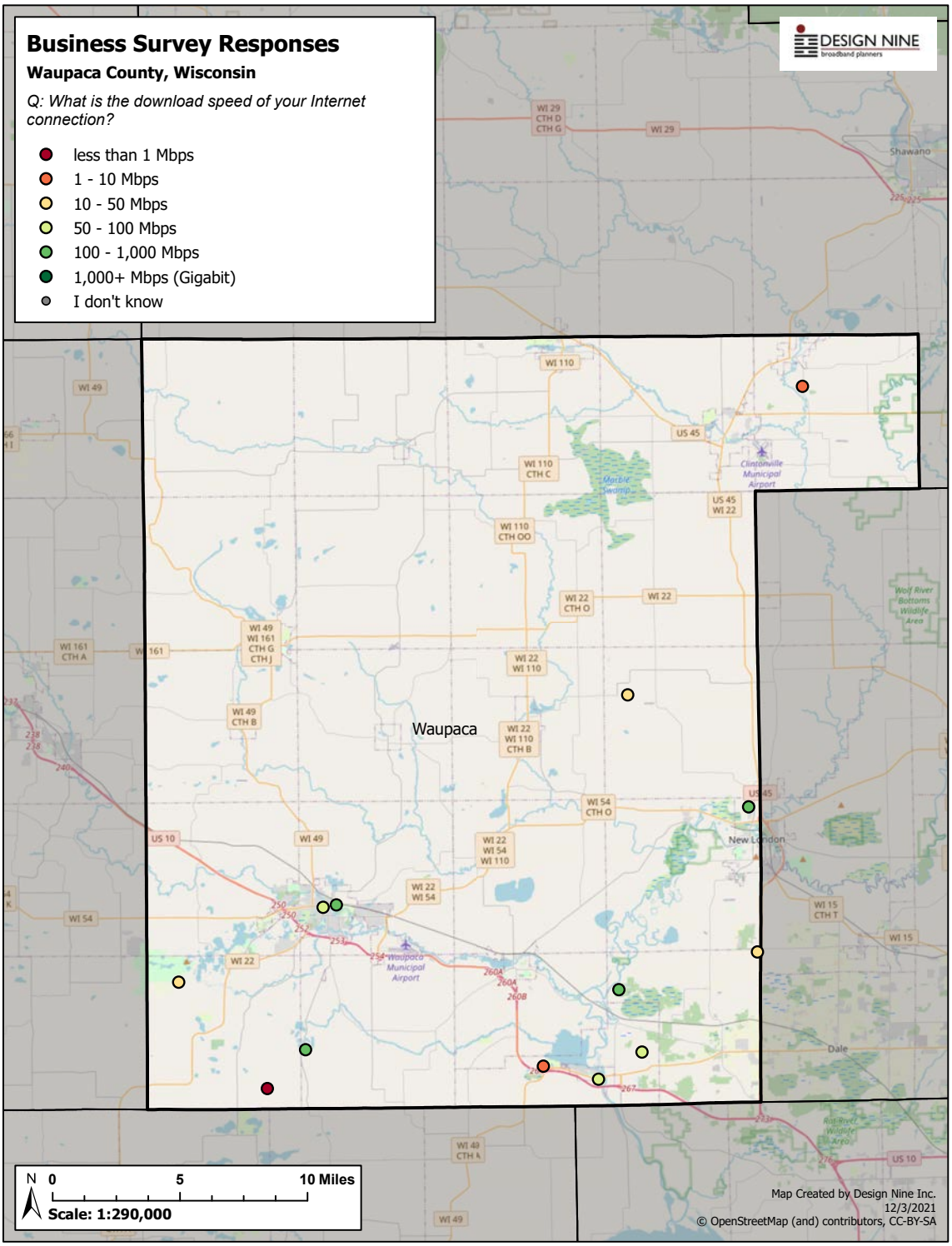
Despite the small number of responses, there is some consensus about the substandard state of business class broadband available In Waupaca County. Over half of the businesses said they were disappointed in the speed and/or reliability of their current service. Most businesses are either on the most reliable Internet service available or have limited other options.

There is also agreement on the importance of the internet to the success of their businesses and all fifteen respondents indicated that they think the Waupaca County government should be involved in improving the internet services in the County.

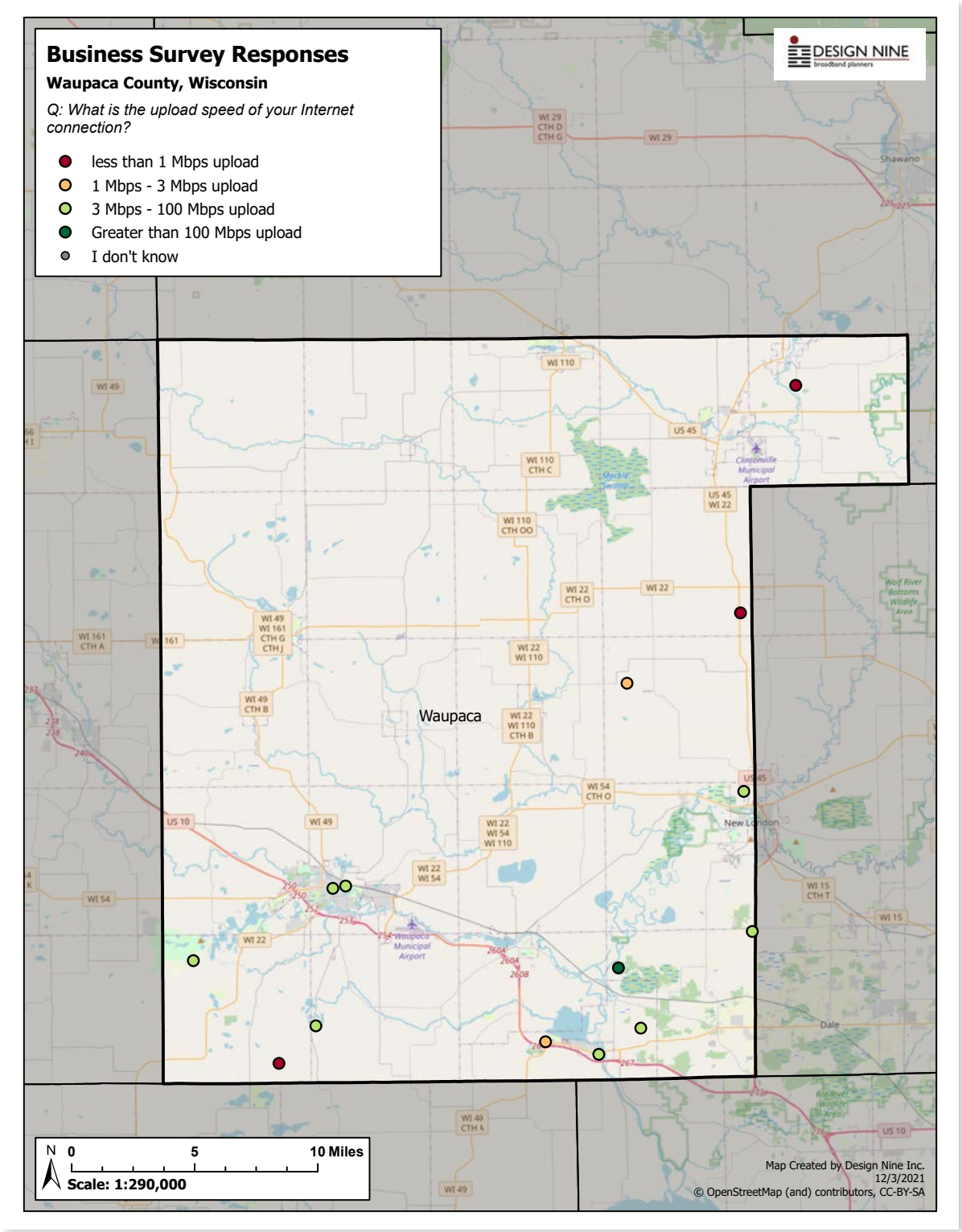
Eleven of the fifteen Business respondents reported having interest or need for employees to have the ability to work from from. A third of respondents say the limited Internet access at employee's residence impacts their business.

5.1 DISTRIBUTION OF BUSINESS SURVEY RESPONSES

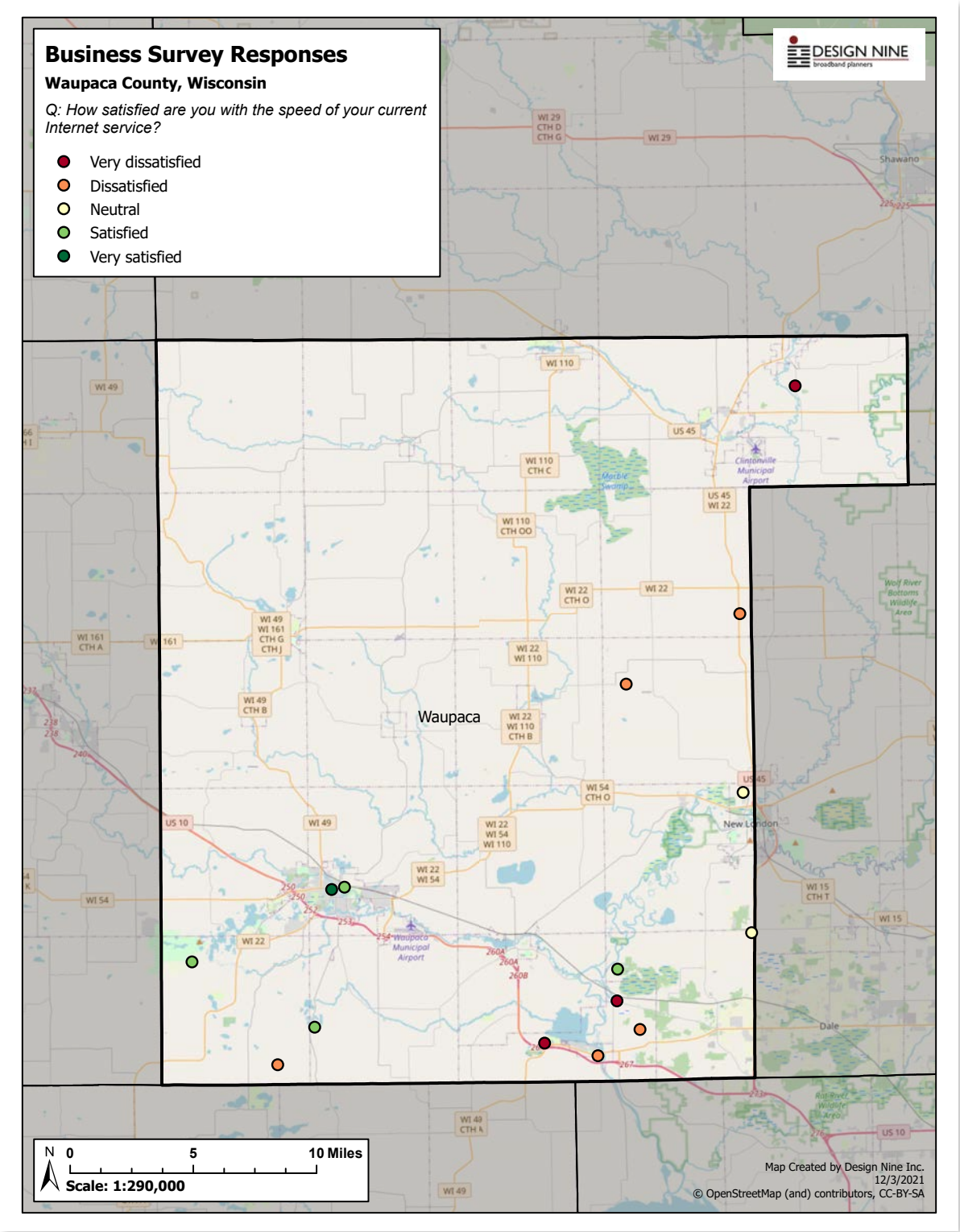
The map below shows the geographic distribution of responses to the business survey, coded according to the *download* speed of their Internet connection (Question 10).



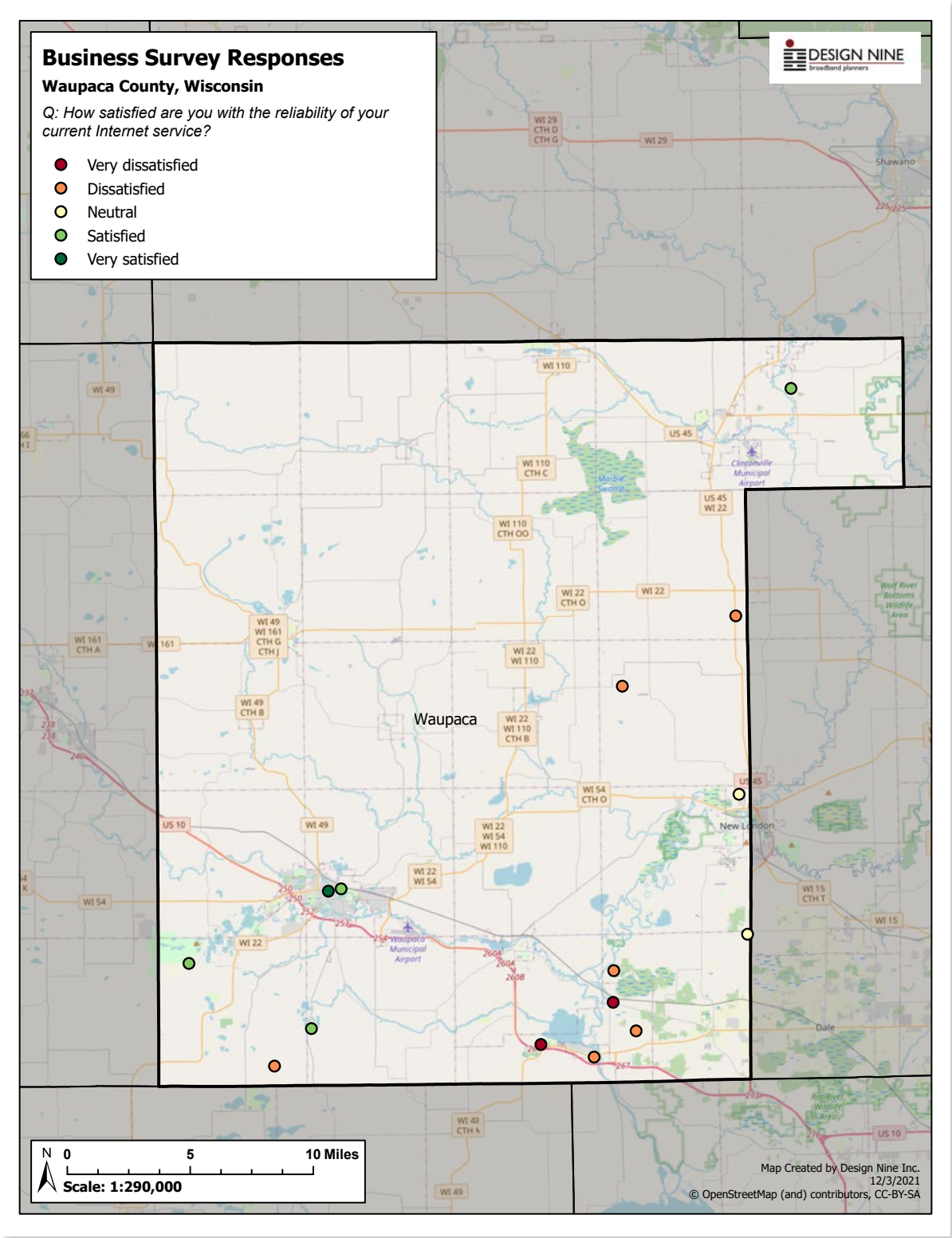
The map below shows the geographic distribution of responses to the business survey, coded according to the *upload* speed of their Internet connection (Question 11).



The map below shows the geographic distribution of responses to the Business survey, coded according to their satisfaction with the *speed* of their existing Internet service (Question 12).



The map below shows the geographic distribution of responses to the Business survey, coded according to their satisfaction with the *reliability* of their existing Internet service (Question 13).



6 HOW MUCH BANDWIDTH IS ENOUGH?

Bandwidth needs for the past several years have been growing by an estimated 30% per year and show no sign of slowing.

This means residential and business bandwidth needs are doubling every three years.

As computers and associated hardware (e.g. video cameras, audio equipment, and VoIP phones) become more powerful and less expensive, new applications and services are continually emerging that drive demand for more bandwidth.

"Next generation" is the term used to describe future planning for network connectivity and infrastructure. Next-generation broadband reaps substantial benefits. There are several key benefits of Next-generation broadband:

- Dramatically faster file transfer speeds for both uploads and downloads.
- The ability to transmit streaming video, transforming the Internet into a more visual medium.
- The means to engage in true-real time collaboration.
- The ability to use many applications simultaneously.
- The ability to maintain flexible work schedules by being able to work from home on a part-time or full-time basis.
- The ability to obtain health-related services for an occasional illness and/or long term medical services for chronic illnesses.

Clearly, consumers have a strong interest in a visual medium from when and wherever they are. YouTube is the second most popular search engine after Google, which demonstrates the need to support the infrastructure to transmit streaming video. In addition to video streaming, true real-time collaboration also provides an effective way for people to interact from wherever they are. People can engage in a two-way real-time collaboration so that fruitful, visual conversations can be held between friends, family, business associates from the state, country, or internationally.

Because of fiber networks, employees have the capability of working from home. Findings suggest that if all Americans had fiber to the home, this would lead to a 5% reduction in gasoline use, a 4% reduction in carbon dioxide emissions, $5 billion in lower road expenditures, and 1.5 billion commute hours recaptured.

In Waupaca County today, many residents and businesses are still relying on copper-based services. The bandwidth tables below show what is likely to be needed over the the next several years in terms of bandwidth. The existing copper infrastructure is going to become a limiting factor in economic development.

6.1 JOB AND WORKFORCE CHALLENGES

Most residents and businesses in the county currently have, at best, Internet service that meets the FCC definition of "fully served," which is 25 Megabits down/3 Megabits up bandwidth. However, what has become painfully clear during the Covid pandemic is that this definition of "fully served" is not adequate to support many kinds of work from home activities. During the Covid lockdown, it

was common to have both spouses trying to work from home while K12 and/or college age children were also trying to use video-heavy distance learning resources.

When home-based workers need to connect to a corporate VPN (Virtual Private Network), bandwidth requirements can increase even more. Work from home and business from home activities should have, at a minimum, a symmetric service of at least 10 Megabits download and 10 Megabits upload speeds. Higher speed service could include service levels like 25 Megabits down/10 Megabits up. The critical requirement is an upload speed that supports work from home.

If the goal is to enhance business access to broadband, there can be no upper limit on the definition of broadband. Saying that broadband (as an example) is 5 Megabits/second of bandwidth or 10 Megabits/second is to tell the residents and businesses in the county that there will be limits on their work and job opportunities.

Broadband is a community and economic development issue, not a technology issue. The essential question is not, "What system should we buy?" or "Is 5G wireless better or cheaper than fiber?" Instead, the question is:

"What do businesses of and home-based workers of Waupaca County need to be able to compete globally over the next thirty years?"

In short, the county today has "little broadband" in the form of DSL limited cable modem service, along with a very limited amount of "big broadband" in the form of fiber to some businesses and residents.

If the County makes investments in broadband and telecommunications infrastructure, it is absolutely critical that those investments are able to scale gracefully to meet business and economic development needs for decades.

Two key concepts that should drive county investments in telecom are:

"Broadband" is not the Internet

Bandwidth is not a fixed number

Broadband and "the Internet" are often used interchangeably, but this has led to much confusion. Broadband refers to a delivery system, while "the Internet" is just one of many services that can be carried on a broadband network. The challenge for the County is to ensure that businesses and homes have a broadband network with sufficient bandwidth to deliver all the services that will be needed and expected within the next three to four years, including but not limited to "the Internet."

The economic impact can include the following effects:

- Difficulty retaining some existing businesses - As business bandwidth needs continue to increase over the next several years, some businesses may need to move out of the county to ensure that they have the right bandwidth to support their business operations.
- Difficulty attracting new businesses - New businesses interested in some of the advantages available in the county (e.g. small town quality of life, good recreational opportunities, affordable housing) may be deterred by the cost and limited bandwidth available, and therefore choose other areas to locate.
- Difficulty keeping younger workers and families in the county - Younger workers and families tend to be heavy users of Internet services, and real estate agents are reporting that younger house buyers are reluctant to live in areas with poor Internet service.

- Reductions in real estate value - Homes with poor Internet service are more difficult to sell, leading to reduced prices and then impacting county property taxes negatively.

6.2 BUSINESS BANDWIDTH NEEDS

The table below shows bandwidth consumption for several types of businesses and a projection of the bandwidth needed 5 and 10 years out. The Covid pandemic has had the effect of dramatically increasing the number of home-based works and has also affected business travel decisions. More and more businesses will invest in high definition (HD) quality business videoconference systems to reduce the need for travel and to maintain high quality communications with a dispersed workforce. These HD systems require substantial bandwidth; a two-way HD video conference requires 20-25 Mbps during the conference, and a three-way conference requires 30-35 Mbps during the conference.

Business Bandwidth Needs

	LARGE BUSINESS		SMALL BUSINESS		HOME BASED WORKER	
DESCRIPTION	A larger business with about 50 workstations.		A small business with 10 to 15 employees, and 7-10 workstations.		One or two people working from home.	
	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps
Telephone	20	5	5	1.5	2	0.5
Credit Card Validation	4	4	1	1		0
Security System	1	5	1	2	2	2
Internet	50	500	7	10.5	2	20
VPN Connection	20	100	5	50	2	5
Data Backup	5	7.5	1	10	2	10
Web Hosting	1	2		0		0
Workforce Training (online classes)	5	20	1	10	2	10
HD Video-conferencing	20	125	2	20	2	10
Totals		**768.5**		**105.0**		**57.5**
5 YEARS FROM NOW	3-10 Gbps		250-500 Mbps		100-200 Mbps	
10 YEARS FROM NOW	10 + Gbps		2-4 Gbps		500-750 Mbps	

As more workers are moved to home-based offices, the business location must provide network access (Virtual Private Network (VPN)) to employees working from home. These home-based workers will make extensive use of videoconferencing to attend routine office meetings remotely and to enhance communications with co-workers, including videoconferences with other home-based workers in the company. A VPN network providing remote access to just two or three home-based employees could require 50 Mbps of bandwidth during normal work hours.

6.3 RESIDENTIAL BANDWIDTH NEEDS

The table below depicts the bandwidth needed for typical residential services which are available now or will be available in the near future. The Covid pandemic has illustrated the shortcomings of cable Internet services, in which the upload and download speeds are highly asymmetric.

For home-based workers, upload speeds need to be equal to or nearly equal to download speeds. Current cable Internet systems are not able to deliver symmetric or near symmetric service. Today's shared networks (cable and wireless in particular) rely on the "bursty" nature of traffic to provide services to end users. If all end users were consuming their advertised maximum bandwidth, today's cable and DSL networks would grind to a halt.

Residential Bandwidth Needs

	RESIDENTIAL DAYTIME		EARLY EVENING		EVENING & LATE NIGHT	
DESCRIPTION	Work from home, K12 distance learning and home schooling, telemedicine, streaming video		Increased Internet use as children arrive home from school and employees from work.		Peak television and Internet use. Multiple TV's are on, phone and computer being used.	
	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps
Telephone	1	0.25	1	0.25	1	0.25
Work From Home	1	10	1	10	1	10
HD TV	1	4	2	8	2	8
Security System	1	2	1	2	1	2
Internet	1	1.5	1	1.5	2	3
Online Gaming	0	0.25	1	5	2	10
VPN Connection	0	0	1	2	1	2
Data Backup		0	1	5	1	5
Telehealth	1	4	1	4	1	4
Distance Learning/ home schooling		0	1	10	1	10
Videoconferencing		0		0		0
Average needed bandwidth		**15-25**		**25-35**		**20-35**
Five years from now	50-75 Mbps		60-90 Mbps		50-100 Mbps	
Ten years from now	150-300 Mbps		200-350 Mbps		175-250 Mbps	

Existing cable modem network users are overwhelming the digital cable networks that were upgraded as little as three or four years ago, and the firms have had to artificially reduce the bandwidth available for certain kinds of high bandwidth services (e.g. peer to peer file sharing). Some cable providers have even run into capacity issues with the TV portion of their networks, and some consumers have observed that some HD TV channels have been so highly compressed that picture quality has been noticeably degraded.

6.4 CURRENT AND FUTURE USES AND SERVICES

When analyzing future service needs, it is important to take into account ALL services that may be delivered over a broadband connection. Broadband is not a service – it is a delivery medium. Using roads as an analogy, broadband is the road, not the trucks that use the road. Internet access is a service delivered by a broadband "road," and that Internet service is just one of many services that are in demand. Today, congestion on broadband networks is not due just to increased use of email and Web surfing, but many other services.

This means that current DSL, wireless, and cable modem services are completely inadequate for future needs. Current DSL offerings are in the range of one Mbps to three Mbps for most residential users, three Mbps to five Mbps for business DSL users, and there are severe distance limitations on DSL. Higher bandwidth is possible, but as the DSL bandwidth goes up, the distance it can be delivered goes down.

Typical wireless broadband (not cellular data service) offerings are in the range of 5 Mbps to 20 Mbps download speeds, and some providers do advertise higher speeds. In practice the actual upload and download speeds can vary substantially, depending on tree cover, terrain, and distance from the tower. Some wireless providers are rolling out advertised 20-40 Mbps services (download) and 3-5 Mbps upload to meet the required FCC 25/3 minimums.

Across the U.S., current average download bandwidth for cable modem services is typically 25-80 Mbps, with cable companies promising much more using the phrase "up to..." to obscure actual bandwidth being delivered. Download speeds on cable Internet systems continue to much lower, with speed tests regularly showing highly asymmetric upload speeds as much as 10-20 times lower than the download speeds.

The highly asymmetric bandwidth (unequal download/upload speeds) of copper-based cable and DSL as well as fixed point wireless continues to highlight the long term superiority of fiber connections, which can and do deliver symmetric bandwidth (equal upload/download speeds). Another key advantage of fiber networks is the ability to upgrade capacity simply by replacing the equipment–properly installed fiber has a useful life span of fifty years or more.

The challenge for the area is to ensure that the businesses, residents, and institutions have a telecommunications infrastructure in place that will meet future needs.

Distance learning, entertainment, and video conferencing are three major applications of internet video. Distance learning from home with live video feeds requires high-performance two to five Mbps connections in the near term, the next two to four years. Over the next four to seven years, there will be many distance-learning courses that will incorporate live HD two-way video feeds, enabling students to participate in classroom discussions at a much higher quality level. Distance learning could be an important home-based application for workforce training and retraining.

U.S. homes now have more than half a billion devices connected to the Internet, according to a study by the NPD Group. Furthermore, the average number of connected devices per household is 10 and growing rapidly. This is more than three times the average number of people per household.

7 CONNECTIVITY SOLUTIONS

7.1 OVERVIEW OF THE TECHNOLOGY

The telecom industry has evolved rapidly over the past twenty years, with several new technologies now beginning to replace the two older telecom systems: telephone copper twisted pair cable and cable TV copper coaxial cable. The table below provides a short summary of the technologies that are now being used throughout the U.S. to deliver broadband and Internet services.

Technology Type	Description
Dial-up modem	There are still some households, mostly in rural areas, still using dial-up. This has, in most areas of the country, been replaced by DSL
DSL	DSL uses the same copper twisted pair wiring employed by telephone companies for the past 100 years. Speeds vary widely depending on the age of the wiring. In many rural areas, the copper phone cables can be forty years old or more.
Cable Internet	Cable systems in the U.S. use copper coaxial cable to deliver TV, Internet, and voice telephone services. Most cable systems have converted to fiber for their core network, but still use the copper coax cable from a neighborhood equipment node to the home. Speeds have improved steadily, with many cable companies promising "up to" Gigabit download speeds. Upload speeds are usually much lower. A major difference between cable Internet and fiber Internet is that fiber systems can deliver fully symmetric service (equal upload and download speeds), which is important for K12 distance learning and work from home.
Fiber	Optical fiber systems are now nearly two decades old, and the cost of equipment is very affordable. Fiber is a future-proof technology with a life span of forty years or more for properly installed fiber cable. It can provide virtually unlimited bandwidth, and can offer symmetric speeds (equal upload and download). Fiber delivered Internet is rapidly becoming more affordable than several other types of technology systems.
Fixed Point Wireless	Fixed point wireless is widely available in many parts of the country. It is not a mobile service like cellular systems. Premises typically have a small antenna/radio attached to a high point on the building or a utility pole, and receive the Internet signal from a tower that can be 2-3 miles away in most cases. Speeds are generally better than DSL, and can now meet the older Federal standard of 25/3 Meg service. Improvements in radios and new frequency spectrum will bring faster speeds over time.

Technology Type	Description
4G/5G Cellular Data	In areas where landline Internet services are poor, many households and businesses rely on cellular data services, which can offer adequate speeds but can be expensive when used regularly for two way video and video streaming.
Geosynchronous Satellite	Geosynchronous satellite Internet service (e.g. HughesNet, Viasat, etc.) is available everywhere in the U.S. The service suffers from long latency times which makes it difficult to use for two way video and voice calls. It is more expensive than some other Internet service options, but is still in wide use in rural/remote areas.
Low Earth Orbit Satellite	Low Earth Orbit (LEO) satellite service is becoming more widely available, primarily through Starlink. It offers good speeds and is somewhat less expensive than older satellite services. At least two other companies have plans to compete with Starlink, which may reduce prices.

In Waupaca County, both fiber and broadband wireless infrastructure improvements will be an important strategy for better Internet access for businesses and residents. The table below summarizes how fiber and wireless can work together in a variety of ways.

Distribution Type	Access Type	Capacity
Fiber	Fiber	Any amount of bandwidth needed, with standard connection typically a Gigabit (1,000 Megabits).
Wireless	Wireless	Typical customer connection starting at 5 to 10 Megabits, can be higher, with 50 Meg connections common. More dependent on the capacity of the wireless Distribution link.
Wireless	Fiber	Users can have fiber Gigabit connections locally, but total throughput dependent upon the capacity of the wireless link, which can be up to a Gigabit, depending on distance and budget.
Fiber	Wireless	Typical customer connection starting at 5 to 10 Megabits, can be higher, with 50 Meg connections common.

Businesses and residents may obtain Internet service:

- With a fiber connection to the fiber installed in areas where economic development is important, and in other areas as additional fiber network segments are added.
- With a small radio directly attached to their home or business that receives a signal directly from a towers owned by a private provider, or from a County-owned tower (e.g. shared with public safety use).
- With a small radio attached to a utility pole (60 or 70′) to improve line of sight to a nearby taller tower.

- With a small radio directly attached to their home or business that receives a signal from a "community" utility pole. The "community" pole will receive a signal from a distant tower and redistribute it locally to a cluster of customers (typically within a half mile).

Both fiber and wireless technologies and systems are going to be important to meet the goal of improving access to broadband. The rest of this section provides more detail and some specific build out strategies.

7.2 DARK FIBER AND LIT FIBER

About Dark Fiber

Dark fiber is installed in conduit underground and/or hung on utility poles. It is called "dark" because no network electronics are installed to "light" the fiber (using small lasers in a fiber switch). For small municipal/local government fiber installations, dark fiber has a significant advantage in terms of management—very little ongoing operational responsibility is required.

Dark fiber is leased out to service providers, who install their own network electronics in cabinets or shelters attached to the fiber cables. The providers typically lease fiber pairs between the cabinet and their customers, and are responsible for all equipment-related management and maintenance. Dark fiber networks can be used by service providers to provision either Active Ethernet or GPON services to their customers.

Dark fiber networks do not generate large amounts of revenue, but this is offset by very low maintenance costs—primarily an emergency break-fix arrangement with a local or regional firm qualified to splice fiber. Emergency break-fix contracts are usually based on a time and materials basis, so there is little or no expense if there are no fiber breaks.

Other costs include "locates," which are called in to Wisconsin 811 (Diggers Hotline) and are performed by either the local Public Works department or a private sector contractor. For small fiber networks, locate costs are generally modest.

About Lit Fiber

A "lit" fiber network includes the network electronics needed to transmit data over the fiber (using the small lasers in a fiber switch, hence there is light traveling over the fiber cable). In a lit network, "lit circuits" are leased out to service providers rather than fiber pairs. The muni/local government/community network provides the network electronics, which reduces costs for the service provider —meaning they are able to pay higher lease fees for the circuits they use to deliver services (like Internet) to their customers. Lit networks generate more revenue, but also have higher expenses because the network electronics have to be monitored and managed on a 24/7/365 basis (this task can usually be outsourced at reasonable cost). However, very small fiber deployments often do not pass enough homes or businesses to generate sufficient revenue to cover the higher costs.

Like dark fiber, a lit network incurs break-fix and locate costs as well.

7.3 WIRELESS TECHNOLOGIES

WISPs (Wireless Internet Service Providers) use a wide variety of radio frequencies to deliver fixed point wireless broadband. By "fixed point," this means that these systems are not designed to

support roaming in the way that cellular voice/data radios are (that is, mobile phone and data services).

Fixed point broadband is broadcast from a tower to individual homes and businesses (fixed points). Most of the frequencies used require clear line of sight between the tower and the location where service is desired.

Hilly topography can work for or against good wireless broadband service. Towers located on the tops of hills and mountains can provide service over a larger area than a tower in relatively flat terrain, but hills also block the signal. A residence can be a short distance from a large tower, but heavy tree cover or an intervening hill will block service. The solution to this can be addressed in several ways:

More larger towers of 180' to 300'

The taller the tower, the wider the coverage, but as tower height increases, the cost of the tower also increases. Towers taller than 199' require a light at the top to make them visible to low-flying aircraft, and lighted towers are more expensive to erect, and the bulbs have to be changed periodically at significant expense. Many broadband towers are 180' to avoid the additional cost of lighting.

Small cell broadband utility poles

Small cell broadband utility poles, often called community poles, are shorter towers or utility poles of typically 60' to 80', located in or very near a cluster of homes. The towers can be wooden utility poles or relatively low cost steel monopoles or steel lattice towers. These towers are located to get above local tree cover so that clear line of sight to a distant taller tower is available. Local access point radios provide service to homes and businesses with line of sight to the pole. In many parts of Waupaca County, these are going to be an important part of a strategy to get better broadband to rural residents and businesses.

Variety of radio frequencies

WISPs are beginning to deploy a wider range of licensed and unlicensed radio frequencies to overcome distance, bandwidth, and line of sight issues. Traditional 2.4 Ghz and 5.7 Ghz WiFi and WiMax frequencies are being supplemented or replaced with LTE and CBRS licensed broadband frequencies that provide better bandwidth and will tolerate light tree cover better (2.5 Ghz, 3.5-3.7 Ghz). Some WISPs are also using lower frequencies (e.g. 900 Mhz) that will travel farther and will also provide better penetration in light tree cover.

7.4 EMERGING WIRELESS TECHNOLOGIES

MIMO Wireless

MIMO (Multiple Input, Multiple Output) describes a variety of technologies that can be summarized as using more than one receive and transmit antenna for wireless data applications. Wireless protocols that are using the MIMO concept include IEEE 802.11n (Wi-Fi), IEEE 802.11ac (Wi-Fi), 4G, LTE (Long Term Evolution), and WiMAX. Each of these protocols use the MIMO technology to increase the amount of available bandwidth in a given section of radio frequency spectrum.

New hardware is required to make effective use of MIMO. While the technology increases wireless bandwidth, the typical amount of bandwidth being used by wireless devices is also increasing rapidly. Some applications where MIMO is likely to provide noticeable improvements are in home wireless routers, where the effective throughput will be able to better handle the demanding bandwidth requirements of HD and 4K video streams. MIMO is slowly being developed for use with cellular smartphones, but both the phones and the cell tower radios have to be upgraded to support MIMO.

LTE/4G/5G

LTE (Long Term Evolution) is a set of protocols and technologies designed to improve the performance of voice/data smartphones. Like MIMO, both the user phone and the cell tower radios have to be upgraded to support LTE improvements. In 2013, only 19% of U.S. smartphone users were able to take advantage of LTE speeds, although that percentage has been increasing rapidly since then, and more than 85% of the U.S. cellular towers have been upgraded to LTE. As noted previously, the actual bandwidth available to a smartphone user is highly variable and depends on distance from the cell tower, the number of smartphones accessing the same tower simultaneously, and the kinds of services and content being accessed by those users.

The primary purpose of cellular bandwidth caps is to keep cellular users from using too much bandwidth and degrading the overall service. While LTE and MIMO improvements will improve overall cellular service, these technologies are not going to replace fiber to the home and fiber to the business.

In 2017, new fixed broadband wireless systems entered the marketplace using LTE frequencies, and many WISPs have begun to replace existing wireless radio systems with LTE equipment. These LTE systems do not provide any cellular voice services; they are designed specifically to support only broadband/Internet service.

In our conversations with both vendors of these systems and WISPs that have begun deploying them, we get two different stories. The vendors have been conservative in discussing the improvements, while some WISPs have been taking single user test results and suggesting that they will be able to deliver higher speeds at greater distances to all users.

> To achieve the full benefit of 5G technology, more fiber is needed.

There is little debate that the LTE equipment offers higher bandwidth, at somewhat greater distances, and with somewhat better penetration of light foliage and tree cover. Over the next two to four years, most WISPs will change out most of their existing radio systems for the improved LTE radios. Perhaps the most significant advantage of LTE fixed point broadband is its ability to provide better performance when clear line of sight between the customer and a tower is not available. LTE provides better penetration of light to moderate tree cover and other line of sight obstacles.

The official standard for 5G radio technologies was release in 2019, and many metro areas of the country now have 5G radio systems. It is worth noting that many smartphones, even some late model smartphones, do not have 5G support built in.

5G does bring much higher speeds to wireless broadband (e.g. it might be able to deliver 30 to 50 Meg of bandwidth consistently). But 5G has significant limitations that do not make it a good solution in rural areas of the U.S.

The fact that 5G can deliver much higher bandwidth means that 5G cell sites will require fiber connections. This is going to effectively limit 5G deployments to denser urban environments where both customers and fiber are plentiful.

There is no free lunch in the physics of radio frequencies. The higher bandwidth of 5G means that cell sites need to be closer together because the 5G frequencies do not travel as far as existing 4G/LTE frequencies currently being used by the cellular industry. Most users will have to be within 500 to 1,000 feet to receive 5G service.

Some experts estimate that more than a million miles of new fiber will have to be deployed just to support the 25 largest metro areas in the U.S. 5G will not appear overnight.

As many as eight to eleven cell sites per square mile may be needed to make 5G widely available in a given area. If, as an example, about 25%, or 187 square miles of Waupaca County is underserved, very conservatively, 1700 or more cell sites would be needed to provide good coverage (as many as nine or ten cell sites per square mile).

For rural areas, the cost of 5G service may be one of the most significant obstacles. The cellular carriers see the increased customer bandwidth use possible on 5G networks as a major revenue opportunity. While they will increase the "standard" bandwidth package for monthly service, bandwidth caps and rate limiting is likely to keep 5G cellular customers bills high.

Many rural areas of Waupaca County have poor or no cellular voice/data service, and somewhat counter-intuitively, more fiber can solve that problem. Cell towers need fiber backhaul connections to provide the best cellular data performance, and so rural fiber will also help address the issue of poor cellular service.

White Space Broadband

White space broadband uses some of the frequencies that were formerly used by analog TV channels. These lower frequencies travel farther and provide better penetration of light foliage. Microsoft has been supporting a number of community white space experiments, and has promised much wider support for this technology, but there are few other users, equipment is still relatively expensive, and few WISPs have ventured into this still largely experimental technology. A Microsoft white space project in southern Virginia, although still underway, serves less than three hundred households and is still regarded as experimental. Other white space pilot projects have reported good results. One ISP experimenting with the technology has indicated that their trials with white space equipment has been able to deliver 50 Meg/50 Meg service.

Low Earth Orbit (LEO) Satellite Internet

The Elon Musk-funded Starlink effort began offering "beta test" service in late 2020. There is a one time equipment and installation fee of $499, and a monthly fee of $99. The company is promising download speeds of between 50 Meg/sec and 100 Meg/sec and upload speeds of up to 20 Meg/sec. Latency is lower than traditional satellite Internet services. If the prices remain reasonable, this is likely to become a much better alternative to the older satellite Internet services.

In early fall of 2021, Starlink announced that the company would be moving the service out of beta, which would make the service more available to more users. The service has received generally favorable reviews from beta users in terms of speed and reliability. It will be important mostly for rural users who have line of sight problems for terrestrial fixed point wireless and for households and businesses that are completely outside the coverage area for fixed point wireless. Service

reports emerging in late 2021 indicated that Starlink was able to provide download speeds reliably at 50 Mbps to 75 Mbps, with a latency of 45 to 60 milliseconds. Low latency is critically important for good quality two way voice and video conversations. By comparison, geosynchronous satellite service may have latency of ten to twenty times higher than Starlink.

Millimeter Wave Service

Millimeter wave services use a variety of very high frequency wavelengths in range of 30 Ghz to 300 Ghz. An emerging wireless broadband service that uses the term "millimeter wave" covers very short wavelengths in the 71-76 GHz, 81-86 GHz, and 92-95 GHz (70/80/90 GHz) bands. These shorter wavelengths permit the use of very small antennas while still being able to provide high directivity and high gain. A primary advantage of the smaller antennas is the ability to use more of them and to make each individual antenna highly directional. The higher frequencies also permit transmission of much higher bandwidth. However, the higher bandwidth rates are distance limited.

In early testing in 2020, U.S. Cellular was able to demonstrate speeds of 100 Mbps at distances of three miles using 5G radio equipment (5G equipment is also close to the millimeter wave spectrum using lower frequencies of 24 Ghz, 28 Ghz, and 39 Ghz for some equipment). Radio equipment tests are often conducted in optimum conditions, and in real world conditions, the practical distance may be lower and the bandwidth may be lower, where buildings and trees can degrade or block the radio signals.

7.5 NETWORK ARCHITECTURE OVERVIEW

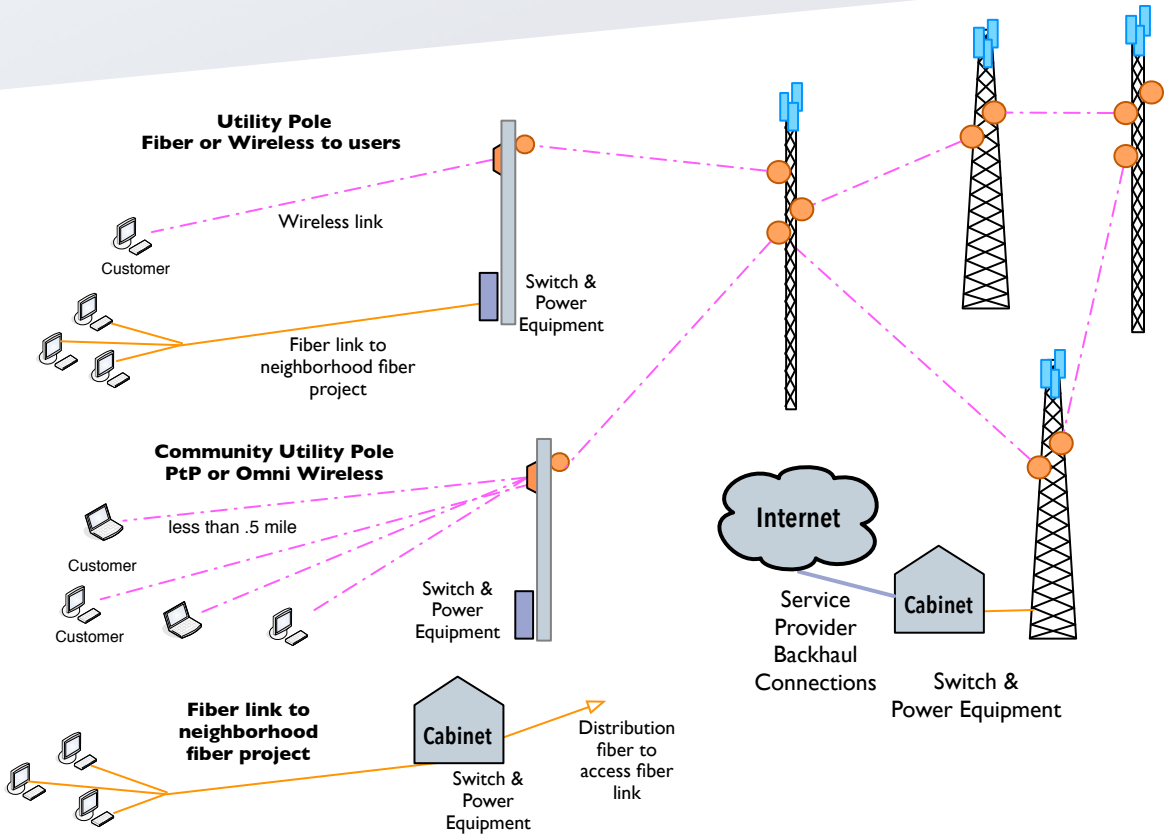
Both wireless and fiber networks, as well as legacy copper-based networks, all share three primary components. How these are designed and deployed can vary greatly, but all networks have these three parts in some form.

- The **Core Network** provides access to the Internet, a place for service providers (ISPs) to distribute their services locally on the network, and for larger institutional and business customers to meet service providers. Waupaca County has both landline and wireless service providers, but there are still areas that are underserved. Each of these providers has their own Core Network, but wireless broadband could be more widely available if additional county-owned towers were available to the private sector providers.
- The **Distribution** portion of the network connects the Core Network with collections of users. A Distribution network can include both fiber and wireless portions of a network.
- The **Access or Last Mile** portion of the network connects residential users and businesses to the network, and like the Distribution network, that connection will be by fiber or by a wireless link.

The illustration below shows the full range of technology options (fiber and wireless) and how they can be connected together in various ways to meet the diverse needs of the county. More detail is provided on the following pages.

Last Mile Access

The Last Mile Access is the portion of the network that connects customers to their service provider and the Internet. Both broadband wireless and fiber links can be utilized to provide service. There are several ways that customers can receive service:



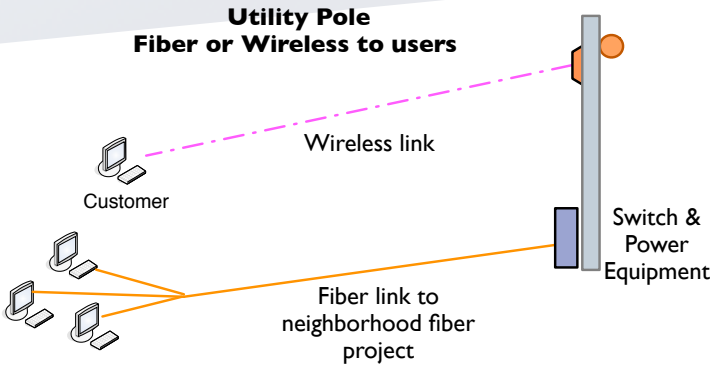
- Service providers can install their own local access radios on the Distribution towers, using both point to multi-point and point-to-point radios to deliver service to their customers.
- A single user utility pole (or inexpensive steel lattice tower) can be installed on the property of a single resident or business. A radio at the top of the pole receives service from another tower site (typically one of the Distribution towers).
- A utility pole (or inexpensive steel lattice tower) can be installed near a cluster of homes (e.g. a rural residential sub-division, several homes in close proximity on a rural road). Service providers can install their point to multi-point radios on this pole and provide economical service to several customers from a single pole.
- A utility pole (or inexpensive steel lattice tower) can be installed in a rural subdivision. A service provider installs a point to point radio on the pole, and fiber cable can be run from the pole past several homes to offer fiber service with wireless backhaul.
- Customers near existing fiber can have a fiber drop installed directly to their home or business.

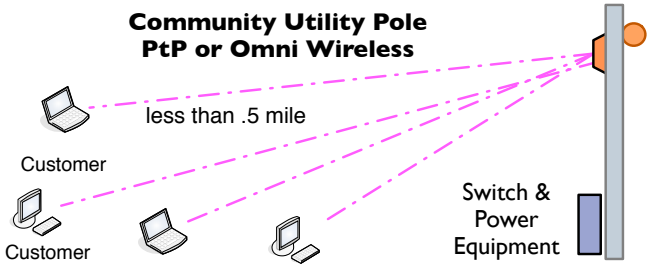
Distribution Network

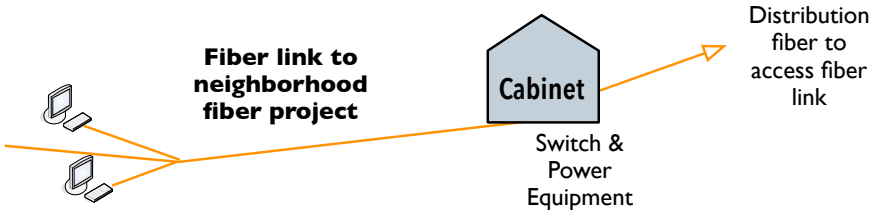
Distribution is the portion of the network between the Distribution sites to the Last Mile Access portion of the network. It is desirable for each distribution site to have a connection back to more than one Distribution site (tower) on a redundant ring. This ring topology protects against

hardware failure at the port level and does provide some protection if one of the tower to tower wireless links is disabled by an equipment failure.

These tower sites are typically 120′ to 180′ tall to provide the height needed to enable Line Of Sight (LOS) between towers, and for local access, to enable service providers to mount point to multi-point radios on the towers.



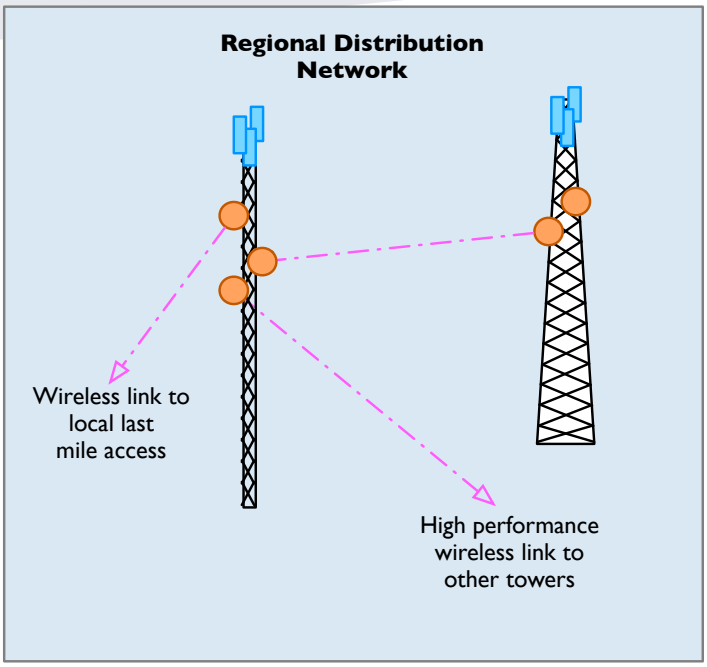




Towers taller than 199′ become subject to FAA regulations because the height can be a potential hazard to airplanes. Towers that exceed 199′ usually have to be painted (alternating red/white) and have a blinking light at the top. These requirements increase the long term maintenance costs, but the taller towers can improve line of sight to other towers.

The towers can provide two functions:

- Space for backhaul connections to other towers in the county.
- Space for local access radios to provide Internet access within 2-3 miles of the tower (or farther with good Line Of Sight).



Core Network and Service Providers

In the past, the telephone company switch office (Central Office, or CO) has provided that function. Today, many communities have either a community-owned data center or a privately owned data center that offers an affordable range of options for customers of broadband services.

The Co-Location facility provides a meet point for various public and private fiber cables and networks to inter-connect. A local facility with space available for both public and private uses could help attract additional private sector investments (e.g. a long haul fiber provider wants connect to this facility because of increased access to customers).

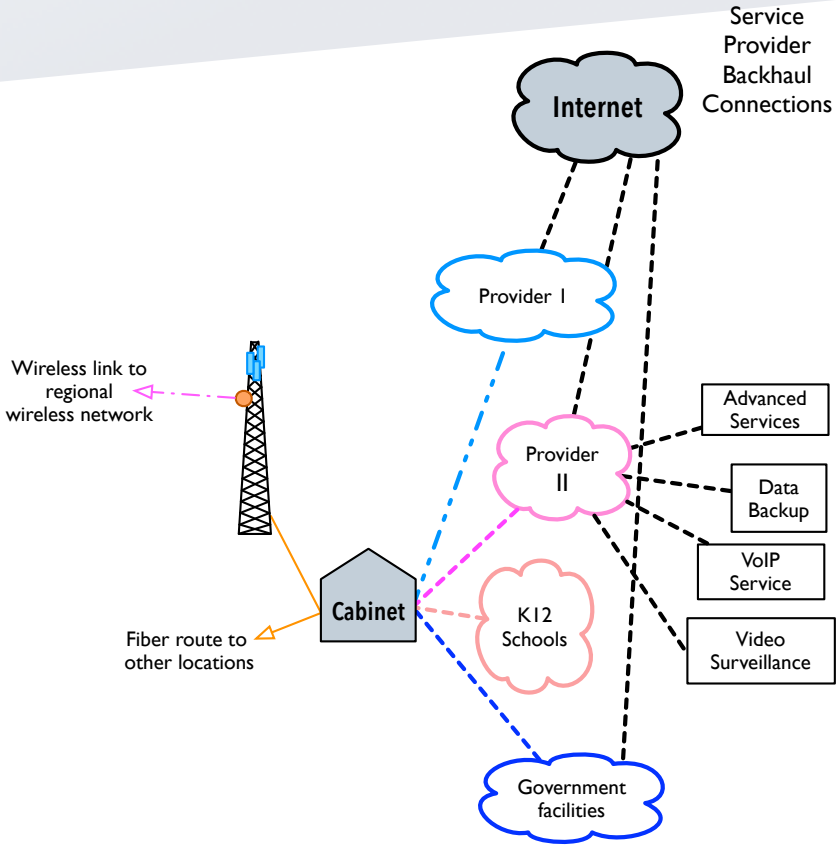
A colocation facility is a controlled environment (i.e. secure, heated, and air-conditioned) room with Internet access through wired and/or wireless systems. The colocation facility is a place where fiber, wireless, and copper-based network facilities meet. It is equipped to house high-end network equipment, servers, and other electronic gear.

A variety of middle layer network components and services can be located within the co-lo including, for example, directory services, replicated content servers, routing services, and other elements needed to deliver new multimedia services to the home and small office from multiple, competing providers.

Characteristics of the colocation facility are:

- A reliable source of AC electric power is required, with backup UPS (Uninterruptible Power Supply) service, and additional power backup available by an onsite generator is desirable.
- Controlled access to the facility (e.g. by electronic keycard) 24 hours/day, seven days a week. Service providers need to be able to gain access to the equipment room as needed, and work activities performed at night or on weekends is common.

- Racks for locating network equipment and servers, and optionally locked cages for equipment racks.
- Sufficient cooling capacity for the network's current and long-term needs. Equipment rooms require both a cool air input vent and an air return vent.



7.6 THE MEET-ME BOX CONCEPT

In some of the larger towns, some smaller communities, rural neighborhoods, and subdivisions, "meet me" boxes could be installed. A meet me box is a telecom cabinet with fiber cables installed between the cabinet and nearby homes and/or buildings. Providers only have to reach the meet-me box, lowering their costs. Both wireline and wireless providers can use this infrastructure. This approach can also be used to provide fiber services in business and industrial parks. A small Virginia county installed five miles of fiber in their business park and was able to attract a Tier One provider to provide service to an existing business (a manufacturing plant that was going to leave if the county did not help them get better Internet service).

The dark fiber approach minimizes operational costs. Service providers would install their own equipment in the cabinet and would pay a small monthly lease fee for the fiber strands they use to connect customers to their services.

For a meet-me box installed in a "main street" area (e.g in an alley behind commercial/retail buildings) with relatively inexpensive and short fiber drop cables into nearby buildings, the lower end of an installation might start at $35,000. For a box installed in a rural sub-division that requires distribution conduit/fiber and drop cables, the cost to connect 25 homes might start at $175,000 on the low end and increase as the number of homes connected increases. Larger numbers of homes or businesses will each add to the cost, but adding more connected premises also increases the value of the infrastructure and increases the revenue potential.

7.7 TERRAIN CHALLENGES

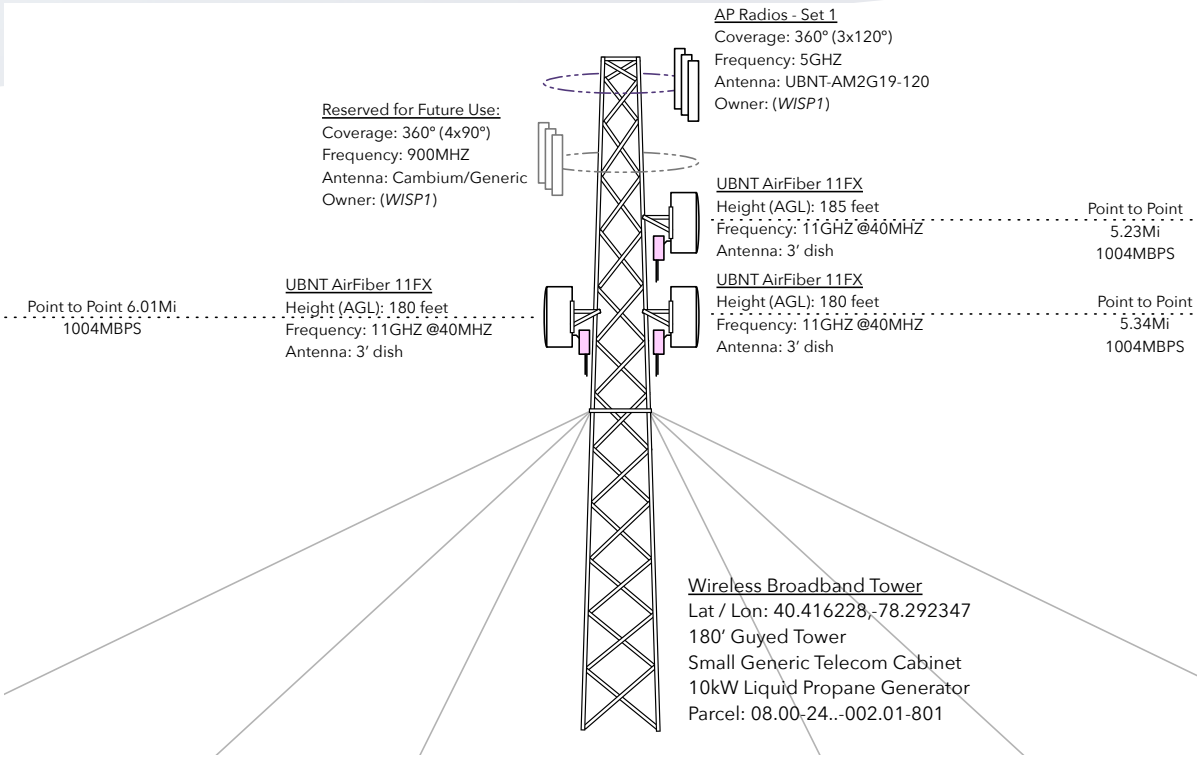
While the terrain in Waupaca County is relatively flat, more towers and perhaps some community poles will be needed to near an adequate solution using fixed point broadband wireless. In some areas, the difficulty of obtaining line of sight for a radio link between two locations may dictate using fiber in place of wireless.

7.8 WIRELESS NETWORK INFRASTRUCTURE

The diagram below shows an example of the equipment typically placed on a tower, and details about the equipment that is planned. Several sets of Access Point radios can be placed on a tower operating in different frequencies, and can be owned/operated by multiple WISPs. Point to point radios link this tower to several other sites.

When developing wireless networks there are several categories of costs at each site. Construction of the network will incur site related costs at each tower site including:

- Site development - clearing the site of trees and vegetation, construction of a tower road for access to the site, and strict adherence to all erosion and sediment control measures required by the Owner.



- Passive site equipment - In most cases, a network cabinet will be installed and a new power service will need to be run to it. At each site there will be a generator and most likely a propane tank also installed. Reliable power systems will be installed inside the cabinets, and other equipment management solutions will be installed in the cabinet for network equipment.
- The tower itself - new towers in this estimate are designed as 180' guyed towers. A guyed tower is usually a small profile lattice type tower that is supported by guy wires at several points on the tower. Guyed towers usually have a smaller visual profile than self supporting towers because they are narrow from the top all the way to the base. Self supporting towers will have the same lattice type structure but the tower widens as you get closer to the base. If the tower base is obscured by trees all around, a self supporting tower may be preferred. Some sites may require design changes based on site conditions. Other types of towers such as monopoles could be considered for this project, especially if the owner is working with cellular providers on developing a site.
- Network equipment such as Point to Point radios, routers, switches, and access point equipment will be installed during the construction of this network. Since the network has built in redundancy the configuration will need to support automatic failover and other high-level network functions. In addition to the networking expertise needed to configure large networks such as this the contractor(s) configuring the network will need to understand spectrum management, wireless signal propagation, and other physical aspects specific to wireless networks.
- Permitting - depending on the locality developing a wireless site usually requires extensive permitting processes that require a relatively long timeline and professional services.

7.9 SMALL CELL BROADBAND POLES

Line of sight issues are a constant problem for rural residents and businesses, as clear line of sight (or near line of sight) is required for fixed wireless Internet services. Even newer technologies like white space and LTE systems work better with clear line of sight to distant towers.

The increased use of wooden utility poles is already common in some other areas of the country, and increased use of this technique to get the customer CPE radio/antenna above tree cover is a relatively simple solution.

The utility poles would normally be placed on private property, subject to existing or updated ordinances governing the placement of wooden utility poles. The local government would have no responsibility for maintenance and repairs.

The cost of placing an eighty foot pole can range from a low of about $2,000 to $7,000 or more, depending on permitting, engineering requirements, and the location of the pole. Some municipalities provide "by right" permitting of these poles if they are placed on private property, which can reduce the cost of installing them.

Because these are placed on private land, local government would not have to provide any direct funding. However, the localities could encourage wider use of this option with a public awareness campaign developed in partnership with wireless providers. Local banks could be encouraged to provide low cost financing of the poles so that property owners could make a small interest and principal payment monthly over several years to reduce the financial impact.

This strategy requires minimal financial support from the County and that it has the potential of improving broadband access in rural areas of Waupaca County quickly. The County should work with WISP partners to promote this option to improve access to new and existing wireless broadband towers.

7.10 NANO-CELL AND WIFI CALLING SERVICE

A common complaint in Waupaca County is the poor cell service in many areas. In some parts of the county, there may be adequate broadband service via DSL or fixed point wireless Internet, but poor cellular phone/data service. There are now two solutions to improving rural cellular service that do not involve the expense or difficulty of attracting and/or building more cellular towers.

WiFi Calling – This approach takes advantage of the WiFi Calling feature that is now common in many late model cellphones. Once the phone is connected to a WiFi network (e.g. in the home using the home's broadband Internet service), the phone will automatically route the call over the WiFi network–phone calls and text work normally, as if the phone is connected to a cellular tower.

Nano-cell Calling – Poor or no cellular service in rural areas can be addressed by promoting the wider use of "nano-cell" devices. These small pieces of equipment are connected to the DSL or wireless broadband connection and provide improved cell service in the home or business. The working distance of these devices is limited, and service generally drops off once you leave the house itself (it may work for some short distance in the yard). These devices work very well and do not require an upgrade to a newer phone.

The cellular providers do not always promote the use of these devices, so many cellular users who would benefit from their use are not aware that this option is available. The device averages around $200 retail, but the cellular providers often provide substantial rebates (50% discount or more) and in some cases may provide them at no charge.

The improved wireless broadband service will also support use of WiFi calling and/or nano-cell devices.

This strategy is important because improved broadband service can also improve cellular service without the need for more cellular towers, especially in parts of the county where cellular providers have not been able to make the business case for more towers.

8 PLANNING FOR BROADBAND

8.1 BROADBAND PROJECT TIMELINE PLANNING

Each kind of project will have its own timeline, and will vary widely depending on the type of funding. Grant-funded projects may need six months to one year to plan and apply for funding, depending on where in the grant cycle the network owner commits to applying for a grant and the length of time that the grant agency takes to review and approve grants.

Tower improvements and construction times can be dependent on weather (more weather related delays are likely in late fall through early spring) and on procurement. Most grant-funded projects require careful attention to a public procurement process, which can add 90 to 180 days to the timeline.

As this report was being completed in late 2021, the supply chain for broadband materials, including fiber cable, conduit, handholes, towers, and some related equipment was already beginning to lengthen. As Federal funding dollars are released in the spring and summer of 2021, the lead times for materials are likely to become even longer. This has the potential to substantially lengthen the average time needed to move a project through the development cycle from funding to completion. Any and all procurement, including both materials and construction contractors, should be expedited and completed as early and as quickly as possible.

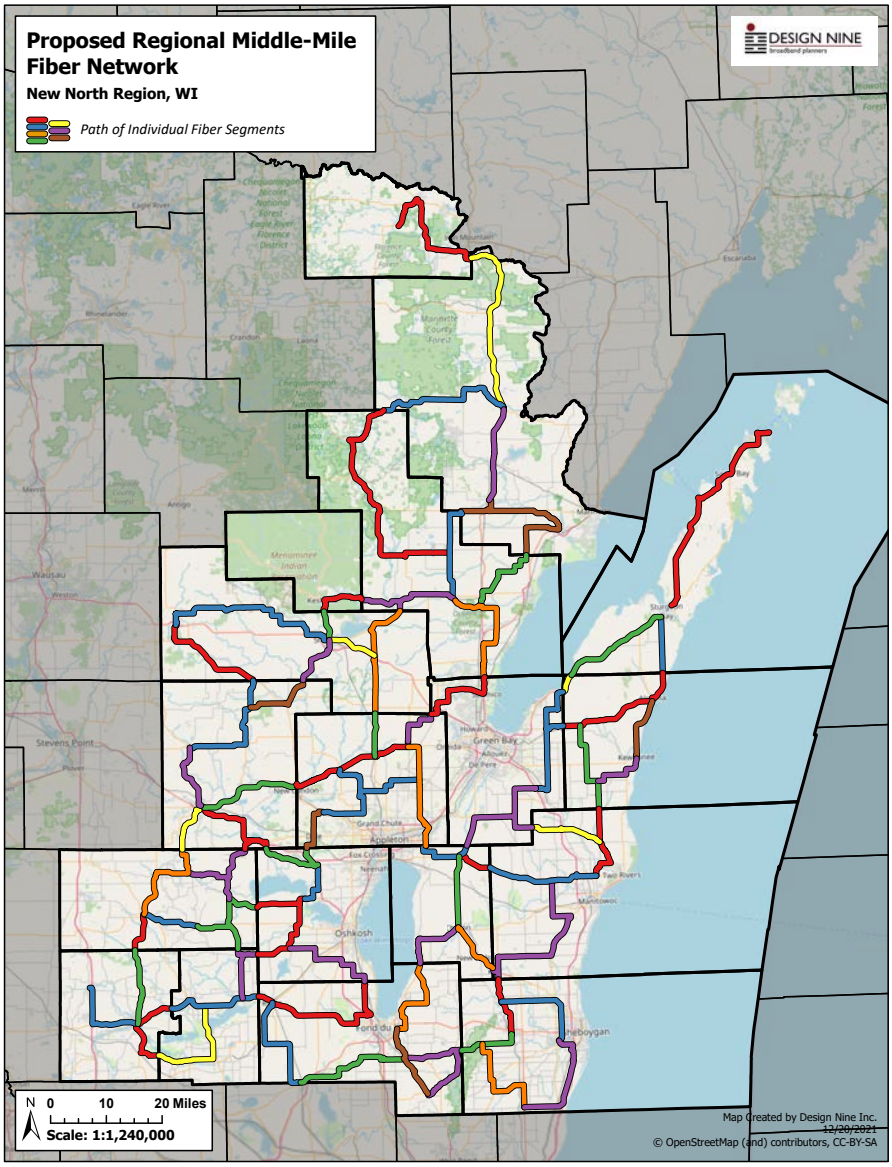
Broadband Construction Timetable

Project Type	Project Execution Planning	Project Procurement	Project Engineering and Construction	Total Estimated Timeline
Improvements to existing towers	2-3 months	3-4 months	2 months	7-9 months
New towers of 180 ft	4-6 months	4-5 months	4-8 months	12-19 months
Small cell community broadband poles	3 months	2 months	2 months	6 months
Point to point tower backhaul links	2-3 months	3-5 months	1-2 months	6-10 months
Fiber to the home/ business projects	4-6 months	4-6 months	6-12 months	14-24 months

8.2 A MIDDLE MILE STRATEGY

Economic development in the 21st century has been and will continue to be driven in part by the availability of affordable, high performance Internet services. Like most of the New North region, Waupaca County has some incumbent DSL and cable Internet service, and fixed point wireless service is also available in most of the county.

What is needed is a robust, open access middle mile network available to all ISPs and WISPs to assist with the growth of their business – especially to assist with rapid expansion of fiber to the home. A middle mile network in the county, passing through many of the smaller communities, can enable faster fiber to the home deployment–any cluster of homes passed by the middle mile fiber could be provisioned with Gigabit fiber service quickly.



This middle mile fiber could be built and owned by the County or by a regional nonprofit consortium, connecting the Waupaca County middle mile network to a larger regional middle mile network. This fiber network would be "dark" (see Section 7.2 for more information). This means that the fiber owner would have very limited day to day responsibility for operations and maintenance. ISPs and WISPs would lease fiber strands and build lateral connections to wireless towers and fiber to the home projects.

The County would not be an Internet Service Provider. It is also important to note that leasing dark fiber is not a telecom "service" and is not prohibited by state law.

Just as importantly, widespread availability of high performance fiber can be a powerful economic development tool to assist with the attraction of new businesses and jobs and to help retain existing jobs and businesses.

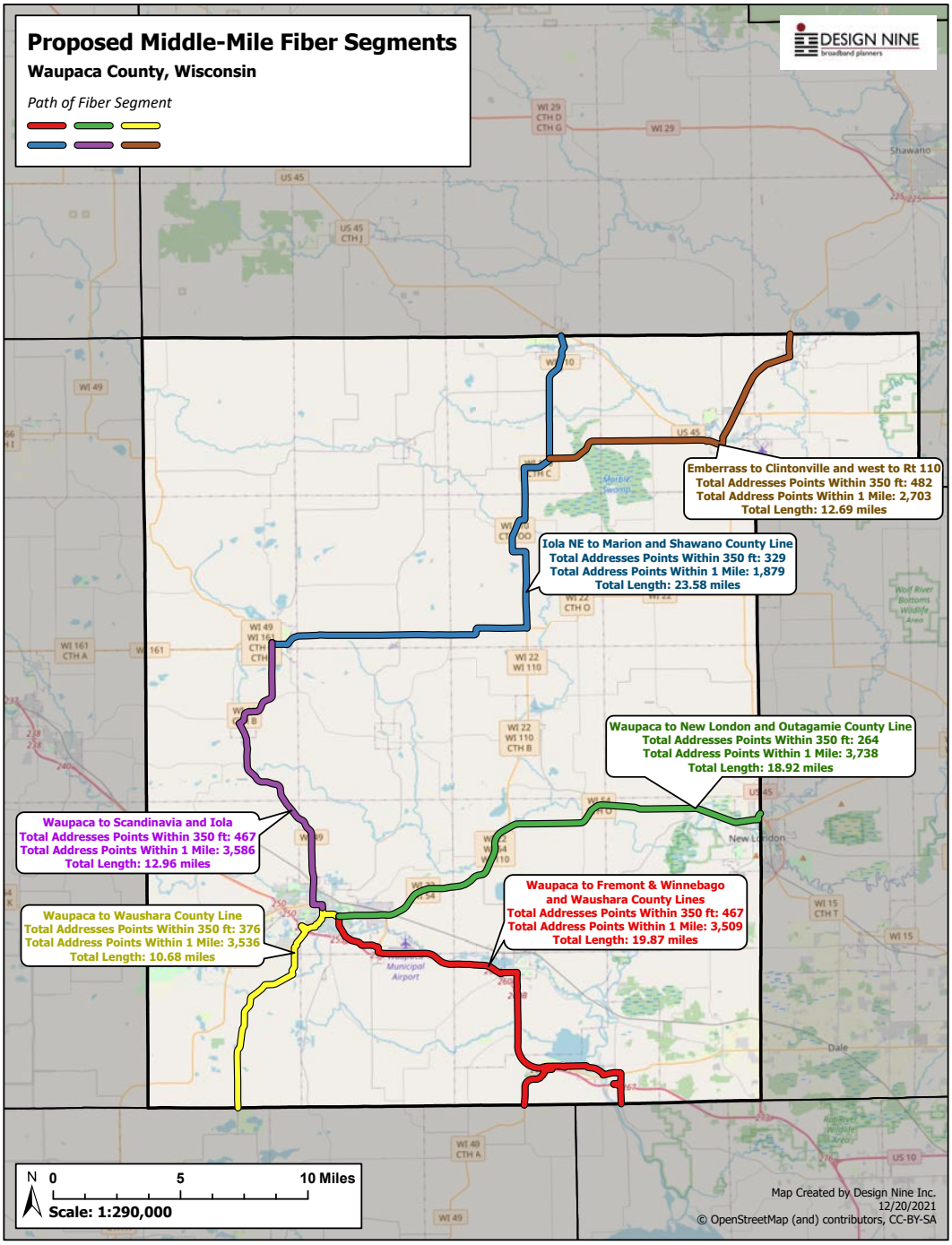
The middle mile network in Waupaca County consists of six segments, as shown in the tables below.

Segment ID	Project Description	Total length (feet)	Total length (miles)
WP1	Waupaca to Fremont & Winnebago and Waushara County Lines	104,918	19.870
WP2	Waupaca to Scandinavia and Iola	68,423	12.960
WP3	Waupaca to Waushara County Line	56,408	10.680
WP4	Waupaca to New London and Outagamie County Line	99,929	18.930
WP5	Iola NE to Marion and Shawano County Line	124,545	23.590
WP6	Embarrass to Clintonville and west to Rt 110	67,031	12.700
	Totals	**521,254**	**98.73**

Segment ID	Estimated Buildings Passed	Estimated Hand Holes	Highway Crossings	Railroad Crossings	Major Water Crossings	Recommended Number of Cabinets
WP1	440	132	4	0	5	4
WP2	440	86	0	1	1	3
WP3	350	71	1	0	0	3
WP4	250	125	1	1	3	4
WP5	310	156	0	0	0	5
WP6	450	84	0	0	0	3

The map below shows the proposed routes for middle mile fiber in the county.

The routes recommended have been developed based on address point density and responses to the broadband survey. If this project is funded, a second phase could build a second middle mile route north, on the east side of the county, creating a fiber ring–providing a more resilient network with built in redundancy.



Segment WP1: Waupaca to Fremont & Winnebago and Waushara

Seg. WP1-Waupaca to Fremont & Winnebago and Waushara County Lines Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	19.88
2	Number of Handholes Installed	132
3	Splice Closures Installed	44
4	Cabinets Installed	4
5	Number of Buildings Connected	88
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP1-Waupaca to Fremont & Winnebago and Waushara County Lines Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$692,091
18	Distribution Labor	1,488,018
19	Structures, Cabinets, and Equipment	$74,120
20	Drop Construction	$103,700
21	**Network Construction Subtotal**	**$2,357,930**
22	Project Management, Network Engineering, Integration, and Testing	$282,952
23	Misc Fees, Advertising, Technical Services	$23,579
24	Bookkeeping and Administration	$17,684
25	Engineering, Permitting	$152,201
26	Legal Costs	$5,895
27	Other Costs Subtotal	$482,311
28	Project Total	**$2,840,241**
29	Contingency at 10%	$284,024
30	Project Total (with contingency)	**$3,124,265**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP1-Waupaca to Fremont & Winnebago and Waushara County Lines SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$23,579
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$240,509
5	Other architectural and engineering fees	$152,201
6	Project inspection fees	$42,443
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$2,283,810
10	Equipment	$74,120
11	Miscellaneous	$23,579
12	SUBTOTAL (sum of lines 1-11)	**$2,840,241**
13	Contingencies	$284,024
14	SUBTOTAL	**$3,124,265**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$3,124,265**

Segment WP2: Waupaca to Scandinavia and Iola

Seg. WP2-Waupaca to Scandinavia and Iola Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	12.96
2	Number of Handholes Installed	86
3	Splice Closures Installed	44
4	Cabinets Installed	3
5	Number of Buildings Connected	88
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP2-Waupaca to Scandinavia and Iola Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$448,500
18	Distribution Labor	988,516
19	Structures, Cabinets, and Equipment	$55,590
20	Drop Construction	$103,700
21	**Network Construction Subtotal**	**$1,596,306**
22	Project Management, Network Engineering, Integration, and Testing	$191,557
23	Misc Fees, Advertising, Technical Services	$15,963
24	Bookkeeping and Administration	$11,972
25	Engineering, Permitting	$99,222
26	Legal Costs	$3,991
27	Other Costs Subtotal	$322,705
28	Project Total	**$1,919,010**
29	Contingency at 10%	$191,901
30	Project Total (with contingency)	**$2,110,911**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP2-Waupaca to Scandinavia and Iola SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$15,963
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$162,823
5	Other architectural and engineering fees	$99,222
6	Project inspection fees	$28,734
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$1,540,716
10	Equipment	$55,590
11	Miscellaneous	$15,963
12	SUBTOTAL (sum of lines 1-11)	**$1,919,010**
13	Contingencies	$191,901
14	SUBTOTAL	**$2,110,911**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$2,110,911**

Segment WP3: Waupaca to Waushara

Seg. WP3-Waupaca to Waushara County Line Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	10.69
2	Number of Handholes Installed	71
3	Splice Closures Installed	35
4	Cabinets Installed	3
5	Number of Buildings Connected	70
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP3-Waupaca to Waushara County Line Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$363,235
18	Distribution Labor	814,819
19	Structures, Cabinets, and Equipment	$55,590
20	Drop Construction	$82,325
21	**Network Construction Subtotal**	**$1,315,969**
22	Project Management, Network Engineering, Integration, and Testing	$157,916
23	Misc Fees, Advertising, Technical Services	$13,160
24	Bookkeeping and Administration	$9,870
25	Engineering, Permitting	$81,843
26	Legal Costs	$3,290
27	Other Costs Subtotal	$266,078
28	Project Total	**$1,582,048**
29	Contingency at 10%	$158,205
30	Project Total (with contingency)	**$1,740,253**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP3-Waupaca to Waushara County Line SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$13,160
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$134,229
5	Other architectural and engineering fees	$81,843
6	Project inspection fees	$23,687
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$1,260,379
10	Equipment	$55,590
11	Miscellaneous	$13,160
12	SUBTOTAL (sum of lines 1-11)	**$1,582,048**
13	Contingencies	$158,205
14	SUBTOTAL	**$1,740,253**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$1,740,253**

Segment WP4: Waupaca to New London and Outagamie

Seg. WP4-Waupaca to New London and Outagamie County Line Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	18.93
2	Number of Handholes Installed	125
3	Splice Closures Installed	31
4	Cabinets Installed	4
5	Number of Buildings Connected	62
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP4-Waupaca to New London and Outagamie County Line Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$648,816
18	Distribution Labor	1,405,675
19	Structures, Cabinets, and Equipment	$74,120
20	Drop Construction	$72,825
21	**Network Construction Subtotal**	**$2,201,436**
22	Project Management, Network Engineering, Integration, and Testing	$264,172
23	Misc Fees, Advertising, Technical Services	$22,014
24	Bookkeeping and Administration	$16,511
25	Engineering, Permitting	$144,928
26	Legal Costs	$5,504
27	Other Costs Subtotal	$453,129
28	Project Total	**$2,654,565**
29	Contingency at 10%	$265,457
30	Project Total (with contingency)	**$2,920,022**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP4-Waupaca to New London and Outagamie County Line SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$22,014
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$224,546
5	Other architectural and engineering fees	$144,928
6	Project inspection fees	$39,626
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$2,127,316
10	Equipment	$74,120
11	Miscellaneous	$22,014
12	SUBTOTAL (sum of lines 1-11)	**$2,654,565**
13	Contingencies	$265,457
14	SUBTOTAL	**$2,920,022**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$2,920,022**

Segment WP5: Iola NE to Marion and Shawano

Seg. WP5-Iola NE to Marion and Shawano County Line Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	23.59
2	Number of Handholes Installed	156
3	Splice Closures Installed	31
4	Cabinets Installed	5
5	Number of Buildings Connected	62
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP5-Iola NE to Marion and Shawano County Line Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$769,171
18	Distribution Labor	1,743,507
19	Structures, Cabinets, and Equipment	$92,650
20	Drop Construction	$72,825
21	**Network Construction Subtotal**	**$2,678,154**
22	Project Management, Network Engineering, Integration, and Testing	$321,378
23	Misc Fees, Advertising, Technical Services	$26,782
24	Bookkeeping and Administration	$20,086
25	Engineering, Permitting	$180,605
26	Legal Costs	$6,695
27	Other Costs Subtotal	$555,547
28	Project Total	**$3,233,700**
29	Contingency at 10%	$323,370
30	Project Total (with contingency)	**$3,557,070**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP5-Iola NE to Marion and Shawano County Line SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$26,782
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$273,172
5	Other architectural and engineering fees	$180,605
6	Project inspection fees	$48,207
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$2,585,504
10	Equipment	$92,650
11	Miscellaneous	$26,782
12	SUBTOTAL (sum of lines 1-11)	**$3,233,700**
13	Contingencies	$323,370
14	SUBTOTAL	**$3,557,070**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$3,557,070**

Segment WP6: Embarrass to Clintonville and west to Rt 110

Seg. WP6-Embarrass to Clintonville and west to Rt 110 Route Overview

0	ITEM/PROJECT	VALUE
1	Miles of Fiber / Conduit Installed	12.7
2	Number of Handholes Installed	84
3	Splice Closures Installed	45
4	Cabinets Installed	3
5	Number of Buildings Connected	90
6	Take Rate - Percentage of the Buildings Passed who are connected	20%
7	Aerial - Percentage of construction expected to be installed on utility poles.	2%
8	Trenching - Percentage of construction installed by trenching	5%
9	Boring - Percentage of construction installed by horizontal drilling.	48%
10	Slot Cutting - Conduit installed in street by special methods.	0%
11	Rock Saw - Required where rock prevents the use of other methods.	0%
12	Direct Bury - Conduit installed by direct bury methods (plow, vibratory plow)	45%
13	Aerial Info	2% Aerial is estimated to account for water body crossings and other obstacles to construction.
14	Other Notes	Estimated labor rates are based upon common rates seen for recent medium sized rural projects.

Seg. WP6-Embarrass to Clintonville and west to Rt 110 Cost Summary

16	ITEM/PROJECT	ESTIMATED
17	Construction Materials	$419,950
18	Distribution Labor	970,454
19	Structures, Cabinets, and Equipment	$55,590
20	Drop Construction	$106,075
21	**Network Construction Subtotal**	**$1,552,069**
22	Project Management, Network Engineering, Integration, and Testing	$186,248
23	Misc Fees, Advertising, Technical Services	$15,521
24	Bookkeeping and Administration	$11,641
25	Engineering, Permitting	$97,231
26	Legal Costs	$3,880
27	Other Costs Subtotal	$314,521
28	Project Total	**$1,866,590**
29	Contingency at 10%	$186,659
30	Project Total (with contingency)	**$2,053,249**

The estimate of costs for this segment is provided below in the categories required for Federal the SF424 expenditure form.

Seg. WP6-Embarrass to Clintonville and west to Rt 110 SF424 Summary

0	ITEM/PROJECT	ESTIMATED
1	Administrative and legal expenses	$15,521
2	Land, structures, rights-of-way, appraisals, etc.	$0
3	Relocation expenses and payments	$0
4	Architectural and engineering fees	$158,311
5	Other architectural and engineering fees	$97,231
6	Project inspection fees	$27,937
7	Site work	$0
8	Demolition and removal	$0
9	Construction	$1,496,479
10	Equipment	$55,590
11	Miscellaneous	$15,521
12	SUBTOTAL (sum of lines 1-11)	**$1,866,590**
13	Contingencies	$186,659
14	SUBTOTAL	**$2,053,249**
15	Project (program) income	**$0**
16	TOTAL PROJECT COSTS (subtract #15 from #14)	**$2,053,249**

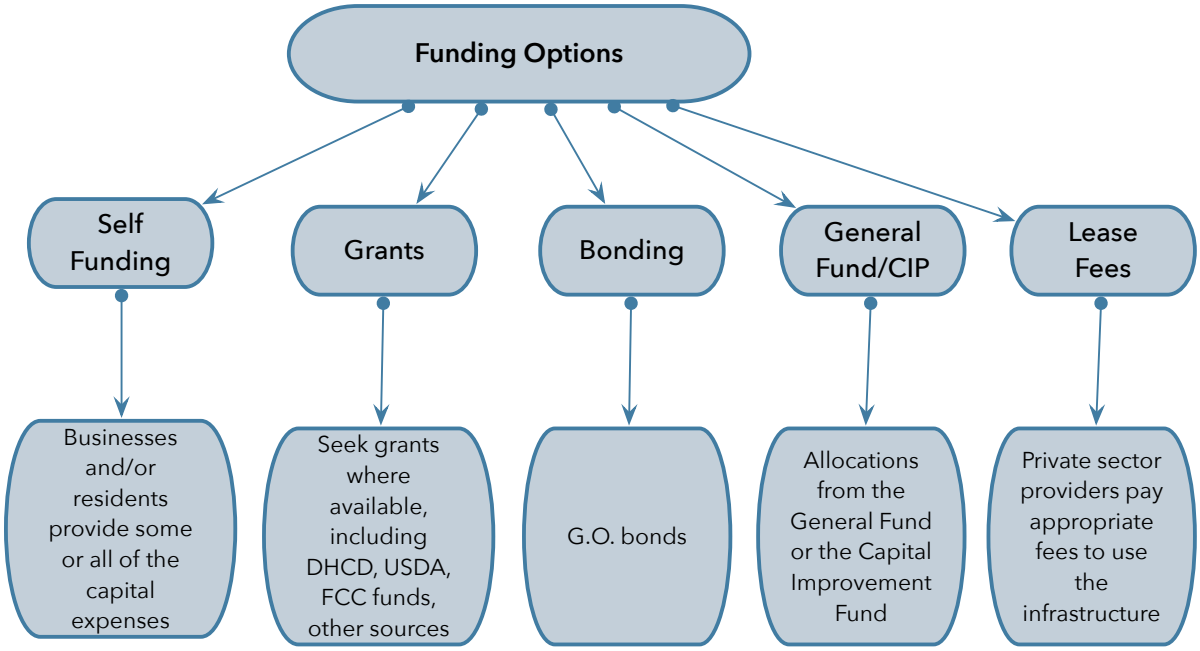
9 INFRASTRUCTURE FUNDING AND GRANT OPPORTUNITIES

It is important to note that any investment by county government in broadband infrastructure should be focused on maximizing the long term benefits of such investments. Fiber, conduit, handholes, and wireless towers are stable assets that will provide service for many decades. This infrastructure can be leased to private sector service providers, generating long term revenue for maintenance and expansion.

Alternatively, funding for these investments can be provided to ISPs and WISPs as part of a public/private partnership (PPP). In a PPP arrangement, it will be better to require the private partner to provide the funding for shorter term assets, especially network electronics.

Leasing passive infrastructure like towers and dark fiber is not a "telecommunications service" (Wisconsin counties are forbidden by state statute from offering telecommunications services).

These assets will have a conservative life span of forty years or more (e.g. wireless towers, conduit, fiber cable). These types of infrastructure investments create hard assets that have tangible value and can then be leveraged for additional borrowing. The demand for services and the associated fees paid for those services will provide the revenue that will pay back loans over time. There is ample time to recoup not only the initial capital investment, but also to receive regular income from the infrastructure.



The financing of local government and/or community-owned telecommunications infrastructure faces several challenges with respect to funding.

Somewhat paradoxically, the cost of an all fiber digital road system is lower when there is a day one commitment to build to any residence or business that requests service. This maximizes the potential marketplace of buyers and attracts more sellers to offer services because of the larger potential market. This is so because:

- Service providers are reluctant to make a commitment to build network infrastructure without knowing the total size of the market. A larger market, even if it takes several years to develop, is more attractive.
- Funding agencies and investors that may provide loans and grants to a local or regional network project want to know how the funds will be repaid and/or that grants will contribute to a financially sustainable project. Knowing that the size of the customer base is the maximum possible for a service area helps reduce the perceived risk for providing loans and grants.

9.1 GRANT APPLICATION ACTIVITIES

Activity	Description	Discussion	Tasks
Develop a grant application	The grant application process, from start to award announcement, can be nine to twelve months.	Broadband grant application requirements have become more stringent over time, with more grant agency oversight and review. Careful planning is essential to develop a successful application.	• Once a grant opportunity has been identified, review grant requirements to determine if the project can qualify. For example, some grants require two years of financial history. • Identify regional agency that will assist • Begin contacting potential ISP partners. • If the project qualifies, identify at least two people to take the lead to prepare application. • Prepare a task list of all grant materials requirements and identify data needed. • Develop a timeline for developing sections of the grant. • Identify requirements for letters of support and matching funds and develop timeline to solicit and collect commitments. • Complete all sections of grant application with assistance from public and private partners. • Submit grant application.

Typical Timeline	Months											
Tasks	1	2	3	4	5	6	7	8	9	10	11	12
Determine grant qualifications												
Identify regional council partner												
Identify ISP or WISP partner if needed												
Appoint grant team												
Create grant task list												
Prepare timeline and assign tasks to partners												
Identify matching fund requirements and letters of support to solicit and collect as needed												
Complete all sections of the grant application												
Submit grant												
Grant agency review												
Awards announcement												

9.2 WISCONSIN FUNDING OPPORTUNITIES

The Wisconsin legislature has been evaluating legislation to improve broadband access in the state. The bills are designed to make it easier and less expensive to build broadband infrastructure in underserved parts of the state. Wisconsin has created a state level Broadband Office that is coordinating and managing both state and Federal funding programs. In early 2021, Governor Evers committed nearly $200 million for broadband, and in 2021 the Broadband Office awarded tens of millions in broadband funds to Wisconsin towns, counties, and ISPs. Most awards required some match; awards to ISPs typically required much higher match amounts than awards to local governments.

Waupaca County should maintain regular communications with the Broadband Office to pursue every possible funding opportunity.

9.3 ARPA AND BEAD FUNDING

The American Rescue Plan Act (ARPA) of 2021 is the biggest federal funding program for broadband projects. ARPA has $350 billion in funding. Each state receives an ARPA fund allocation, and how much is targeted toward broadband initiatives will be decided by a state legislative committee and/or the governor of the state.

The 2020 CARES (Coronavirus Aid, Relief, and Economic Security Act) funding was typically distributed by state governments to localities (e.g. counties, towns, cities), which were then able to make decisions on how to spend the money within both the state and Federal guidelines attached to the funds.

ARPA funding has fewer requirements and "strings" attached than many other Federal broadband grant programs, and the County should make obtaining ARPA funds for county broadband projects a priority in 2022. Nearly $100 million in broadband funding for 2022 has already been approved by the State of Wisconsin, with an average match of 50%.

The State of Wisconsin has a well-organized Web page with much information on ARPA funding and how to apply (https://psc.wi.gov/Pages/Programs/BroadbandGrants.aspx). The next deadline

A second Federal grant program, the Broadband Equity, Access, & Deployment Program, (BEAD) has 42 billion allocated for broadband infrastructure. Rules for applying for those grants were released in the spring of 2022. States will apply for the funds, and the state governments will solicit local and regional grant applications. Areas that intend to apply for BEAD funds should start planning immediately, as the application preparation process requires time and attention.

9.4 HUD COMMUNITY DEVELOPMENT BLOCK GRANTS

The U.S. Housing and Urban Development CDBG State Program allows the Wisconsin state government to award grants to smaller units of general local government (e.g. counties, towns) that develop and preserve decent affordable housing, to provide services to the most vulnerable in our communities, and to create and retain jobs. In recent years, CDBG funds have been successfully used for broadband infrastructure development where the local government applicant can show the improvements meet the general guidelines of the program—so grant funds have to spent in low and moderate income areas.

Over a 1, 2, or 3-year period, as selected by the grantee, not less than 70 percent of CDBG funds must be used for activities that benefit low- and moderate-income persons. In addition, each activity must meet one of the following national objectives for the program: benefit low- and moderate-income persons, prevention or elimination of slums or blight, or address community development needs having a particular urgency because existing conditions pose a serious and immediate threat to the health or welfare of the community for which other funding is not available. More information is available here (https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs).

9.5 USDA RECONNECT PROGRAM

The ReConnect program is a new funding program managed by the USDA Rural Development Office. This program is sometimes called the USDA e-Connectivity pilot program. Grant applications can be a combination of 100% grant, 50% grant/50% loan, or 100% loan. $1.1 billion has been allocated to the program for 2022, and a wide variety of entities can apply, including non-profits, coops, and state and local governments.

As much as $200 million will be available for loans, with another $250 million allocated for loan/grant combinations. A $350 million fund will be distributed with a 25% matching requirement and another $350 million in grants with without a match, for projects in tribal and socially vulnerable communities. Applications are due in the spring of 2022, and USDA will begin accepting

applications in late 2021. More information is available here: (reconnect.usda.gov). A mapping tool is available on the Web site to show areas that are eligible. To qualify as an eligible area, households must have less than a minimum of 10 Megabit down/1 Megabit up broadband service.

9.6 RDOF/CAF2 FUNDING

The second round of the FCC Connect America Fund (CAF2) (Rural Digital Opportunity Fund) continues to provide funds to incumbent and competitive service providers. The funds must be used in unserved or underserved areas as defined by Federal census blocks. To be eligible, a census block could not have been served with voice and broadband of at least 10/1 Mbps (based on Form 477 data) by an unsubsidized competitor or price cap carrier.

The FCC published the final eligible census blocks for the auction on February 6, 2018. The final areas were based on FCC Form 477 data as of December 31, 2016 (the most recent publicly available FCC Form 477 data at the time). So there is a time lag between the determination of a qualifying census block or blocks and the schedule for submitting a bid to serve those areas. The first round of funding was announced in early 2021, and was immediately met with widespread criticism. SpaceX (Starlink) was awarded almost $900 million, and it may have to return some of those funds because the company appears to have included some ineligible census blocks. Many large incumbents also received substantial awards when some smaller ISPs that might have offered competition to the incumbents received much less or no funds.

Because many CAF2 qualifying areas are only served by low performance DSL (e.g. less than 10/1 Mbps service), incumbent carriers use the awards to upgrade DSL switches, which is not a long term solution. More recently, competitive carriers are applying for CAF2 funds to provide higher performance broadband wireless and in some cases fiber to the home. Because the use of CAF2 funds are so restricted, it has not had as much impact as many hoped. The FCC, as of fall 2021, has not announced the rules for the second round of funding.

9.7 LEASE FEES

Initiatives like tower access and access to local government-owned conduit and fiber can create long term revenue streams from lease fees paid by service providers using that infrastructure. The City of Danville, Virginia has recovered their entire initial capital investment from lease fees paid by providers on the nDanville fiber network.

10 WORKING WITH PROVIDERS

Because nearly all telecom infrastructure includes some use of public right of way, public/private partnerships are always a requirement for broadband infrastructure. Among County and private entities like ISPs and WISPs, the more common synergies are:

- The need for more bandwidth,
- The need for more affordable bandwidth, and
- The need for more affordable bandwidth to be more widely available.

Potential project partners include Internet Service Providers (ISPs) and Wireless Internet Service Providers (WISPs), as they will be the companies receiving grant funds to build fiber and tower infrastructure and/or leasing tower space and/or conduit/fiber infrastructure.

Any County passive infrastructure investments would be a public/private enterprise, and service providers would be the primary users of the infrastructure.

Throughout the U.S., many WISPs are aggressively pursuing public-private partnerships (PPPs) with county governments. These partnerships may include a variety of strategies: collaboration on a grant opportunity, shared costs of developing a new tower site, revenue sharing, fee waivers, and other sorts of cost and revenue sharing. The advantage of this kind of PPP is that the WISP typically is responsible for most of the day-to-day management of the network assets.

Waupaca County can pursue public/private partnerships with technically qualified and financially stable ISPs and WISPs. Where appropriate, the County can channel grant funds to providers while will use the funds to build and manage new broadband infrastructure.

Selected providers should be able to show technical competency and have a demonstrable track record of managing substantial fiber and/or wireless builds on time and within budget. It will also be important for any public/private partnership agreement have a claw-back agreement. When public funds are transferred to a private company, the County should have the ability to "claw back" the built infrastructure for a minimum of five to ten years.

Conditions for a claw back could include bankruptcy of the ISP, sale to a third party (where substantial profit taking leverages the public funds), poor service, unreasonably high cost of service, and/or poor service reliability.

10.1 ATTRACTING PROVIDERS TO THE NETWORK

The Internet service provider business is challenging. Setting the high cost of towers and fiber infrastructure aside, a WISP or an ISP making a commitment to offer competitive services in a new area must engage in a significant marketing and sales effort to identify customers who want service.

For ISPs that are interested in leasing dark fiber, the company must not only develop and execute a marketing plan, but must purchase fiber switches and customer equipment.

WISPs also have similar cost challenges. Because most broadband wireless frequencies, including the newer LTE frequencies, require or work best with line of sight between the customer and the tower, the WISP, even after identifying a potential customer, must often send a technician to the prospective customer location to determine if line of sight or near line of sight is available. It is common that a low hill, a building, trees, or other vegetation will degrade or block the signal.

If line of sight or near line of sight is available at the customer location, a second visit to install the customer antenna may be required before the customer can receive service. At this point, the WISP may have spent several hundred dollars on the acquisition of a single customer, and it can take many months of service before the WISP will even break even.

The cost of fiber routes and of tower access are both expensive parts of offering Internet service. If a WISP or an ISP has capital funds, it must choose where to place towers and where to build fiber to the home, and smaller ISPs and WISPs rarely have the capital to build enough towers or fiber to cover an entire county. Note that the 2022 ARPA funding, in many localities, is going to be used to assist ISPs and WISPs with network expansion.

Just as government builds roads to enable commerce and services offered by the private sector, local government and/or regional nonprofit consortiums can also build middle mile fiber and towers to enable Internet services. Space on those towers and fiber strands is offered to ISPs and WISPs for modest fees with the goal of expanding and improving Internet access.

Activity	Description	Tasks
Attract Internet Service Providers (ISPs, WISPs)	One or more service providers will be needed to lease poles, and/or manage the network, and to partner for grant funds.	• Once owners/stakeholders have approved the plan, contact local and regional ISPs to assess partnership interest. • Schedule individual meetings with the ISPs to present project goals and objectives. • Assess interest of the companies in public-private partnership. • If interest is positive, reach agreement on which grant opportunities to pursue jointly and in what area. • Develop an MOU (Memo of Understanding) that identifies what tasks the WISP will perform for grant application and what project will perform.

10.2 WORKING WITH INFRASTRUCTURE LEASES

Once dark fiber cable and/ existing or new towers have space available to lease to WISPs, there are policy and contract decisions that must be evaluated.

Tower Lease Considerations

- There should be a single public fee schedule for all providers that want to lease space on the tower.
- There should be a single tower space agreement that is used for all providers.
- Tower access should be made available in ten foot vertical segments, as high as possible on the tower without interfering with other uses (e.g. public safety antennas). Note that it is unlikely that any tower will have more than two providers on it.
- Leases should be a minimum of two years and should auto-renew if the ISP is meeting performance requirements.
- It may be more effective to have a single lease agreement with access to all towers, and the contract should require the ISP to put equipment on all towers within a certain period of time (e.g. nine to twelve months). This limits ISPs from "cherry picking" towers with more potential customers and ignoring towers in parts of the county with lower population density.
- Monthly tower lease fees should be on the order of $200 to $250 per tower. Higher fees make it difficult for providers to make a business case for the cost of equipment and the extensive marketing required to develop a customer base around a tower.
- For a typical tower, identify two (2) ten foot spaces (where space is available) on existing towers and designate/reserve those for WISP use. The spaces should be as high as possible on each tower without interfering with other local government and public safety use. The lease cost of the lower space should be at least 20% less than the higher space. Tell WISPs exactly what space is available at each tower and at what heights; this makes it easier for WISPs to evaluate the potential market that could be served from each tower.
- An initial grace period of three to six month should be offered on fees, and/or offer a one year sliding scale of fees (e.g. first three months, fee waived; months four to six, 25% of normal fee; months seven to nine, 50% of normal fee; months ten to twelve, 75% of normal fee). There are many ways to structure the initial fee period, but it is important to recognize that the WISPs incur substantial early costs to develop revenue and customers for a new tower.
- All tower leases should expire on the same date even if started at different times. This allows the enterprise to potentially make a smoother transition to a new provider if there are performance issues, and will give the project entity (e.g. County government) more leverage and control over the WISPs.
- Leases should be a minimum of two years and should auto-renew if the ISP is meeting performance requirements.
- In contracts, fee reductions should be worded as discounts that can be revoked if performance requirements are not adequately being met.

- There are considerations for ground-space (e.g. WISP cabinets, shelters, H-frames for electric service) that will have to be evaluated at each tower site. If new shelters will be allowed, the ownership entity should set minimum standards for new shelters.

Dark Fiber Lease Considerations

Passive fiber infrastructure (i.e. no electronics) can include conduit, fiber cable, splice closures, and cabinets. Because all powered network equipment would be provided by the lessee (i.e. the ISP), there is no day to day management responsibilities and only occasional routine maintenance. Emergency break-fix for situations like a cable broken by a construction firm working in the right of way can be outsourced to a qualified private sector provider. Local governments routinely manage much more complex water and sewer systems. Some guidelines for leasing dark fiber include:

- There should be a single public price list for the cost of leasing fiber strands.
- A standard master agreement should be used for leases. This agreement will typically require an SLA (Service Level Agreement) that specifies repair times for emergency break-fix (i.e. the fiber cable has been damaged and a qualified break-fix repair firm must be on call to make repairs).
- It will also be important to have IRU pricing (Indefeasible Right of Use). Fiber strand leases are typically for periods of ten years or less. IRUs are long term leases and are typically twenty to thirty years in length. IRU fees have two parts: a single upfront payment that usually reflects some portion of the construction cost for the fiber route. As an example, if a lease will include twelve strands of fiber on a ten mile route of 144 strand fiber that cost $100,000 to construct, the one time fee might be 12/144 * $100,000 = $8,333. Most IRUs also have a modest annual maintenance fee that reflects the cost of maintenance and repairs; this would also be pro-rated to reflect the number of fibers assigned to the IRU agreement.
- Splice points and who is allowed to open handholes to perform splicing must be identified in the master agreement.

10.3 PREPARING FOR TOWER EXPANSION

Activities Preparing for Tower Expansion

ACTIVITY	DESCRIPTION	DISCUSSION	TASKS
Draft tower site lease agreement	Tower site lease agreements between the property owner and the broadband entity will be needed.	The county attorney may be able to provide most or all of the legal agreements needed.	• **Establish a basic tower lease agreement that will be used with all providers.** • **Identify legal counsel who will provide a draft agreement.** • **Circulate draft agreement for comments.** • **Approve lease agreement for use.**
Identify prospective tower sites	New towers will be needed in the county. The broadband plan identifies the general area where towers will be needed and most effective, but specific tower locations will have to be identified with the assistance of residents in the area and property owners. This will be an ongoing activity for at least the first year.	Height above the surrounding terrain, proximity to roads, and proximity to electric service are factors that have to be evaluated.	• **Review broadband plan and prepare a list of sites to survey.** • **Determine road access and electric service. Closer is better.** • **Meet with property owner to discuss a potential lease.** • **If site owner is agreeable, add site to list of grant-ready tower sites.**
Identify prospective community pole sites	Many community poles will be needed to provide the maximum amount of wireless broadband availability.	Community poles should only be placed where there is a cluster of nearby residents who are prepared to purchase Internet service from the provider on the pole.	• **For each area in a build out phase, identify clusters of typically 12-25 homes.** • **Identify a local champion willing to talk to neighbors and assess demand.** • **If demand meets target, add to list for next grant application with community poles.**

Timeline Preparing for Tower Expansion

TASKS	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
Obtain agreement on using one lease for all counties												
Identify legal counsel to draft agreement												
Circulate draft agreement for comment												
Obtain approval for site lease agreement												
Develop list of potential tower sites												
Assess road, electric service access												
Meet with property owners												
Add agreeable owners to prospective tower list												
Identify clusters of residents for community poles												
Add clusters that meet demand to prospect list for community poles												

Active network: Typically a fiber network that has electronics (fiber switches and CPE) installed at each end of a fiber cable to provide "lit" service to a customer.

Asymmetric connection: The upload and download bandwidth (speed) are not equal. Cable Internet and satellite Internet services are highly asymmetric, with upload speeds typically 1/10 of download speeds. Asymmetric services are problematic for home-based businesses and workers, as it is very difficult to use common business services like two way videoconferencing or to transfer large files to other locations.

Backhaul: Typically refers to a high capacity Internet path out of a service area or locality that provides connectivity to the worldwide Internet.

Colo facility: Colo is short for Colocation. Usually refers to a prefab concrete shelter or data center where network infrastructure converges. A colo or data center can also refer to a location where several service provider networks meet to exchange data and Internet traffic.

CPE: Customer Premises Equipment, or the box usually found in a home or business that provides the Internet connection. DSL modems and cable modems are examples of CPE, and in a fiber network, there is a similarly-sized fiber modem device.

Dark fiber: Dark fiber is fiber cable that does not have any electronics at the ends of the fiber cable, so no laser light is being transmitted down the cable.

Drop: A telecom term for the small fiber cable that is installed from the street or a utility pole to a home or business.

Fiber switch: Network electronic equipment usually found in a cabinet or shelter

Fiber Optic Splice Closure: See **FOSC**.

FOSC: Fiber Optic Splice Closure. Typically a water and air tight cylindrical container where fiber cable is split open to allow splicing (connecting together) of fiber strands for a drop to a premises.

FTTH/FTTP/FTTx: Fiber to the Home (FTTH), Fiber to the Premises (FTTP), and Fiber to the X (FTTx) all refer to Internet and other broadband services delivered over fiber cable to the home or business rather than the copper cables traditionally used by the telephone and cable companies.

Handhole: Handholes are open bottom boxes with removable lids that are installed in the ground with the lids at ground level. The handholes provide access to fiber cable and splice closures that are placed in the handhole. Handholes are also called **pull boxes**.

IP video: Video in various forms, including traditional packages of TV programming, delivered over the Internet rather than by cable TV or satellite systems.

Latency: The time required for information to travel across the network from one point to another. Satellite Internet suffers from very high latency because the signals must travel a round trip to the satellite in stationary orbit (22,500 miles each way). High latency makes it very difficult to use services like videoconferencing.

Lit network: A "lit"network (or lit fiber) is the same as an active network. "Lit" refers to the fact that the fiber equipment at each end use small lasers transmitting very high frequency light to send the two way data traffic over the fiber.

MST: Multiport Service Terminals are widely used in fiber to the home deployments to connect individual home drop cables to larger distribution cables on poles or in handholes. Pre-connectorized drop cables snap into the MST ports and do not require any splicing.

Passive network: Refers to infrastructure that does not have any powered equipment associated with it. Examples include wireless towers, conduit (plastic duct), handholes, and dark fiber.

Pull boxes: Pull boxes (also called handholes) are used to provide access to fiber cable and splice closures. They are called pull boxes because they are also used during the fiber cable construction process to pull the fiber cable through conduit between two pull boxes.

Splice closures: Splice closures come in a variety of sizes and shapes and are used to provide access to fiber cable that has been cut open to give installers access to individual fiber strands. Splice closures are designed to be waterproof (to keep moisture out of the fiber cable) and can be mounted on aerial fiber cable or placed underground in handholes. Also called **FOSC**s.

Splicing: The process of providing a transparent joint (connection) between two individual fiber strands so that laser light passes through. A common use of splicing is to connect a small "drop" cable of one or two fiber strands to a much larger (e.g. 144 fiber strand) cable to provide fiber services to a single home or business.

SCADA: Supervisory Control and Data Acquisition. Used by the electric utility industry and some other utilities (e.g. water/sewer) to manage their systems.

Symmetric connection: The upload and download bandwidth (speed) is equal. This is important for businesses and for work from home/job from home opportunities.

Virtual Private Network: A VPN creates a private, controlled access link between a user's computer and a corporate or education network in a different location. VPNs are often encrypted to protect company and personal data. VPNs usually require a symmetric connection (equal upload and download speeds) to work properly.