Broadband Feasibility Report

Vermilion County, Illinois

November 18, 2024

CCG Consulting
Finley Engineering

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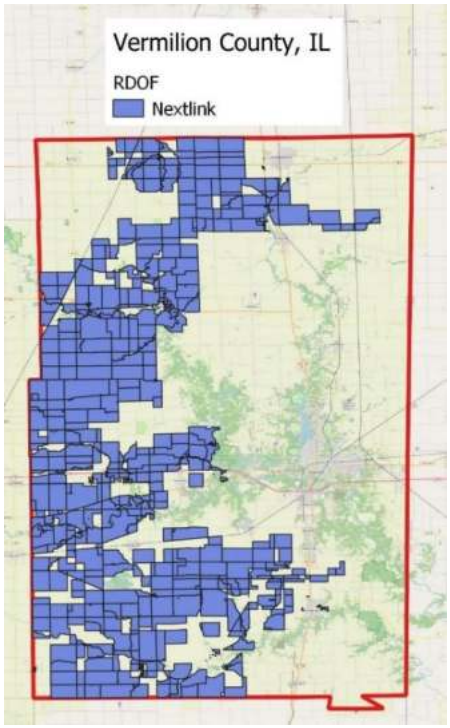
EXECUTIVE SUMMARY

CCG Consulting and Finley Engineering submit this Broadband Feasibility for Vermilion County, Illinois. We've written this report as an actionable plan for seeking better broadband for the rural residents who don't have good broadband today. We believe we have described a compelling story for ISPs to use to pursue grant funding for all unserved areas of the county. We also think the County can play an important role in finding a broadband solution for everybody.

There is a lot of broadband grant money coming to Illinois. The NTIA announced that the State will be receiving a little over $1 billion in BEAD grant funding. There are other federal and state grants that can also benefit broadband infrastructure. There are also federal and state grants available to tackle the digital divide, get computers into homes, and train folks how to use computers.

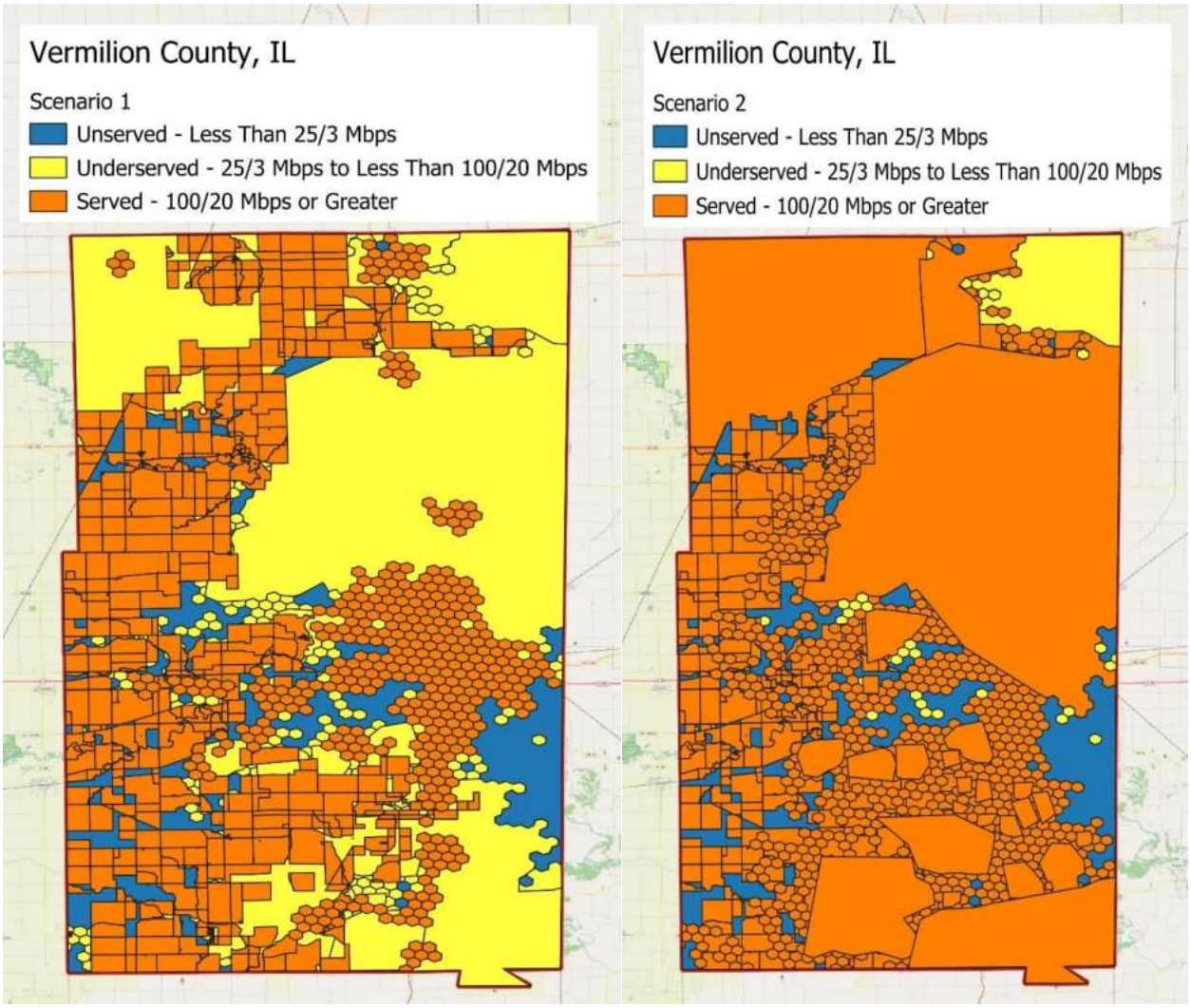
The Illinois Broadband Office (IBO) has been making progress to be able to launch the BEAD grants. The Volume 1 and 2 rules defining the grant process have been approved. The IBO conducted a map challenge to define the areas eligible for BEAD. The expectation is for the first round of BEAD grant applications to be submitted later this year or early next year.

One of the requirements of this study was to identify the number of homes and businesses in the county that are eligible for the BEAD grants. One issue of concern for the County is that the FCC made a large subsidy award in 2020 in the Rural Digital Opportunity Fund (RDOF) that provided $2 million to AMG Technology Group (Nextlink) to build faster broadband to 939 locations that cover a huge amount of the rural geography of the county (shown on the map below). Nextlink is satisfying the RDOF awards using fixed wireless technology. These areas are not eligible for BEAD grants. Nextlink has until 2028 to bring the promised broadband solution to every RDOF commitment in the state, and the County has to be concerned that the promised broadband gets built and reaches everybody.



The broadband study looks at bringing broadband to every other unserved part of the county. Our analysis is based on two different scenarios. There is a debate nationwide asking if areas served today by licensed wireless spectrum should be eligible for BEAD grants. As of the date of writing this report, the Illinois Broadband Office has not yet determined this issue for the BEAD grant process. The following two maps show the areas that are eligible for BEAD grants in the two scenarios.

The first map shows the grant-eligible if licensed wireless broadband areas are eligible for BEAD grants. In this scenario, 4,287 homes and businesses are eligible for grant funding. The second scenario shows the grant-eligible area if licensed wireless areas are not eligible for grant funding. This would bring BEAD grants to 1,527 locations. On the maps, the blue areas are unserved, meaning the fastest broadband available today is at speeds under 25/3 Mbps. The yellow areas are underserved, meaning broadband speeds are between 25/3 Mbps and 100/20 Mbps. The orange areas are served, with broadband speeds at 100/20 Mbps or faster.



Our analysis shows that it is feasible for ISPs to build fiber using BEAD grants. Our more detailed financial analysis helped us to draw some interesting conclusions about bringing better broadband to the unserved and underserved parts of the County:

- The cost to build fiber in the county is between $9,100 and $9,400 per customer in the two scenarios. This is lower than what we see in many other rural counties since the housing density in the unserved and underserved areas is around 6 homes and businesses per mile of constructed fiber – higher than we see elsewhere.
- Even though the costs are high, it looks feasible for ISPs to win BEAD grants that are below the BEAD threshold where the grants will fund up to 75% of the costs of the assets.
- Through sensitivity analysis we quantified how ISPs can perform better than the conservative assumptions we used in our analysis, which make it even easier to build using a BEAD grant.

The BEAD grant rules give a significant role to the County in determining which ISPs will win the BEAD grant funding. There are significant grant points awarded for an ISP that gets a letter of support from the County. Even more points are awarded if the County provides meaningful financial support to a BEAD applicant. Altogether, the County has a role in awarding up to 8% of the total points needed by an ISP to win the grant.

Following is a summary of the findings of facts made during our analysis. Following are recommendation for the steps the County should consider achieving your goal of getting broadband to everybody in the County.

Findings

Following is a summary of the other major findings from our research.

Existing ISPs. There are a lot of ISPs serving within Vermilion County today.

- AT&T and Frontier are incumbent telephone companies.
- Comcast and Sparklight are incumbent cable companies.
- AT&T, Pavlov Media, and Conxxus provide fiber broadband in the county.
- Surf Internet, MF Wireless, Rise Broadband, Nextlink, and WATCH Communications provide broadband using fixed wireless technology.
- T-Mobile, AT&T, and Verizon are selling cellular hotspots and/or FWA cellular broadband using cellular spectrum.
- Viasat, HughesNet, and Starlink provide satellite broadband across the county.

Existing Broadband Prices. Following is a table of some of the key broadband prices offered in the county that shows the prices for the broadband product for each ISP that is closest to a speed of 100 Mbps download. There is a list of all broadband prices in the county in Section III.A. Note that in many cases the speed shown is the advertised marketing speed for each product, and customers might receive slower speeds than advertised.

Provider	Technology	Download	Upload	Price
Frontier	DSL	Best Effort	Best Effort	$54.99
AT&T	Fiber	300 Mbps	300 Mbps	$65
Comcast	Cable	150 Mbps	5 Mbps	$66.00 + $15 router
Sparklight	Cable	100 Mbps	20 Mbps	$55 + $12.50 router
Conxxus	Fiber	100 Mbps	10 Mbps	$65 + $5 router

Pavlov Media	Fiber	1 Gbps	1 Gbps	$69.99
Surf Internet	Fixed Wireless	50 Mbps	5 Mbps	$99.95
MF Wireless	Fixed Wireless	100 Mbps	10 Mbps	$100
Rise Broadband	Fixed Wireless	50 Mbps	Best Effort	$96.95
Nextlink	Fixed Wireless	100 Mbps	Best Effort	$79.95 + $8.99 router
WATCH Comm	Fixed Wireless	100 Mbps	20 Mbps	$120
Verizon	FWA Cellular	300 Mbps	20 Mbps	$45 - $60
T-Mobile	FWA Cellular	100 Mbps	20 Mbps	$65

Broadband Gaps. Vermilion County has a significant broadband competition gap, meaning that there are a lot of homes and businesses that don't have the option to buy fast broadband. The County is a story of broadband haves and have-nots. Only residents in Danville and unincorporated Hillery have two fast landline providers. Some parts of the county have relatively fast fixed wireless and FWA cellular broadband, but the best coverage often overlaps towns as well. The vast majority of the geographic area of the county have either one or no fast ISP.

There are also other broadband gaps in the county, such as an affordability gap, a computer gap, and a computer literacy gap. The report discusses ways that the County might help tackle these issues while also tackling the more important availability gap.

The report also highlights that the customer demand for broadband continues to grow at a rapid pace. Broadband networks and technologies that are adequate today might not be adequate in the future due to increasing customer demand. Consider the nationwide average monthly broadband usage for households just in recent years:

1st Quarter 2018	215 Gigabytes
1st Quarter 2019	274 Gigabytes
1st Quarter 2020	403 Gigabytes
1st Quarter 2022	514 Gigabytes
1st Quarter 2023	561 Gigabytes
1st Quarter 2024	641 Gigabytes

Speed Tests. As part of the analysis, we obtained a trailing twelve months of Ookla speed tests (speedtest.net) for the county - the most widely used speed test in the country. The table below shows the average results of the speed tests for the year for each broadband technology used in the county.

Technology	Download	Upload	Latency (ms)
DSL	41	8	60
Cable	290	29	23
Fiber	426	356	8
Fixed Wireless	44	6	47
Fixed Cellular	173	26	50
LEO Satellite	103	14	38
GEO Satellite	36	4	630

Speed tests demonstrate the obvious differences between technologies. Fiber is the only technology with fast download and upload speeds. Cable company broadband and FWA cellular broadband have fast download speeds but slow upload speeds. DSL, fixed wireless, and satellite have the slowest speeds.

Latency is the time delay between data being transferred between its original source and its destination, shown in milliseconds. As the table above shows, fiber and cable networks have the least amount of latency delay. The latency for high-orbit satellites is off the chart compared to other technologies.

Stakeholder Interviews. CCG Consulting reached out to key stakeholders in the county to get a more in-depth understanding of the rural broadband issue. Some of the key things we heard include:

- We heard repeated stories from rural residents with poor broadband options including. Many claimed that DSL, fixed wireless, and cellular hotpots are slow and unreliable where they live.
- We heard there is good broadband in schools. But we heard of the challenges of giving remote homework due to poor broadband options at homes. In many cases there is no home broadband available, but in other cases affordability is an issue.
- We heard from business including a hospital, health clinics, and a senior home that broadband is unreliable and not fast enough to support everything they wish to accomplish.
- We heard from several people who struggle to work from home. We heard from one person who said it take 3-4 minutes to upload even small documents and that larger documents won't upload at all. We heard from several people who must visit a friend or use public WiFi spot to upload documents.
- We heard of some of the practical repercussions of slow broadband. For example, we heard from a trucker who can't connect to his burglar alarm or cameras when away from home.
- We heard a lot of complaints about rural broadband prices, with rural residents having to pay far more than $100 per month to get broadband solutions that often doesn't work well. There seemed to be a general understanding that folks in towns have better and less expensive broadband options.
- Not all of the stories we heard were negative. We heard from a family with multiple children who said his Sparkling broadband was good enough for everything the family wants to do. We heard from several families who are happy with Starlink.

Broadband Competition. The County has one of the smallest geographic areas we have seen in a long time that have competition between two fast ISPs. This is a concern since a single ISP with fast broadband in an area can easily act like a monopoly, which often means higher prices, less concentration on customer service, and longer times to fix problems. Even if the County gets better broadband in rural areas, you should consider a long-term plan to attract more competition.

Engineering Analysis. Section II.A. of the report discusses the technologies we found during the engineering field review. Section II.B. discusses issues that affect broadband speed. Section II.C. Discusses the various broadband technologies in use in the county today. Section II.D. discusses the network design used to estimate the cost of building fiber for the unserved and underserved parts of the county. Exhibit I shows a network diagram for the parts of the county where Finley Engineering estimated the cost of building a fiber network.

Finley Engineering investigated the technology options for bringing broadband and selected XGS-PON technology, which delivers symmetrical 10-gigabit broadband to small neighborhood clusters of residents and businesses. The network was designed using the following primary assumptions:

- The network was designed to pass every unserved and underserved home and business.
- Fibers were sized to fit the needs of each route using industry-standard fiber sizes of 12, 24, 48, 72, 144, and 288 fibers.
- The network was designed to accommodate future growth.

Cost of the Needed Network**.** Below is a summary of the cost to build the needed fiber network for the two scenarios discussed earlier. In the first scenario, areas served today by licensed wireless technologies are considered eligible for BEAD grants (4,247 locations). In the second scenario, areas served by licensed wireless technologies are not eligible for BEAD grants (1,527 locations).

	Scenario 1	Scenario2
Fiber	$11,985,120	$32,667,434
Drops	$ 1,193,491	$ 3,366,019
Electronics	$ 1,057,556	$ 2,982,076
Operational Assets	$ 159,155	$ 221,098
Total	$14,395,322	$39,236,627
Passings	1,527	4,287
Cost per Passing	$9,427	$9,152

The cost per passing is perhaps the most important number that defines the ease of funding a broadband network with grants. In both scenarios there are approximately 6 homes and businesses per mile of fiber construction. We've worked in other counties in the state where the unserved areas had only three of four homes per mile – making it much harder to fund a fiber network.

Results of the Financial Analysis. The detailed results of the financial analysis are shown in Section III.B. of the report. A full summary of financial results is included in Exhibit II. The purpose of the analysis was to understand if ISPs could be successful if they can win a BEAD grant. Those grants can pay up to 75% of the cost of building the needed fiber network.

We considered two scenarios. In Scenario 1, BEAD grants would be available to areas served by licensed fixed wireless broadband today. This scenario brings broadband to 4,287 locations. Scenario 2 assumes that the locations served by licensed fixed wireless are not eligible for BEAD grants and would cover 1,527 locations. As of the date of this report, the State Broadband Office has not announced how such locations will be treated.

Perhaps the most important statistic in the financial analysis is customer density, meaning the number of customers per mile of fiber. In both scenarios, there are roughly six homes and businesses for each mile of constructed fiber. As the analysis shows, that is enough density to make BEAD grants viable at levels significantly below the 75% maximum grant. This is important because the grant office is using the cost per passing as a key element in scoring grant applications. We've worked in other counties, including in Illinois, where the cost per passing is two or more times higher than in Vermilion County.

It looks to be achievable for ISPs to win reasonable BEAD grants in the County. In Scenario 1, with 4,287 eligible passings, an ISP could achieve a breakeven scenario with a BEAD grant that covers only 53% of the cost of the assets. In the smaller Scenario 2, with 1,527eligible passings, and ISP can break even with

a BEAD grant of 70% of the cost of the assets. ISPs will want to do better than break even, and that looks possible with BEAD grants able to award grants up to 75% of the cost of the assets.

Our base assumptions are conservative, and we looked at a sensitivity analysis that shows ways for ISPs to perform better than our conservative assumptions. The assumptions with the biggest impact on financial performance are the customer penetration rate, broadband prices, and the interest rate on debt needed to support a grant.

There doesn't look to be any true partnership opportunities for the rural areas where the County would own the network and work with ISP partners. This is not surprising in rural areas where the operating costs are high and the margins low – there is not enough cash generated to support two partners.

Other Grant Funding Opportunities. The most likely grant funding opportunities will be from various federal broadband grants. The three most likely sources of upcoming grant funding are:

- There is strong bipartisan support to add more funding for the ReConnect grants administered by the Rural Utility Service (RUS) that is part of the U.S. Department of Agriculture.
- There are also substantial grants available for digital equity – getting computers into homes and training people how to use them.

Finding ISP Partner. Section IV.A discusses ways the County can identify ISP partners for pursuing grants.

Benefits of Broadband. Section IV.B. discusses the many benefits to the County and your residents of having good broadband.

STRATEGIC CONSIDERATIONS

The Wireless Broadband Issue

We considered two scenarios to define areas that need better broadband in the county and that could be eligible for BEAD grant funding. The difference between the two scenarios is the treatment of wireless broadband.

For purposes of the BEAD grants, the NTIA has determined that broadband customers served by unlicensed spectrum are considered to be unserved and eligible for BEAD grants. Unlicensed spectrum mostly means WIFI spectrum – the same spectrum that is used inside the home to reach devices can also be used to reach between towers and customers. The NTIA has ruled that using unlicensed spectrum is unreliable, regardless of the speed achieved at any given customer location.

States are taking different approaches to licensed spectrum. In most licensed spectrum scenarios, a carrier has purchased spectrum from the FCC which provides exclusive use. For example, practically all cellphone traffic uses licensed spectrum, and every cellular carrier operating in the county uses a different set of specific spectrum bands that they are allowed to use. Some state broadband offices have decided that licensed spectrum is reliable enough that customers served by a wireless carrier are considered to be served as long as the customer can achieve speeds of at least 100/20 Mbps. Other state broadband offices don't consider this to be served. We still don't know how Illinois is going to treat licensed wireless spectrum, so we looked at both options – licensed spectrum area as served or as unserved.

There is one spectrum band that is treated differently from all others. The spectrum that is being claimed by WISPs (Wireless ISPs) as licensed in rural areas is the Citizens Broadband Radio Service (CBRS) spectrum. The FCC approved the use of this spectrum in 2019 for rural broadband. This is a swath of spectrum covering 150 MHz of spectrum between 3550 and 3700 MHz.

The FCC auctioned 70 MHz of this spectrum in June 2020 – and anybody that purchased the spectrum is a licensed spectrum holder just like a cellular company. The FCC sold CBRS spectrum in an auction using a geographic area known as a Priority Access License (PAL). There are generally several PAL areas in every county. Any owner of a PAL license can use the spectrum without hindrance, except for the military, which always gets priority. The FCC identified areas before the auction where there is a known military use of the spectrum.

The remaining 80 MHz of the CBRS spectrum was set aside for unlicensed public use, similar to WiFi. Anybody using the unlicensed portion of CBRS cannot claim to be a licensed wireless ISP.

The licensed 70 MHz of spectrum also must be shared with other users. ISPs, or other users are allowed to apply for a license to share the spectrum, which is referred to as General Authorized Access (GAA) license. In the grant world, the NTIA has labeled any ISP that has a GAA license as being "licensed by rule."

The use of the CBRS spectrum is monitored by an authorized SAS administrator. The FCC has named five administrators: Amdocs, CommScope, Federated Wireless, Google, and Sony. A SAS administrator must use the following rules when authorizing an ISP to use the CBRS spectrum.

- If two signals are competing for priority, the SAS administrator looks at which signal has the top-tier access and gives that user permission to use the spectrum.
- A lower-tier user in the band must yield to the incumbent's right to use the spectrum, and the SAS will move a lower-tier user to another channel or reject the requested use of the spectrum if there is no spectrum available.
- This shared-licensed use is powered by a combination of dynamic channel sharing, smaller geographic license areas, and lower power limits than in many licensed-exclusive bands.

What does this license-sharing mean in practice?

- The military always has priority for using the spectrum.
- The PAL license holder (the winner of the auction) has full use of the spectrum unless the military wants to use it. In most places in the country there is only limited military use.
- A GAA license holder is last in line. A GAA license holder will be denied the use of spectrum if it is requested by the military or by a PAL license holder.

In Vermilion county, the only ISPs with a PAL license are WATCH Communications and Mediacom. The other WISPs claiming licensed spectrum, Rise Broadband, Surf Internet, and MF Wireless, are relying on the GAA license - licensed by rule. In the county. the license status for Rise Broadband and Surf Internet don't matter since both are claiming speeds less than 100/20 Mbps.

The final determination of how licensed spectrum will be treated in Illinois will have a huge impact on the number of homes and businesses that can get better broadband in the BEAD grant process. If licensed spectrum is considered to be unserved, then 4,287 homes and businesses will be eligible for BEAD grant funding. If licensed spectrum with claimed speeds of at least 100/20 Mbps is considered as served, then only 1,527 locations will be eligible for BEAD.

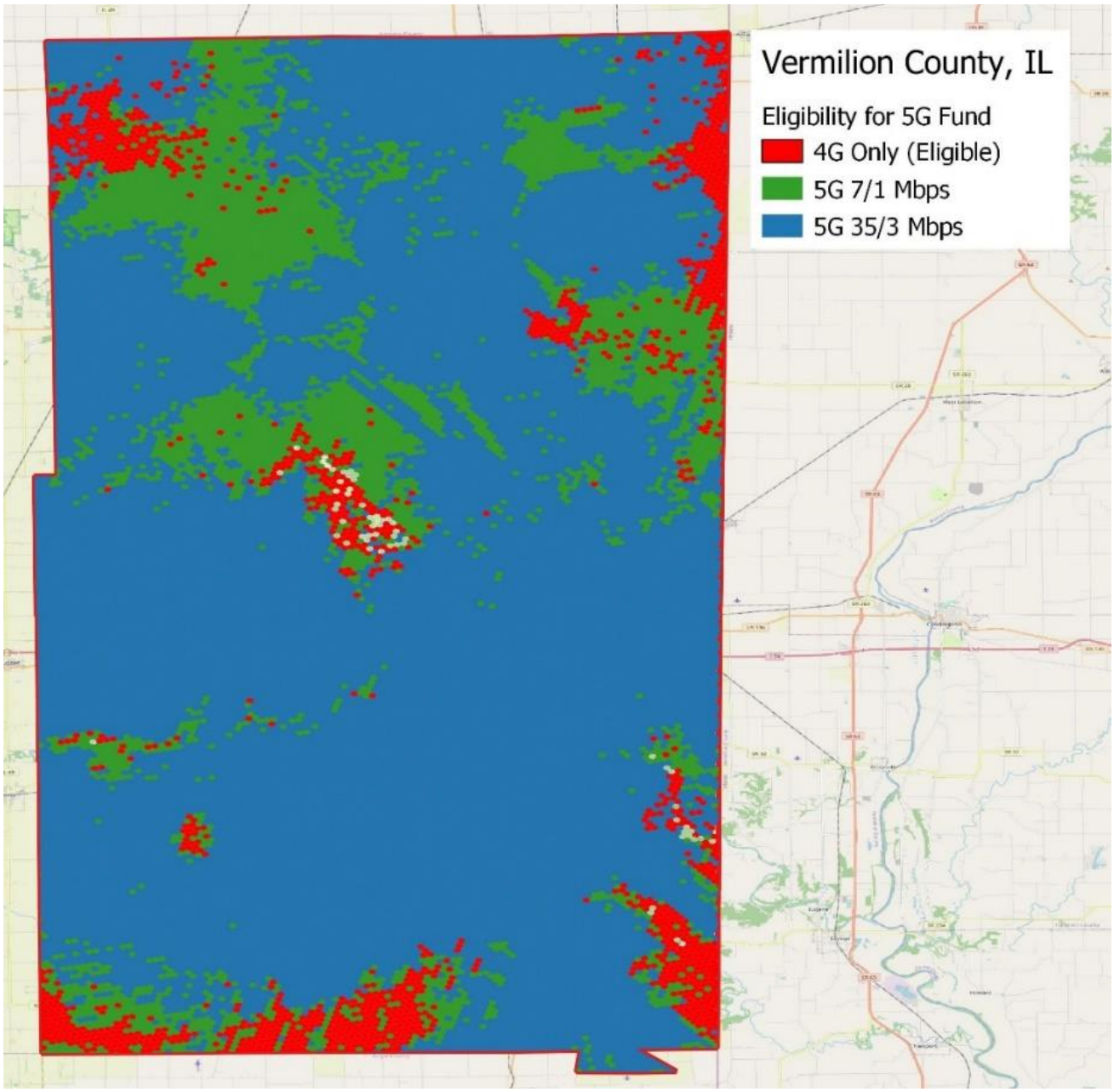
Getting Better Cellular Coverage

The FCC has proposed a new 5G Fund for $9 billion that will fund new rural cell towers. The FCC is proposing to award this new funding based on speeds and coverage areas reported by cellular carriers. The current map of this coverage is below. In this map, the areas that might be eligible for new cell towers are the red patches.

The industry consensus is that there are major flaws with the FCC cellular maps. However, the FCC has proposed to move forward with awarding the funding based on the map below – with no possibility for local governments to challenge the FCC maps.

What Can the County Do? First, the County should consider the map above. If you agree that the red areas are the only places that need new cell towers, then no further action is needed.

However, if you think that more of the county has poor cellular coverage, the County should lobby your national politicians to ask them to get the FCC to slow down the 5G Fund award process. This would give the County, and other local governments a chance to provide input to the FCC before it finalizes this funding.



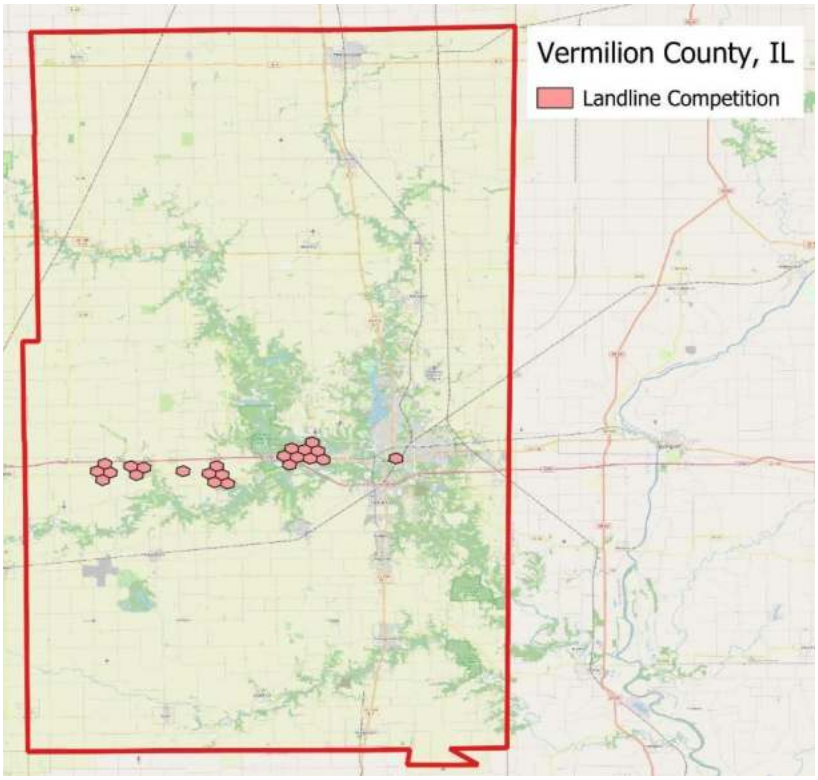
If There is a Map Challenge. If the FCC decides to have a map challenge process, the County can take steps to improve your chances of getting better cellular coverage. The process for doing this is to organize a mass speed test effort to demonstrate that cellular coverage is worse than shown on the map.

The FCC only considers speed tests collected through using its own speed test app – not speed tests taken on other speed test websites. Unfortunately, the FCC requires a lot of speed tests in a given neighborhood before the FCC will consider the results. This would mean a concentrated effort to get folks to take the FCC speed test in rural areas where the cellular coverage is poor. This also means getting folks who subscribe to different carriers to take the tests. You're going to want AT&T, T-Mobile, and Verizon customers to use the FCC app.

The Broadband Competition Gap

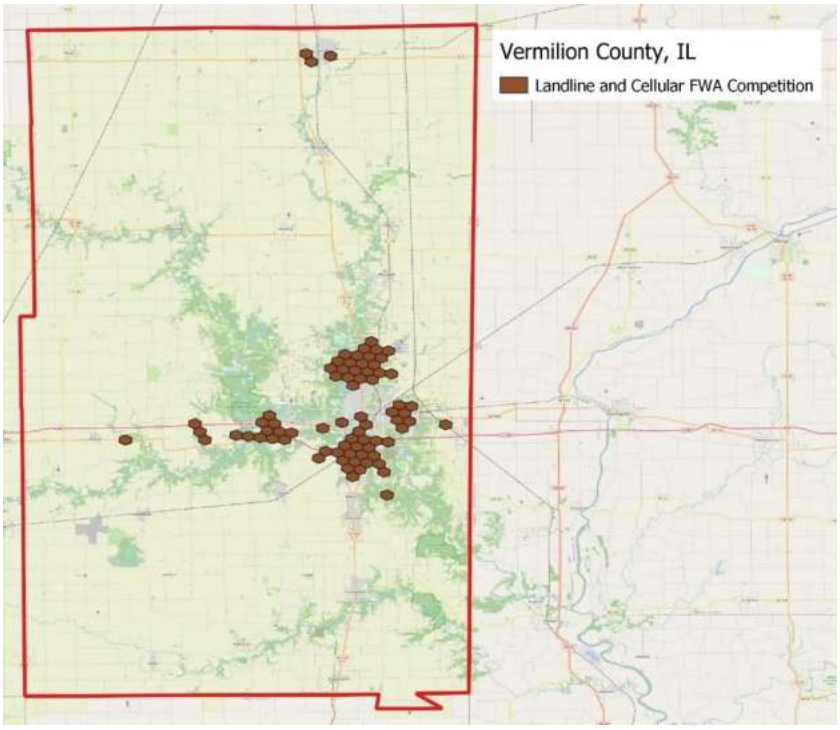
Like most counties in the country, there are still a lot of places in the county that don't have competition between two or more ISPs that offer broadband faster than 100/20 Mbps. This study focuses on bringing fast broadband to the rural areas that don't have fast broadband – but those areas will likely also only have one fast ISP after grants are awarded. We didn't find more than a handful of places in the county where there is more than one competitor offering a speed of 100/20 Mbps or faster. This means that most of the county has what we call a competition gap – where people don't have a choice between multiple fast ISPs.

The only two fast landline technologies in the county today are hybrid fiber-coaxial networks operated by Sparklight, Comcast, and Conxxus and fiber technology deployed by AT&T and Conxxus. This first map shows the area where there are two competing wireline ISPs, meaning a cable company competing against a fiber ISP.



This second map layers on competition provided by T-Mobile and Verizon FWA cellular where speeds are claimed at faster than 100/20 Mbps. There are a few areas in the county that receive both fast landline and cellular broadband.

- Customers in Danville can purchase broadband from AT&T, Comcast, Verizon, and T-Mobile.
- Customers in Hoopeston can purchase fast broadband from T-Mobile and Sparklight.
- Muncie Village customers can purchase fast broadband from Comcast, Pavlov Media, and AT&T FWA.
- Oakwood Village can purchase fast broadband from Pavlov Media, Comcast, and T-Mobile.
- Customers in Tilton Village can purchase fast broadband from Comcast, Sparklight, or Verizon.



There are real consequences for any neighborhood that has only one fast ISP. Such neighborhoods have no competitive options, and the one fast ISP is effectively a broadband monopoly in that community. There are clearly documented consequences of being served by ISPs that have a virtual monopoly. CCG Consulting has seen the following benefits for communities that get real competition between two or more ISPs that offer gigabit speeds.

- Lower Prices. The conventional wisdom is that competition lowers prices by at least 15%.
- Improved Customer Service. When a new competitor moves into an area that was previously a monopoly, it's almost inevitable that the former monopoly ISP will step up its game. ISPs respond to customer outages and troubles more quickly when there is competition.
- Technology Upgrades. ISPs operating in a competitive market tend to introduce upgrades a lot sooner than in non-competitive markets.

RECOMMENDED NEXT STEPS

Following are some specific steps that we think you'll want to consider.

Who Will Tackle the Next Steps?

One of the first things to consider after getting this public is to determine who specifically needs to get involved in the next steps. Every next step requires some effort, and some will require additional funding. There may be tasks that current staff might be able to tackle, but that might mean dedicating somebody to work on broadband issues. You may need to hire outside help to get some of these tasks done in time to get ready for upcoming grants. Once you've decided which recommendations to consider and pursue, the next question is to ask who will make sure that it gets done in a timely manner.

Supporting BEAD

As discussed in the previous section, ISPs will be asking the County to provide letters of support for BEAD grants and hoping that the County will make local grants to help match the BEAD grant. ISPs can win significant grant scoring points by getting these from the County. The letters of support are easy if you decide to give them to every ISP. It's going to be more challenging if you decide to only support some ISPs.

The process for picking ISP partners is similar in terms of the letters of support and the funding. We've seen two methods used to pick ISP partners:

- The County can talk to ISPs informally. In fact, any ISP interested in BEAD grants should soon be knocking on your door to ask for support. You could use these conversations to pick the ISPs you want to support.
- Many counties have used a more formal process by using either a Request for Information (RFI) or a Request for Proposal (RFP) that asks ISPs to describe their BEAD grant plans in writing. This will make it easier for the County to conduct a side-by-side comparison of different ISPs. We've seen many counties where the legal or purchasing folks have given the opinion that a more formal process is needed if the County is going to award some of your ARPA funding to ISPs.

These processes are straightforward. The County would issue an RFI, RFP, or even a simple request letter that asks ISP to tell you their plans. You'd identify the characteristics that you think are important for a good ISP – the technology they will use, their experience as an ISP, their financial ability to provide the matching funds needed for the BEAD grants, etc. The County would then need to sift through these responses and pick winners.

Educate the Public

A lot of this report was written to inform staff and the general public about broadband issues. You should determine the best way to inform the public of the results of this report. We've seen communities tackle public education in some of the following ways.

- Publish This Feasibility Report. While not a lot of people will wade the whole way through a report of this size, it has been written for the layperson.
- Hold Public Meetings. Meetings can be held to explain the results of this report, or meetings could be more generic and be aimed at explaining the broadband issues.
- Gather a List of Broadband Proponents. One valuable tool is to create a database of local broadband proponents – citizens who say they support fiber. Having a list of emails, home addresses, and phone numbers can be useful when you want to ask for public support for specific tasks or want to notify people of upcoming meetings.
- Outreach Meetings. One of the most successful ways to reach the public is what CCG calls outreach. This means sending a spokesperson to meetings of local organizations to talk about better broadband. This can be any sort of group – PTAs, church groups, service organizations, youth groups, etc. Most organizations will allow time for a short presentation. It's vital to have a prepared presentation to get across whatever message you want the public to know. These outreach meetings are best done by those who are strong broadband proponents.

Review Local Policies Related to Fiber Construction

Local rules and ordinances can have a big impact on fiber construction. Before ISPs ask to build everywhere, one of the first steps is to become aware of all of the local rules that might hinder fiber construction. Some of the areas that can be a problem include:

- Granting rights-of-ways to construct a network. This includes coordinating with local, County, State, and federal regulations.
- Obtaining permits to construct a network.
- Locating existing underground utilities where fiber is to be buried.
- Inspection of the network during construction.
- Following local rules for traffic control, notifying homeowners, etc.
- Providing records of what's been constructed.

Tackle the Digital Equity Gaps

The report discusses ways to tackle the other broadband gaps, such as the homework gap, the computer ownership gap, and the digital literacy gap. There is currently a huge amount of federal grant funding available at both the state and federal level to tackle these issues. The grants are mostly intended to be awarded to local governments or non-profit entities willing to tackle these issues.

The County can play a key role in making sure that you get your fair share of this funding. The grants will require one or more stakeholders in the County to step up to tackle the broadband gap issues. For example, one entity might be willing to work to get computers into homes while somebody else is willing to tackle training folks how to use broadband.

The County needs to decide if you should play a role in this issue. If you want to get involved, the steps to do so would be:

- First, find out what various stakeholders are doing or planning for pursuing the grant funding or tackling the digital equity issues.
- If there is not a collaboration of stakeholders working to find funding together, the County could pull the stakeholders together and try to create the needed collaboration.
- The County can also provide funding or assistance to write the needed grants.

Timing of Infrastructure Upgrades

AMG Technology Group (Nextlink) won a little over $2 million in the RDOF reverse auction to provide broadband to 939 locations in the county. Due to this funding, these areas are not eligible for BEAD or other broadband grants. Nextlink pledged to the FCC that it would build either fiber or wireless technology, but nationwide, the company seems to be almost entirely building wireless technology. Nextlink has until the end of 2028 to fulfill this commitment.

Many counties are concerned about the RDOF awards to wireless companies. Counties are concerned that it's taking a long time to see any infrastructure deployment. There have been rumors that some of the RDOF winners might default on the awards. Even if that doesn't happen, counties are worried that the RDOF winners won't aggressively try to bring broadband to every house in the award areas. In these rural

areas, the RDOF winner is likely going to be the only fast ISP since these areas are off-limits to other broadband grants.

We recommend that the County stays in close contact with Nextlink to make sure that upgrades are done in a timely manner and that the company strives to bring broadband to the areas where it has largely been given a broadband monopoly.

I. MARKET ANALYSIS

This section of the report looks at broadband prices in the county. The report also analyzes speed tests gathered for the County from Ookla. The market analysis includes maps showing the claimed service areas of ISPs. Finally, this section of the report looks at the broadband gaps in the County.

A. Broadband Rate Study

There are a lot of ISPs serving in Vermilion County today. The following ISPs claim broadband coverage in the county in the latest FCC broadband maps:

- AT&T and Frontier are incumbent telephone companies.
- Conxxus, Sparklight, and Comcast are incumbent cable companies.
- AT&T, Pavlov Media, and Conxxus claim residential fiber broadband. Comcast claims fiber only for businesses.
- MF Wireless, Rise Broadband, Surf Internet, WATCH Communications, and Nextlink claim broadband coverage using fixed wireless technology.
- T-Mobile, AT&T, and Verizon provide cellular hotspots and/or FWA cellular broadband using cellular spectrum.
- Viasat, HughesNet, and Starlink provide satellite broadband.

ISPs are supposed to report locations to the FCC maps that they can serve within ten days of a customer request for service. Following is a list of the locations claimed in the FCC maps for each ISP, by technology. (for example, AT&T has a separate number of locations served by DSL, FWA, and fiber).

Provider	Technology	Passings
Sparklight	Cable	10,265
Comcast	Cable	17,455
AT&T	DSL	17,524
Frontier	DSL	2,308
AT&T	Fiber	307
Conxxus	Fiber	1,214
Pavlov Media	Fiber	804
MF Wireless	Licensed Fixed Wireless	296
Rise Broadband	Licensed Fixed Wireless	2,704
Surf Internet	Licensed Fixed Wireless	13
WATCH Communications	Licensed Fixed Wireless	16,723
Nextlink	Unlicensed Fixed Wireless	5,629
Rise Broadband	Unlicensed Fixed Wireless	4,800
WATCH Communications	Unlicensed Fixed Wireless	9,982
AT&T	FWA Cellular	2,555
T-Mobile	FWA Cellular	26,133

Verizon	FWA Cellular	8,359
HughesNet	GEO Satellite	35,558
Viasat	GEO Satellite	35,559
Starlink	LEO Satellite	35,559

Broadband Labels

The FCC recently began to require all ISPs to publish a broadband label for each broadband product. The labels look a lot like the food labels required on cans of food. The purpose of the labels is to provide full disclosure to the public for the fees, speeds, and other issues related to their broadband products. These labels represent a big change in the industry because many ISPs have not been transparent about prices, speeds, fees, and other aspects of broadband. The labels require ISPs to provide accurate information to the public, and the FCC has warned ISPs of significant fines for failure to comply with the new label rules.

Here are a few of the key requirements of the broadband labels, and there are others:

- Use the FCC Format. ISPs can't customize the label and must follow the FCC format.
- Covered Products. ISPs must create a separate label for each broadband product. ISPs must provide labels for both residential and small business broadband.
- Where to Show the Label. At a minimum, ISPs have to make the labels available where customers can get a price for their particular address – although ISPs can also make the labels available to everybody.
- Prices. ISPs must show unbundled standalone rates for each service offering. This must be the retail price before any promotions or discounts are applied to the product. They are allowed to separately describe if discounts are available.
- Fees. ISPs must disclose all fees associated with each product. This would include fees for a modem, gateway, or router. Fees like deposits or fees for late payment must be disclosed. Any fees for cancelling the contract must be disclosed. Installation fees must be shown.
- Introductory Rates. If an ISP offers introductory rates, they must disclose the discounted price, the length of a discount period, and the rates after the introductory rate expires.
- Contracts. ISPs must disclose if a contract is required to get the listed price and must provide a link to the contract terms that would apply.
- Taxes. ISPs must disclose if taxes will be charged on the product but don't have to disclose the exact amount of tax. We note that there are not many taxes that apply to broadband.
- Speeds and Latency. ISPs must disclose the 'typical' download and upload speed and latency for each product. Speeds should be based on internal testing done by the ISP. This is a stern warning for ISPs that advertise 100/20 Mbps but deliver 20/5 Mbps. The same rules apply for reporting latency.
- Network Management Practices. These don't go on the label, but there must be a link near the labels that directs the public to a description of network practices associated with blocking, throttling, and paid prioritization.
- Privacy Policy. ISPs must also provide a link that discloses the privacy policies for dealing with customer data.

Following is an analysis of the broadband prices being charged in Vermilion County today. The prices discussed below are the 'list' prices – the price paid by a customer paying the full price for standalone

broadband. We know that many customers pay lower rates due to bundling discounts or special promotional discounts. Some customers are grandfathered into old rates that don't change if they keep the original product.

Cable Companies

Comcast Xfinity[1] is the incumbent cable TV provider in Danville, Fairmount, Fithian, Georgetown, Indianola, Muncie, Oakwood, Olivet, Ridge Farm, and Tilton. Comcast markets and bills using the "Xfinity" brand name. The company offers the traditional triple play of cable TV, broadband, and voice services. Comcast is the largest cable TV company in the U.S. with 2023 revenues of $121 billion and is the second largest cable company in the world. It is headquartered in Philadelphia. At the end of the second quarter of 2024, the company had almost 32.1 million broadband customers.

In addition to providing triple-play services, Comcast also provides cellular service in most markets and offers home security and smart home applications. The company owns a number of media assets like NBC, Telemundo, MSNBC, CNBC, USA Network, the Golf Channel, Syfy, numerous regional sports networks, Universal Pictures (and theme parks), Dream Works, and the Philadelphia Flyers hockey team and arena.

Standalone Residential Broadband

Following are the most recent list prices for standalone residential broadband. These rates include a $3 rate increase announced in January 2024. New customers are generally not offered products below the 300 Mbps tier.

Connect	150/5 Mbps	$ 66.00
Connect More	300/5 Mbps	$ 86.00
Fast	500/5 Mbps	$ 96.00
Superfast	800/15 Mbps	$106.00
Gigabit	1000/35 Mbps	$116.00
Gigabit Extra	1200/35 Mbps	$126.00
WiFi Modem		$ 15.00
WiFi Modem (Gigabit Pro)		$ 19.95

Business Broadband

Business Standard	300/35 Mbps	$149.95
Business Performance	500/35 Mbps	$199.95
Business Advanced	800/35 Mbps	$249.95
Business Gigabit	1250/35 Mbps	$399.95
WiFi Modem		$ 22.95

All business prices above are for broadband plus security. Comcast charges an additional $10 to add a telephone. We note that Comcast charges a wide range of rates for business broadband, and these are the maximum list prices that they are showing on the newly created broadband labels.

[1] https://www.xfinity.com

In Vermilion County, Comcast has a 1.2 Terabyte (1,200 gigabytes) data cap per month. When customers exceed the cap for a given month (the usage adds together both download and upload data usage), Comcast bills $10 for each additional fifty gigabytes of data used, with a maximum billing of $50 extra.

Comcast offers low-price broadband to lure new customers. As this paper was being finalized, the promotional prices are:

150 Mbps	$ 30
300 Mbps	$ 50
500 Mbps	$ 75
800 Mbps	$ 85
1000 Mbps	$ 85
1200 Mbps	$105
WiFi modem	$ 15

Telephone

Comcast sells standalone residential telephone service. The prices are as follows.

Basic	$40
Additional Line	$9.95

The basic line is a telephone line with standard features but no long-distance option. Comcast used to offer a telephone line with unlimited long-distance, but that's no longer available. We think it now directs customers to the Comcast cellular service for those wanting unlimited calling.

Cable TV

The following prices are for standalone cable TV. The Limited Basic tier includes network broadcast channels like ABC, CBS, FOX, NBC, and PBS. The Popular tier includes most of the popular channels that people expect from a cable subscription. The Ultimate tier includes every non-premium channel offered by Comcast.

Choice TV	$30
Popular TV	$70
Ultimate TV	$90
Set-Top Box	$10
DVR Service	$10

Hidden Fees

Comcast charges significant hidden fees to new customers. These are fees that are often not mentioned when Comcast advertises to get new customers, but which are included in the customer bill.

- The broadcast fee is $25.50 per month. This is a fee where Comcast has accumulated increases in programming costs into this side fee rather than raising the basic price of cable.
- The regional sports fee is $17.25 per month – the fee varies by market depending upon the local sports networks that Comcast carries. Again, the company has accumulated rate increases for sports programming to hold down the advertised price of cable TV.

- Comcast also charges $10.00 for each settop box – a fee that is not included in the advertised price.
- A first-time customer buying the $30 basic cable product from Comcast could get the first bill of almost $75 – a startling difference.

Comcast also has what most in the industry consider as hidden fees for broadband. The company charges $15 per month for a WiFi modem. The biggest surprise for a new customer is the Comcast data cap on broadband. The company charges $10 for each 50 GB of data over the data cap limit, with a maximum monthly fee of $50.

The Comcast Bundle

Comcast uses bundles to entice customers to buy more than one service from the company and increases discounts for buying multiple products. Because the company has so many products, it offers a dizzying array of bundles, with prices that change often as inducements to get customers to buy additional products. Comcast has learned that customers who buy multiple products – particularly products in addition to the triple play – rarely churn and become loyal customers.

One of the most important aspects of bundles is that the company punishes customers for dropping a bundled service. Consider the following simplified example of how this works. Suppose that a customer purchased the $66 broadband product and the $70 cable product and is given a $20 bundling discount and charged $116 for the bundle. If a customer drops either product, the customer will likely lose the entire $20 discount, and the remaining product will revert to the list price.

The Comcast bundle creates challenges for competing ISPs. If a customer tries to break a bundle to move broadband to a competitor but wants to leave cable TV with Comcast, the cable prices revert to list prices. This is a big disincentive for customers to break the bundle.

Comcast has expanded the bundle in the last few years. Their newest offering is cellular service, which is only available for customers buying Comcast broadband. The pricing is simple and inexpensive. Cellular customers pay $20 for each gigabyte of data used. For $40 per month, customers get unlimited data, with the first 30 gigabytes used each month being premium data. For $50 per month, customers get unlimited data, with the first 50 gigabytes used each month being premium data. Comcast uses the Verizon network to carry the traffic, but the company recently purchased wireless spectrum and uses its own towers to serve some customers. Comcast benefits from customers using cell phones when near WiFi.

Comcast also provides smart home products under the brand name Xfinity Home. The company is now supporting the home automation devices of nine major manufacturers: August (smart locks), Automatic (automobile), Cuff (fitness tracking), Lutron (smart lighting) Leeo (alarms), Nest (thermostat), Rachio (sprinkler system), Skybell (doorbell), and Whistle (pet tracking). Comcast also offers traditional home security with hardware developed at Comcast Labs. This includes the traditional suite of burglar, fire, and other alarms that are monitored and reported to authorities when there is a problem.

Sparklight[2] is a brand name for Cable One, which also sells broadband under the brand name Clearwave. In Vermilion County, the company provides service in Belgium, Catlin, Danville, Georgetown,

[2] https://www.sparklight.com/

Hoopeston, Rossville, Tilton, and Westville. Cable One had a little less than 1 million broadband customers in 21 states at the end of the second quarter of 2024. Cable One had 118,000 cable customers at the end of the second quarter of 2024 and has an unusual strategy for the industry by not fighting to keep cable customers.

The company has been growing through acquisitions. In 2021, Cable One purchased the remaining shares of Hargray Communications, giving it 100% equity control of the company. The acquisition was for $2.2 billion. In July 2020, Cable One purchased Valu-Net, an all-fiber ISP in Kansas, for $38.9 million. In 2019, Cable One acquired Fidelity Communications for $526 million. In 2018, Cable One bought Clearwave Communications. The purchase added 2,400 route miles of middle-mile fiber and approximately 2,700 business towers and data centers.

Following are the prices for Sparklight broadband:

Residential Broadband		
100 Mbps	$ 55.00	
300 Mbps	$ 65.00	
600 Mbps	$ 85.00	
1 Gbps	$ 95.00	
Modem	$ 12.50	
Television		
Economy	20 Channels	$54.00
Standard	100 Channels	$131.75
Digital Value Add On	24 Channels	$16.00
Settop Box:		$10.50
Telephone		
Economy	$20	
Standard	$50	
Long-Distance	Price varies by location	

Hidden Fees

One of the most interesting ways that big cable companies and telephone companies compete is through the use of hidden fees – which are fees that are not clearly identified in advertising. The motivation for having hidden fees is clear – it lets a cable company advertise a low price for basic service by not mentioning the hidden fees. It's an odd tactic since customers find out about all of the hidden fees when they get the first bill.

The Sparklight hidden fees for cable TV are significant. Consider the following:

- The company no longer specifies the hidden fees on its website. When last posted, the broadcast fee was between $12.95 - $21.77 per month. Sparklight also has a Broadcast TV Delivery Surcharge of $3.95 in some areas. This is a fee where Sparklight and other cable companies have accumulated increases in programming costs into this side fee rather than raise the basic price of cable.

- The regional sports fee is $9.20 per month for Standard cable customers. Again, the company has shifted rate increases into this fee to hold down the advertised price of cable TV.
- Sparklight also charges $10.50 extra for a settop box – a fee that is not included in the advertised price.
- A first-time customer buying the $54 economy cable product from Sparklight could get the first bill for over $95 – a startling difference.

Sparklight also has what most in the industry consider as hidden fees for broadband. The company charges $12.50 per month for a WiFi modem. In some markets Sparklight charges a $2.75 Internet surcharge fee.

Incumbent Telephone Companies

Frontier Communications[3] is the fifth-largest telephone company in the U.S.. Frontier grew through acquisitions. In 2015, it bought 2.2 million customers from Verizon in Florida, Texas, and California. The company spent $8.5 billion to buy more customers from Verizon in 2009, and in 2013 bought the Connecticut operations of Verizon. As of the end of the second quarter of 2024, the company had a little more than 3 million broadband customers.

In big industry news, Verizon recently announced that it was buying Frontier, and if regulators approve the sale, it will happen sometime in 2025.

The company says it reaches 5.5 million fiber passings at the end of 2022 and said it plans to continue to aggressively build fiber to reach 10 million passings by the end of 2025. The company does not claim to provide any fiber in the county.

Frontier is an incumbent telephone provider and is considered a provider of last resort, meaning it must make reasonable efforts to try to provide telephone service to anybody within its defined service area.

Frontier DSL.

Frontier Internet	Best Effort	$ 74.99

Telephone Rates

Like with other telcos in the state, the rates have been deregulated. Frontier charges by the minute for long-distance. This means that free calling is only available to those living close to the serving area, while there is an extra fee to call anywhere else. For all telephone lines, Frontier charges an additional $6.50 for the Subscriber Line Charge and up to $1 for an Access Recovery Charge (ARC). Frontier offers a dizzying array of other telephone services.

AT&T[4]**.** AT&T is the incumbent landline telephone provider for most of the southern half of Vermilion County. AT&T still sells traditional telephone service and legacy DSL broadband under the AT&T brand name. AT&T offers DSL, fiber, and fixed cellular in the county. For many years, the company sold broadband under the AT&T U-verse brand name, but in March of 2020, the company rebranded

[3] https://frontier.com/

[4] https://www.att.com/

everything to the original AT&T brand name. In October 2020, the company announced that it would no longer sell new DSL. For now, existing customers can keep DSL, but nobody can add the product.

At the end of the second quarter of 2024, the company had almost 15.1 million broadband customers. AT&T added over 1.2 million customers to fiber in 2022 and has built fiber to pass 19.7 million passings (potential customers). The company's goal is to eventually pass 30 million homes with fiber.

AT&T is now offering FWA cellular broadband in rural areas as a replacement for rural DSL. This is only available where the company has updated its cell sites. AT&T is clearly in the process of shedding the legacy DSL business.

DSL.
AT&T has two classes of DSL service. The older products under 25 Mbps are still classified as DSL. AT&T Internet DSL uses two copper pairs that can double the speeds. AT&T did not report any of the AT&T Internet products in the county.

DSL	Download Speed	Price
Basic 5	5 Mbps	$ 60
Internet 10	10 Mbps	$ 65
Internet 25	25 Mbps	$ 65
DSL Modem		$ 10
AT&T Internet		
Internet 50	50 Mbps	$ 65
Internet 75	75 Mbps	$ 65
Internet 100	100 Mbps	$ 65
DSL Modem		$ 10

There is a monthly data cap on total usage of 150 gigabytes for basic DSL customers, meaning customers are charged for exceeding the cap. The data cap for AT&T Internet customers is 350 gigabytes per month. Overage charges are $10 for an additional 50 gigabytes of data. For $30 extra per month, a customer can get unlimited data.

Fiber Broadband. While AT&T has built fiber widely in some communities, its normal method of deploying fiber is to build in small neighborhoods. The company builds small pockets of fiber scattered throughout a community. The following are the residential prices for AT&T broadband on fiber. Speeds on fiber are symmetrical for upload and download. There is evidence of this product in pockets in Vermilion County.

Fiber		Price
Internet 300	300 Mbps	$ 65
Internet 500	500 Mbps	$ 75
Internet 1000	1 Gbps	$ 90
Internet 2000	2 Gbps	$155
Internet 5000	5 Gbps	$255
Modem rental included		

Fiber Overbuilders

Conxxus[5] is a cable and fiber provider headquartered in Sullivan, Illinois and founded in 2002. The company provides fiber in 89 communities in Illinois. The company is actively expanding its fiber network throughout the state. In Vermilion County Conxxus provides service in Potomac, Armstrong, Bismark, and Rankin.

During the provider interview, the company mentioned plans to upgrade all of its serving area in the county to fiber. The company has notified the County of plans to build fiber infrastructure in the village of Ridge Farm.

While the company claims slower upload speeds than download speeds to the FCC, Ookla speed tests show the up and down speeds are symmetrical.

Residential Fiber Broadband	
20/20 Mbps	$ 55
100/100 Mbps	$ 65
300/300 Mbps	$ 75
1/1 Mbps	$ 85
2.5/2.5 Gbps	$134
5/5 Gbps	$199
Router	$ 5
Voice	
Basic	$20

Pavlov Media[6] is an ISP that specializes in providing the triple play to off-campus housing and luxury apartments. The company works nationwide in forty-four states, serves 170 university communities, and connects to 800 large apartment buildings and complexes. The company claims to be the largest provider of off-campus housing broadband. The company provides residential broadband to 24 communities in Illinois and claims to serve in the communities of Oakwood, Muncie, and Fithian.

Residential Broadband	
1/1 Gbps	$69.99
2/2 Gbps	$79.99
5/5 Gbps	$99.99
8/8 Gbps	$134.99

[5] https://conxxus.com/

[6] https://pavlovmedia.com/

Fixed Wireless

Surf Internet[7] is a fiber and fixed wireless provider started in 1999 in Elkhart, Indiana. The company provides services in Indiana, Illinois, and Michigan. The company serves 600 communities and has 140,000 fiber passings in the three states. In Vermilion County, the company provides fixed wireless service in the northeast corner.

Residential Fixed Wireless Broadband	
5/1 Mbps	$54.95
10/1 Mbps	$64.95
15/2 Mbps	$84.95
25/3 Mbps	$104.95
Installation	$99

Voice	
Basic	$10

MF Wireless[8] is a fixed wireless provider headquartered from Camargo, Illinois. The company provides service in Camargo, Villa Grove, Murdock, Newman, Longview, Bongard, Pesotum, Tolono, Chicken Bristle, Atwood, Pierson Station, Allerton, Broadlands, Hindsboro, Arthur, Chesterville, and Arcola. In Vermilion County, the company provides service in the southwest corner.

Residential Broadband		
Basic	50/5 Mbps	$ 85
Premium	100/10 Mbps	$100
Ultimate	150/20 Mbps	$125
Installation		$ 99

WATCH Communications[9] was founded in 1991 and is a subsidiary of the Benton Ridge Telephone Company of Lima, Ohio. WATCH Communications offers fixed wireless and fiber optic internet, TV, hosting, and VoIP phone services throughout Illinois, Indiana, Kentucky, and Ohio. WATCH Communications offers fiber TV in Indiana and parts of Ohio and has partnered with DISH to provide satellite television in its other service territories. In Vermilion County, WATCH Communications provides both .licensed and unlicensed fixed wireless service across much of the county.

Residential Internet		
Watch Essentials	10/1 Mbps	$ 59.99
Watch Choice	15/1 Mbps	$ 69.99
Watch Preferred	25/5 Mbps	$ 79.99
Watch Premium	50/10 Mbps	$ 99.99
Watch Elite	100/20 Mbps	$120.00

[7] https://surfinternet.com/

[8] https://www.mfwireless.com/

[9] https://watchcomm.net/

Additional	
Equipment Maintenance Plan	$ 5.00

Voice	
VoIP	$24.99

Rise Broadband[10]. In 2015, Skybeam, Digis, T6, Prairie Net, and Rhino Communications were rebranded under the Rise Broadband name. Rise Broadband was founded in Englewood Colorado in 2005 and provides fixed wireless broadband and VoIP services. The company operates a mix of licensed and unlicensed spectrum throughout the county.

Residential Internet	250 GB Cap	1 TB Cap	Unlimited
Up to 5 - 15 Mbps	$42	$61.95	$81.95
Up to 20 - 25 Mbps	$47	$66.95	$86.95
Up to 50 Mbps	$57	$76.96	$96.95

Additional data is $5 for 10 Gigabytes.
Rise Broadband does not charge an installation or modem rental fee.

Nextlink[11] is a fiber and fixed wireless provider throughout Texas, Oklahoma, Kansas, Nebraska, Iowa, and Illinois. Nextlink was started in 2012 in Weatherford, Texas and currently ranks as the 6th largest fixed wireless provider in the United States. In Vermilion County, Nextlink claims to provide unlicensed fixed wireless across much of the county.

Residential Fixed Wireless	
25 Mbps	$ 49.95
35 Mbps	$ 59.95
50 Mbps	$ 69.95
100 Mbps	$ 79.95
200 Mbps	$ 94.95
300 Mbps	$109.95
400 Mbps	$124.95
500 Mbps	$139.95
Router	$ 8.99
Installation	$250.00

Cellular Data

Cell Phone Broadband

All three major cellular companies now advertise unlimited data plans for cell phones – but plans are not actually unlimited and have data caps in the range of 20 - 40 gigabytes per month of downloaded data.

[10] https://www.risebroadband.com/

[11] https://nextlinkinternet.com/

These plans might provide some relief to homes that rely on cell phones for home broadband, although there have been reports of Verizon disconnecting rural customers who use too much data on these plans. These cellphone plans have limits on how much data can be used when tethering from a cell phone to connect to other devices. T-Mobile claims to offer unlimited data that throttle customers after 50 gigabytes of data usage in a month.

Hotspots and FWA Broadband.

Cellular companies have traditionally sold home broadband plans known as hotspots. These plans have small data caps similar to traditional cellular plans.

Starting in 2021, cellular carriers introduced home broadband plans using the new spectrum that each company labels as 5G. These plans are generically referred to in the industry as FWA broadband. These plans are only available in places where a carrier has upgraded cellular cell sites and where the new product has been opened for marketing. The business has exploded – at the end of the second quarter of 2024, T-Mobile had 6 million customer, Verizon had 3.8 million, and AT&T had 350,000.

AT&T has historically offered hotspot plans. More recently, it is offering fixed cellular plans that use the new bands of spectrum labeled as 5G. AT&T reported fixed cellular speeds of 25 Mbps in parts of the county.

4G Hotspots	
15 Gigabyte of data	$35
100 Gigabyte of data	$55
Additional 1 Gigabyte	$10

Air Internet (5G FWA Fixed Wireless)	
Up to 100 Mbps	$60
Discount for autopay	$ 5
Unlimited usage	

T-Mobile historically offered hotspot plans. More recently, it offers fixed wireless plans that use the new bands of spectrum labeled as FWA Cellular 5G. T-Mobile advertises speeds as fast as 100 Mbps for this product in the county.

4G Hotspots	
5 Gigabyte data cap	$20
10 Gigabyte data cap	$30
30 Gigabyte data cap	$40
50 Gigabyte data cap	$50
Discount for autopay	$ 5

Speeds revert to 3G speeds when the cap has been met. The plans include unlimited texting.

5G FWA Fixed Wireless	
Up to 100 Mbps	$65
Discount for autopay	$ 5

Verizon historically offered cellular hotspot broadband. More recently, it offers FWA cellular wireless using the new bands of spectrum labeled as 5G.

4G Hotspots	
15 Gigabyte data cap	$ 20
50 Gigabyte data cap	$ 40
100 Gigabyte data cap	$ 90
150 Gigabytes data cap	$110

Customers also have the option to purchase an additional 1 gigabyte of data for $15 or 5 gigabytes for $35. If a customer doesn't buy extra data, the speeds are significantly choked to be slow.

5G Home	
With a Verizon cellphone plan	$ 45
Standalone	$ 60
Discount for autopay	$ 10
Speeds up to 300 Mbps	
Unlimited usage	

Satellite Broadband

Geosynchronous Satellite. Viasat and HughesNet use satellites parked at a stationary orbit 22,000 miles above the Earth. Customers complain that satellite costs too much (Viasat reported in the second quarter of 2023 that the average residential broadband bill was $89.71). Customers also hate the high latency, which can be 10 to 15 times higher than terrestrial broadband. The latency is due to the time required for the signals to go to and from the high-orbit satellites. Most real-time web applications, such as using voice-over-IP or connecting to a school or corporate server, only function reliably with latency under 100 milliseconds. Satellite broadband has a reported latency between 400-900 milliseconds.

The other common customer complaint is about the tiny data caps. As shown in the pricing below, monthly data caps range from 40 gigabytes to 300 gigabytes. To put those data caps into perspective, OpenVault announced recently that the average U.S. home used 641 gigabytes of data per month in the fourth quarter of 2023. The small data caps on satellite broadband make it impractical to use for a household with school students or for a household that wants to use broadband to work from home.

Viasat satellite broadband has gotten better over time. The broadband on the ViaSat-1 satellite launched in 2011 was relatively slow, with speeds up to 25 Mbps. The company advertises speeds as fast as 100 Mbps download on the ViaSat-2 satellite launched in 2017. The company plans three new ViaSat-3 satellites with even higher capacity, the first launch was in May 2023, the second launch was in February 2024, with the third launch expected to be in late 2024.

Prices are high compared to other broadband products. The latest pricing from the company is as follows:

	Price	Data Cap
Up to 25 Mbps	$ 69.99	40 Gigabytes
Up to 50 Mbps	$ 99.99	60 Gigabytes
Up to 75 Mbps	$149.99	100 Gigabytes
Up to 100 Mbps	$199.99	150 Gigabytes
Up to 100 Mbps	$299.99	300 Gigabytes
Equipment Fee	$ 14.99	

A customer must sign a 2-year contract to get these prices and pay a fee of $15 for each remaining month if a customer breaks the contract. Online reviews say that speeds can be throttled to as slow as 1 Mbps once a customer reaches the monthly data cap.

HughesNet is the oldest satellite provider. They have recently upgraded the satellites and now offer speeds advertised as 25 Mbps download and 3 Mbps upload for all customers. Prices vary according to the size of the monthly data cap. The speeds are severely throttled after meeting the data caps. The packages are as follows:

15 Gigabytes	$ 64.99
30 Gigabytes	$ 74.99
50 Gigabytes	$ 99.99
100 Gigabytes	$174.99

Low-Orbit Satellite. There has been a lot of recent news about low-orbit satellite companies. Where the older satellite companies park satellites at over 20,000 miles above the Earth, these companies are putting satellites between 300 and 600 miles above the Earth.

Starlink is owned by Elon Musk. The company recently reached 2 million worldwide customers. The company had almost 6,371 functional satellites in orbit as we wrote this report and plans on 12,000 to complete its first constellation.

<u>Residential Broadband</u>	
Standard	$ 120
Receiver	$ 599
<u>Business Broadband</u>	
Priority 40 Gigabytes	$ 140
Priority 1 Terabyte	$ 250
Priority 2 Terabyte	$ 500
Hardware	$2,500
<u>Mobile</u>	
Regional	$ 150
Global	$ 200
Hardware	$ 599

Mobile Priority	
Priority 50 Gigabytes	$ 250
Priority 1 Terabyte	$1,000
Priority 5 Terabytes	$5,000
Hardware	$2,500

Business and mobile customers can now purchase priority data. The company states that customers who purchase priority data will receive network priority and faster and more consistent download and upload speeds until the priority data cap is reached.

Mobile satellite service allows customers to move the receiver, and customers use the service in campers or even backpacking.

A few months ago, the company claimed the following speed capabilities on its website; however, it no longer posts any claims about residential speeds. Interestingly, the speed claims below are much slower than promised as recently as September 2022. For example, residential customers were told in 2022 that download speeds would be between 50 – 200 Mbps with upload speeds of 10 - 20 Mbps. Customers have been saying online that speeds are getting slower – something that Ookla speed tests have validated. Ookla recently released a report stating the nationwide median download speed for Starlink was 64.5 Mbps.

	Download	Upload
Residential	20 – 100 Mbps	5 – 15 Mbps
Business	40 – 220 Mbps	8 – 25 Mbps
RV	5 – 50 Mbps	2 – 10 Mbps

Low-Income Broadband Programs

There are several federal subsidy programs available or qualified low-income households. Some ISPs also have low-income rate programs.

Comcast Internet Essentials

Comcast has a low-income program called Internet Essentials that provides broadband to qualifying households. Comcast delivers 50/5 Mbps speeds for $9.95 per month. The program was created as a condition by the FCC for the purchase of NBC Universal in 2011. For a long time, the program was lowkey, and the company barely advertised it to customers. But over the years, the company has embraced the program, and in August 2019, it announced it had connected over eight million people to the Internet with the program.

In addition to the low monthly broadband rate, those in the plan are eligible to buy a low-cost computer for $149.99. Comcast also offers broadband training in Internet basics, online safety, and security, using basic computer tools and programs, etc. These training courses are available online or can be taken in person.

Comcast has widened the eligibility for the program over the years, and current eligibility covers families that participate in Medicaid; live in public housing; participate in SNAP, TANF, SSI, National School Program, Headstart, LIHEASP, or WIC; attend college using a Pell grant; receive a VA pension; or receive various kinds of tribal assistance are eligible for the program.

Access from AT&T

AT&T has a low-income program called Access from AT&T that provides broadband to qualifying households. The program offers a free modem, no annual contract, no deposit, and up to $10 off per month with a maximum speed of 25 Mbps. The amount of savings depends on the fastest speed available at the address.

Households must have one or more members that receive one of the following assistance programs: Supplemental Nutritional Access Program (SNAP), Supplemental Security Income (in Michigan only), income of 135% or less than the Federal Poverty Guidelines, or National School Lunch and Head Start Programs.

Federal Lifeline Program

Frontier, Nextlink, Rise Broadband, and WATCH Communications participate in the FCC Lifeline program, which is a part of the Universal Service Fund. With the program, a customer can receive a discount of $9.25 per month off a telephone bill or a broadband bill for qualifying customers. The program works with the ISP providing a discount to customers, and the FCC reimbursing the ISP. This means it costs an ISP nothing to offer the discount.

To qualify, a customer must participate in one of the following programs: Medicare, SNAP (formerly Food Stamps), SSI, Federal Section 8 housing, VA Veterans pension, or VA survivor's pension. The FCC has recently established a web portal where participating carriers can check the eligibility of households to meet one of the above tests. Telephone companies don't tend to aggressively market this discount to eligible households – but they will enroll anybody who qualifies and asks for the discount.

ISP Pricing Philosophies and Practices

Factors that Impact Broadband Rates.

One fact that becomes clear by examining broadband rates from various ISPs is that there is a wide range of different philosophies on how to price broadband. CCG Consulting has hundreds of clients that provide broadband over fiber networks. In talking to these clients, we see the following factors affecting the decision of how ISPs set rates.

Competition. Most ISPs start by considering the existing broadband rates of existing ISPs. Even when a new ISP will be offering faster speeds, they want to know how much households in the area are spending on broadband each month. ISPs have learned that it's a lot easier to sell broadband if you don't have to ask customers to spend more than they spend today.

Market Perception of Rates. Market perception of existing rates is different than an analysis of the actual existing rates. Many ISPs undertake market surveys before launching into a new market and often find out surprising things about the market perception of rates. For example, we've seen communities where a large percentage of potential customers think existing rates are too high – even if that is not true. Other nearby communities might not share the same perception of the identical rates. This doesn't seem to be strictly related to demographics – we've seen relatively wealthy communities complain about high rates and communities with lower incomes that are willing to pay for good broadband.

Over the years of helping ISPs understand market rates, CCG Consulting boiled this issue down to the concept of perceived value. Some communities grow to have a widespread perception that the existing ISP is not providing value – this perception might not be due only to rates but can be due to outages, slowness in fixing problems, or poor customer service experience. What we've seen is that when an ISP is disliked, the public often comes to think they are paying too much. This is an interesting bias that a new ISP entering the market must deal with if they intend to charge the same or higher prices than the unpopular incumbent.

Marketing versus Actual Speeds. One of the dilemmas faced by fiber-based ISPs is how to compete against competitor products that don't deliver the advertised speeds. It's not unusual for the big ISPs to advertise 'up-to' speeds but deliver slower speeds than advertised. The public has no easy way to distinguish between an ISP selling an honest broadband product and another that advertises the same speed but delivers less. This can be a challenge for a fiber ISP that can largely deliver the speeds it promises – how does it convince the public of the difference?

Goals for the ISP Business. One of the biggest factors in setting rates is the overall goal of the ISP business. For example, a commercial ISP probably has a goal of making some targeted amount of profit, while the cooperative might be happy breaking even. This difference in goals can have a drastic impact on rates.

As an example, big cable companies now have base prices over $90 per month when considering the mandatory add-ons like a required modem. While the big cable companies might have low introductory rates for new customers, the companies expect that customers will eventually pay the higher list price. These higher prices are set to satisfy Wall Street earnings expectations - in fact, industry analysts have been pushing the big cable companies to migrate base prices to be over $100.

Bias of Decision-Makers. This is an issue that can apply to any ISP but is prevalent in municipally-owned ISPs and cooperatives. The initial pricing philosophy is often driven by the perception and biases of the elected officials or Board of Directors who approve rates. We've seen the philosophies of decision-makers direct the rates to be either too high or too low – instead of being based on market factors.

Simplicity versus Complexity.

It's not hard to find ISPs at both ends of a simplicity scale. There are a few ISPs like Google Fiber and Ting that offer only a single broadband product for a set price that doesn't vary. Both of those ISPs sell a gigabit of speed for a set price – Google Fiber at $70 and Ting at $80. Google Fiber had changed to a 2-product offering but eventually returned to the flat-rate $70 gigabit product. An ISP with this philosophy is not trying to capture everybody in the market – they are instead only willing to sell a product with a decent margin to customers willing to pay the set price. There are examples at the opposite extreme. We

know some mid-sized cable companies with hundreds of different bundles and combinations of broadband, cable TV, and telephone service. The majority of ISPs are somewhere in the middle between these two extremes and offer a limited number of broadband products.

Residential Pricing Philosophies

Most ISPs have a pricing philosophy that brings the above factors together into a set of rates and policies. It's not unusual to have different philosophies for business and residential customers. It's also somewhat normal to adopt a policy that is a blend of two of the following philosophies:

Low Price / Internet for Everybody. ISPs in this category are almost often municipalities or cooperatives. This ISP will have a low-price product that will make broadband affordable for most homes in the market. Note that this is different than having a low-income product that only qualifying households can buy. This ISP is looking to serve the greatest number of customers, with the philosophy that this is best for the community. This ISP focuses on the customer penetration rate.

Good Everyday Prices. This is probably the most common ISP pricing philosophy for smaller ISPs. This ISP will price most products slightly below market prices so that it is always less costly than the competition. This ISP rarely uses any gimmicks like bundling discounts, new customer incentives, or hidden fees. This ISP generally advertises with, "What you see is what you get."

Maximize Profits. This doesn't necessarily mean high prices, but it could. Instead, this ISP charges for everything. There's a connection fee. There is a fee to get a paper bill. There is a separate bill for the modem and advanced WiFi. There's a fee for paying late. There's a fee for a technician visit to the home. There may be a fee for data caps. This ISP will probably have pricing plans that make it easy for customers to upgrade and spend more.

Charge Premium Prices for Superior Technology. Maybe the best historical example of this was Google Fiber. When the company launched, it had one broadband product priced at $70 for a symmetrical gigabit. At the time, nobody else sold gigabit speeds, and this price was more than charged by other ISPs. It's clear the company wanted every customer to generate a good margin.

Simple to Use. This ISP offers only a few products and makes it easy to become a customer. Perhaps the most recognizable example of this is also Google Fiber. They started with only one broadband product priced at $70. They offered Google Voice (which is also available to anybody with broadband, not only to their broadband customers). They offer YouTube TV as an online video product. This was a simple triple play based on only three simple products.

Attract Customers with Special Incentives. This ISP practically gives away broadband to get a new customer. The marketing campaign is all about super-low introductory prices and almost nothing else. After a 1 – 3 year contract, prices revert to the higher market prices, and a lot of customers will bail. This is still how most of the big cable companies and most of the big telcos advertise.

Business Pricing Philosophies

It's not unusual for an ISP to have a different philosophy for business and residential customers. The following are the most typical business broadband pricing philosophies:

Good Everyday Prices. An ISP with this philosophy probably publishes business rates. They think the rates are fair. There is no negotiation with customers and no bundling. They sell a menu of products, each with a price tag that they think is fair. Many government-owned ISPs price in this manner since they feel they cannot discriminate among customers and must charge and treat all businesses the same.

Maximize Profits. This ISP publishes no rates, and they negotiate a unique price with every business. This is the predominant business sales model for most ISPs that sell to businesses. ISPs will typically offer a price to a new customer that is lower than what the customer is already paying – even if the current rate is higher than market rates. This ISP will require a contract and will ruthlessly enforce it.

Charge Premium Prices for Superior Technology. This philosophy is used by some fiber ISPs. Their sales pitch is that fiber is a premium technology, and they market on reliability and low downtime rather than price. This is also the philosophy for ISPs that sell specialized broadband products, such an ISP that sells to a specialized customer like a hospital complex.

Attract Customers with Special Incentives. This is rare for selling to businesses, and if introductory incentives are used, it's typically only done to attract small businesses.

Common Pricing Methods

Rate Bundles. Large cable companies are well-known for having bundles of products that provide a discount to customers buying more than one product. CCG does market surveys, and it's still common to find half of the cable company customers are buying a bundled package.

Generally, customers buying a bundle don't know the price for any individual product inside the bundle. Customers know they get a discount for buying extra products and don't really worry about where the discount is applied. Many consumers are shocked when they try to cut the cord or drop one of the products in the bundle and find that the cable company will assign the entire discount to whatever product they are trying to drop. At CCG, we refer to this as the bundling penalty because big cable companies make it costly for a household to drop only one or two products from a bundle. The bundle makes it harder to sell to cable company customers since they might decide to stick with the cable company once they realize the cost of breaking the bundle. In fact, the industry uses the term stickiness to describe pricing strategies that can persuade customers to stick with current prices.

Most smaller ISPs don't use bundled prices. Verizon announced in 2020 that it was doing away with bundled rates for new customers. This was the first big ISP to eliminate bundles. Verizon described the new rate structure as more open and honest and what customers want. Verizon's new rates are similar to car dealerships that post the real prices on new cars and no longer haggle over price.

Introductory Rates. The big telcos and cable companies are well-known for advertising low introductory rates that increase dramatically after a term contract of one or two years. The real rates for these ISPs are

generally buried in the small print of marketing materials, if shown anywhere. Customers have come to dislike the introductory rate process because they invariably get a big, unexpected rate increase when rates jump back to list prices.

Most small ISPs don't offer introductory rates. The biggest problem with a low introductory rate is that it tells customers that an ISP's rates are negotiable. Customers will expect the ISP to continue to negotiate rates at the end of the introductory period. Having low rates also requires having term contracts and keeping track of the timing of contract rate changes. Most small ISPs don't want the extra paperwork and set rates they think are fair and refuse to negotiate.

Grandfathered Rates. One interesting subset of special rates is what we call grandfathered rates. Cable companies and large telcos sometimes allow customers to stick with low-price broadband products if the customer is willing to keep the original broadband speed. For example, we sometimes still find a customer from a big cable company that might be paying a low rate for a broadband product that only delivers 20 Mbps. That customer might have purchased that product a decade ago and is being allowed to keep the original rate as long as they agree to keep the original product. Generally, a grandfathered customer is forced to upgrade if they want to make any changes to the existing product.

Hidden Fees is an industry term referring to rates that are routinely charged to customers but that are not mentioned or quoted in advertising (or perhaps only in the small print). For the larger ISPs, the following types of charges are routinely considered to be hidden fees – broadcast TV fees, regional sports fees, settop box or modem rental, WiFi routers, and various administrative fees.

As this report is being written, there is a national move to eliminate hidden fees. The Federal Trade Commission has announced regulations that will be effective in April 2025 that will ban hidden fees. The FTC would make companies refund all overbilling and also assess fines. The FCC has also opened an investigation to specifically disallow hidden fees for cable TV service.

Installation Costs. ISPs vary widely in the philosophy of charging for installation. There are two types of installation fees that most ISPs consider:

- Routine Installation Fee. This covers part of the cost of building the fiber drop and connecting a customer to the network. It's common in a competitive environment for ISPs to routinely waive this fee. An examination of the financial benefit of the installation fee will show that the long-term benefits of having a customer far outweigh any advantage of an installation fee. If the impact of a routine installation fee is to dissuade some customers from joining the network, then the ISP is turning away good customers by charging the fees.

  There is a middle position, which is to have customers sign a contract and agree to only pay the installation fee if the customer leaves the network earlier than the term of the contract. Waived installation fees are generally prorated in the industry, meaning that the penalty for leaving early reduces over time. For example, if the normal installation fee is $120 with a one-year contract, then the amount that a customer would owe for leaving early would be reduced by $10 per month.
- Aid-to-construction or Network Extensions. ISPs often charge a share of construction costs to add a customer that is not within easy reach of the existing network. The big challenge of charging aid-to-construction is determining the amount to charge to a given customer since the cost of extending the network is always going to be unique. It's not unusual to spread aid-to-constriction over time,

but doing so should always include a contract that specifies that the customer owes the whole fee if they drop service before the full aid-to-construction has been recovered.

Customer Contracts. ISPs vary widely on the philosophy of requiring customer contracts. We've always boiled down the question of having contracts to the willingness of an ISP to pursue a broken contract. For example, many municipal ISPs don't require contracts for residential customers because they know the City would be unlikely to pursue a citizen for leaving the network early. Commercial ISPs often reach the same conclusion for residential customers since they think it would hurt their reputation in a market to sue non-paying residential customers who left because they didn't like the products or services.

There are circumstances discussed above that should always require a contract:

- Business premium service. Contracts are generally provided for anything considered as a premium service to document the rights and benefits of the business customer. This might mean a simple contract or something more extensive to document a Service Level Agreement.
- Deferred installation or aid-to-construction. A contract should be created to document and get a customer to pay deferred installation fees or aid-to-construction fees, assuming that the ISP will pursue these fees if a customer is unhappy with the service.
- Term discounts. It's routine to have a contract to recognize term contracts, meaning that a customer is given a discount for agreeing to buy service for multiple years. ISPs that have term discounts need to keep up with pending expired contracts because the rates ought to be increased to normal rates at the end of the contract (or another term contract put in place).

Broadband contracts don't need to be complex, and contracts for things like term agreements might fit on a single page. Service Level Agreements for big companies like AT&T are over 100 pages long.

Business Broadband Products

There is a huge range of industry philosophies for how to set business broadband prices. Business broadband rates vary more widely than residential rates. The following is a discussion of the ways that ISPs think about business broadband.

Published Rates. Most ISPs don't publish broadband prices for businesses – ISPs instead negotiate with each business that is interested in buying the service.

Premium Rates. Most ISPs charge higher rates for businesses than for residential customers. This is a carryover from the days of regulated telephone companies when regulators forced telephone companies to charge more for businesses to keep residential rates low. There was a time in the past when it was assumed that businesses used more broadband and should pay more – but with the explosive growth of home broadband usage, this is no longer true. The average home today uses more broadband than the average small business.

Many ISPs negotiate rates with businesses based on what they are already paying today. This means that a business that paid a lot for broadband in the past will likely continue to do so. This sales philosophy has kept many business rates high, even after decades of competition.

Bundling with Telephone Service. Many of CCG's ISP clients tell us that businesses prefer to buy both broadband and telephone service from one ISP. Businesses often prefer one service provider for all telecom services because they fear the runaround that can happen when different service providers point the finger at each other when there is a problem. Many of CCG's clients sell bundled voice to more than 50% of their business customers.

Premium Broadband. It is difficult to justify charging a premium price for businesses if broadband speed is the only factor determining broadband prices. It's hard to justify a price difference based on cost difference because the cost of providing broadband service to a home, a small retail business, or even a large factory might be similar. Speed alone is a poor way to define the difference between residential and business products if the speeds are the same for both products.

ISPs that sell to businesses have found ways to distinguish business broadband from residential broadband. Following are some of the most common ways to define business broadband as separate from residential broadband:

> Service Level Agreement (SLA). This is a contract between an ISP and a customer that generally provides penalties for the ISP for not maintaining service to a customer. For example, an SLA contract might make specific guarantees of bandwidth or specific guarantees against network outages and then provide monetary penalties to the ISP for not delivering what was promised. Customers who get an SLA should pay a premium price because they are being guaranteed a premium level of service compared to other customers.
>
> Guaranteed Repairs and Maintenance. One of the most common benefits offered to premium customers is guaranteed priority repairs and maintenance. For example, a premium customer might be guaranteed same-day repair on outages, meaning the ISP will dispatch a maintenance or repair crew in the evening or on weekends. A premium customer might be assigned to a specific customer service representative. Non-premium customers will instead be offered normal maintenance and repair schedules.
>
> Term and Volume Discounts. Premium customers are often offered additional discounts for a term and/or volumes. A term discount will provide a lower price for an ISP that contracts for a service for a given term – generally two to five years. Volume discounts are applied to customers who buy multiple connections.

Large Business / Carrier Broadband. There are specialized broadband products that are sold to larger businesses and carriers like cellular companies. These specialized broadband products generally fall into three categories, described as follows:

- Dedicated Broadband. Some businesses are willing to pay more for dedicated broadband. To a business, dedicated broadband means two things – the broadband stream is not 'shared' with another business, and the amount of bandwidth is guaranteed.

  The idea of sharing bandwidth on a fiber network is quaint because data streams of different customers are not mixed in any of the current fiber technologies. Both Active Ethernet and PON technologies on fiber encrypt the bandwidth between the ISP and a given customer in a way that is impossible to crack.

The customer perception of 'sharing' broadband comes from the experience of having broadband provided with DSL or from a cable company network. Data speeds can slow down for both technologies when too many customers are using the network. Businesses that don't want shared bandwidth are asking for broadband that is not affected by what their neighbors are doing. If fiber networks are configured properly, there will be no noticeable slowdown of broadband speeds unless there is an extraordinary amount of traffic on a network, such as after some sort of major emergency. Businesses are not really concerned about having other businesses listen in on their broadband traffic, and this is not possible on any of the common broadband technologies, which all use encryption.

It's common for ISPs to label dedicated access as a VPN (virtual private network). There are some specialized features that can be added to a VPN, but most such products on a fiber network are just a dedicated fiber connection.

- Dark Fiber. This involves selling the use of fiber that is not connected to electronics. The customer buying the dark fiber is responsible for providing and operating the electronics necessary to use the fiber. ISPs have strong opinions about offering or not offering dark fiber. The following issues are involved in deciding to sell dark fiber:
    - Most ISPs that sell dark fiber are only willing to do so for long contract terms ranging from three years to twenty years. The dark fiber customer must make a financial commitment to install electronics and usually wants the connection to last for the length of the expected life of the electronics.
    - One of the biggest concerns for selling dark fiber is that it uses fiber that can't be used for anything else. We know of examples where an ISP sold too many dark fibers and ten years later didn't have enough fiber left for other connections. It's essential to coordinate the sale of dark fiber with a long-range plan for the network.
    - One common way to sell dark fiber is through an IRU (Irrevocable Right of Use). This is a long-term fiber lease that lays out the operational and financial terms for the long-term sharing of fiber. It's not mandatory, but most IRUs require a sizeable payment upfront as part of the arrangement. It's normal for an IRU customer to pay a proportionate share of ongoing network maintenance to keep the fiber operating for the long term. This could be a monthly fee for maintenance or perhaps an occasional assignment of larger fees to cover the cost of repairing fiber cuts or other network events. IRUs generally define the specific processes for the customer to use the fiber and interface with the network. It would not be unusual for an IRU to include collocation for customer electronics.
    - There is no 'standard' or market pricing for dark fiber or IRUs. The price is strictly negotiated between the two parties. Pricing can be structured in any mutually agreeable way, from flat pricing to paying for dark fiber by the mile.
- Transport. Transport means fiber that connects more than one location in the same local market. For example, a bank might want a network that connects to several banks and ATM locations. A transport network most typically aggregates traffic from multiple routes and locations back to one point of handoff to the customer. The customer uses the transport network to communicate between locations. There is generally no standard pricing for transport.

B. Interviews

As part of the study, we interviewed some key stakeholders in the County. The purposes of the interviews was to hear more about problems in rural areas that are being caused by lack of broadband. We talked to stakeholders who had knowledge of the impact of broadband across large parts of the rural areas. The stakeholders included school districts, social agencies, non-profits, healthcare providers, real estate agents, and farmers.

Following are some of the key things we learned in the interviews:

- We heard repeated stories from rural residents whose only broadband choices are DSL, fixed wireless, or satellite.
    - We heard that DSL service from Frontier is slow and often unreliable.
    - We heard from a number of customers who used fixed wireless who told us the service was too slow and unreliable.
    - We heard horror stories about rural cellular hotspots, and if anything, we heard that rural cell coverage is even worse than rural broadband coverage.
- We heard from several school superintendents. Schools have had a policy for years of having a computer device for every student. Because of this, students are able to use broadband in the schools. However, a few school districts said that a significant percentage of their students don't have broadband or cellular coverage at home, making it difficult or impossible to do homework. Schools also said that affordability is an issue for students to have home broadband. The schools try to work remotely during snow days, but a significant number of students call in sick on these days due to the lack of home connectivity.
- We heard from a farmer that has to sustain three broadband subscriptions. He uses cable company broadband at his home. He needs a cellular connection to connect to his outdoor equipment and machinery. He needs a second cellular connection to connect to his grain elevator.
- We heard from a hospital that has routine broadband outages which are majorly disruptive. The hospital and its associated clinics use telemedicine to connect to customers, and they are losing a lot of revenue when customers can't connect to them with a broadband connection or cellphone. In such cases, the clinics call customers on the phone, but the insurance reimbursement for a landline phone call is much lower than the same connection made on broadband or cellphone.
- We heard from several people who struggle to work from home. We heard from one person who said it take 3-4 minutes to upload even small documents and that larger documents won't upload at all. We heard from several people who go to a friend's house or public WiFi spot to upload documents.
- We heard of some of the practical repercussions of slow broadband. For example, we heard from a trucker who can't connect to his burglar alarm or cameras when away from home.
- We heard from a senior care facility where the broadband won't support the residents for streaming videos or doing other functions on the Internet.
- We heard a lot about broadband prices, with rural residents having to pay far more than $100 per month to get broadband solutions that don't even work well. There seemed to be a general sense that folks in towns had better and less expensive options.
- Not all of the stories we heard were negative. We heard from a family with multiple children who said his Sparkling broadband was good enough for everything the family wants to do. We heard from several families who are happy with Starlink.

If it's possible, there seem to be even more complaints about bad cellular coverage than broadband coverage. We heard there are large parts of the county with little or no cellular coverage. We heard from several people who said that they have decent cellular coverage at home, but not in their cars as they drive around the County.

C. The Mapping Story

The easiest way to visualize the current state of broadband in the county is by mapping available broadband data. Our analysis starts with publicly available broadband mapping data. As will be discussed below, we know that a lot of the FCC mapping data is inaccurate, so Finley Engineering and CCG Consulting have created maps that we think more accurately portray the real state of broadband coverage in the county.

The FCC Definition of Broadband

The FCC officially defines the speed of broadband to meet a legal requirement. Congress established a requirement for the FCC in Section 706 of the FCC governing rules that the agency must annually evaluate broadband availability in the country. Further, the FCC must act if broadband is not being deployed in a timely manner. The FCC is supposed to report the state of broadband to Congress every year - although the most recent FCC broadband report is for 2020.[12] In these reports, the FCC compiles data about broadband speeds and availability and offers an opinion on the state of broadband in the country. In every report to date, the FCC has acknowledged that there are broadband gaps of various kinds, but the FCC has never determined that the problems are so bad that they need to take extraordinary measures to close any broadband gaps. Most recent FCC reports claim that the broadband situation is improving due to actions taken by the FCC.

In 2015, the FCC set the definition of broadband at 25/3 Mbps (which is 25 Mbps download and 3 Mbps upload). Prior to 2015, the definition of broadband was 4/1 Mbps, set a decade earlier. The FCC didn't use empirical evidence like speed tests when setting the definition of broadband in 2015. Instead, it conducted what is best described as a thought experiment. The FCC listed the sorts of functions that a typical family of four was likely to engage in and determined that a 25/3 Mbps broadband connection was fast enough to satisfy the typical family.

The FCC asked again in 2018 and 2020 if 25/3 Mbps was still an adequate definition of broadband. They took no action and left the definition at 25/3 Mbps. FCC Chairman Jessica Rosenworcel recently opened a docket to ask if 25/3 Mbps is still a good definition and recommended that the definition be increased to 100/20 Mbps. On March 14, 2024, the FCC changed the definition of broadband from 25/3 Mbps to 100/20 Mbps.

[12] The FCC report to Congress for 2020 can be found at https://docs.fcc.gov/public/attachments/FCC-20-50A1.pdf and https://docs.fcc.gov/public/attachments/FCC-20-50A2.pdf.

FCC Broadband Maps

The FCC decided a decade ago that the way for it to track broadband utilization is to require ISPs to periodically tell them where broadband is deployed. This resulted in an elaborate process of gathering broadband data that ultimately resulted in what is generally referred to in the industry as the FCC broadband maps.

For many years, the maps were not used for purposes other than the FCC's broadband report to Congress. The FCC took some heat because the broadband reports to Congress were badly flawed, but ultimately, the broadband industry didn't care a lot because there were not a lot of real-life consequences of the bad maps.

Over time, the FCC started to rely on the information in the mapping data for setting policies. For example, the FCC started to cite statistics from the broadband mapping system as justification for making decisions that impact rural broadband.

More importantly, the FCC began using the maps to determine the parts of the country that are eligible for federal broadband grants. This created an outcry in the industry that has led to a process to improve the mapping data. Following is the story of the original FCC maps and the progress that has been made to transition to better maps.

The Original FCC Maps

The FCC historically gathered data about the broadband being delivered to customers in each Census block in the country. A Census block is a finite geographic area defined by the U.S. Census Bureau that typically covers between 60 and 120 homes. In a city, a Census block might be just a city block, but in a rural area, it might cover a substantial portion of a county.

There were a lot of flaws in earlier FCC maps due to the reporting requirements for ISPs:

- ISPs have been free to report coverage anywhere, even in places that are not covered. As an example, there are many ISPs that claim coverage over an entire county when actual coverage is much smaller.
- If an ISP followed the rules, it showed a Census block as covered if there was only one customer in the Census block. This overstated broadband coverage, particularly in rural areas that have large Census blocks.
- The FCC allowed ISPs to report marketing speeds to describe the broadband being delivered. To give a simple example, a telephone company might advertise that its DSL can deliver speeds up to 25/3 Mbps. The telephone company might deliver that speed to a few customers who live close to the DSL transmitter, but DSL speeds decrease drastically with distance from that transmitter. In the areas surrounding a town, the actual DSL speeds might be only a few Mbps. If the telephone company reports the marketing speed of 25/3 Mbps everywhere, then the FCC accepts that speed is available, when in fact, the majority of rural DSL customers have much slower actual speeds – if they can buy DSL at all.
- Perhaps the biggest problem with the FCC maps is that there have been almost no consequences for ISPs that exaggerate speeds or coverage. There are only a few examples of ISPs being ordered to fix clearly untrue mapping inputs.

These factors taken together mean that the traditional FCC broadband maps have been inaccurate, sometimes grossly so. Even in towns, the broadband speeds likely represent marketing "up to" speeds instead of actual speeds. Speeds for areas just outside of towns and cities are routinely overstated and often show broadband coverage where there is none. Many ISPs providing rural DSL or fixed wireless overstate the broadband speeds to the FCC.

The New FCC Maps

Congress passed legislation that required the FCC to fix the maps. In March 2020, Congress passed S.1822, the Broadband Deployment Accuracy and Technology Availability (DATA) Act. That bill requires the FCC to gather granular service data for wired, fixed wireless, cellular, and satellite broadband providers. The law requires a crowdsourcing process to allow the public to participate in data collection. The Act provides penalties for ISPs that knowingly or recklessly submit inaccurate mapping data. Finally, the Act requires that all federal agencies begin using the new mapping database before awarding any major broadband funding.

As often happens in the government, this bill didn't provide any funding to make the needed changes. The FCC started the process of formulating new rules around the Act but didn't take any action to fix the maps due to the lack of funding. Congress finally provided $98 million in funding from the American Rescue Plan Act (ARPA) in December 2020, which included $65 million to create better maps. The first round of the new updated FCC maps was released in November of 2022, with updates mandated every six months.

The new mapping system is now called the Broadband Data Collection (BDC) process and replaces the old mapping system. The FCC's goal is to make the new maps more accurate. The big change in the BDC data collection is that ISPs now have two choices for reporting broadband availability. First, an ISP can submit shapefiles for polygons that define the various service territories. Each polygon should include existing broadband customers along with homes or businesses that can be connected within ten business days of a request for service. If an ISP doesn't want to provide shapefiles, it can provide the detailed location of each customer. The 477 reporting now also requires traditional telephone and VoIP subscriber data.

The FCC maps have recently taken on extra importance since Congress dictated that the FCC maps would be the basis for deciding the eligible areas for the $42.5 billion BEAD grant program.

The first version of the new FCC maps was released in November 2022. As might be expected when changing to a drastically different system, there were a lot of mistakes in the new mapping data. A lot of the errors were in the mapping fabric. This is the underlying database that is intended to identify, on a map, every potential broadband customer. The FCC hired CostQuest to create the mapping fabric, and the company used a variety of data sources to pinpoint locations on the fabric. This included gathering national GIS mapping data, 911 data, and aerial photos from Google Earth.

A simplistic explanation of the CostQuest approach is that they placed a dot on the map for every known residential and business passing. Not surprisingly, identifying every residential living unit in the country is a massive challenge. Considering that the U.S. Census spends many billions every ten years to identify where people live – the FCC is trying to do this accurately twice a year on a much smaller budget. There

are huge challenges in identifying potential customers. As a few examples, how can the FCC make the distinction between an abandoned home and one where the owners are looking for a tenant? What does the FCC do about the many properties that contain multiple buildings? What's the right way to account for vacation homes, cabins, hunting lodges, etc.? Apartment buildings are really tough to accurately count.

Following is a map from the CostQuest system showing a small part of the county. Each green dot represents a location that is a potential broadband customer. To the right is a table that shows the ISPs that claim to be able to provide service to the home, shown by the blue pointer.

Broadband Availability Availability Challenge

Provider	Technology	Down (Mbps)	Up (Mbps)	Chall.
AT&T	Copper	50	10	
HughesNet	GSO Satellite	100	5	
Starlink	NGSO Satellite	220	25	
T-Mobile	Licensed Fixed Wireless	25	3	
Viasat	GSO Satellite	100	3	
Xfinity	Cable	1200	35	
Business-only Service				
Viasat	GSO Satellite	100	4	

This FCC map tells us a lot about the broadband coverage claimed by ISPs in this particular neighborhood.

- AT&T claims to provide speeds of 50/10 Mbps on its DSL network.
- Comcast claims to provide speeds of 1200/35 Mbps on its cable network.
- HughesNet and Viasat claim to provide speeds of 100/5 Mbps and 100/3 Mbps, respectively, from geostationary satellites.
- Space Exploration Technologies (Starlink) says it offers a download speed of 220/25 Mbps.
- T-Mobile claims to provide 25/3 Mbps on its fixed cellular network.

There is a process for state and local governments to challenge the mapping fabric by disputing if the FCC correctly identified the location of residential living units and businesses. When the maps first came out, the State of Vermont sent a challenge letter to the FCC saying that 11% of the locations in the FCC mapping fabric don't exist. Even worse, Vermont said that 22% of locations are missing from the FCC map. Vermont made the point that it is impossible to count the number of homes with or without broadband without first accurately counting the total number of homes.

The second issue with the new maps is the claimed broadband coverage of broadband. The new maps were supposed to be more accurate by fixing the inherent problems of reporting broadband coverage by Census block. Unfortunately, just the opposite happened. The first draft of the new FCC map showed significantly fewer homes that don't have broadband. States know this to be false since many of them have created their own broadband maps where they looked closely at actual broadband speeds being delivered.

Consider the effort undertaken by the State of Georgia in 2021. The State worked closely with ISPs to define coverage areas. The State also undertook a big effort to gather speed test results to distinguish actual speeds from marketing speeds. The results from the Georgia mapping effort are stunning. The

Georgia maps showed that over 507,000 homes and businesses and 1 million people don't have access to 25/3 Mbps broadband. That is double the 252,000 homes identified by the FCC maps.

Vermont also undertook a mapping exercise. The State was shocked to see that the new FCC maps showed that over 95% of Vermont homes have access to broadband of at least 100/20 Mbps. The State's broadband maps show that only 71% of homes in the state can receive broadband at 100 Mbps or faster at the end of 2021. In looking at the new FCC data, the difference seems to come from claims by satellite and fixed wireless ISPs that claim to be able to deliver fast speeds to huge numbers of homes – something that is not realistic or possible in hilly and wooded Vermont. There also are ISPs that claim speeds that are faster than what the State believes is being delivered.

Will the FCC Maps Get Better?

It is unfortunate that the new FCC maps were issued in the middle of the process of trying to determine the BEAD grant funding. Congress said that the amount of funding for each state must be based upon the FCC maps – and the first few drafts of the FCC maps have been clearly flawed. The FCC whiffed in many cases in counting the location of homes and businesses, and ISPs clearly exaggerated the broadband speeds available to customers.

Is there any hope that the maps will get better? Getting better maps requires improving the three basic flaws of the new FCC maps – the accuracy of the mapping fabric that defines the location of possible customers, the claimed coverage that defines where broadband is available, and the broadband speeds available to customers.

The mapping fabric will get better over time if state and local governments decide this is something that is important to fix. But there are two reasons why the fabric might never be fixed. Many rural counties do not have the staff or resources to try to fix the mapping fabric. There are still a lot of counties that don't have a GIS mapping system that shows the details of every home, business, land plot, etc. But even counties with GIS systems often cannot count broadband passings – for example, the GIS data doesn't include details about whether a home is occupied. There is also a big chance that since BEAD funding is now allocated, that state and local governments will quickly lose interest in the FCC mapping fabric.

The FCC says it hopes the maps will get better over time. One new feature of the new FCC maps is that any homeowner can dispute that a given ISP can deliver broadband to their home. If a cable company incorrectly claims a home can get broadband, the homeowner can challenge this in the FCC map – and if validated, the map must be corrected. It's not likely that most folks will go through the formal process of challenging the maps. Without challenges, the new FCC maps will only be as accurate as ISPs are honest.

The issue that most people care about is broadband speeds. Unfortunately, the new maps are as badly flawed on this issue as the old maps. ISPs are still allowed to claim marketing speeds instead of some approximation of actual speeds. The ISP gets to define what it means by marketing speeds.

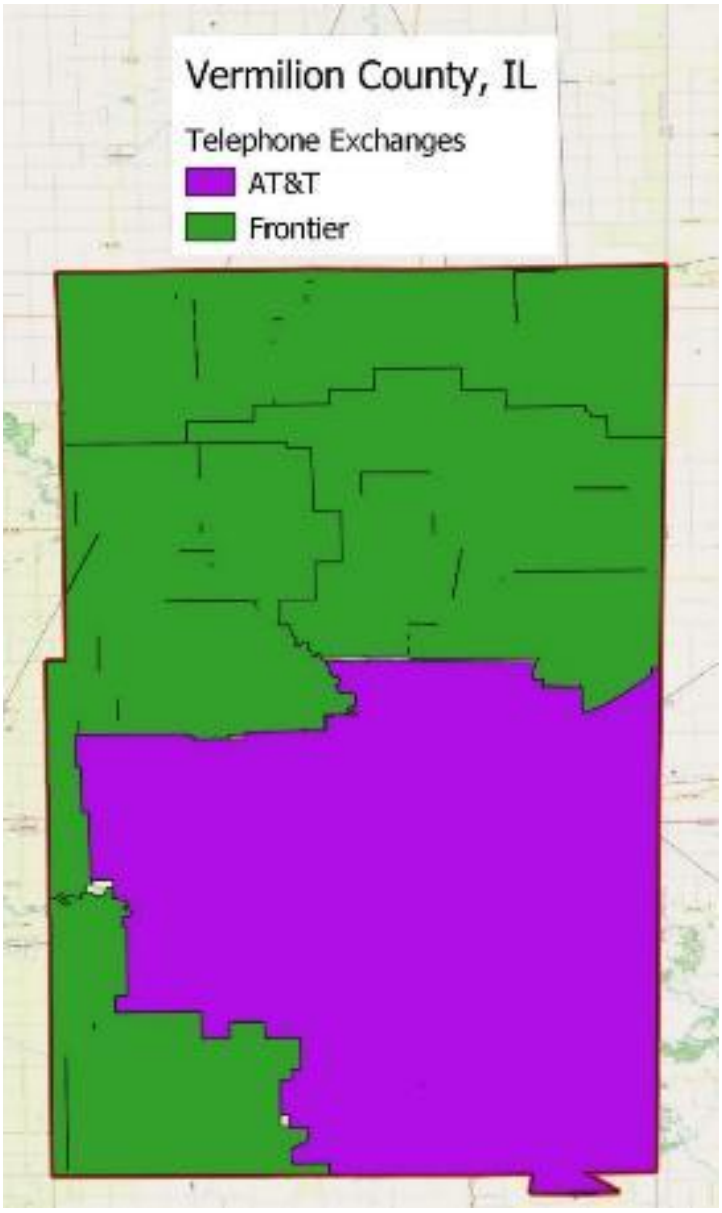
Other than the challenge process, there is one other possible remedy for fixing mapping problems. The Broadband Deployment, Accuracy, and Technology Availability (DATA) Act that created the new maps gives the FCC the ability to level fines against ISPs that knowingly or recklessly submit inaccurate mapping data.

FCC Data for the County

Even with the many faults, there is still some good information in the FCC broadband data. If nothing else, the FCC BDC maps are a starting point for identifying the ISPs that claim to serve a given area, and the speeds claimed.

Telephone Company Exchange Boundaries. The incumbent telephone companies in the county are AT&T, and Frontier. The following map shows the historical monopoly boundaries for each telephone company. These boundaries were formally recognized by the Illinois Commerce Commission, and each telephone company was given monopoly status within the borders shown on the map.

Map 1 - Telephone Exchange Boundaries



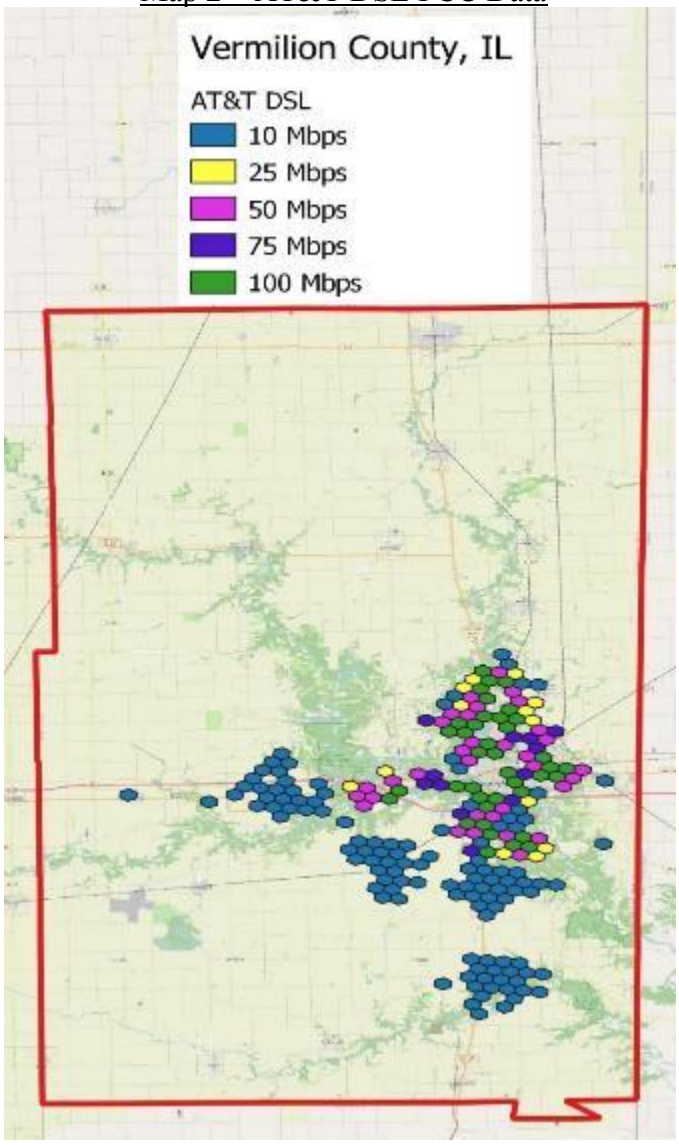
AT&T

AT&T is the incumbent DSL provider throughout the western and southern parts of the county. In the most recent FCC BDC reporting, AT&T claims 17,524 DSL passings using copper technology that can provide speeds between 10/1 and 100/20 Mbps. AT&T claims 307 passings using fiber with speeds of 5/5 Gbps.

AT&T claims to provide 2,555 passings with its fixed cellular (FWA) technology. The company claims speeds between 25/3 Mbps and 100/20 Mbps on its FWA network. The 25/3 Mbps speeds are where AT&T offers its traditional 4G hotspots. The 100/20 Mbps areas are where the company offers its newer 5G fixed cellular product.

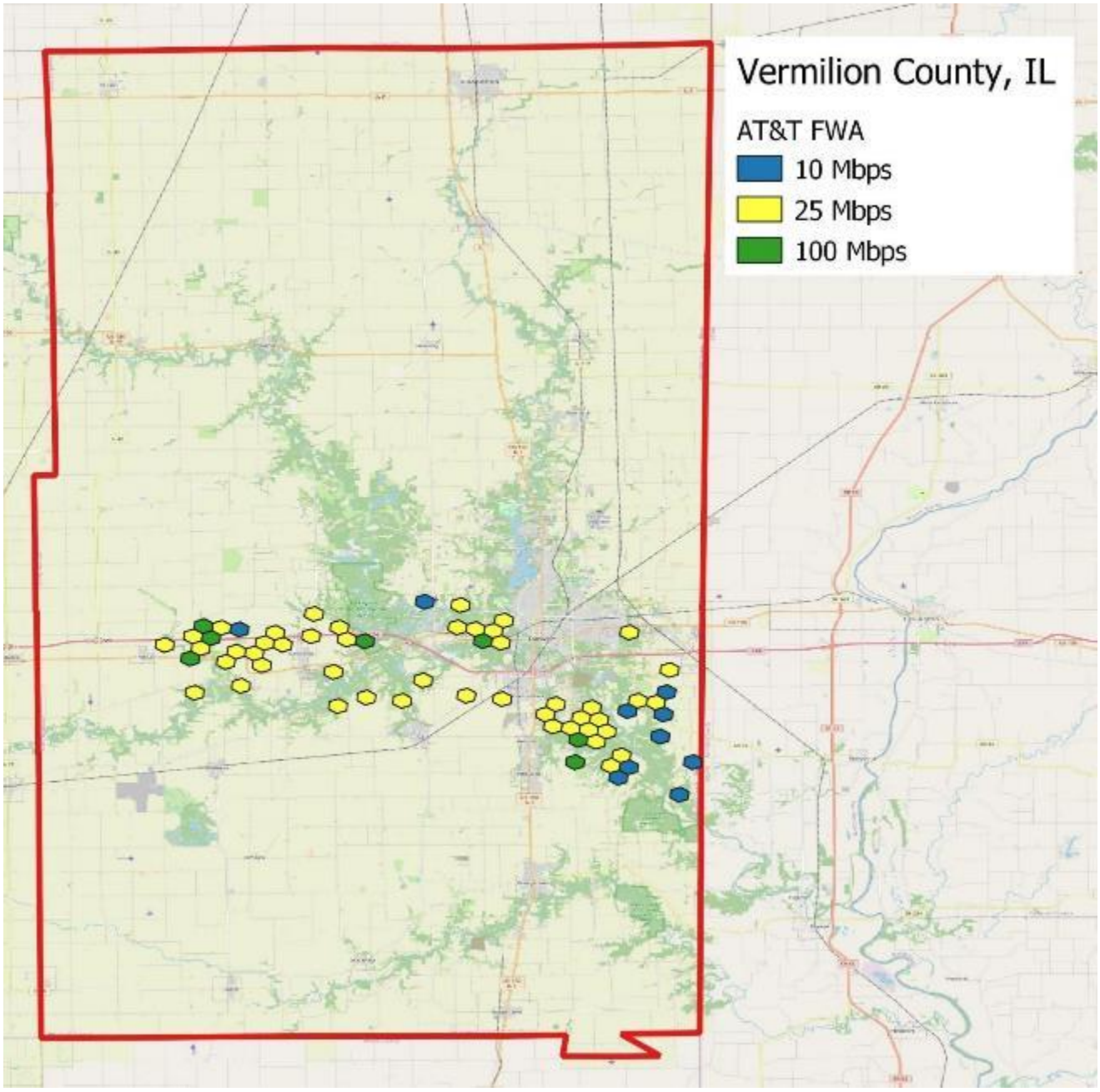
According to the Ookla speed test data, the average AT&T DSL speed in the county was 41/6 Mbps, the average fiber speed was 242/206 Mbps, and the average cellular FWA speed was 142/69 Mbps.

Map 2 – AT&T DSL FCC Data



Map 3 – AT&T Fiber FCC Data

Map 4 – AT&T Cellular FWA FCC Data

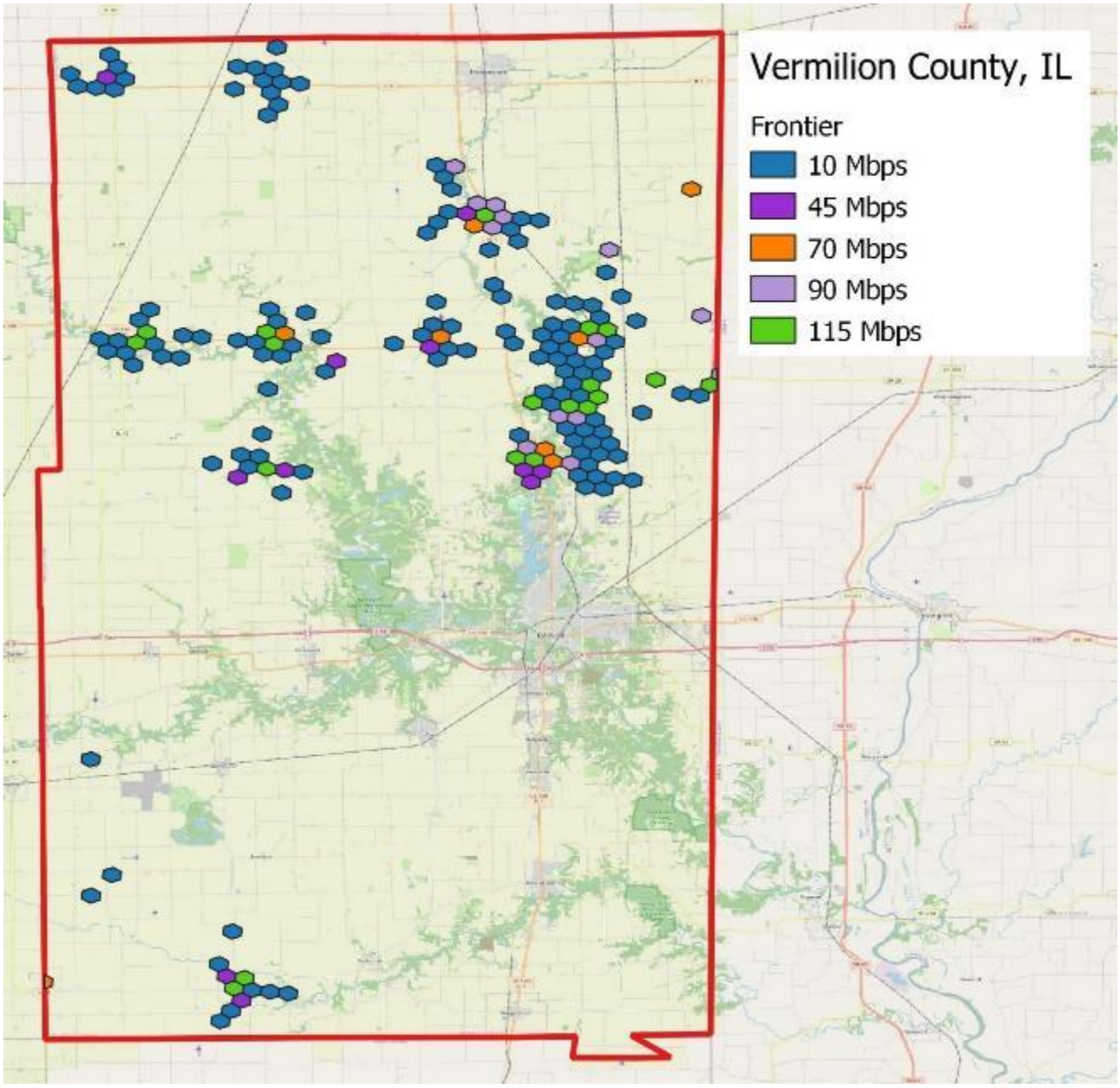


Frontier

Frontier is the incumbent telephone company in the northern and southwestern parts of the county. The company claims 2,308 passings using DSL on copper. The company claims speeds of 10/1 to 115/7 Mbps on its DSL network in the most recent FCC maps. The average Ookla speed for Frontier DSL was 33/14 Mbps.

Frontier does not claim fiber service to the FCC. However, Ookla reported a small number of fiber speed tests, and we suspect the fiber is being provided to businesses or government customers.

Map 5 –Frontier FCC Data

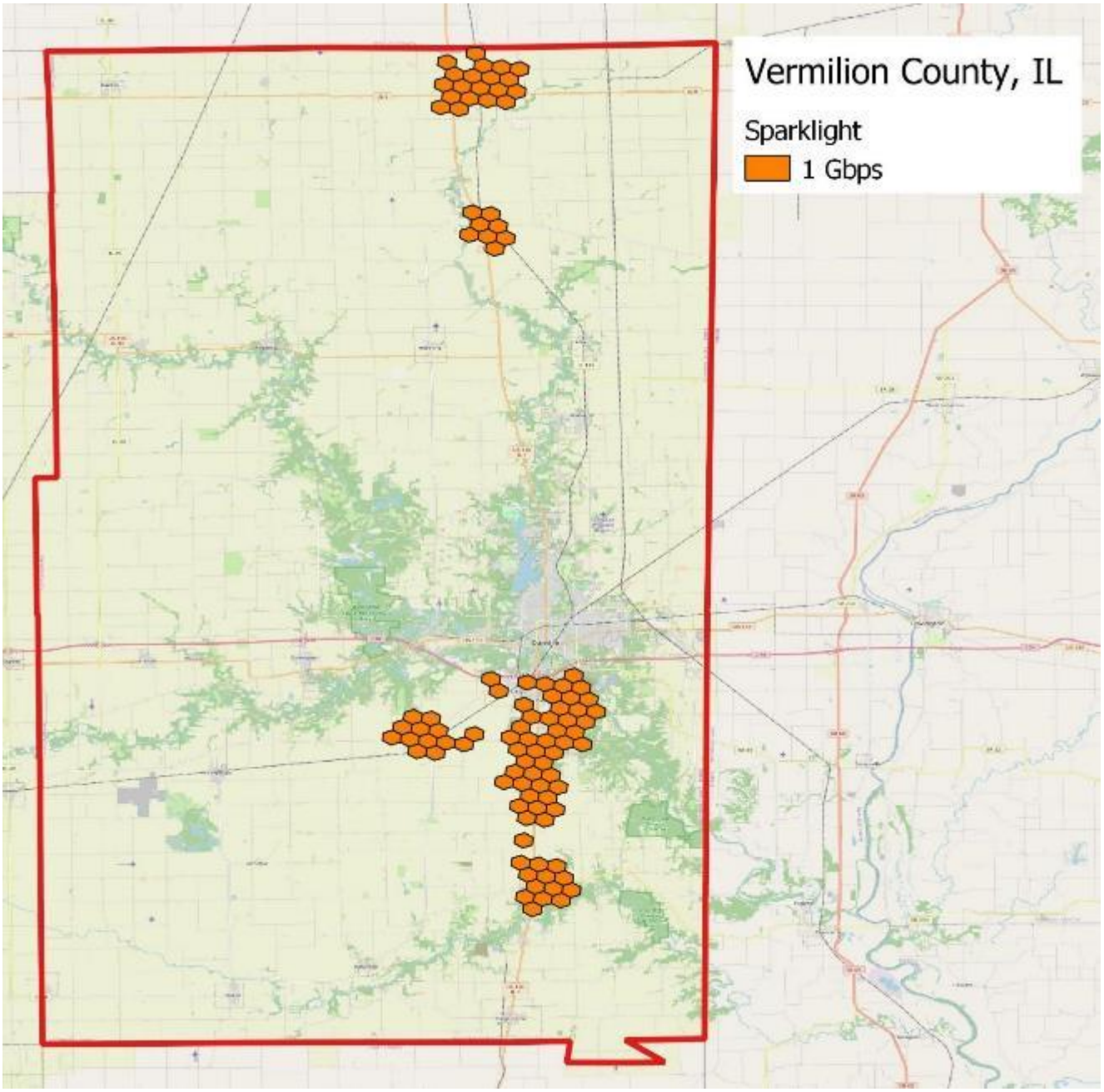


Sparklight

Sparklight is the incumbent cable provider in Belgium, Catlin, Danville, Georgetown, Hoopeston, Rossville, Tilton, and Westville. The company claims 10,265 passings in the FCC mapping database.

Sparklight claims to be able to offer 1 Gbps/50 Mbps speeds on its networks, shown in orange on the map below. The average Ookla speed test for Sparklight was 265/33 Mbps.

Map 6 – Sparklight FCC Data

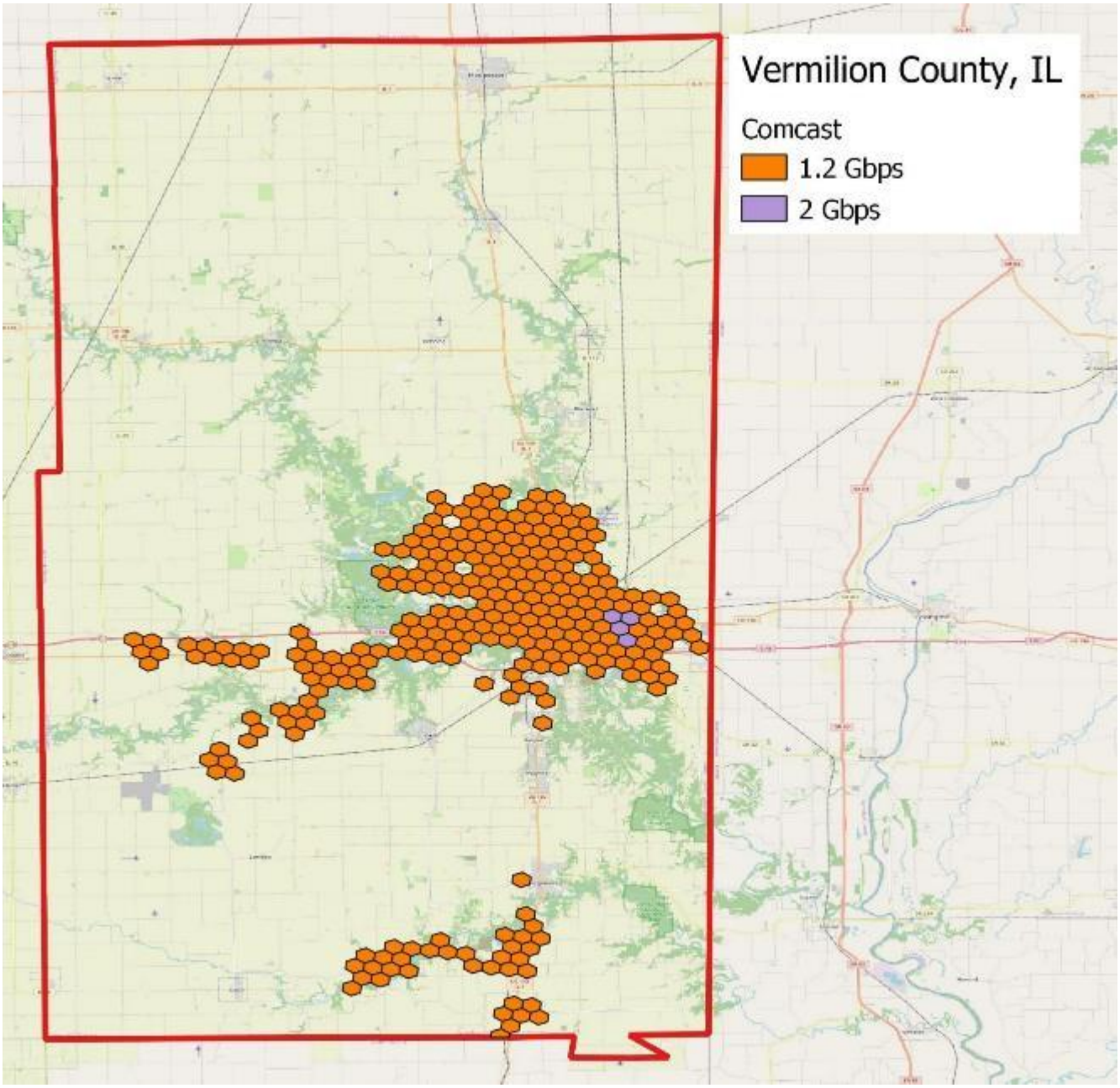


Comcast

Comcast is the incumbent cable provider in Danville, Fairmount, Fithian, Georgetown, Indianola, Muncie, Oakwood, Olivet, Ridge Farm, and Tilton.. The company claims 17,455 passings for its hybrid fiber-coaxial networks. The company claims speeds of 1.2 Gbps/35 Mbps and 2000/200 Mbps on its cable network in the FCC map reporting.

The average speed for Comcast according to the Ookla speed test data was 318/25 Mbps.

Map 7 – Comcast Cable FCC Data

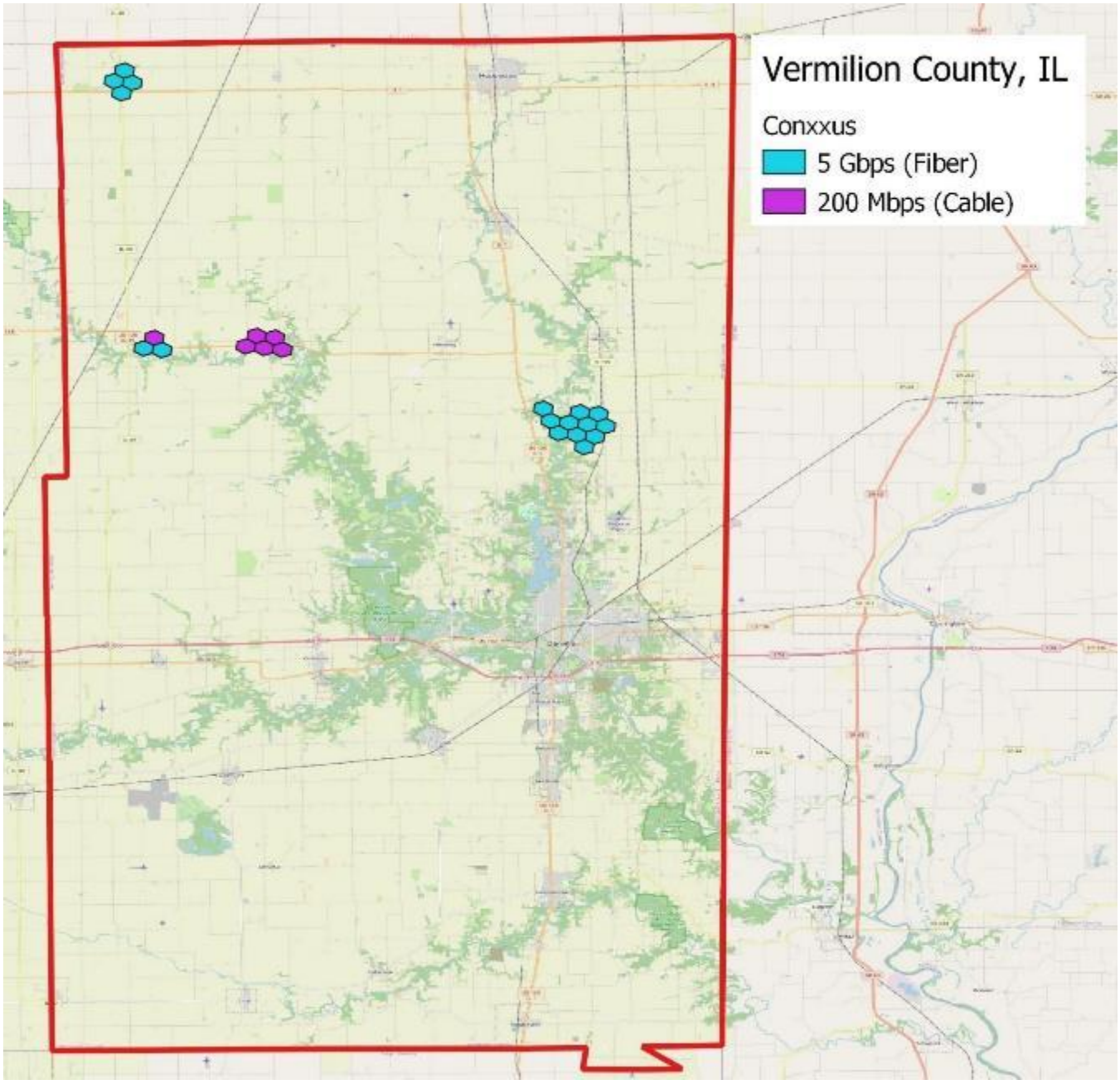


Conxxus

Conxxus claims to provide fiber in Armstrong, Bismark, and Rankin. The company claims to provide cable in Armstrong and Potomac. The company claims 1,214 passings at speeds of 5/5 Gbps on its fiber network and 384 locations at speeds of 200/20 Mbps on its cable network.

Conxxus had an average speed of 58/8 Mbps on its cable network and 393/364 Mbps on its fiber network according to the Ookla speed test data.

Map 8- Conxxus Fiber & Cable FCC Data

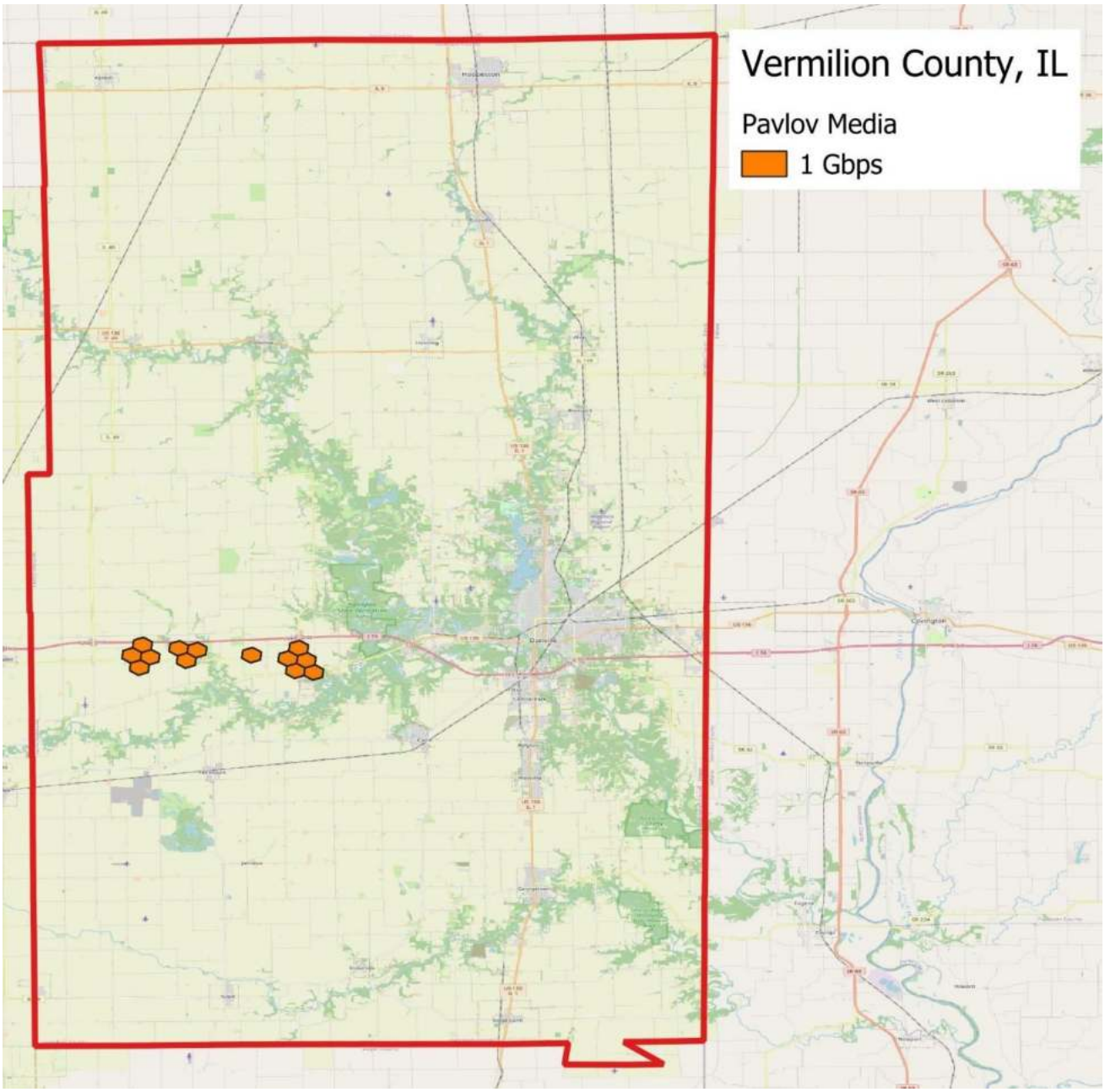


Pavlov Media

Pavlov Media claims to provide fiber to the villages of Oakwood, Muncie, and Fithian. The company claims 804 passings at speeds of 1/1 Gbps on its fiber network.

The average Ookla speed for Pavlov Media was 588/375 Mbps.

Map 9 – Pavlov Media – FCC Data

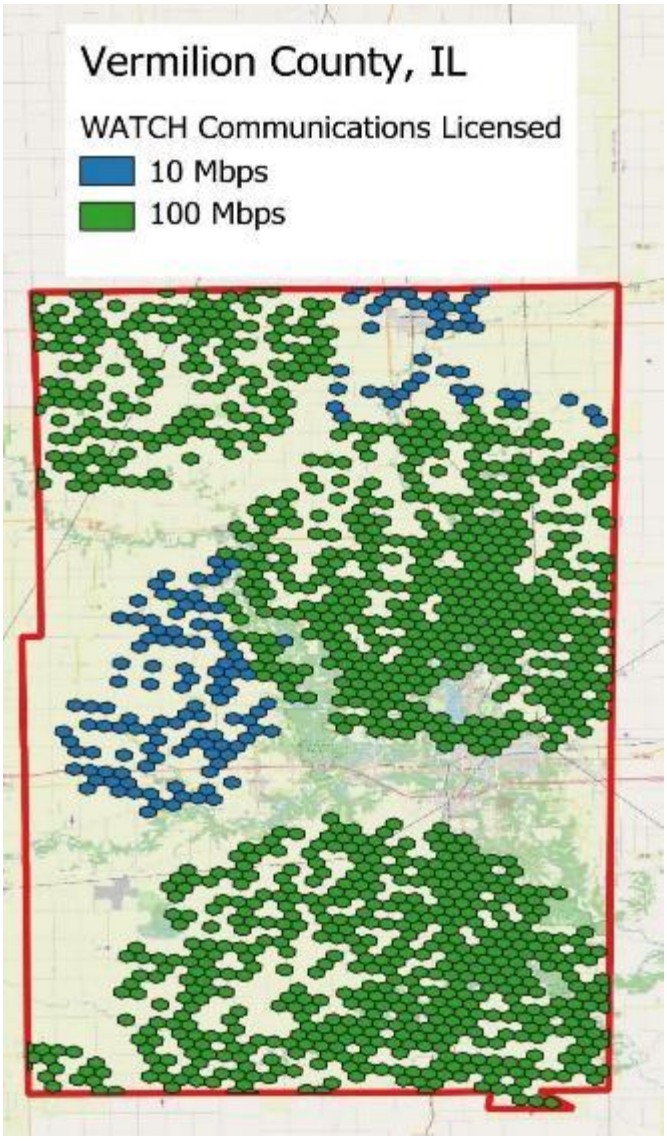


WATCH Communications

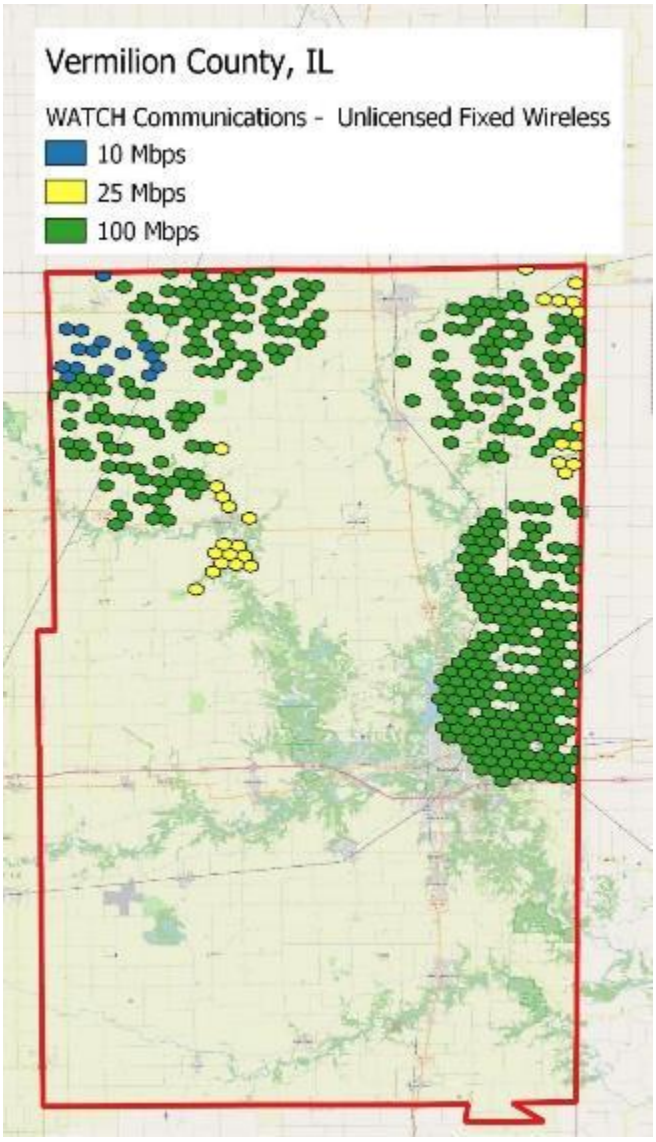
WATCH Communications claims to provide licensed and unlicensed fixed wireless throughout the county. In the most recent FCC reporting the company claims to cover 16,723 passings with its licensed fixed wireless with speeds between 10/1 Mbps and 100/20 Mbps. The company claims to cover 9,982 passings on its unlicensed fixed wireless network with speeds between 10/1 Mbps and 100/20 Mbps.

The average Ookla speed for WATCH Communications was 44/6 Mbps.

Map 10 – WATCH Comm – Licensed FCC Data



Map 11 – WATCH Comm – Unlicensed FCC Data

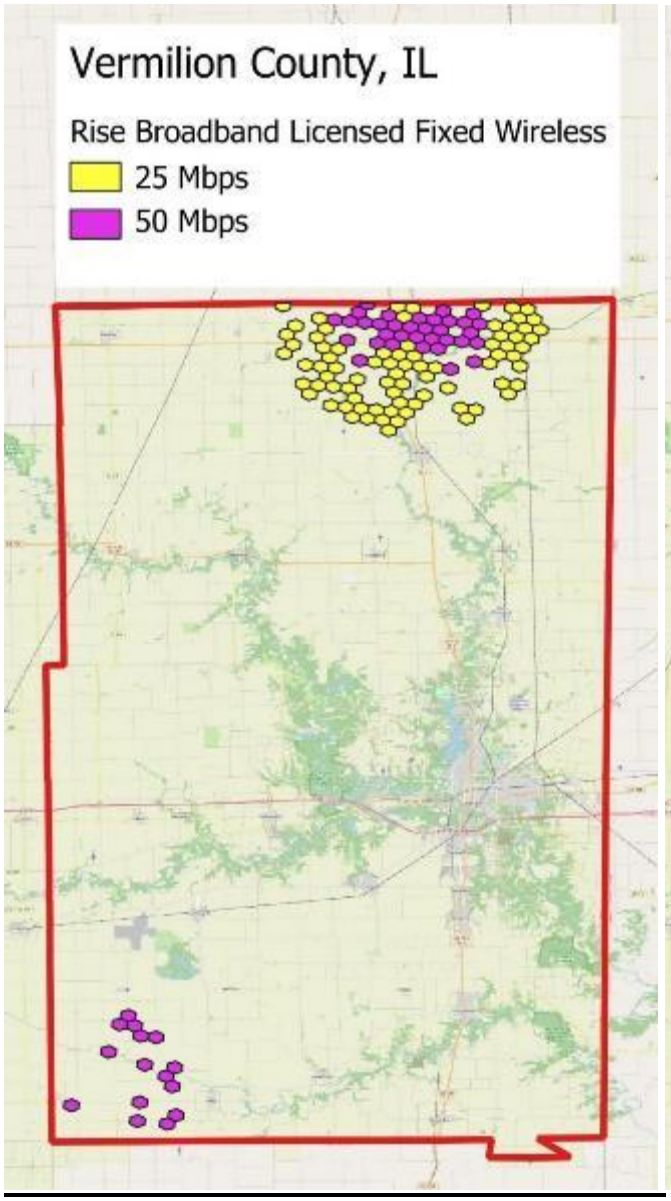


Rise Broadband

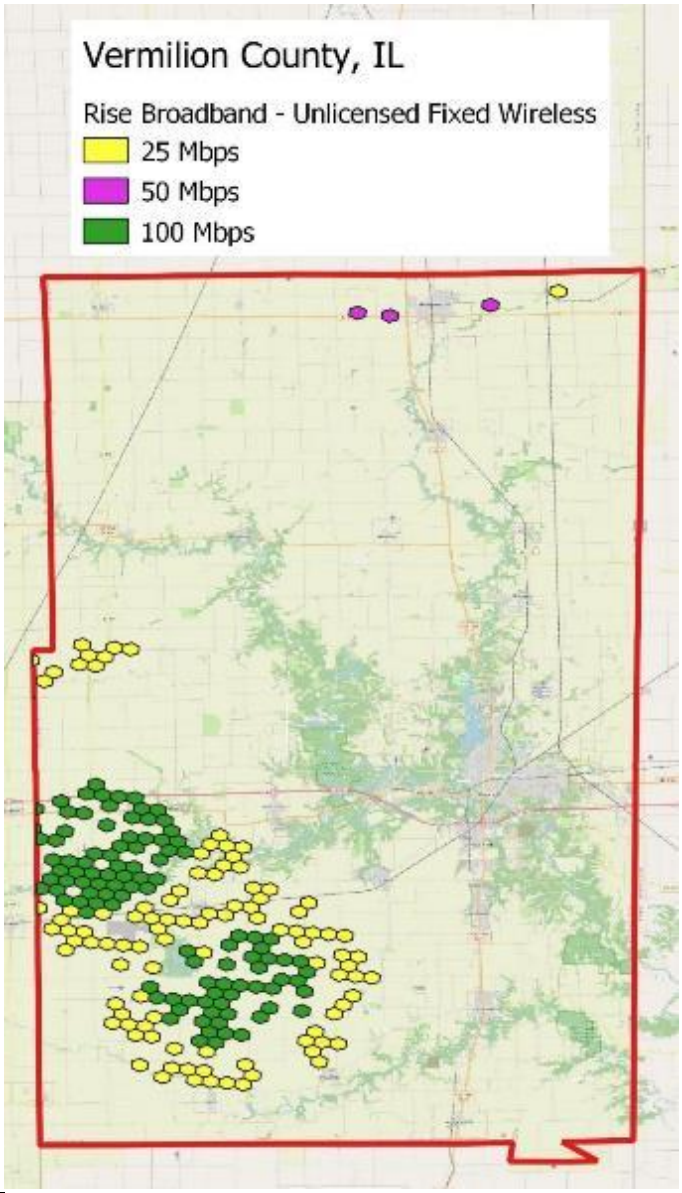
Rise Broadband provides licensed and unlicensed fixed wireless broadband throughout the county. The company claims 2,704 passings using its licensed technology with speeds of 25/5 Mbps and 50/10 Mbps. The company claims 4,800 passings on its unlicensed network with speeds of 25/5 Mbps (yellow), 50/10 Mbps (pink), and 100/20 Mbps (green).

The average speed recorded from the Ookla speed test data was 24/8 Mbps.

Map 12 – Rise Broadband Licensed FCC Data



Map 13 – Rise Broadband Unlicensed FCC Data

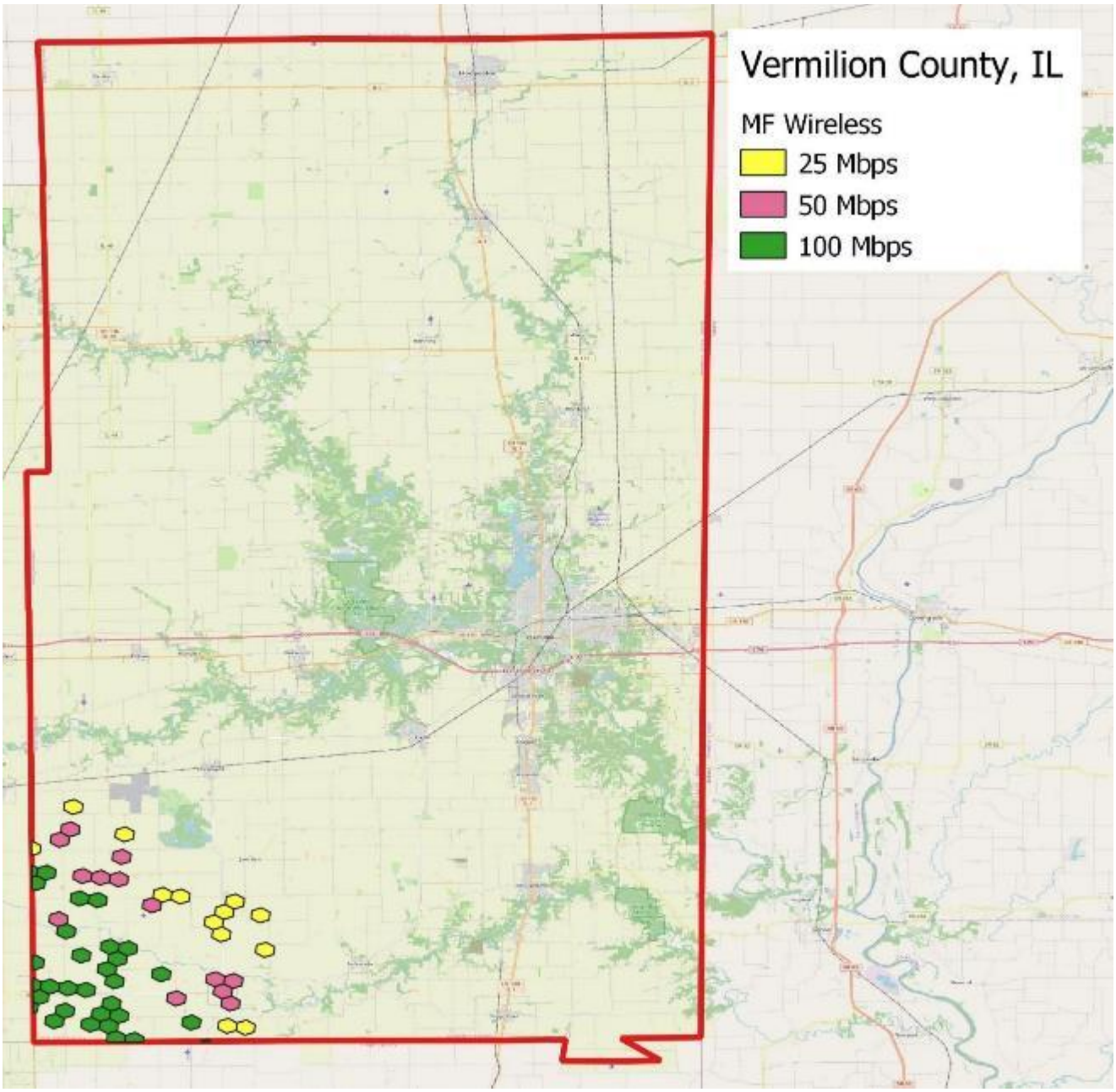


MF Wireless

MF Wireless is a licensed fixed wireless provider in the southwest part of the county. In the most recent FCC reporting, the company claims to serve 296 passings with licensed fixed wireless at speeds between 25/5 Mbps and 100/20 Mbps.

The average Ookla speed for MF Wireless was 83/12 Mbps.

Map 14 – MF Wireless FCC Data

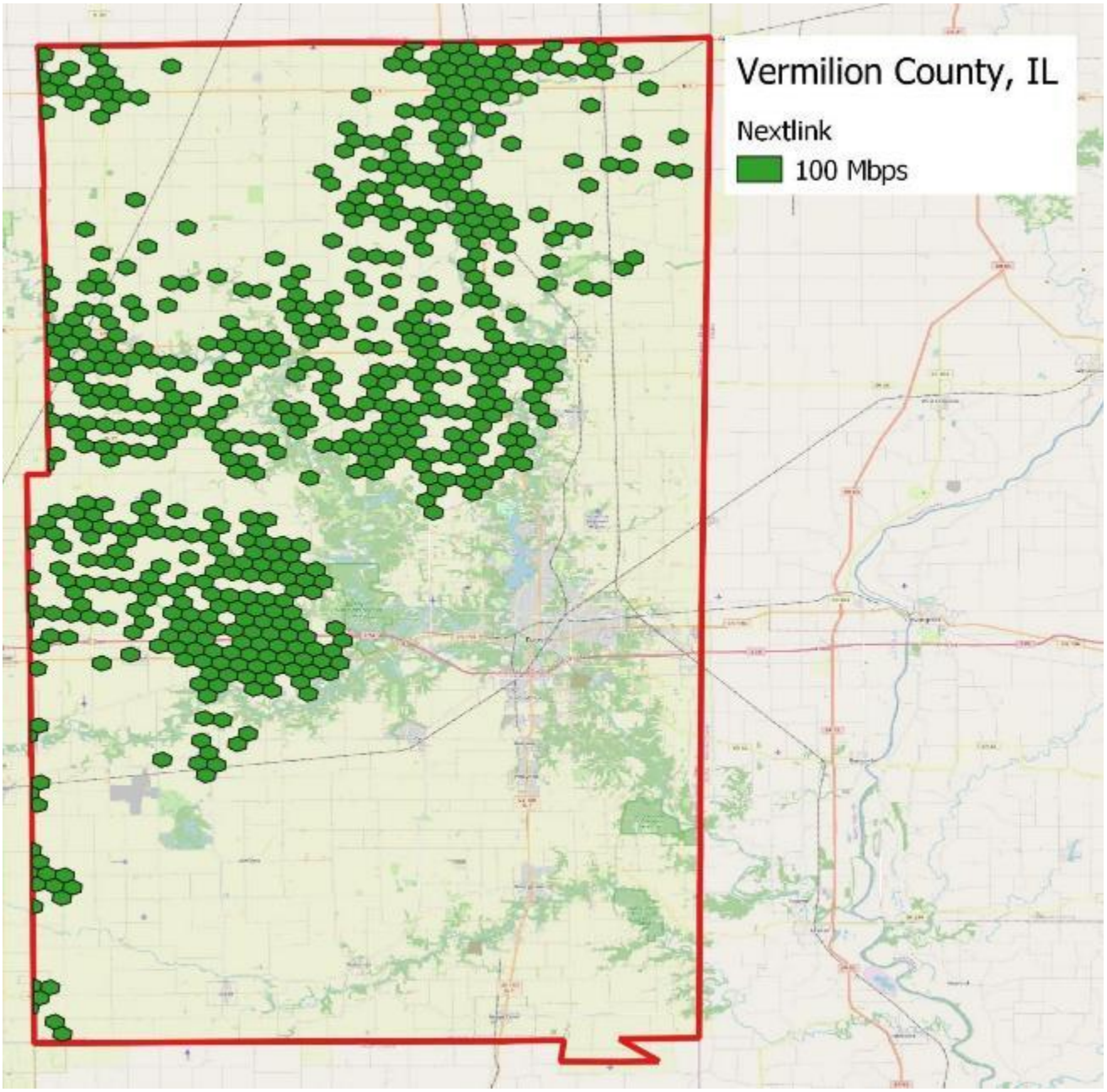


Nextlink

Nextlink claims to serve 5,629 passings with unlicensed fixed wireless throughout the county and claims speeds of 100/20 Mbps. The company is required to bring fast broadband to much of the county as a result of an RDOF subsidy.

According to the Ookla speed test data, Nextlink's average speed was 63/29 Mbps.

Map 15 – Nextlink Fixed Wireless FCC Data

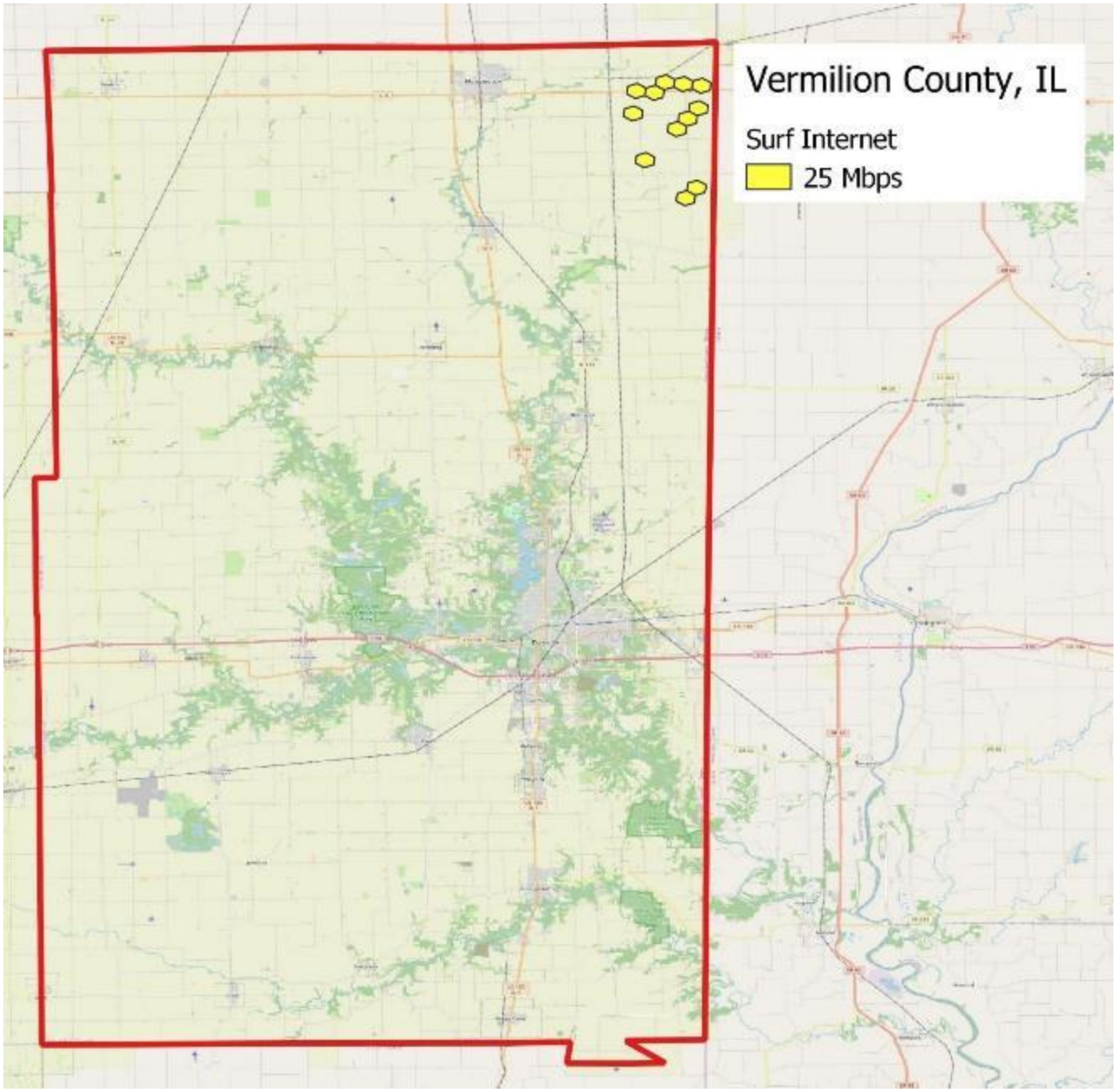


Surf Internet

Surf Internet is a licensed fixed wireless provider serving the northeastern corner of the county. In the most recent FCC maps, Surf Internet claims to cover 13 passings with speeds of 25/3 Mbps.

The customers of Surf Internet didn't take any Ookla speed tests in the twelve-month period.

Map 16 – Surf Internet Fixed Wireless FCC Data

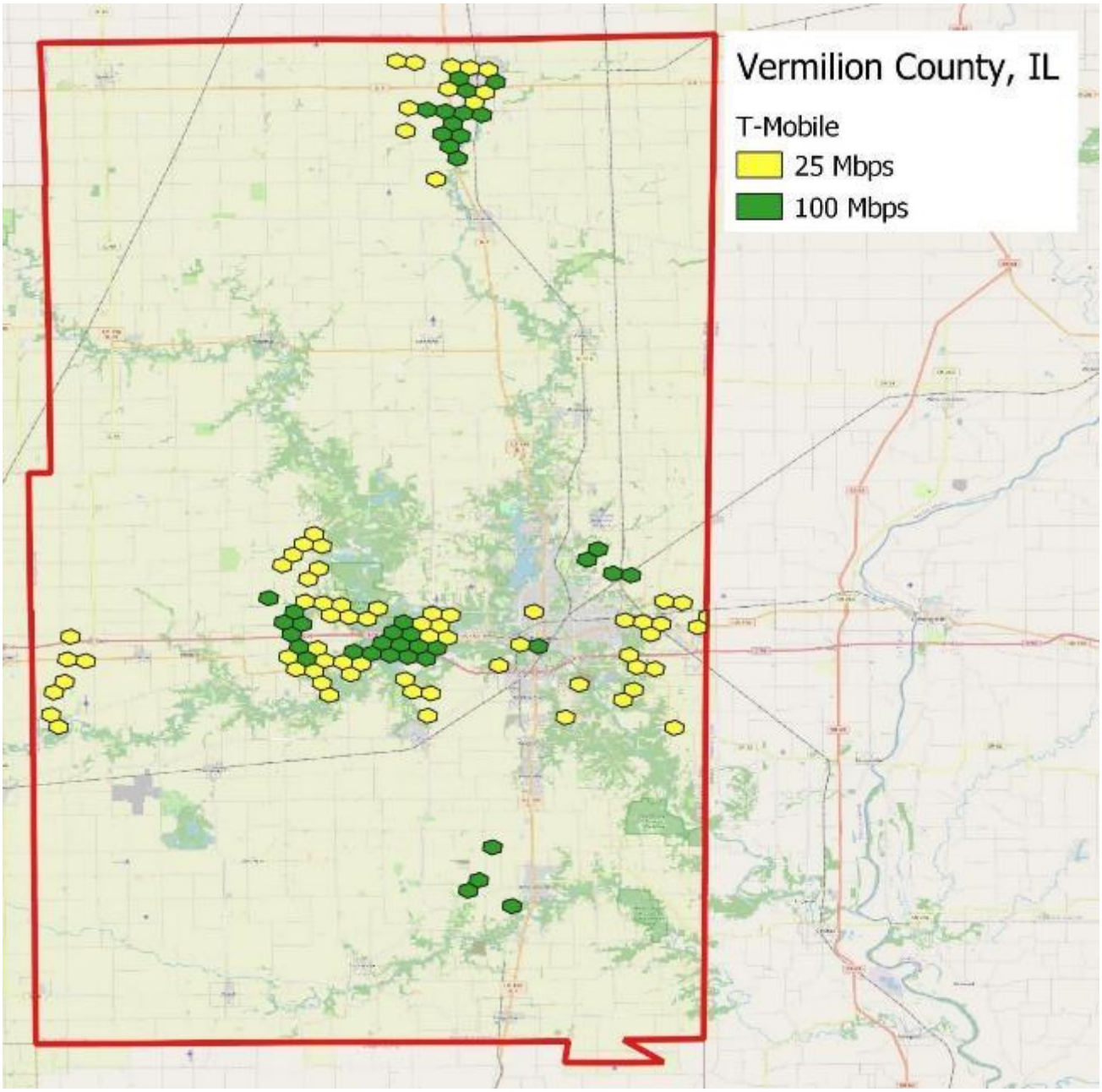


T-Mobile

T-Mobile reports coverage in the county using its cellular spectrum. The company claims to be able to serve 26,133 passings. We suspect that the green areas represent the new FWA cellular product, where T-Mobile claims a speed capability of 100/20 Mbps to the FCC. Many of the 25/3 Mbps speeds are likely still from the older hotpots served by the 4G LTE network. With cellular technology, the fastest speeds possible can only be delivered to customers who live within a mile or two of a cell site.

According to the Ookla speed test data, T-Mobile had an average speed of 206/21 Mbps.

Map 17 – T-Mobile FCC Data

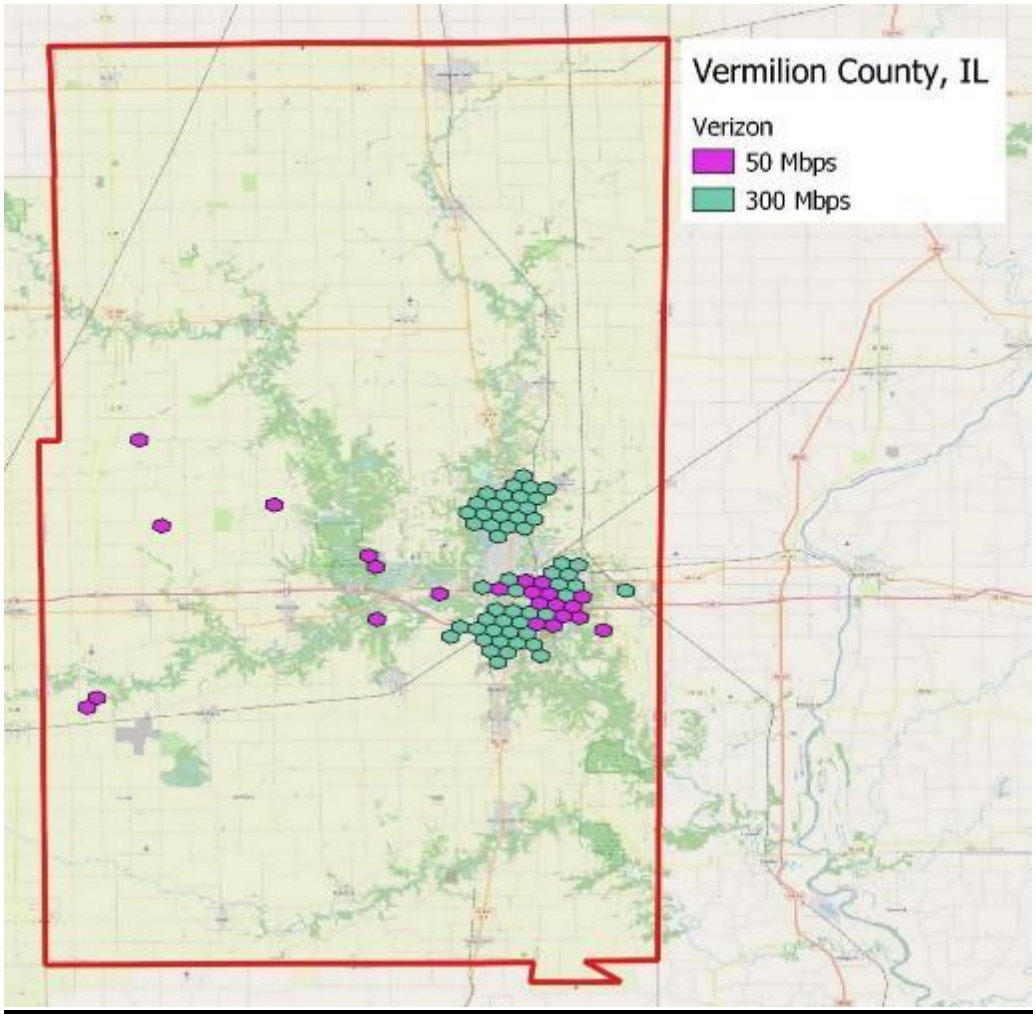


Verizon

Verizon reports coverage across the county using its cellular spectrum. Verizon claims to be able to serve 8,359 passings in the county at speeds of 50/5 Mbps where Verizon offers its traditional hotspots using 4G LTE spectrum. Verizon is offering its new FWA technology using 5G spectrum with speeds up to 300/20 Mbps. Only customers living close to a tower can receive the full claimed speeds.

According to the Ookla speed test data, the average speed for Verizon customers was 36/7 Mbps.

Map 18 – Verizon FCC Data



Other ISPs

The list includes ISPs in Ookla data but not in the FCC data. A few common types of ISPs that are not required to report to the FCC include wholesalers, resellers, and private networks. Wholesale refers to ISPs that sell internet service to ISPs or businesses, allowing the purchasers to connect to the internet but not providing retail service to end users. Resellers purchase broadband from wholesale providers and then

offer the service to end customers under a different brand name. Private networks are where a company purchases wholesale internet and provides its own broadband.

AT&T Enterprise
Comcast Business
Gifford Wireless
Consolidated Communications
Illinois Century Network
i3 Broadband

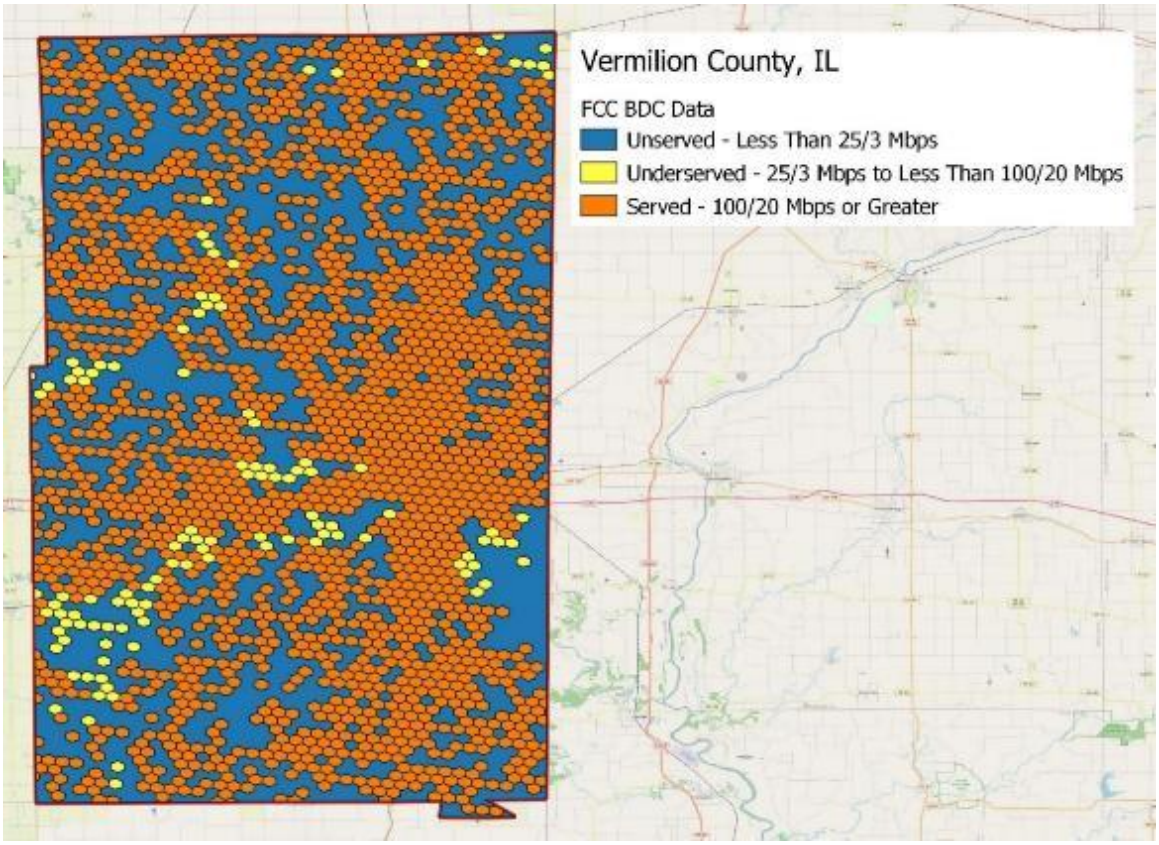
Composite FCC Maps

For purposes of qualifying for BEAD and other current federal broadband grants, geographic areas are typically categorized by speeds as follows:

- Unserved. Any place that has speeds under 25/3 Mbps.
- Underserved – Any place that has speeds between 25/3 Mbps and 100/20 Mbps
- Served – Any place with broadband of 100/20 Mbps or faster.

The map below shows the fastest broadband speed that is reported to the FCCs for each part of the county. This map was created using hexagons, and the speed shown is the fastest speed claimed by any ISP within that hexagon. In this map, unserved areas are blue, underserved areas are yellow, and served areas are orange. If this map were accurate, the only areas that would be eligible for BEAD grants are the blue and yellow areas. However, we know this map is not accurate.

Map 19 - Composite of all FCC BDC Mapping Data



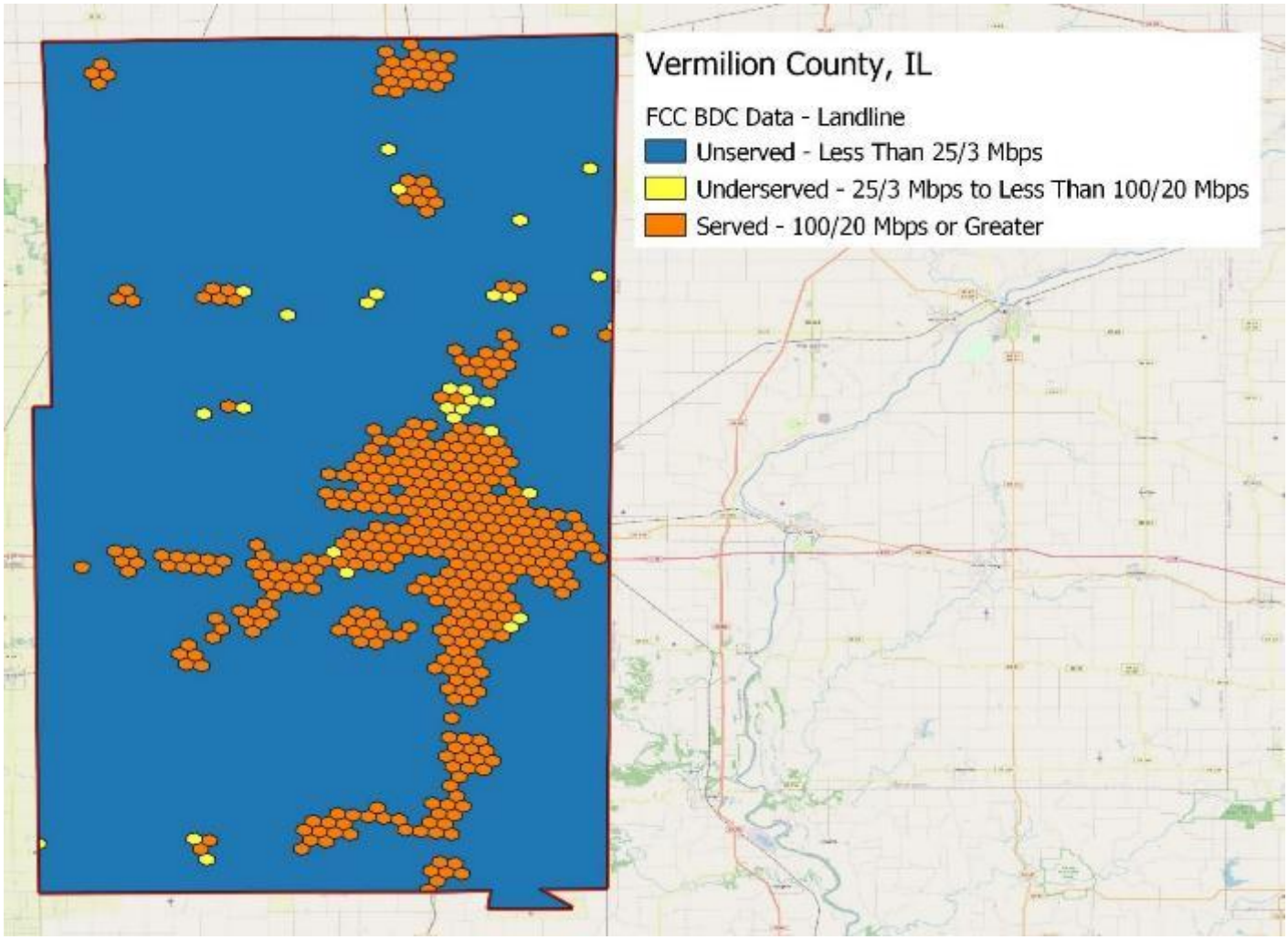
Finley Engineering gathered GIS data from the County that allowed us to identify and count homes and businesses, so we can count the houses inside each hexagon or houses inside any municipal or geographic boundary. According to the FCC maps, the passings in the county for Map 19 above are as follows:

	Speeds	Passings
Unserved (blue)	25/3 Mbps or Less	489
Underserved Yellow)	From 25/3 Mbps to 100/20 Mbps	515
Served (orange)	100/20 Mbps or faster	35,412
Total		36,416

FCC Landline Broadband

The map below shows the fastest landline broadband speed that is reported to the FCCs for each part of the county. This map was created using hexagons, and the speed shown is the fastest speed claimed by any ISP within that hexagon. In this map, unserved areas are blue, underserved areas are yellow, and served areas are orange.

Map 20 - Composite of Landline FCC BDC Mapping Data



	Speeds	Passings
Unserved (blue)	25/3 Mbps or Less	5,166
Underserved Yellow)	From 25/3 Mbps to 100/20 Mbps	590
Served (orange)	100/20 Mbps or faster	30,660
Total		36,416

Creating an Accurate Broadband Map

We can get a more accurate map by considering certain adjustments, as follows.

Edge Distortions. Some adjustments are made when ISPs claim a serving area in the maps where they don't seem to have the needed technology.

Speed Exaggerations. Another common problem with FCC reporting is that ISPs are allowed to report marketing speeds instead of speeds close to actual speeds. In many cases, ISPs claim a marketing speed that is significantly higher than the actual speeds being delivered to customers. We are able to judge if the speeds are exaggerated in two ways. In the field review we were able to review the technology in use, and in some cases, the reported speeds are faster than what the technology can support. We also have access to the trailing twelve months of Ookla speed data, where we can see the actual speeds being captured by Ookla speed tests.

Timing Differences. The FCC maps are always six to twelve months behind due to the time lag between when the FCC collects and publishes the mapping data. We often learn about or see network upgrades that are not reflected on the FCC maps.

Known Grants and Subsidies. The FCC mapping process does not recognize areas as served where state, local, or federal grants have been awarded but that have not yet been constructed. Many grant awards give ISPs multiple years to build a new network, and the maps will continue to reflect the older existing technology until the upgrades from a grant are completed. We take some risks when we show grant areas to be served in the adjusted map – because occasionally, an ISP will default on a grant, and it never gets built.

Pending Upgrades. The FCC maps will also not reflect any planned expansions where ISPs plan to upgrade networks without the use of grant funding. We often find out about these areas when we interview ISPs.

Change in Definitions. There was a change in the definition of technologies that are grant-eligible for the $42.5 billion BEAD grant program. The NTIA (the federal agency in charge of the BEAD grants) has declared that for the purpose of the BEAD grants that fixed wireless ISPs are only considered as providing broadband if they use licensed spectrum. Areas covered by WISPs using unlicensed spectrum are assumed to be unserved, regardless of the speed delivered. In making this decision, the NTIA ruled that unlicensed spectrum is unreliable.

The following entities own licensed spectrum in the county that can be used for wireless broadband:

- WATCH Communications purchased 30 MHz of CBRS spectrum for $300,900.
- Mediacom purchased 30 MHz of CBRS spectrum for $354,000.
- Dish purchased 10 MHz of CBRS spectrum for $118,000.
- Cellular companies all use licensed spectrum for communications with cellphones. This means that FWA wireless uses licensed spectrum.

Nuances of CBRS Spectrum. The spectrum that is being claimed by WISPs as licensed in rural areas is the Citizens Broadband Radio Service (CBRS) spectrum. The FCC approved the use of this spectrum in 2019 for rural broadband. This is a swath of spectrum covering 150 MHz of spectrum between 3550 and 3700 MHz.

The FCC auctioned 70 MHz of spectrum in June 2020 – this is where the companies above gained a license to use the spectrum. The FCC sold frequency in the auction using a geographic area known as a Priority Access License (PAL). There are generally several PAL areas per county. Whoever owns the PAL license for a given geography can use the spectrum without hindrance, except for the military, which always gets priority. The FCC identified areas before the auction where there is a known military use of the spectrum.

The remaining 80 MHz of the CBRS spectrum was set aside for unlicensed public use, similar to WiFi. Anybody using the unlicensed portion of CBRS cannot claim to be a licensed wireless ISP.

The licensed 70 MHz of spectrum also must be shared with other users. ISPs, or other users are allowed to apply for a license to share the spectrum, which is referred to as General Authorized Access (GAA) license. In the grant world, the NTIA has labeled any ISP that has a GAA license as having "licensed spectrum by rule."

The use of the CBRS spectrum is monitored by an authorized SAS administrator. The FCC has named five administrators: Amdocs, CommScope, Federated Wireless, Google, and Sony. A SAS administrator must use the following rules when authorizing an ISP to use the CBRS spectrum.

- If two signals are competing for priority, the SAS administrator looks at which signal has the top-tier access and gives that user permission to use the spectrum.
- A lower-tier user in the band must yield to the incumbent's right to use the spectrum, and the SAS will move a lower-tier user to another channel or reject the requested use of the spectrum if there is no spectrum available.
- This shared-licensed use is powered by a combination of dynamic channel sharing, smaller geographic license areas, and lower power limits than in many licensed-exclusive bands.

What does this license-sharing mean in practice?

- The military always has priority for using the spectrum.
- The PAL license holder (the winner of the auction) has full use of the spectrum unless the military wants to use it. In most places in the country there is limited military use.
- A GAA license holder is last in line. A GAA license holder will be denied the use of spectrum if it is requested by the military or by a PAL license holder.

We believe that the NTIA erred in determining that GAA license holders should be able to claim areas as served for grant purposes. A GAA license holder can only use the licensed spectrum

sometimes – when it is not being used by the PAL license holder or the military. This means that the licensed spectrum is not reliably available to a GAA license holder. That is a key determination because the NTIA has repeatedly said in other contexts that for a broadband connection to qualify as served, it must be reliably available to customers. ISPs with a GAA license cannot guarantee the use of licensed spectrum.

In Vermilion county, the only WISPs with a PAL license are WATCH Communications and Mediacom. The other WISPs claiming licensed spectrum, Rise Broadband, Surf Internet, and MF Wireless, are relying on the GAA license - licensed by rule. There is a huge industry controversy on counting licensed-by-rule locations as served, and a number of county governments in Illinois challenged this during the states BEAD map challenge. As of the date of writing this report, the State Broadband Office has not yet made an official determination of this issue.

In Vermilion County, the other wireless ISPs like Rise Broadband and Surf Internet have a no impact on the passings that are eligible for the BEAD grants since the companies don't claim any speeds of 100/20 Mbps or faster in the FCC maps.

Adjustments Made for this Study

Speed Exaggerations. Frontier and Brightspeed reports speeds up to or faster than 100 Mbps using DSL technology. Most State Broadband Offices have decided that DSL can be disregarded when determining existing served locations, so for purposes of this study we assumed that these areas are eligible for the BEAD grants.

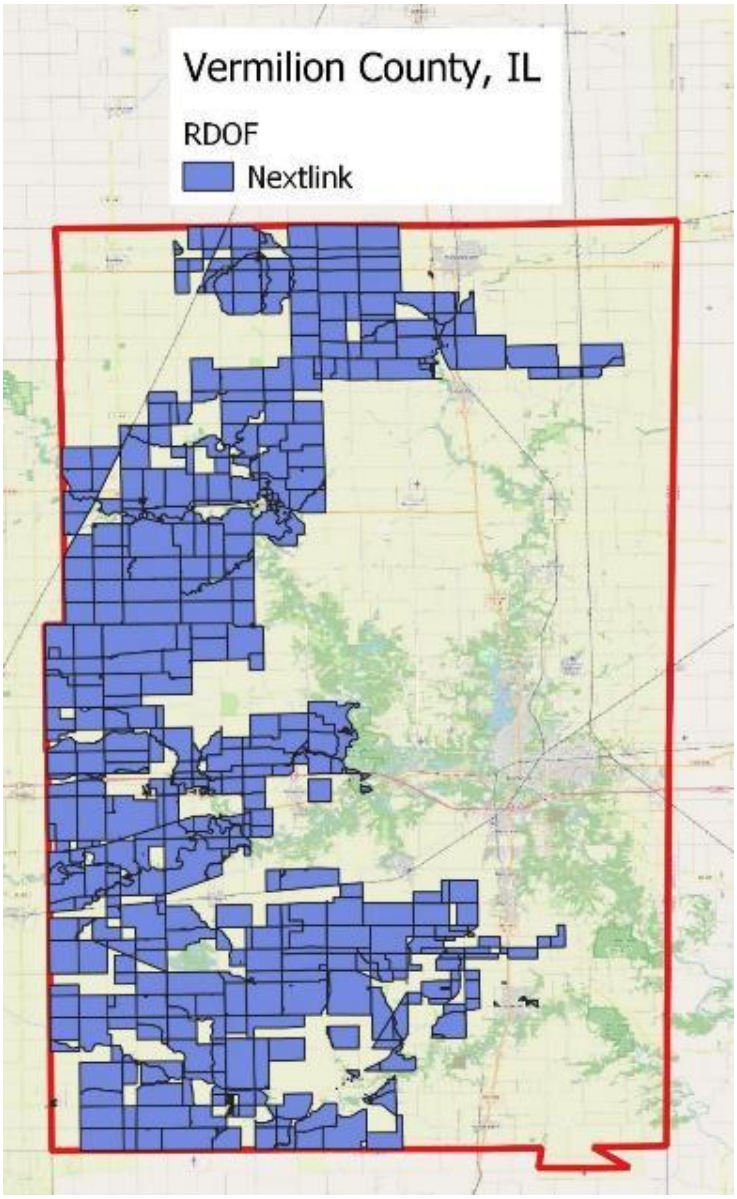
Known Grants and Subsidies. Large areas of the county received an FCC subsidy to build broadband under the Rural Digital Opportunity Fund (RDOF). This program is funded by the FCC from the Universal Service Fund. ISPs won the right to serve rural areas by competing for funding in an FCC reverse auction that concluded in December 2020. ISPs tentatively won over $6 billion nationwide to improve broadband in rural America. This is considered a subsidy program and not a grant because the FCC pays the RDOF awards to the winners evenly over ten years as a way to subsidize the construction of broadband.

The following map shows where the RDOF winner won in the county.

- Nextlink won $6,688,975 to serve 2,290 locations in the county. Nextlink pledged in the RDOF auction to meet its obligations using fixed wireless technology, with speeds promised to be at least 1 Gbps/500 Mbps.

As can be seen on the following map, this is a huge deal for the County. The RDOF subsidy covers 2,290 rural locations and a huge percentage of the rural parts of the county. All of the areas shown in blue for Nextlink will see a fixed wireless solution.

Map 21 - RDOF Auction Winners



In our field review we found no evidence of RDOF infrastructure in the county. The FCC gave RDOF winners a long time to implement RDOF. An RDOF winner must:

- Satisfy 40% percent of deployments by the end of the third full calendar year following funding authorization.
- 60% of deployments by the end of the fourth year.
- 80% of deployments by the end of the fifth year.
- 100% of deployments by the end of the sixth year.

These buildout timeline requirements must be met statewide. That means that Nextlink must satisfy the above percentages for the whole state, not in each County. Vermilion County could be anywhere in the six-year timeline, including the final year.

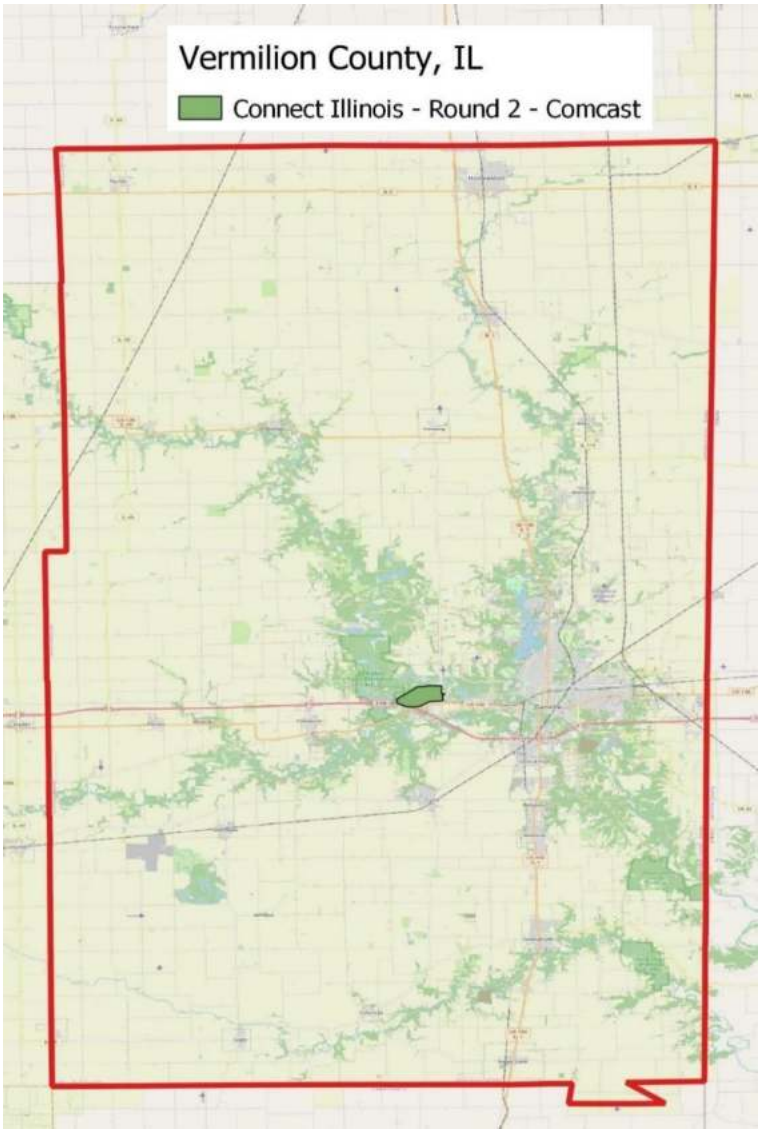
- Nextlink was authorized by the FCC on August 31, 2022. This means the company needs to be 60% complete statewide by the end of 2026 and fully complete by the end of 2028.

Connect Illinois Round 2

Connect Illinois is a competitive State broadband grant program. Through the 2019 Rebuild Illinois Infrastructure Program the state allocated $400 million for competitive broadband grants. The goal of the program is for homes, businesses, and community anchor institutions to achieve ubiquitous statewide broadband access.

- In Vermilion County, Comcast won a $630,903 grant to provide fiber connectivity to approximately 270 homes, businesses, and community anchor institutions just to the west of the unincorporated community of Hillery.

Map 22 – Comcast Connect IL



Adjusted Broadband Maps

The following are two maps that show the areas that might be available for BEAD grants after considering all of the adjustments described above.

- The first map assumes that BEAD grants will be allowed in areas where the only fast broadband is provided by a wireless carrier. As described above, there are three kinds of possible licensed wireless carries. The first is cellular carriers, which almost exclusively use licensed spectrum. WISPs can be considered as licensed in two ways. The first is to have purchased wireless spectrum from the FCC. The second is to participate in what is called 'licensed by rule.' WISPs without a formal license can use CBRS spectrum by agreeing to the FCC's frequency sharing rules. These rules say that the U.S. military has first use of the spectrum, followed by priority of any licensed spectrum holder. A 'licensed by rule' ISP can only use the spectrum when it's not being used by somebody else.

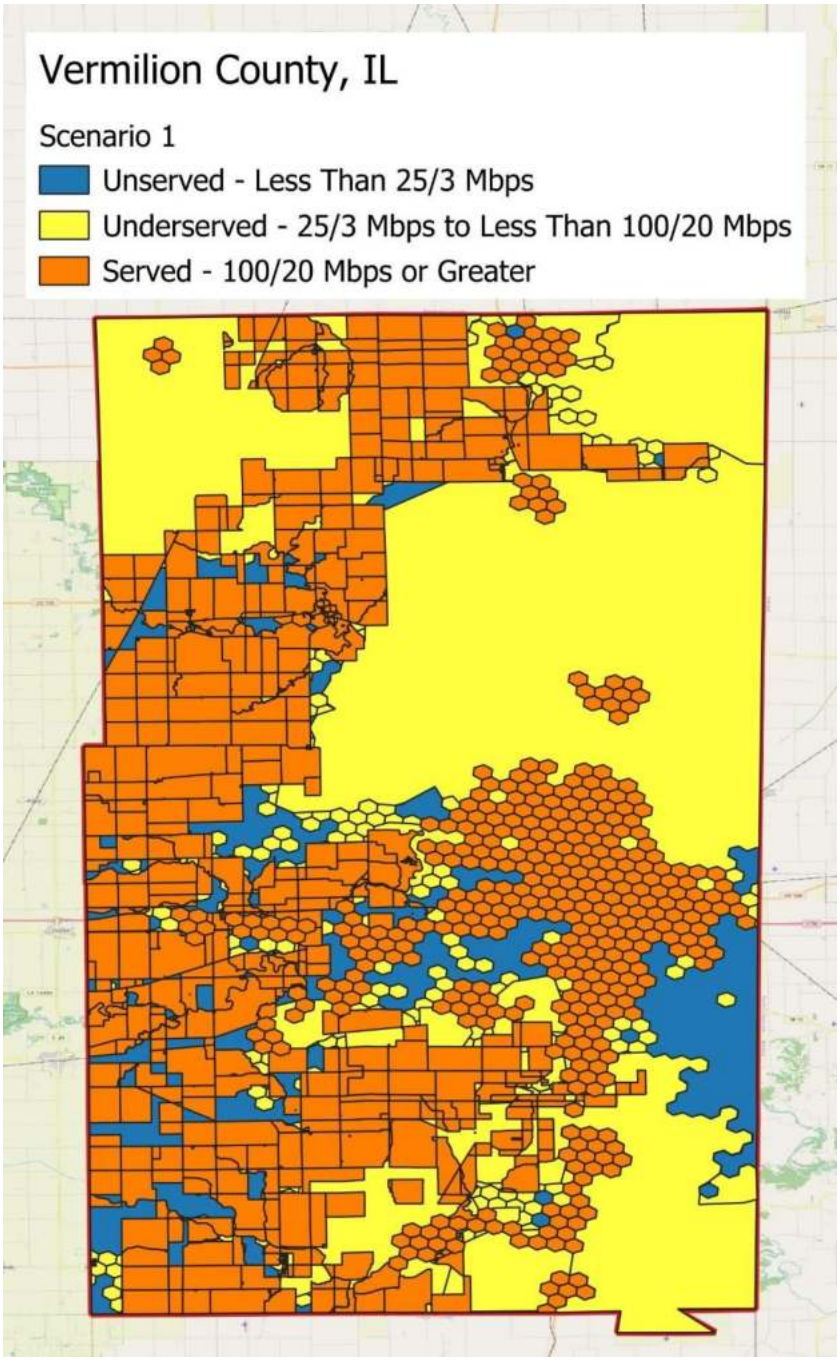
  Many state broadband offices have decided that ISPs using wireless spectrum are not automatically assumed to be served, even if speeds are faster than 100/20 Mbps. It's typical that wireless speeds vary significantly by customer depending on distance from a wireless tower and any impediments in the environment that might impede the wireless signal.

  This first map assumes that the Illinois Broadband Office will decide that areas where the only fast broadband is wireless are considered to be eligible for BEAD grants. As can be seen by comparing to the second map below, this assumption results in a much larger area eligible for BEAD grants along with a lot more homes.
- The second map assumes that wireless technologies are considered as served as long as the ISP is claiming 100/20 Mbps speeds to the FCC. In this scenario, areas where the only fast ISP is wireless are not eligible for BEAD grants.

There are scenarios in between these two sets of assumptions. The State Broadband Office might decide that only specific wireless ISPs are eligible or not eligible for BEAD grants.

In both maps, blue areas are unserved and yellow areas are underserved – both are eligible for the BEAD grants. Orange areas are considered as served, meaning there is a broadband option faster than 100/20 Mbps – either available today or coming due to a known grant or upgrade.

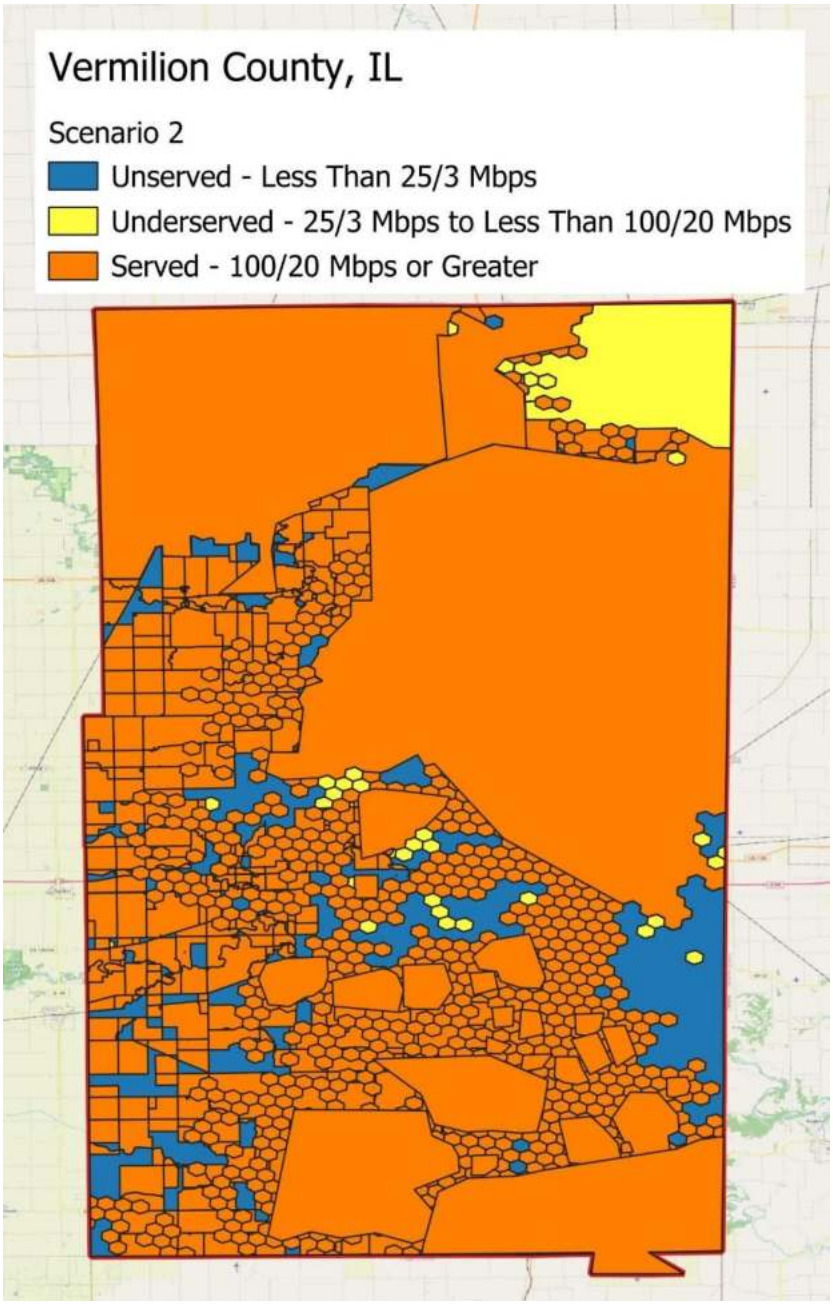
Map 23 – Wireless Areas are Eligible for BEAD Grants



The following are the passings associated Map 23.

Speeds		Passings
Unserved	Less than 25/3 Mbps	1,267
Underserved	From 25/3 Mbps to 100/20 Mbps	3,020
Served	100/20 Mbps or faster	32,129
Total		36,416

Map 24- Wireless Areas are Not Eligible for BEAD Grants



The following are the passings associated Map 24.

	Speeds	Passings
Unserved	Less than 25/3 Mbps	1,267
Underserved	From 25/3 Mbps to 100/20 Mbps	260
Served	100/20 Mbps or faster	34,889
Total		36,416

D. Broadband GAP Analysis

A broadband gap is a situation where some residents of an area are disadvantaged in their ability to use the Internet. This report will look at the various kinds of broadband gaps as described below.

- The Gap in Broadband Availability. There are homes with no landline broadband available.
- The Gap in Broadband Speeds. Broadband speeds vary widely in the county, as documented in the preceding section of the report.
- The Competition Gap. This gap is created whenever there are areas that are served by only one high-quality ISP, leaving residents and businesses with no choice of provider.
- The Gap in Broadband Affordability. There are households in every community that don't subscribe to broadband because of the cost.
- The Gap in Computer Ownership. There are households that don't subscribe to broadband because they can't afford a computer.
- The Gap in Broadband Skills. There are citizens who don't buy broadband because they lack the skills needed to operate in the digital age.
- Future Broadband Gaps. Even where there is adequate broadband today, we can expect the natural growth of broadband usage to create new broadband gaps in the future.

After describing the different broadband gaps, this report will look at the consequences of the broadband gaps and will ask the question if there are any practical solutions to the broadband gaps that Vermilion County could facilitate.

The Gap in Broadband Availability

The mapping analysis above shows the coverage areas and the claimed broadband speeds of the various ISPs in the county. This section of the report will look at other data sources to tell us more about the state of broadband in the study area.

A large portion of this report talks about broadband availability. There are residents in every rural area who say they can't buy broadband. We've found that this usually means that there are no broadband alternatives they are willing or able to buy. Many folks won't spend money on a broadband product that doesn't work well enough to meet their needs.

Many people won't consider high-orbit satellite broadband as an option. We've talked to many rural residents who tried satellite broadband and rejected it. The speeds are often far below what is advertised since trees and hills can block a satellite signal. The latency is dreadful, and high latency means a household can't rely on being able to make and hold connections needed for real-time transactions. This means it might be difficult or impossible to make a Zoom call, connect to a school or work server remotely, or even hold a connection to a website long enough to do routine tasks like shopping. Satellite data plans also come with tiny data caps, and people find it impossible to make it through the month with a 40 - 60 gigabyte data cap.

There are numerous complaints from rural areas that the performance of DSL over copper lines is slow as to be nonfunctional. That can be seen in the county where DSL has the slowest broadband speeds of all technologies.

Many customers have the same complaint about cellular hotspots. This technology might deliver 25 Mbps to customers who are within a few miles of a cell tower, but speeds get slower as the distance between a customer and a tower increases. Hotspots are also limited by tiny monthly data caps, the same as satellite service.

FCC Availability of Broadband

The Federal Communications Commission (FCC) looks at the availability of broadband by county, meaning the percentage of homes that could buy broadband at various speeds. The following is what the FCC reported to Congress in 2021 about Vermilion County:

Vermilion County

The following is what the FCC reported to Congress in 2021 about Vermilion County.

Urban population:	51,053
% that can buy at least 25/3 broadband	99.0%
% with 4G LTE coverage at 5/1 Mbps	100%
% with both	99.0%
Rural population:	24,705
% that can buy at least 25/3 broadband	85.4%
% with 4G LTE coverage at 5/1 Mbps	100%
% with both	85.4%

The FCC data coverage looks accurate for urban areas. Most of the cities and villages in the county have fast broadband from Comcast, Sparklight, Conxxus, and AT&T Fiber. Comcast provides service in Danville, Fairmount, Fithian, Georgetown, Indianola, Muncie, Oakwood, Olivet, Ridge Farm, and Tilton. Sparklight provides service in Belgium, Catlin, Danville, Georgetown, Hoopeston, Rossville, Tilton, and Westville. AT&T provides fiber service in Danville. Conxxus provides service in Bismark, Rankin, Farm Ridge, and Potomac.

The FCC data shows that 85.4% of the rural parts of the county can buy 25/3 Mbps broadband. Rural residents in the county have fewer broadband options. Some can purchase landline broadband from Frontier or AT&T DSL, but most rural residents must choose between fixed wireless or cellular hotspot broadband. Increasingly, rural customers can buy Starlink satellite service, but the company limits the number of people it will serve in a given geographic area.

We also note that the speeds claimed by ISPs in rural areas are often overstated. In this county we are doubtful about the coverage and the speeds claimed by WATCH Communications and Nextlink. We believe the percentage of rural residents who can purchase broadband faster than 25/3 Mbps is lower than the FCC data indicates.

Comparing Vermilion County with the Rest of Illinois

According to FCC data, Alexander and Pulaski Counties have the greatest percentage of locations that can't get speeds of at least 25/3 Mbps coverage in the state at 0.1% and 44.9%, respectively. At the other end of the scale, the FCC says that 23 counties have 100% coverage of 25/3 Mbps broadband. According to the FCC data, Vermilion County is in the middle of the pack compared to other counties.

The Gap in Broadband Speeds

One of the biggest controversies concerning broadband speeds is the methods allowed by the FCC when ISPs report available speeds. The FCC mapping rules allow an ISP to claim a 'marketing' speed rather than an approximation of the actual speeds being delivered. This one rule has resulted in huge numbers of locations where an ISP claims the ability to deliver 100/20 Mbps but can't deliver at that speed. Sometimes, the exaggerations are extreme. We've seen cases of fixed wireless carriers claiming the ability to deliver gigabit speeds and DSL providers claiming the ability to deliver 100/20 Mbps. Both claims are technologically impossible, at least in rural areas. It's possible to deliver both speeds for a very short distance from a broadband hub, assuming the ISP owns technology capable of these speeds.

This means that the speed claims made in the preceding section are likely overstated. Many of the locations that the FCC and the State of Illinois count as having 25/3 Mbps or 100/20 Mbps broadband likely can't achieve those speeds.

This section examines the use of speed tests to measure actual speeds instead of ISP claimed speeds. Generally speaking, fiber technology supports the fastest speeds, followed by coaxial cable, then licensed fixed wireless, and finally DSL. There are a number of reasons why ISPs might not deliver the claimed speeds. These issues are discussed in greater detail in Section II.B.

- Backhaul. This is the technical term to define the amount of bandwidth that is available to between customers and the Internet. If an ISP doesn't purchase enough backhaul bandwidth, then every technology and customer slows down when the network gets busy. But many ISPs don't provide enough backhaul bandwidth to ever achieve the claimed speed. For example, an ISP can't claim a gigabit speed for a location if the backhaul to that neighborhood is at a speed slower than a gigabit.
- Distance. DSL technology, fixed wireless technology, and cellular technologies all have distance limitations. In all of these technologies, customers living closest to the broadband hub get the fastest speeds, and speeds get slower as the distance to customers increases. At some distance for each technology, it is impossible to deliver any broadband.
- Condition of the Network. The speeds available from landline technologies degrade as networks get older and don't perform to original specifications. This is true for DSL and coaxial copper technologies and even for fiber. The other portion of a network that can underperform is the electronics used to deliver the signal to customers. It's common for ISPs to continue operating older technologies to get the most economic life from the equipment. Older versions of every technology likely mean slower speeds.
- Environmental Conditions. This particularly impacts wireless and satellite technologies. Every wireless technology performs best when there is a perfect line of sight between the customer and the transmitting radio. Hills, buildings, and trees will invariably slow down the signal. These technologies also slow down during rain, snow, and fog events.

- Wireless Channel Size and Other Factors. This will be explained in more detail in Section II.C, but there are a lot of factors specific to wireless systems that can have a huge impact on the speed delivered to any given customer. A good example is the channel size being used. WISPs use different frequencies, and each uses different channel sizes – the best analogy is the bigger the channel, the more bandwidth that can be delivered.

Ookla Speed Test by State

Ookla[13] collects speed tests across the country. It is the most popular speed test website, making it an excellent resource for looking at current broadband speeds in any area of interest. In 2020, Ookla started to report median download and upload speeds and latency by state. The median means the speed at which half of all broadband speeds are slower, and half are faster. Below are the average speeds for the whole state as reported by Ookla since the fourth quarter of 2022.

	Download	Upload
4th Quarter 2022	166 Mbps	22 Mbps
1st Quarter 2023	174 Mbps	22 Mbps
2nd Quarter 2023	167 Mbps	22 Mbps
3rd Quarter 2023	174 Mbps	22 Mbps
4th Quarter 2023	187 Mbps	23 Mbps

As seen in the table above, download broadband speeds have been improving rapidly in Illinois. From the fourth quarter of 2022 to the fourth quarter of 2023, the median download speed increased from 166 Mbps to 187 Mbps. There are three likely reasons for this trend:

- Cable companies have increased speeds across the board. Where the speed for the most common product might have been 100 Mbps a few years ago, cable companies have increased the speeds for the same product to 200 Mbps or 300 Mbps.
- Fiber networks are being built around the state. When fiber is built in rural areas, the speeds dramatically improve overnight.
- A significant number of rural homes are upgrading to Starlink, which is far faster than the other existing technologies.
- As is shown later in this section, there is a big trend of people across the country upgrading to faster speeds with their existing ISP.

According to Ookla, Charter is the fastest ISP in Illinois, with a median download speed of 259 Mbps.

Speed Tests

One of the most important aspects of obtaining broadband grants is that the grants are only available in areas where the existing broadband speeds are below par. Speed tests provide a way to judge the quality of broadband, which differs significantly from other ways to measure broadband performance. A given speed test is not 100% reliable and doesn't always deliver a true picture of the broadband being delivered

[13] https://www.speedtest.net

to a given address. However, we've found that when speed tests are administered in mass for a whole community, we can gain a good understanding of the overall quality of broadband. Following are a few of the criticisms that ISPs rightfully make about any individual speed test:

- A speed test only measures the speed of a ping and a short-term connection of less than a minute between a user and the test site router used by the speed test. That doesn't necessarily indicate the speed of every activity on the web, such as downloading files, making a VoIP phone call, or streaming Netflix.
- Every speed test site on the market uses a different algorithm to measure speed. The two most commonly used speed tests sites are provided by Ookla and M-Labs. The Ookla speed test generally connects to a local or regional server and also tests several connections at the same time. M-Labs attempts only one connection.
- A speed test can be slowed due to network issues within the home, such as problems with a home WiFi router or faulty wire inside a home. A slow speed test doesn't always mean that the ISP was providing a slow connection.
- Internet speeds vary throughout the day, and anybody who takes multiple speed tests during the same day will see this. Taking only a single speed test might not tell the real story about a given customer.
- Some ISPs use something called "burst" technology. This provides a faster Internet connection for one or two minutes. ISPs know that a large majority of Internet activities are of short duration – things like opening a web page, downloading a file, reading an email, or taking a speed test. The burst technology increases the priority of a customer during the burst window, and the Internet connection then slows down when the temporary burst is over. This raises an interesting question – what's the real Internet speed of a customer that gets 100 Mbps during a 2-minute burst and something slower after the burst – there is no consensus in the industry.

Ookla Speed Tests

As part of the study, Finley Engineering acquired detailed speed test data from Ookla[14], which operates the most-used speed test site in the country. The tests cover twelve months ending July 2024. The following table shows the average broadband speeds by technology for tests taken during the last year.

Technology	Download	Upload	Latency (ms)
DSL	41	8	60
Cable	290	29	23
Fiber	426	356	8
Fixed Wireless	44	6	47
FWA Cellular	173	26	50
LEO Satellite	103	14	38
GEO Satellite	36	4	630

[14] https://www.speedtest.net/

The following table shows the same results by ISP.

ISP	Technology	Download (Mbps)	Upload (Mbps)	Latency (ms)
AT&T DSL	DSL	41	6	63
Frontier	DSL	33	14	46
Comcast	Cable	318	25	24
Conxxus Cable	Cable	58	8	35
Sparklight	Cable	265	33	22
AT&T Fiber	Fiber	242	206	15
Conxxus Fiber	Fiber	393	364	8
Frontier	Fiber	385	287	17
Pavlov Media	Fiber	588	375	4
MF Wireless	Fixed Wireless	83	12	29
Nextlink	Fixed Wireless	63	29	28
Rise Broadband	Fixed Wireless	24	8	45
Watch Comm.	Fixed Wireless	44	6	47
AT&T FWA	FWA Cellular	142	69	65
T-Mobile	FWA Cellular	206	21	46
Verizon	FWA Cellular	36	7	56
Starlink	Satellite	103	14	38
HughesNet	Satellite	31	4	617
Viasat	Satellite	40	4	641

This table shows the following for broadband speeds:

- The ISPs with the fastest average download speeds are Pavlov Media, Conxxus Fiber, and Comcast.
- DSL speeds were slow for all providers.
- Fixed wireless speeds were slow for all providers.
- Starlink had faster speeds than HughesNet and Viasat.
- T-Mobile and AT&T cellular speeds are faster than 100 Mbps download claimed in the FCC maps since the company has introduced FWA 5G products at some cell sites. The speed tests for Verizon reflect hotspot technology.

Latency is also an important factor for broadband and is discussed in more detail in Section II.B. of the report. Latency measures the delay in delivering a broadband signal across different technologies and networks. Fiber technology generally has the lowest latency. Cable companies have the second lowest latency, which is still much higher than fiber. The latency is significantly higher on DSL and fixed wireless. Starlink has a latency close to some landline technologies, but the latency for the high-orbit satellite companies is far higher than any other technology. The FCC warns that latency higher than 100 makes it difficult to complete real-time connections like a video call on Zoom or connecting to a school server from home.

The Ookla speed test data showed the time of the day for each speed test. This allowed us to look at the average speeds for ISPs during the day, evening, and nighttime hours. A few ISPs had slower speeds in the evening than during the daytime. This might be an indication of a network that gets overloaded when a bigger share of the customers use the network. This includes MF Wireless (27% slower), Starlink (27% slower), Comcast (17% slower), Verizon (48% slower), and T-Mobile (20% slower).

We were able to collect data from the FCC showing the number of passings where each ISP claims to be able to provide service. Unfortunately, ISPs do not disclose their customer counts to the FCC in the public mapping data. We know that there can be a big difference between claimed passings (locations where an ISP can theoretically provide service) and the actual number of customers. One of the reasons for this is an FCC rule that allows an ISP to show a passing if it can provide service to a customer within ten working days of a request for service. A passing shown in the FCC map does not mean that the claimed technology is connected to that location – but rather that the ISP believes they can bring service quickly after getting a customer request for service.

We think that it's possible to approximate the number of customers that an ISP has by looking at the number of speed tests. We have no reason to think that customers of any particular technology are likely to perform more speed tests than other technologies. This is only speculation, but making this comparison produces results that we think correlate to the number of customers buying each kind of broadband.

The following chart compares the number of speed tests to the number of passings in the FCC mapping data claimed for each technology:

Technology	Speed Tests	Passings	Tests per Passing
DSL	2,704	19,832	0.14
Cable	21,022	28,018	0.75
Fiber	1,818	2,425	0.75
Fixed Wireless	2,250	22,207	0.10
Cellular	3,237	28,765	0.11

This table raises some interesting questions:

- Both fiber providers and the cable companies have a high ratio of speed tests per passing. This indicates that these ISPs have a relatively high customer penetration rate.
- The other technologies have a much lower ratio of speed tests compared to passings. This indicates that these technologies have a relatively lower customer penetration rate compared to cable and fiber.

The following table makes the same comparison for all ISPs.

ISP	Technology	Speed Tests	Passings	Tests per Passing
AT&T DSL	DSL	1,977	17,524	0.11
Frontier	DSL	727	2,308	0.31

Comcast	Cable	10,932	17,455	0.63
Conxxus Cable	Cable	296	384	0.77
Sparklight	Cable	9,794	10,265	0.95
AT&T Fiber	Fiber	73	307	0.24
Conxxus Fiber	Fiber	776	1,214	0.64
Pavlov Media	Fiber	242	804	0.30
MF Wireless	Fixed Wireless	52	296	0.18
Nextlink	Fixed Wireless	26	5,629	0.00
Rise Broadband	Fixed Wireless	178	4,800	0.04
Watch Communications	Fixed Wireless	1,994	9,982	0.20
AT&T FWA	Fixed Cellular	464	2,555	0.18
T-Mobile	Fixed Cellular	2,316	26,133	0.09
Verizon	Fixed Cellular	457	8,359	0.05
Starlink	Satellite	1,238	35,559	0.03
HughesNet	Satellite	39	35,558	0.00
Viasat	Satellite	50	35,559	0.00

There are some interesting observations that can be made from the above table:

- The table suggests that Sparklight has a higher penetration rate in its footprint than Comcast. This might be true since Sparklight serves in smaller towns and villages and has less competition.
- As would be expected by the statistics from the earlier table, individual WISPs have a low ratio of speed tests per passing. Both Nextlink and Rise broadband have extremely low ratios, which is an indication that each has very few customers in the county.
- We know that AT&T uses its FWA wireless as a replacement for copper technology. The low ratio of passings and the presence of FWA customers indicates that the replacement of rural coper is underway.
- In our interviews with stakeholders we heard that a number of rural residents use Starlink – yet the relatively small number of speed tests don't support that. There looks to be a small number of households using Viasat and HughesNet.

The Gap in Broadband Adoption and Affordability

The FCC reports that the total broadband adoption in the country is around 89%. Even after accounting for the rural areas that have no broadband option, this means there are many millions of people who don't buy broadband when it is available. Numerous studies and surveys have investigated this issue, and the predominant reason that people elect to not buy broadband is the price – people say they can't afford broadband.

Statistics on Affordability

The FCC conducted a study a few years ago that compared broadband adoption rates to household income. This is a study that only the FCC can undertake since ISPs report actual broadband customers to the FCC,

but that data is not publicly available. The table below comes from the Fourteenth Broadband Deployment Report released in January 2021.

The table shows two things. First, there is a definite correlation between household income and broadband adoption - the higher the household income, the higher the percentage of homes that buy broadband. Second, the higher the household income, the greater the percentage of households who buy faster broadband products. The FCC study showed that only 38.4% of households in the lowest quartile of earnings were buying broadband, while twice as many households were buying broadband in the highest quartile.

Average County Overall Adoption Rate for Fixed Terrestrial Services by County Level Demographic Variable (December 31, 2019)

	10/1 Mbps	25/3 Mbps	50/5 Mbps	100/10 Mbps	250/25 Mbps
Median Household Income					
First Quartile (Lowest Median Household Income)	38.4%	28.3%	23.4%	20.2%	4.7%
Second Quartile	51.6%	41.6%	36.4%	31.0%	6.0%
Third Quartile	58.8%	47.6%	42.2%	35.2%	6.2%
Fourth Quartile (Highest Median Household Income)	71.2%	61.3%	56.7%	43.8%	8.1%
Population Density					
First Quartile (Lowest Population Density)	48.8%	34.2%	26.8%	22.7%	8.0%
Second Quartile	43.9%	34.3%	30.1%	25.0%	4.8%
Third Quartile	55.1%	46.5%	42.6%	36.0%	5.0%
Fourth Quartile (Highest Population Density)	72.0%	63.6%	58.8%	46.1%	7.8%

There are studies available for those who want to dig deeper into quantitative and qualitative research into broadband affordability for low-income households. The first was published by the Benton Foundation and authored by Dr. Colin Rhinesmith.[15] The second report is issued by the Quello Center and is authored by Bianca Reisdorf.[16] This report looks at a study conducted in three low-income neighborhoods of Detroit.

Both reports say that low-income households with a limited budget appreciate the advantage of having broadband at home but often can't fit it into their budgets. They find it difficult or impossible to prioritize broadband compared to paying rent or buying food. These studies indicate that a big part of the solution for getting broadband into homes without it is going to have to involve finding a way to pay for monthly broadband access.

[15] Digital Inclusion and Meaningful Broadband Initiatives. https://www.benton.org/publications/digital-inclusion-and-meaningful-broadband-adoption-initiatives

[16] Broadband to the Neighborhood. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3103457

The Pew Research Center shows a direct correlation between income and broadband adoption. The non-profit has been conducting an ongoing investigation into broadband-related issues since 2000[17]. Pew shows that as of February 2021, only 57% of homes with household incomes less than $30,000 have broadband, compared to 92% of homes with household incomes over $75,000.

The survey shows that 4.4 million households currently don't have broadband because of affordability. That works out to be 3.5% of all households in the country. Some of the statistics cited by Pew about homes without broadband include:

- 45% have a household income below $25,000 per year.
- There is a higher percentage of African Americans and Hispanics that can't afford broadband.
- There is a much higher percentage of households with no members with a post-secondary education.
- 29% of the homes previously had broadband but no longer do.

The National Telecommunications and Information Administration (NTIA) conducts surveys about broadband adoption. The table below shows survey results released in October 2022 that show some interesting statistics on broadband affordability.

Selected Characteristics by Home Internet Use or Non-Use
Percent or Mean Response of Households, 2021

	Internet at Home	No Need/Interest	Too Expensive
Total Households	108.5 million	13.8 million	4.4 million
Family Income < $25K/Year	15%	35%	45%
School-Age Child Present	24%	12%	19%
Located in Rural Area	12%	16%	14%
Internet Use at Other Locations	85%	13%	24%
Previous Home Internet Use	N/A	14%	29%
Household Reference Person* Characteristics			
Mean Age	50.6	60.5	51.3
No Post-Secondary Education	30%	59%	57%
White, non-Hispanic	66%	61%	49%
African American, non-Hispanic	12%	16%	25%
Hispanic	14%	17%	19%
Willingness to Pay for Home Internet Service (Per Month)			
Mean Price	N/A	$5.92	$15.69
Price is $0 or "None"	N/A	83%	54%

* The reference person is the first individual in each household who is identified as owning or renting the housing unit.

[17] Demographics of Internet and Home Broadband Usage in the United States | Pew Research Center. https://www.pewresearch.org/internet/fact-sheet/internet-broadband/?menuItem=2ab2b0be-6364-4d3a-8db7-ae134dbc05cd

Illinois Statistics on Adoption

The Illinois Broadband Advisory Council commissioned a study in 2021 that examined, among other topics, the relationship between broadband adoption and affordability by region across Illinois. The work of John Horrigan, Colin Rhinesmith, and Brian Whitacre provided the following comparison of broadband technology adoption by region:

Economic Development Region	Households	Broadband of any type	Cellular data plan	Cellular data plan with no other type of internet subscription	Broadband such as cable, fiber optics, or DSL	Satellite internet service
Central	238,223	78.7%	63.3%	13.2%	59.7%	8.2%
East Central	144,104	82.4%	74.8%	15.3%	62.2%	9.4%
North Central	250,379	82.3%	68.3%	12.9%	64.7%	6.3%
Northeast	3,241,195	87.8%	80.4%	10.4%	74.7%	5.6%
Northern Stateline	173,362	86.1%	78.0%	12.0%	69.8%	7.7%
Northwest	159,011	83.9%	74.6%	15.0%	62.4%	8.4%
Southeast	201,715	82.7%	73.3%	16.6%	57.5%	10.5%
Southern	130,474	78.9%	72.3%	24.0%	47.0%	9.3%
Southwest	214,260	85.1%	76.1%	12.4%	67.8%	6.5%
West Central	113,283	80.4%	66.4%	13.9%	60.3%	8.2%
TOTAL Households (state)	**4,866,006**	**86.0%**	**77.5%**	**11.8%**	**70.4%**	**6.4%**

The study also summarized the adoption of various broadband technologies by income:

	All	Less than $25K	Between $25K and $50K	Between $50K and $75K	Between $75K and $150K	Greater than $150K
Broadband of any type	86.0%	64.9%	81.1%	89.2%	94.6%	97.0%
Wireline broadband subscription	70.4%	44.4%	61.8%	71.8%	80.8%	89.5%
Computer (desktop or laptop)	77.1%	49.5%	67.0%	78.8%	89.7%	95.8%
Tablet computer	61.2%	33.4%	48.8%	59.1%	74.6%	85.4%
Smartphone	86.4%	69.2%	80.9%	88.3%	94.0%	96.5%
Number of households	**4,864,664**	**884,587**	**977,945**	**784,015**	**1,409,588**	**808,529**

The next table summarizes the same data as the table above, but only for metro areas:

	All	Less than $25K	Between $25K and $50K	Between $50K and $75K	Between $75K and $150K	Greater than $150K
Broadband of any type	86.5%	65.2%	81.8%	89.2%	94.9%	97.2%
Wireline broadband subscription	71.4%	44.6%	62.8%	72.4%	81.8%	90.4%
Computer (desktop or laptop)	77.6%	49.7%	67.4%	78.7%	90.0%	96.0%
Tablet computer	61.6%	34.0%	49.0%	58.4%	74.8%	85.5%
Smartphone	86.8%	69.8%	81.8%	88.3%	94.2%	96.6%
Number of households	**4,307,493**	**773,961**	**849,638**	**681,168**	**1,253,163**	**749,563**

This last table looks at the adoption of broadband technologies for rural and exurban areas:

	All	Less than $25K	Between $25K and $50K	Between $50K and $75K	Between $75K and $150K	Greater than $150K
Broadband of any type	82.2%	62.9%	76.2%	88.7%	91.9%	94.5%
Wireline broadband subscription	62.6%	43.5%	54.9%	67.9%	72.9%	78.8%
Computer (desktop or laptop)	73.6%	48.5%	64.7%	79.1%	87.4%	93.5%
Tablet computer	57.9%	29.2%	47.7%	63.4%	73.2%	83.6%
Smartphone	82.5%	64.7%	75.2%	88.0%	92.7%	95.2%
Number of households	**557,171**	**110,626**	**128,307**	**102,847**	**156,425**	**58,966**

Some of the key takeaways from these tables:

- There is a huge difference in broadband adoption between homes with incomes under $25,000 (64.9%) and those over $150,000 (97%).
- There is a significant difference in landline broadband adoption in cities (71.4%) and rural households (62.6%).
- Broadband adoption varies by region of the state from Central (78.7%) to Northeast (87.8%).

To be fair, not every resident in the county wants or needs fast broadband. There are households who are not interested in broadband. Some households are light broadband users. There are also households that will accept slower broadband to get a lower price. A nationwide survey[18] released by *U.S. News and World*

[18] https://www.usnews.com/360-reviews/services/internet-providers/internet-cost-speed-value-survey

Report shows that 85% of households use the Internet every day, and 31% of households say that they are online constantly. Most broadband users want fast speeds if available and if they can afford it.

Demographics in the County

Vermilion County Demographics

There are many economic studies that suggest that demographic factors are a key factor in whether homes can afford broadband. This section of the report looks at some of the key demographics in Vermilion County. These statistics are based on the recent 2020 Census data.

Population Demographics

Community	Population	Change Since 2010	Percentage Under 5	Percentage Under 18	Percentage Over 65
Vermilion County	71,652	-9.1%	6.0%	23.4%	20.7%
Illinois	12,812,508	-0.1%	5.4%	21.6%	17.2%
United States	331,449,281	7.4%	5.6%	21.7%	17.3%

Vermilion County is losing population at a far greater rate than the state. Vermilion County has a higher percentage of residents under the age of five, under age 18, and over 65 compared to the state and national averages.

Home Ownership and Educational Demographics

Community	Percent with High School Degree	Percent with Bachelor's or Higher	Percentage Home Ownership	Median Home Cost
Vermilion County	90.6%	15.6%	69.5%	$91,000
Illinois	90.1%	36.7%	66.7%	$239,100
United States	89.1%	34.3%	64.8%	$281,900

The above table highlights that Vermilion County has a slightly higher percentage of residents with high school diplomas and a far lower percentage of residents with higher education than Illinois and the national average.

Vermilion County has a higher percentage of homeownership than the state or national average, but this may be due to the median home price in the county being far lower than the state and national median.

Income Demographics

Community	Household Income	Per Capita Income	Percentage in Poverty
Vermilion County	$52,787	$28,933	17.3%
Illinois	$78,433	$43,198	11.9%
United States	$75,149	$41,261	11.5%

In Vermilion County, the household income and per capita incomes are significantly lower than the state and national median. The county has significantly more residents living in poverty than the state and national averages.

Our primary takeaway is that the demographics indicate that affordability is likely a big issue in the county. Consider the following:

- The county has a significantly lower percentage of residents with a higher education.
- The residents of the county have a significantly lower household and per capita incomes.
- The county has a significantly higher percentage of residents living in poverty.

Low - Income Statistics for the County

HUD collects nationwide data that is often used when awarding broadband grants. The data is used to identify lower-income parts of a community – areas that are often given preference in grants for housing, economic development, and broadband deployment. Following is what HUD says about the study area.

HUD (Department of Housing and Urban Development). The Department of Housing and Urban Development (HUD) was established as a Cabinet Department in 1965. HUD is the federal agency responsible for the national policies and programs that address America's housing needs, enforce fair housing laws, and look for ways to improve neighborhoods with below-average incomes.

HUD Distressed Cities and Persistent Poverty Technical Assistance Program (DCTA)

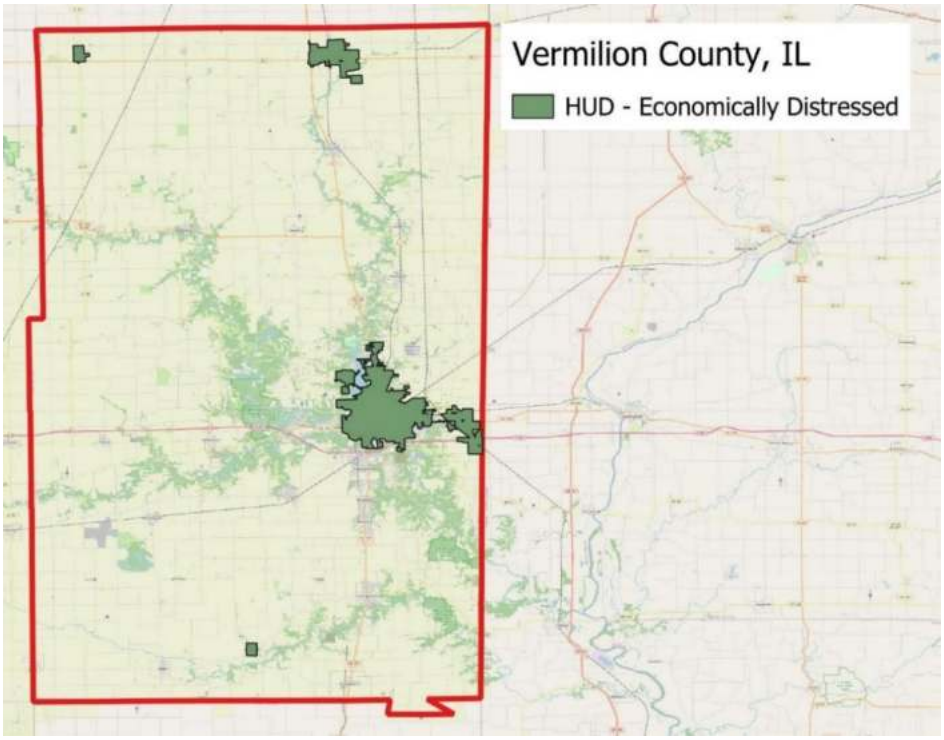
The Distressed Cities and Persistent Poverty Technical Assistance Program (DCTA) is a HUD program that identifies and aids local governments throughout the United States. As part of the DCTA program, HUD identifies two vulnerable categories for smaller communities. The two categories are economically distressed and persistent poverty.

Economically distressed local governments are governments with populations of less than 50,000, have an average unemployment rate of 9% or higher over the past three years using the American Community Survey (ACS) 5-year estimates, a poverty rate of 20% or higher among individuals not enrolled in higher education as of the most recent ACS 5-year estimates, or a population decline of 5% or higher between the 2010 Decennial Census and the most recent ACS 5-year estimate. According to HUD, the cities of Hoopeston and Dansville and the villages of Rankin and Indianola are considered to be economically distressed.

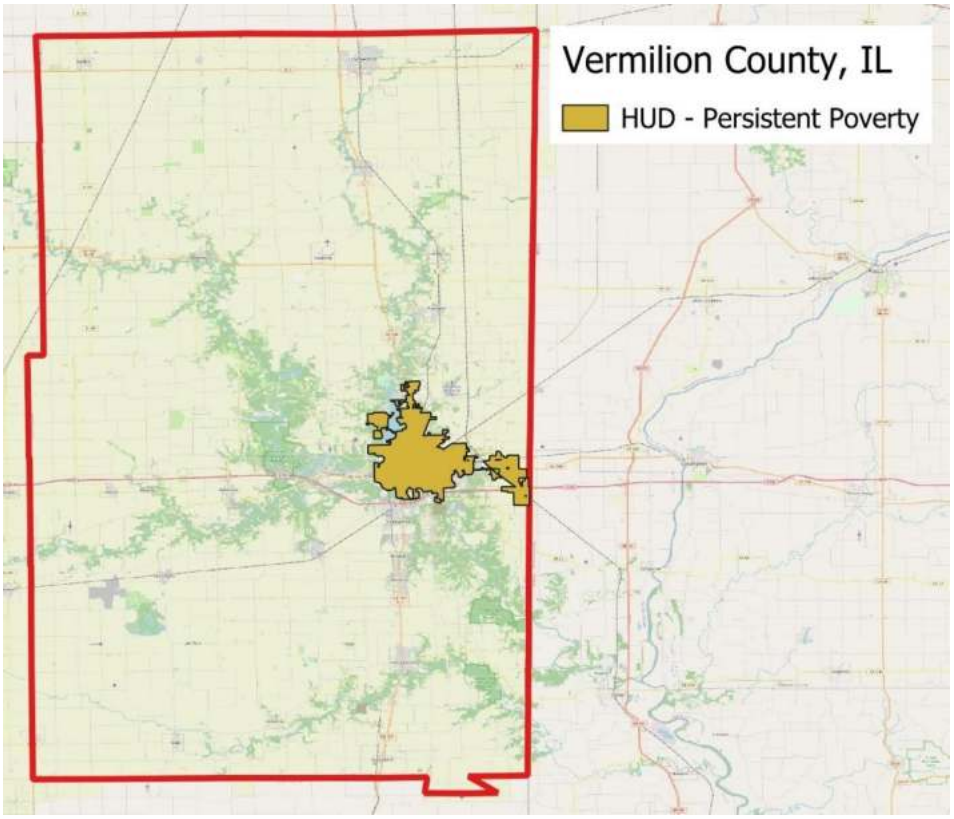
The second category for the DCTA program is persistent poverty. To qualify, local governments must have a population of less than 50,000. Persistent poverty is defined as a census tract with a poverty rate of 20% or higher over the past 30 years. According to the HUD, the city of Dansville is considered to be in persistent poverty.

According to HUD, the cities of Dansville and Hoopeston and the villages of Rankin and Indianola meet the requirement for being economically distressed. The city of Dansville is also considered to be in persistent poverty according to the HUD. This means that any project in these areas will potentially be given a higher priority for grant applications.

HUD Economically Distressed



HUD Persistent Poverty

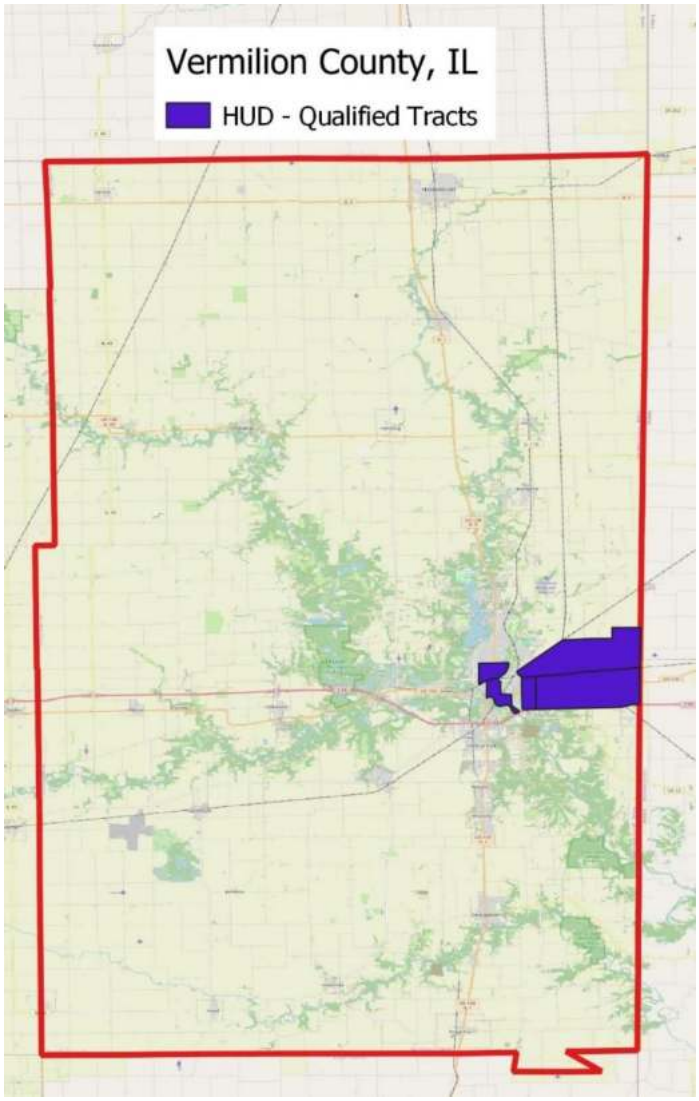


HUD Qualified Tracts

As part of the Low-income House Credit program, HUD identifies Qualified Census Tracts in communities. For a tract to qualify, it must have 50% of households with incomes 60% below the area median gross income. The 60% income standard is determined by:

1. Calculating the average household size of the census tract.
2. Applying the income standard after adjusting it to match the average household size.
3. Calculating the number of households with incomes below the income standard.

HUD uses its Very Low-income Limits to standardize the calculations. HUD then uses a mapping tool to identify areas it labels as Qualified Census Tracts. These areas cannot exceed 20% of the area's total population. In Vermilion County, three Census Tracts have been identified as qualified HUD tracts by meeting the requirement of having over 50% of the population with incomes below 60% of the area's median gross income.



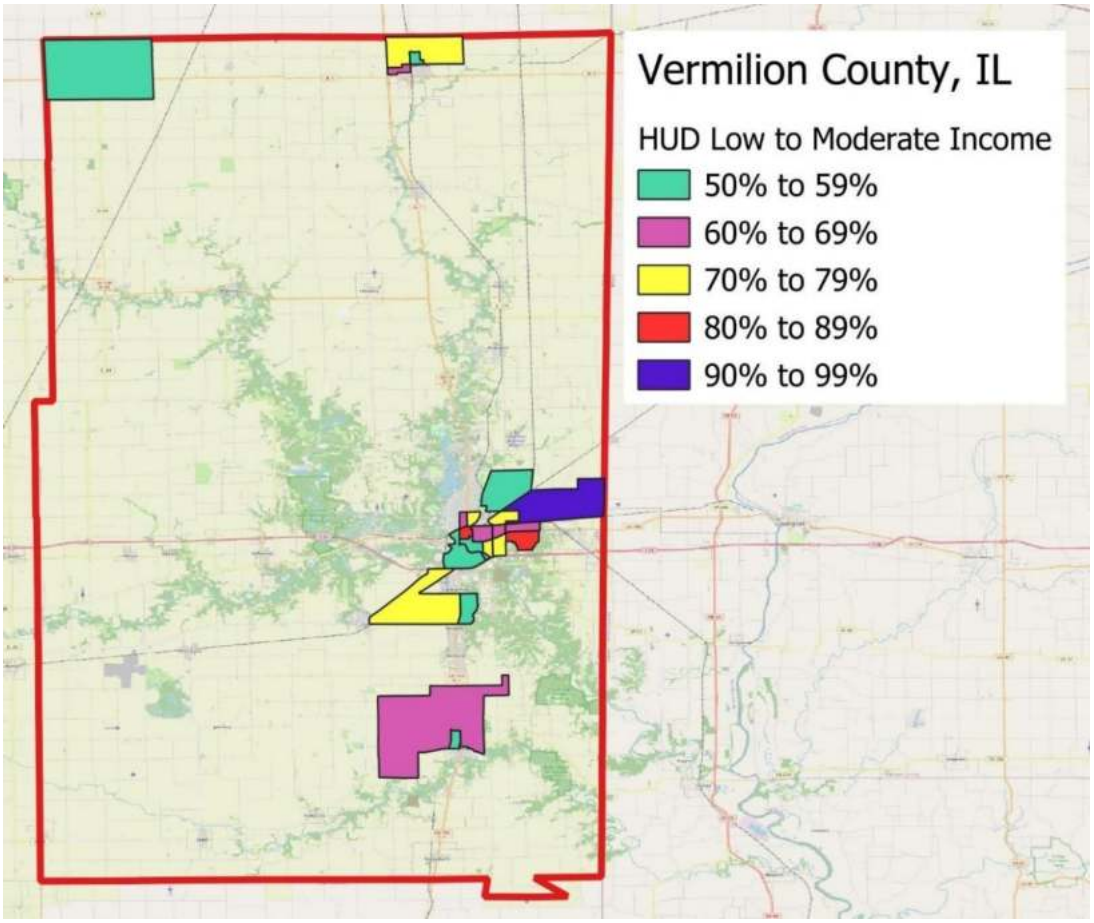
HUD Community Development Block Grant (CDBG). The Community Development Block Grant is a program that must actively benefit low and moderate-income (LMI) persons. The grants can benefit things like housing and jobs. Additionally, services may qualify for CDBG assistance if the activity will benefit all residents of a residential area where at least 51% of the residents are low- and moderate-income persons. The CDBG program is discussed in detail in the funding for broadband networks section of the report.

HUD uses two sources of statistical information to calculate income levels around the country. The first is the American Community Survey (ACS), and the second is the Income Limits for Metropolitan Areas and for Non-Metropolitan Counties.

HUD calculates the area median income for any area of interest and uses the sources to estimate a community's income. Income levels are classified into three categories:

- Low Income (up to 50% of the Area Median Income (AMI))
- Moderate Income (greater than 50% AMI and up to 80% AMI)
- Medium Income (greater than 80% AMI and 120% AMI)

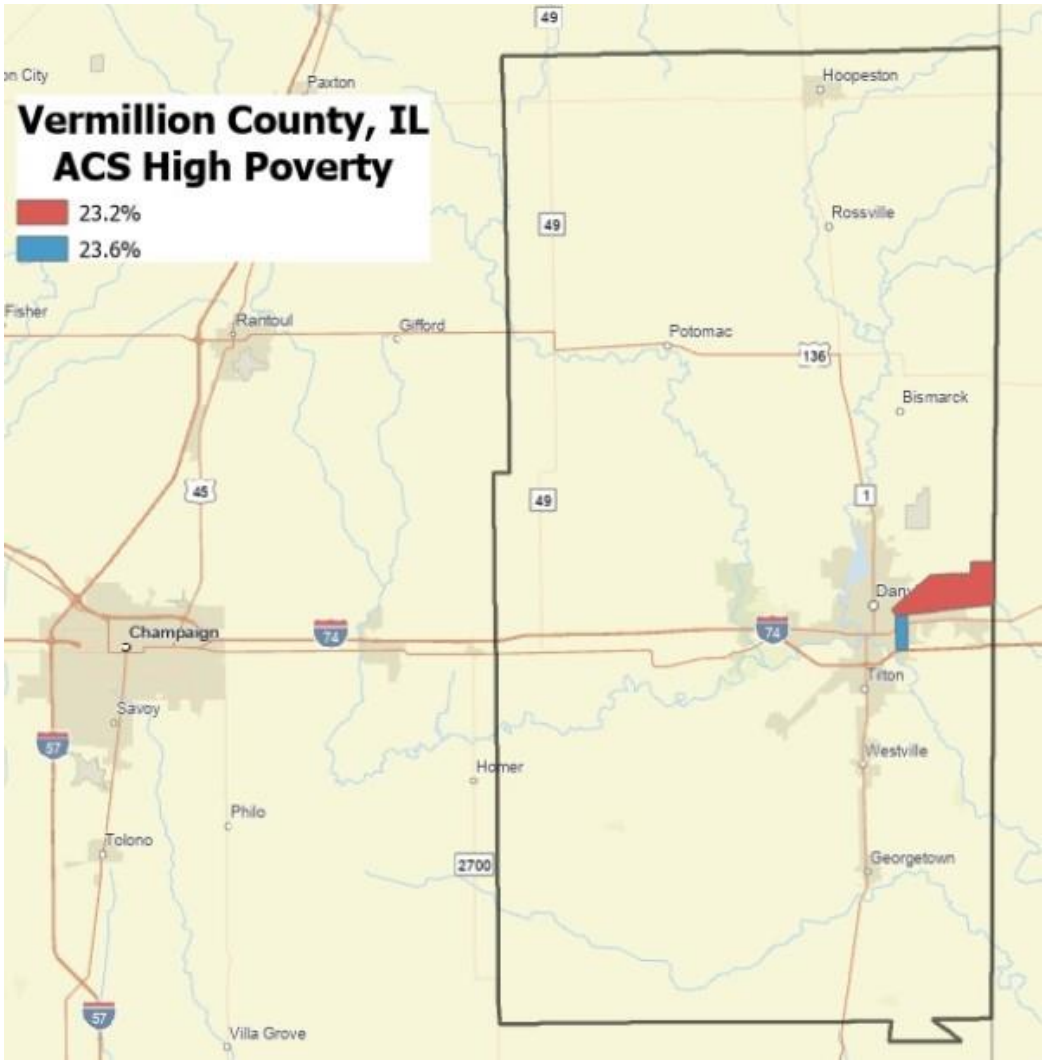
CDBG identifies areas where 51% of the population is considered low or moderate-income. As seen in the map below, HUD has identified parts of the study area as having over 51% of the population as low to moderate-income.



The American Community Survey (ACS) is an ongoing nationwide survey conducted by the Census Bureau that updates information about communities between the 10-year census periods. The ACS gathers information on jobs, occupations, educational attainment, veterans, whether people own or rent their homes, and related topics. The ACS helps local officials, community leaders, and businesses understand the changes taking place in their communities.

ACS Poverty. Household incomes are collected in the ACS survey to measure areas with poverty. This report has detailed the correlation between income and broadband adoption. Census data shows that areas with low incomes often have a lower rate of broadband adoption.

ACS identifies every Census Tract in the county that have over 20% of the population living in poverty. Families are classified as being in poverty if their household income is less than their poverty threshold calculated as a result of the ACS survey. The areas that are considered to have the most poverty are shown on the following map:



The poverty threshold varies by the number of family members. See the table below for the poverty thresholds for the year 2023, which is the most recent year of accessible ACS data.

Size of family unit	Weighted average thresholds	Related children under 18 years								
		None	One	Two	Three	Four	Five	Six	Seven	Eight or more
One person (unrelated individual):	15,480									
Under 65 years	15,850	15,852								
65 years and over	14,610	14,614								
Two people:	19,680									
Householder under 65 years	20,490	20,404	21,002							
Householder 65 years and over	18,430	18,418	20,923							
Three people	24,230	23,834	24,526	24,549						
Four people	31,200	31,428	31,942	30,900	31,008					
Five people	36,990	37,901	38,452	37,275	36,363	35,807				
Six people	41,860	43,593	43,766	42,864	41,999	40,714	39,952			
Seven people	47,670	50,159	50,472	49,393	48,640	47,238	45,602	43,808		
Eight people	52,850	56,099	56,594	55,575	54,683	53,416	51,809	50,136	49,710	
Nine people or more	62,900	67,483	67,810	66,908	66,151	64,908	63,198	61,651	61,268	58,907

Source: U.S. Census Bureau, 2024.

Summary

The demographic mapping and other information we gathered about the county show areas where grants will have a better chance of being funded due to the presence of low-income neighborhoods.

The Computer Gap

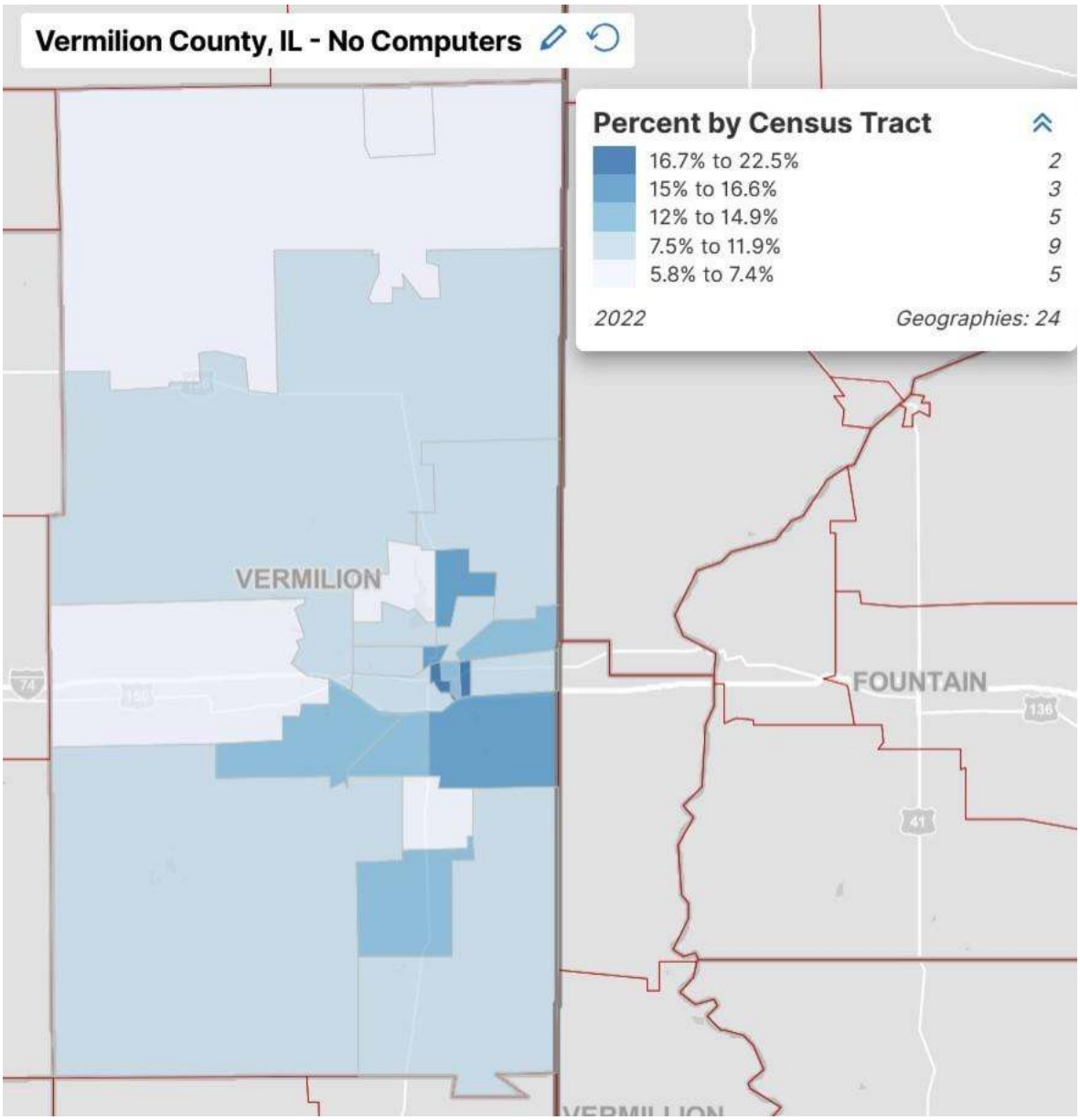
Digital inclusion advocates have learned it is often not enough to get affordable broadband to a home unless residents can afford a computer or other device to use the broadband. It's also now clear that cell phones are good tools for things like shopping online, but they are inadequate for students trying to do homework. Any plan to close the digital divide must find solutions for closing the computer gap.

A survey by the Pew Research Center in 2021 shows a huge disparity between income and technology adoption. Consider the following results of that poll:

	Less than $30,000	$30,000 to $100,000	Over $100,000
Home Broadband	57%	83%	93%
Smartphone	76%	87%	97%
Desktop	59%	84%	92%
Tablet	41%	53%	68%
All the Above	23%	42%	63%

Other studies have shown that the percentage of homes that possess any of these technology tools is even smaller than shown in the table for homes making under $25,000 per year. A big issue for low-income homes is that they can't afford both broadband and the cost of buying and maintaining a computer or similar device. Computers are some of the shortest-lived electronics we can buy and typically must be replaced every three or four years.

We created the following map to show the different levels of computer ownership around the county. This map comes from U.S. Census data from 2020 and shows the percentage of homes that don't have a home computer in different parts of the county. The percentage of homes without computers varies from 5.8% to 22.5% in different parts of the area.



It is a challenge to bring broadband to a home that doesn't have a computer - a solution is needed to bring both. As will be discussed below, many homes also need computer training.

The historical solution to a lack of computers was to put computers in libraries and public places. However, in rural communities, this solution is inadequate for many reasons. First, it requires people to travel to where the computers are. In communities where a lot of students don't have computers, it's

difficult to have enough computers to meet the demand. There is the additional issue that rural libraries often don't have good enough broadband to support multiple simultaneous users.

However, the best reason to get computers into homes instead of libraries is that numerous studies have shown that computers in the home have a huge positive impact on students compared to any other alternative. Computers have the biggest positive impact on students when they are a part of daily life and convenient to use when needed.

A major study quantified the impact on students of not having a home computer. The study was released in March 2020 and was done by the Quello Center, part of the Department of Media and Information at Michigan State University.[19] This is a definite study because it used study techniques that isolated the impact of having home broadband from other factors such as sex, race, and family incomes. The study involved 3,258 students in Michigan in grades 8 – 11 from schools described as being in rural areas.

The study showed significant performance differences for students with and without home broadband. Students with no Internet access at home tested lower on a range of metrics, including digital skills, homework completion, and grade point average. Some of the specific findings include

- Students with home Internet access had an overall grade point average of 3.18, while students with no Internet access at home had a GPA of 2.81.
- During the study, 64% of students with no home Internet access sometimes left homework undone, compared to only 17% of students with a high-speed connection at home.
- Students without home Internet access spend an average of 30 minutes longer doing homework each evening.
- The study showed that students with no Internet at home often had no alternative access to broadband, such as a library. 35% of students with no broadband also didn't have a computer at home. 34% of students had no access to alternate sources of broadband, such as a library, church, community center, or the home of a neighbor or relative.

One of the most important findings was that there is a huge gap in digital skills for students without home broadband. To quote the study, "*The gap in digital skills between students with no home access or cell phone only and those with fast or slow home Internet access is equivalent to the gap in digital skills between 8th and 11th grade students*." Digital skills not only require competence in working with technology but also the ability to work efficiently, communicate effectively with others, and manage and evaluate information. This is a devastating finding that students without home broadband fall three grades behind other students in terms of developing digital skills.

Lower digital skills correlate directly to performance on standardized tests. A student who is even modestly below average in digital skills (one standard deviation below the mean) tends to rank seven percentiles lower on the total SAT/PSAT score, five percentiles lower in math, and eight percentiles lower in evidence-based reading and writing.

The study also showed lower expectations for students without broadband at home. For example, 65% of students with fast home broadband have plans to pursue post-secondary education. Only 47% of students

[19] http://quello.msu.edu/wp-content/uploads/2020/03/Broadband_Gap_Quello_Report_MSU.pdf

with no Internet access have such plans. Students with even moderately lower digital skills are 19% less likely to consider a STEM-related career (science, technology, engineering, and math).

We can't forget that computers aren't only for students. Adults need computers to participate in the modern world. Computers are needed to hunt for a job. Computers are needed to pursue online training and education. Computers are needed to consider jobs that allow working from home. Computers are needed today to interface with many government programs.

The Gap in Broadband Skills

The current U.S. job market is robust due to the low unemployment rate, which is low by historical standards. However, a closer look at the statistics tells a different story.

Over half of all job openings in the country are classified as middle-skill jobs (with the three categories being high-skilled jobs, middle-skill jobs, and unskilled jobs). Middle-skill jobs generally don't require a college degree. An analysis by the Benton Foundation a few years ago showed that over 80% of middle-skill jobs require some degree of digital literacy. Unfortunately, a lot of people seeking middle-skill jobs lack the digital skills needed to land these jobs.

This lack of sufficient digital literacy to find middle-skill jobs is perhaps the best way to describe the broadband skills gap. These are not jobs that need coders but want employees to know basic computer skills like knowing how to use Microsoft Word or Excel. It means being able to type fast enough to do data entry, write emails, or do other expected tasks in the average workplace.

At the turn of this century, there were computer training courses available in most communities that taught basic computer skills. Today it is assumed that students graduate from high school with these skills. However, a student who has never had a home broadband connection or a computer and who only did homework on a cellphone probably doesn't have the needed digital skills. Over time, the number and quality of digital skills training classes have dropped almost everywhere.

There is now hope for solving the computer gap and the digital skills gap. There are now significant state and federal grants aimed at closing these gaps by providing computers for homes and the training to use them. These grants will be discussed in more detail in the report that discusses grant opportunities.

The Competition Gap

Like most counties in the country, there are still a lot of places in the county that don't have competition between two or more ISPs that offer broadband faster than 100/20 Mbps. This study focuses on bringing fast broadband to the rural areas that don't have fast broadband – but those areas will likely also only have one fast ISP after grants are awarded.

Why does this matter? It is becoming clear nationwide that the majority of people and businesses want fast broadband. There has been a huge shift in customer demand for faster speeds. People also want competition and choice. The public generally believes that competition brings lower prices and better service. However, there are very few places in the county where there are two or more ISPs offering speeds faster than 100 Mbps. This means that almost the entire county has little or no real competition.

There are ISPs that will dispute this fact and say that most folks have multiple choices of ISPs. This is backed up by the FCC broadband maps. If you look at most homes and businesses on the FCC maps, there are multiple ISPs that claim to be able to serve any given address. But when you look harder at the details, you'll see that most broadband options other than cable or fiber broadband or fiber can't deliver the fast speeds that most residents and businesses are looking for. The FCC maps often show the following competitors:

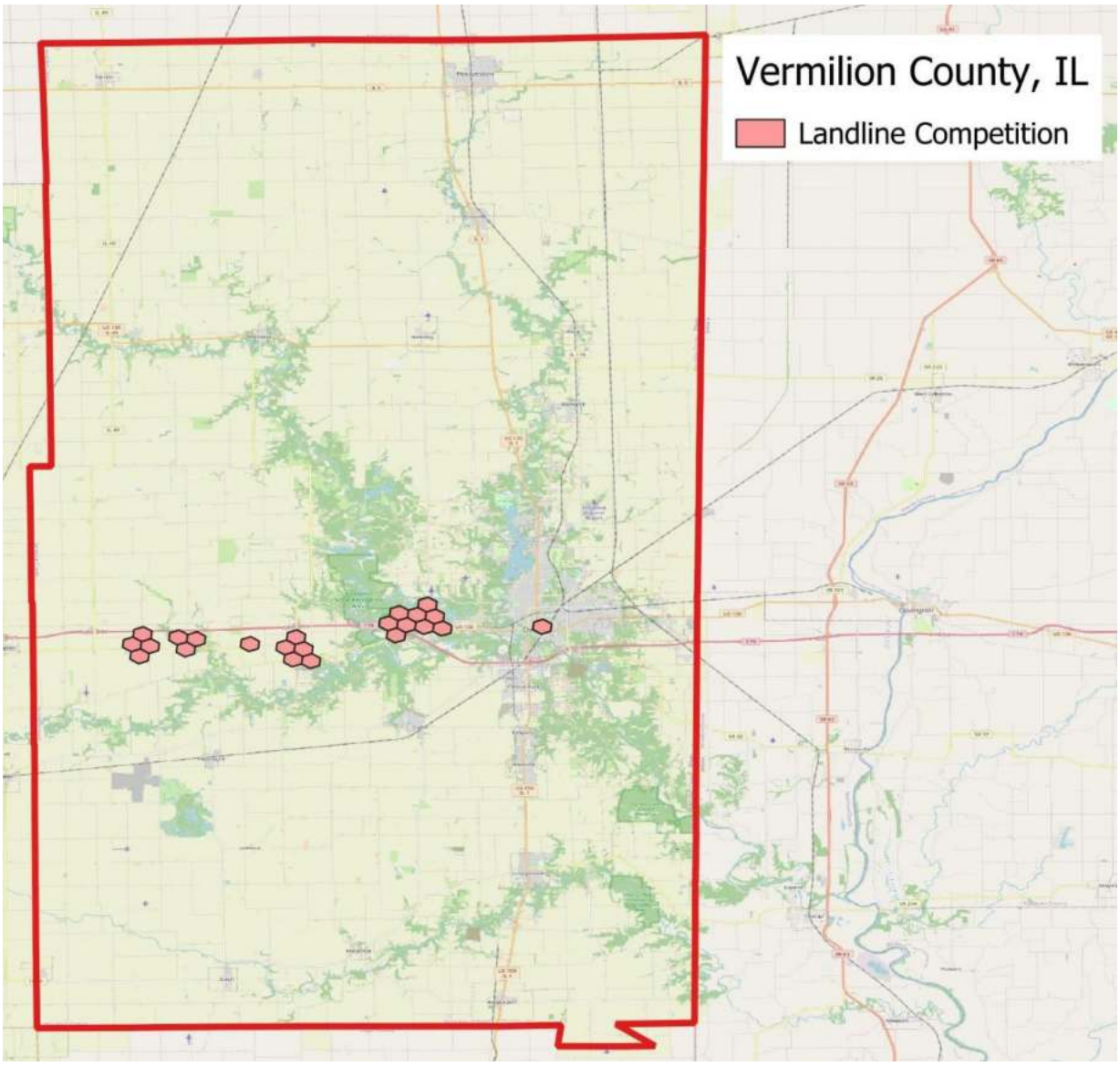
- There are likely two high-orbit satellite providers listed as an option for most homes and businesses. Most people who have tried the broadband from Viasat and HughesNet find that the latency in the signal from a satellite that is 22,000 miles above Earth means that it's hard to do real-time functions like stream live video, maintain a Zoom call, or connect to a work or school server. Speed tests for these companies are also consistently under 100 Mbps.
- Starlink will be listed as a broadband option. The speeds on Starlink have dropped steadily over the last few year, and the average speed tests we see for the company in most places is between 50 Mbps and 70 Mbps. Interestingly, there some Starlink speed tests at much faster speeds. We assume the fast speeds only happen when a satellite is directly overhead and isn't being used by a lot of customers at the time of the test.
- There are three WISPs in the county using licensed fixed wireless broadband. Rise Broadband claims speeds of 25 and 50 Mbps. MF Wireless claims speeds of 25, 50, and 100 Mbps speeds. WATCH Communications claims speeds of 10 and 100 Mbps. Surf Internet offers speeds of 25 Mbps. Even as the technology gets faster, fixed wireless technology is mostly a rural technology and won't be bringing faster speeds to the towns and cities.

We can't find more than a handful of places in the county where there is more than one competitor offering a speed of 100/20 Mbps or faster. This means that most of the county has what we call a competition gap – where people don't have a choice between multiple fast ISPs. Consider the following:

- The only two fast landline technologies in the county today are hybrid fiber-coaxial networks operated by Sparklight, Comcast, and Conxxus and fiber technology deployed by AT&T and Conxxus.
- There are a few places in the county where there are two fast wireline providers. There are also pockets of fast broadband offered by T-Mobile using FWA cellular technology. The fast broadband coverage for this technology is generally for an area within two miles of a tower.

This first map shows the area where there are two competing wireline ISPs, meaning a cable company competing against a fiber ISP.

- In Danville and the surrounding area of Hillery, customers can purchase fast landline broadband from AT&T and Comcast.
- In Oakwood, Fithian, and Muncie, customers can purchase fast landline broadband from Pavlov Media and Comcast.

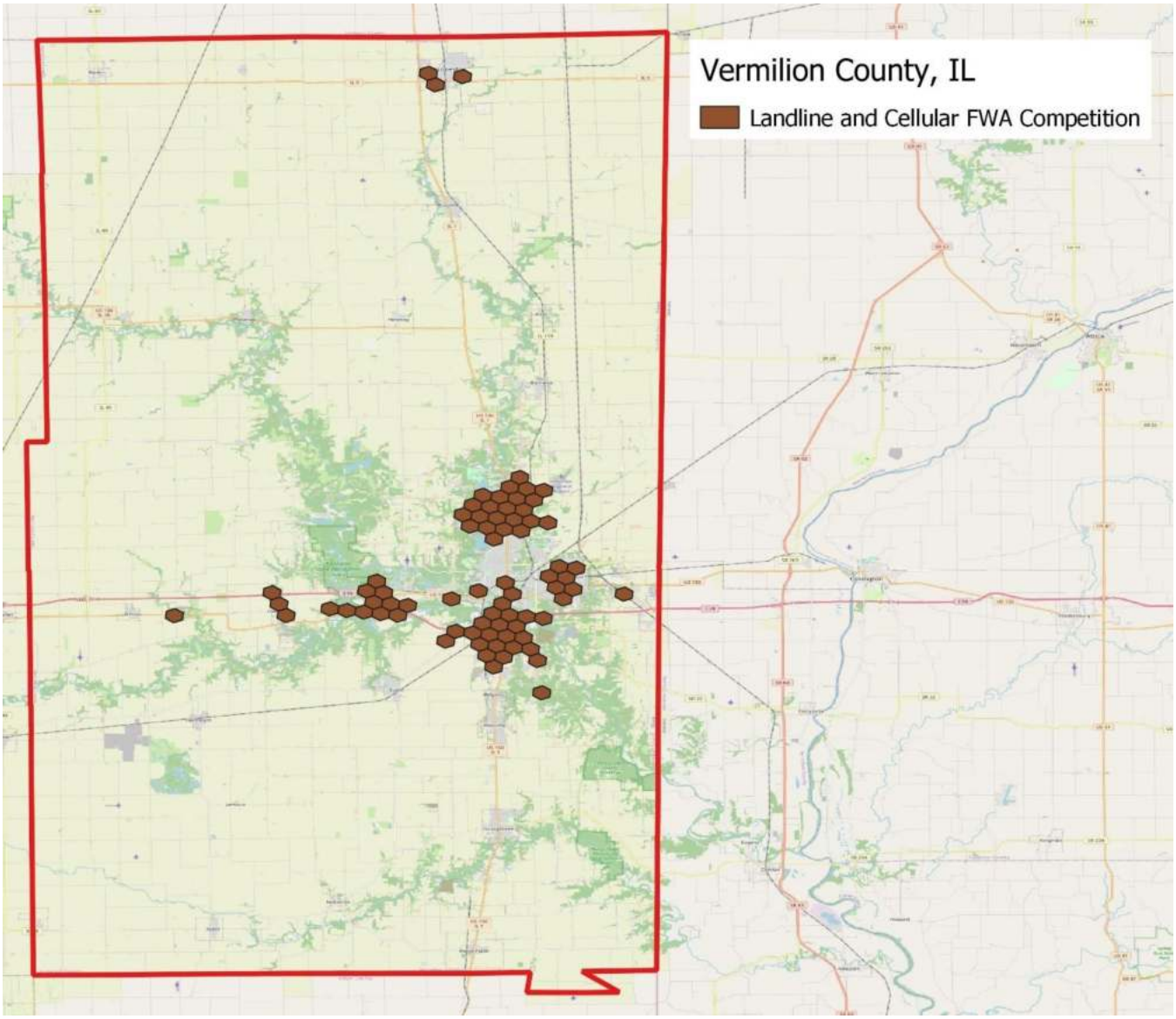


This second map layers on competition provided by T-Mobile and Verizon FWA cellular where speeds are claimed at 100/20 Mbps speeds or faster. These maps show a higher degree of competition when considering FWEA cellular. However, that technology is not capable of serving every customer. For example, T-Mobile recently said it has one million customers on a waiting list for FWA service. Both T-Mobile and Verizon use excess cellular capacity to serve FWA customers. However, the companies will not sell so much FWA at a given cell site that would lower the quality of cell phone data – which is the primary product for both companies. The map exaggerates the level of competition between the two technologies.

There are a few areas in the county that receive both fast landline and cellular broadband.

- Customers in Danville can purchase broadband from AT&T, Comcast, Verizon, and T-Mobile.
- Customers in Hoopeston can purchase fast broadband from T-Mobile and Sparklight.
- Muncie Village customers can purchase fast broadband from Comcast, Pavlov Media, and AT&T FWA.

- Oakwood Village can purchase fast broadband from Comcast, Pavlov Media, and T-Mobile.
- Customers in Tilton Village can purchase fast broadband from Comcast, Sparklight, or Verizon.



Why Choice is Important

There are real consequences for any neighborhood that has only one fast ISP. Such neighborhoods have no competitive options, and the one fast ISP is effectively a broadband monopoly in that community. There are clearly documented consequences of being served by ISPs that have a virtual monopoly.

Broadband competition between ISPs of equal capabilities brings tangible and well-known benefits to a community. These benefits don't occur when the one fast ISP is competing against slower technologies like DSL. CCG Consulting has seen the following benefits for communities that get real competition between two or more ISPs that offer gigabit speeds:

- Lower Prices. For many years, the conventional wisdom was that competition lowers prices by at least 15%. That was based on several detailed studies done in the early days of fiber overbuilders. While the 15% savings is no longer a valid metric that can be used everywhere, it's rare when competition doesn't bring lower prices. Cable companies react to competition by offering low-price special promotions.
- Improved Customer Service. When a new competitor moves into an area that was previously a monopoly, it's almost inevitable that the former monopoly will step up its game. Calls to customer service get answered more quickly, technicians start showing up at the times that were promised, and repairs are made more quickly.
- Technology Upgrades. When fiber overbuilders started to build networks to compete against cable companies, the big cable companies put a lot of pressure on CableLabs, the research arm of the collective cable companies. When Google Fiber introduced gigabit speeds, most cable company networks had speeds that topped out at 250 Mbps download, and the most common broadband product sold delivered 60 Mbps. CableLabs accelerated the introduction of DOCSIS 3.1, and cable companies upgraded competitive markets as quickly as they could to offer gigabit download speeds. When the pandemic struck and suddenly created an upload bandwidth crisis, the cable companies put the same pressure on CableLabs to increase upload speeds. The ultimate upgrade will be DOCSIS 4.0, which is probably still a few years away from being market-ready. In the interim, CableLabs came out with a reasonable-cost upgrade to upload speeds using mis-split technologies. This increases upload speeds to the range of 100 - 200 Mbps, and the big cable companies are currently installing the upgrade in competitive markets.

  These two technology upgrades were implemented much sooner than would have happened without the rapid expansion of fiber. For example, most cable markets had been upgraded to gigabit speeds within a year or two before the start of the pandemic. At that time, big cable companies universally said they thought they wouldn't make any more upgrades for at least a decade. However, the pandemic and the explosion of fiber construction happened, and big cable companies are almost universally upgrading upload speeds and have plans for more upgrades when DOCSIS 4.0 becomes available. These upgrades aren't happening everywhere. The big cable companies don't necessarily make upgrades in smaller cities like rural county seats unless there is an active fiber overbuilder. CCG has run across some rural markets of Comcast and Charter that still haven't been upgraded to gigabit speeds. Competition pushes innovation and upgrades.

What Can the County Do to Promote Competition?

The only way to increase competition is to get ISPs to build competing networks in places where there is only one ISP today. This can take a lot of effort, but we see communities all over the country that are attracting competition. Following are a few ideas on how the County might help increase competition.

Work With Cities to Attract Fiber Overbuilders. One approach is to work with any towns or cities that don't yet have fiber to help them attract a fiber overbuilder. This feasibility study concentrated on the unserved and underserved parts of the county. Cities can consider a similar process to gather the facts needed to attract a fiber overbuilder. It's not mandatory for a city to undertake a full feasibility study, but some might want to do some research to get an in-depth understanding of the broadband in the city before tackling a search for an ISP partner.

Even without a feasibility study, a city will need to ask and answer a lot of questions before undertaking a search for a new ISP:

- How much do the residents care about broadband, and do a lot of them want a competitive option? This probably means a survey at the city level.
- What's the approximate cost to build a fiber network in the city? Are there factors in a city that might contribute to a new network costing more than average? This might mean existing utility poles that are not adequate or factors that make burying fiber more expensive than normal, such as a lot of rock under streets and sidewalks. This requires some engineering analysis and advice.
- Are there local policies that are barriers or that increase the cost of building fiber? This means looking at things like the permitting process, construction inspection processes, rights-of-way, or franchise fees.
- Is the city willing to contribute towards the cost of a network? Is a city willing to excuse any of the normal fees associated with building a new network? Are there benefits a city might offer, such as being an anchor tenant on a network, providing land or building space, etc.?

If a city decides it wants to undertake finding an ISP, there are several processes that can be used for the search. The most common approach is to issue an RFI or RFP looking for an ISP partner – but there are other ways. That process is described later in this report.

Provide Infrastructure to Make it More Attractive to Build Last-Mile Fiber. One way to lure ISPs by building middle-mile fiber to reach neighborhoods that are lacking competition. This might be something to consider if the BEAD grants don't attract the kind of broadband that is needed in the rural areas.

There are other reasons to consider building a middle-mile fiber. A lot of counties have built fiber networks to satisfy local government purposes. A middle-mile network might be built to connect to County facilities, to connect to the government hub in each city, and to be built near important anchor institutions like schools, hospitals, 911 centers, public safety networks, etc. There can be big advantages to having a private network for the County and cities:

- Savings. There can be significant savings from what is being spent with existing ISPs for broadband when connections are moved to a private network. As an example, rather than buying individual broadband connections to each County facility, you could buy one large broadband connection and distribute it yourself to each location. The ultimate savings come if the County can act as its own ISP and not have to pay outsiders for broadband. Many communities have made the transition and say that the savings repaid the cost of the network in ten years or less.
- Redundancy. Increasing community redundancy, in this case, means having a second broadband connection so that the County and key facilities don't lose broadband if there are network outages. One of the most dramatic examples of this concept comes from several counties in Colorado that joined together to build a middle-mile network because the communities had suffered through several multi-day broadband outages when the regional CenturyLink network went down. Just a few days after the first legs of the new network were activated, CenturyLink had another major outage, but the hospital and the 911 center in Aspen did not lose connectivity because they were the first places connected to the new network. Since that early start, a dozen communities have moved mission-critical facilities to the new fiber network.
- Consolidation of Duplicative Networks. If designed right, a countywide middle-mile network could incorporate and supplement existing networks used for roads and traffic, schools, public safety, etc.

- Large Bandwidth. One of the advantages of having a County-owned fiber network is that it can provide large bandwidth to your County facilities at little extra cost. A decade ago, CCG Consulting helped Anoka County, Minnesota establish a middle-mile network. This was one of the first local networks to provide 10-gigabit connections to schools and government buildings. A network built today would probably be designed to provide 100-gigabit broadband.
- Collaboration. One of the biggest benefits of larger-scale government networks is not just the broadband-related benefits but the mindset changes that can come when local governments start sharing a common network. For example, every city operates a lot of different software systems to provide government services, and there can be huge savings for buying and operating these systems for multiple cities. We've also seen counties able to lower the cost of IT functions by consolidating this so that each local government doesn't have to cover its own costs. In today's world of having to protect against malware – an approach for the whole county is a lot more cost-effective and safer than each city seeking its own solution.
- Benefit for Related Entities. A countywide network doesn't have to only benefit government entities.
    - ISPs. The earlier discussion started with the idea that middle-mile fiber might encourage more last-mile fiber construction. We've seen communities where small ISPs tackle tiny pockets of homes, only a few hundred – something that could be made possible with affordable middle-mile connections.
    - Non-profits. Many local governments extend government-owned networks to benefit the non-profit community.
    - Economic Development. Having your own network could bring in the option of offering free or low-cost fiber connections for companies bringing new factories or other large employment opportunities.
- Wholesale Revenue Opportunity. There are carriers and others that will be interested in leasing the use of a middle-mile network. This might include cellular carriers, existing ISPs looking for redundancy, state and federal agencies, large corporations, and nationwide fiber network providers. Over time, you'd be able to sell capacity on the network to such entities.

Future Broadband Gaps

The gap analysis above discusses existing broadband gaps. It's important to realize that there will be new broadband gaps coming in the future that we can already predict. One of the issues to consider when looking forward is that the need for good bandwidth is a moving target since the demand for residential and business bandwidth grows every year. This is not a new phenomenon, and the need for bandwidth has been growing at the same rate since the early 1980s.

As an example, 1 Mbps DSL felt really fast in the late 1990s when it was introduced as an upgrade from dial-up Internet. The first 1 Mbps DSL connection was 20 times faster than dial-up, and many people thought that speed would be adequate for many years. However, over just a few years, households needed more speed, and a 1 Mbps connections started to feel too slow; ISPs introduced faster generations of DSL and cable modems that delivered speeds like 6 Mbps, 10 Mbps, and 15 Mbps. Cable modem speeds continued to grow in capacity and eventually surpassed DSL, and in most cities, cable companies have captured the lion's share of the market by offering gigabit speeds.

Bandwidth requirements are continuing to grow. Firms like Opensignal track speeds achieved by large numbers of households by examining Internet traffic that passes through the major Internet hubs. Both companies estimate that home Internet demand for broadband speeds has historically been growing at about 21% annually. Business requirements for broadband speeds have been growing at 23% annually.

This report discussed earlier how the FCC set the definition of bandwidth speed in 2015 at 25/3 Mbps. If 25/3 Mbps was an adequate definition of bandwidth in 2015, then growing the need for faster speeds by 21% annually would result in the following speed requirements.

Download Speeds in Megabits / Second

2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
25	30	37	44	54	65	79	95	115	139

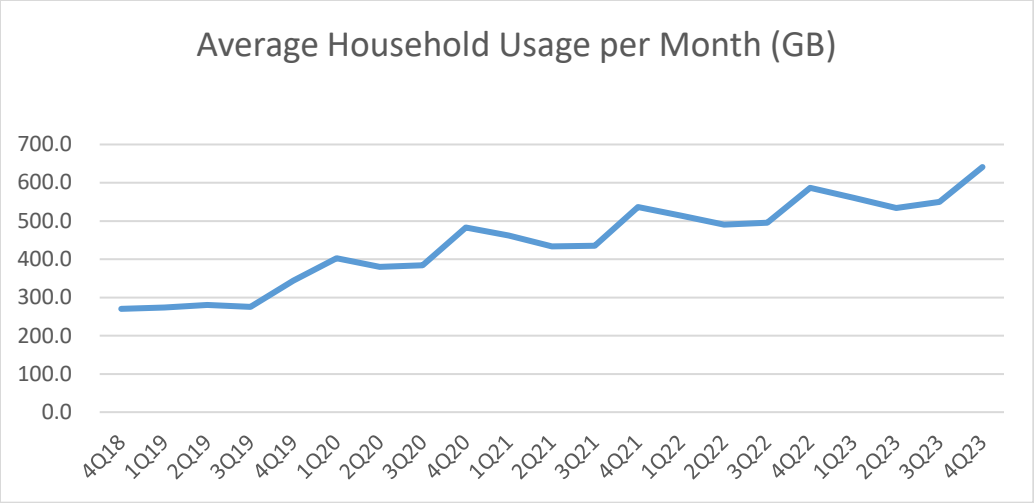
This is somewhat arbitrary because it assumes that the broadband requirement in 2015 was exactly 25 Mbps. However, it pretty accurately predicts that we should have been talking about changing the definition of broadband to 100 Mbps in 2022 – something that happened. Because of political issues, the FCC didn't get around to changing the definition of broadband to 100/20 Mbps until 2024.

Broadband is not only measured by speed, and there are firms that track the volume of data that households and businesses use. The firm OpenVault measures total usage using software deployed by the biggest ISPs around the country and around the world. Consider the following statistics that show the average nationwide broadband usage per customer. These numbers combine download and upload usage.

1st Quarter 2018	215 Gigabytes
4th Quarter 2018	270 Gigabytes
4th Quarter 2019	344 Gigabytes
4th Quarter 2020	483 Gigabytes
4th Quarter 2021	536 Gigabytes
4th Quarter 2022	587 Gigabytes
4th Quarter 2023	641 Gigabytes

This data shows several things. First, it shows extraordinary growth in the average use of home broadband usage across the country. Even before the pandemic, broadband usage was growing rapidly. For example, there was a 27% increase from the end of 2018 until the end of 2019. Usage skyrocketed during the pandemic, and in 2020, broadband usage grew by 40%. In 2023, growth slowed to 9%.

The following chart shows the same data, by quarter, since 2019. As can be seen, the overall trend for broadband has been steadily upward. The amount of usage measured at the end of quarters varies due to explainable factors. For example, at the end of June, most students are out of school, and broadband usage is less than during the school year.



OpenVault recently began reporting upload and download usage separately. The table below shows the download and upload data usage from December 2020 to September 2023. The table below shows that data usage (in gigabytes) fluctuates from quarter to quarter and spikes during the 4th quarter.

	Download	Upload
4th Quarter 2020	483 GB	31 GB
4th Quarter 2021	504 GB	32 GB
4th Quarter 2022	551 GB	35 GB
4th Quarter 2023	601 GB	40 GB

OpenVault also tracks download usage by businesses and homes separately, as shown below:

	Gigabytes per Month	
	Business	Home
4th Quarter 2018	111	276
4th Quarter 2019	146	350
4th Quarter 2020	227	489
4th Quarter 2021	263	543
4th Quarter 2022	309	596
4th Quarter 2023	345	652

Admittedly, the growth in 2020 was extraordinary due to the pandemic. But there is no question, just like with the bandwidth speeds, that broadband usage has been growing for both homes and businesses. For the last five years, business broadband usage grew by 311% (25.5% per year), and home broadband usage grew by 236% (18.8% per year).

Another interesting statistic from OpenVault is what they call power users – homes that use more than one terabyte of data per month (1,000 gigabytes). Consider the following statistics showing the percentage of homes that use a terabyte or more of data per month. OpenVault recently predicted that by the end of 2024 that 30% of homes might be using a terabyte of data each month.

4th Quarter 2018	4.0%
4th Quarter 2019	7.2%
4th Quarter 2020	14.1%
4th Quarter 2021	16.1%
4th Quarter 2023	21.6%

Within these numbers are also what OpenVault calls extreme power users, which are households that use more than two terabytes of data per month. That's grown from 0.3% of households in 2019 to 2.1% in the first quarter of 2022. In the fourth quarter of 2023, the percentage of households using two terabytes of data grew to 4.7%.

One of the most interesting statistics is the migration of customers in recent years to faster broadband tiers. The following table shows the percentage of nationwide households subscribed to various broadband speed plans from 2019 through 2023.

	4Q 2019	4Q 2020	4Q 2021	4Q 2022	4Q 2023
Under 50 Mbps	23%	12%	9%	7%	6%
50 - 99 Mbps	24%	9%	8%	13%	4%
100 - 199 Mbps	37%	51%	37%	12%	16%
200 - 499 Mbps	11%	16%	28%	32%	34%
500 - 999 Mbps	4%	4%	10%	10%	7%
1 Gbps	3%	9%	26%	26%	33%

At the end of 2019, almost half of all broadband households were subscribed to speeds under 100 Mbps. In 2019, only 3% of households subscribed to gigabit Internet. The change over four years has been astounding, with a third of all households subscribing to gigabit broadband. There are a number of reasons for the big surge in the desire for faster broadband:

- The biggest reason is that cable companies have unilaterally increased speeds for customers. A customer who was buying a 100 Mbps package from a big cable company in 2019 has likely been increased to 300 Mbps.
- The pandemic sent people home to work, and many of them found that they didn't have enough speed to function. While the culprit was likely the upload speeds, this led many households to upgrade to faster packages.
- Homes with online gamers seem to always want faster and faster broadband. They really want better latency, but they upgrade speeds looking for a better connection.

OpenVault also validates what's been reported widely by ISPs – that the pattern of broadband usage is changing by the time of day. For the last decade, the peak period for broadband usage – the busy hour – was always in the evenings. During the pandemic, the volume of usage in the evenings remained flat, while students and home workers increased broadband usage during the daytime.

OpenVault says that nationwide broadband usage peaked in the third week of March 2020. It will be interesting to see how home usage changes in the future. OpenVault doesn't have any better crystal ball than the rest of us, but they are predicting that broadband usage will never return to historical patterns.

They predict that a lot of people will continue to work from home, meaning increased broadband demand during the day. They believe there will be continued pressure on the upload data paths. A lot of people now routinely use video calling, a practice that is likely to continue into the future. Companies and employees who realize they can be productive at home are likely to work more from home, even if only on a part-time basis.

One takeaway from this section of the report is that we shouldn't get hung up on the FCC's definition of broadband when looking at the broadband gap. Most people who use broadband would acknowledge that they download and upload a lot more data today than they did just a few years ago.

It's also important to look toward the future when considering broadband needs. For example, if an ISP builds a new broadband solution today, that solution should be prepared to handle the broadband requirements a decade from now. Consider the following chart that predicts broadband needs moving forward. The chart applies the 21% historical annual growth rate for broadband speed, assuming that 100 Mbps is the right definition of broadband in 2022. Forward-looking predictions are often criticized for being too aggressive, but when considering that the demand for broadband speeds has been growing at the same rate since the early 1980s, it is not a big stretch to predict broadband needs into the future.

Download Speeds in Megabits / Second

2022	2023	2024	2025	2026	2027	2028	2029
100	122	149	182	222	271	331	405

This chart implies that we should be talking about increasing the definition of broadband to 500 Mbps download by 2030. That doesn't mean that the FCC will continue to increase the regulatory definition. There is a political downside when the FCC increases the definition of broadband – it reclassifies millions of homes as not having broadband. Politics is always likely to keep a lower regulatory definition than what the market is experiencing.

The download speeds in this table get really large if extended even further into the future. If the demand for broadband download speed continues to grow at 21% annually, then the need in 2040 would be 2.9 Gbps. It's easy to think that such future speeds are not possible but recall that just 20 years ago, a 1 Mbps DSL connection was considered to be blazingly fast broadband. The only current technologies that can keep up with this growth in demand are fiber and cable company coaxial networks. Today's fiber gear can deliver 10 Gbps download speeds, and coaxial networks are expected to have the same capabilities within five or six years.

For a cable company to meet future speed demands would require several major technology upgrades. DOCSIS 3.1 networks can deliver download speeds up to a gigabit today. However, the secret that cable companies don't want to talk about is that they can't give that much speed to everybody unless they build a lot more fiber and further reduce node sizes. This will mean upgrades to DOCSIS 4.0 to get speeds faster than 1 gigabit. Cable companies are already failing to meet the demand for upload speeds.

It's not hard to put this prediction into perspective. The large cable companies serve around 65% of all broadband customers in the country, and almost all now advertise a minimum speed of 200 Mbps or 300 Mbps. The marketing departments at cable companies have regularly been keeping ahead of the demand curve to keep customers happy.

One of the conclusions that can be reached by this analysis is that any new network built today ought to be capable of meeting the expected broadband speeds for the next decade. The only technologies capable of meeting the projected future needs for download bandwidth are fiber-to-the-premise and cable company hybrid-fiber technology. Cable companies are only going to be able to provide speeds above 1 gigabit by implementing another round of expensive upgrades. There is a lot of speculation in the industry that cable companies will upgrade to fiber-to-the-home rather than make another expensive upgrade on old copper.

II. ENGINEERING DESIGN AND COST

A. Existing Provider Analysis

Our analysis began with an internal review of available broadband mapping data followed by a field reviews in Vermillion County on October 15th-18th, 2024, by Sam Tennant of Finley Engineering. The final competitive analysis incorporates this fieldwork when determining the broadband deployment in the county. The purpose of the field review is to examine and understand existing broadband infrastructure that has been deployed in the county.

Finley's internal review reviews existing broadband data reported to the FCC using detailed speed reporting and technology codes contained in the FCC's broadband maps for December 31, 2023. We also reviewed all open and awarded State and Federal Funding locations to understand where broadband infrastructure may have been installed or will be deployed in the near future. Finley also examined the detailed Ookla speed tests which were gathered by location and ISP using data from August 2023 through August 2024.

Finally, we tried to interview all of the ISPs operating in the county prior to our field review. Our goal was to learn more about their network capabilities, their construction plans, and to let them know we are coming to the county. We contacted every ISP, and only Frontier, Nextlink, Xfinity, and Pavlov Media agreed to an interview with us.

We used all of the internal analysis to decide where to focus the field review. The data we gathered was compiled to create a GIS map for the Vermillion County field review. This analysis identified fifty-six specific locations where we wanted to verify existing infrastructure.

We drove extensively through Vermillion County to examine existing infrastructure supporting broadband, such as electronic sites supporting broadband in the ATT, Conxxus, Xfinity, Consolidated Communications, Frontier, and Sparklight. The in-person field review allowed us to see the deployed technology used by each ISP. Understanding the existing gear, vendors, and condition of the current networks enable us to understand the reliability of the networks serving residents today.

During the field review we were also able to examine the physical infrastructure in the county. For example, we could see where current wires and cables are buried or placed on poles. We were able to see the general condition of utility poles, something that is useful for us when we make an estimate of the cost of building broadband in the county.

The following summary of our visit is a review of what we found for various ISPs in terms of existing network, planned network expansions, and whether they have the technological capability to provide broadband speeds greater than 100/20Mbps (which is the current definition of served).

Many of the providers expressed an interest in applying for BEAD or other broadband grants in the county. Almost every ISP mentioned that they would need financial or other support from the county due to the high cost of building rural broadband. Several pointed out the rocky nature of much of the soil and terrain in the county.

AT&T

AT&T primarily serves the east-central portion of the county serving the cities of Danville and Tilton along highway 136, 150, and 74. They use a mix of technologies in this area. They mostly have deployed a traditional DSL copper network, have upgraded some places to fiber, and recently have begun to provide broadband using licensed cellular spectrum.

While some customers living close to a DSL node can get speeds as fast as 100 Mbps on DSL, the average DSL speed on Ookla speed tests was 41/6 Mbps. Even where download speeds reach 100 Mbps, the upload speeds would not qualify customers as served by broadband. The average speed tests on the cellular FWA wireless were much faster at 142/69 Mbps. Fiber is being advertised as capable of 5 Gigabit symmetrical. AT&T did not agree to an interview, and we don't know if the company has any upgrade plans.

DSL Cabinet (E Williams St.)

DSL Cabinet (South Danville)

Frontier

Frontier is the incumbent telephone company in the northern part of the county. In the interview they indicate the company currently offers internet services primarily over existing buried copper cables with a combination of legacy ADSL, ADSL2+, and VDSL equipment. The faster DSL technology is offered in several small towns served by the company. The cities served by DSL are Rukin, Pellville, East Lynn, Rossville, Armstrong, Potomac, Henning, Bismark and Collison.

The company reports speeds to the FCC that range between 10 Mbps and 115 Mbps download. Ookla speed tests showed an average speed of 33/14 Mbps.

In the interview Frontier indicated that some fiber upgrades are planned for the area. Moving forward, all fiber upgrades will use XGS-PON technology which is capable of providing 10 gigabit symmetrical service. At this point they said they are probably not interested in BEAD grants but plan to privately fund fiber upgrades in some of the towns. The current Frontier network is mostly aerial on poles, and they would hope to deploy fiber aerially as well.

Buried Transport Fiber

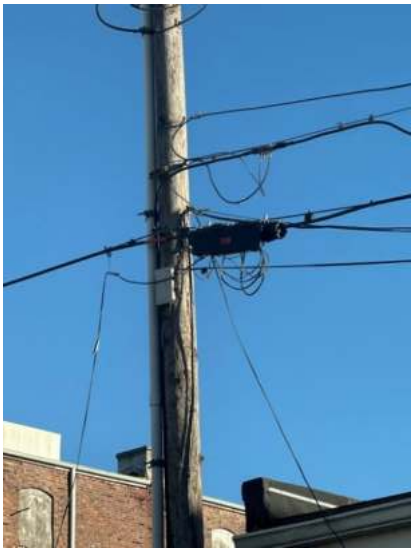
Central Office

Xfinity (Comcast)

Comcast currently deploys hybrid fiber-coaxial ("HFC") technology in the county. This technology builds fiber into neighborhoods to reach a serving node where optical signals are converted to electrical or radio frequency for distribution over the coaxial network to subscribers. Households and businesses can access Comcast's full suite of products and services, including broadband at speeds ranging from 50 Mbps to 1.2 Gbps and voice, video, cellular, and home security services. Comcast currently provides service in Danville, Fairmount, Fithian, Georgetown, Indianola, Muncie, Oakwood, Olivet, Ridge Farm, and Tilton

Ookla speed tests show average speeds of 318/25, which are considered as served. We found a few speed tests with speeds under 100/20 Mbps, but we don't know if those speeds are from customers who purchased a broadband package with speeds less than 100/20 Mbps or from customers with technical issues.

Aerial HFC Fiber (Danville)



Pavlov Media

Pavlov Media is a fiber-to-the-home provider for businesses and residents in various parts of the county. They were kind enough to speak with us about their current network and expansion plans within the county. During our field review, we did not take photos of their underground infrastructure but have ensured their ability to surpass the 100/20-speed threshold through other conversations. At this time they are interested in pursuing grant funding opportunities with the intention to partner with the county.

B. Issues That Affect Broadband Performance

There are several factors other than speeds that affect the quality of a broadband connection. It's easy to take a simplistic view and assume that all broadband signals are the same – that a 100 Mbps connection on any technology is basically identical. That is not the case, and this discussion explains how factors like latency, jitter, oversubscriptions, and technology can impact broadband performance.

Latency. Latency is a measure of the time it takes for a data packet to travel from its point of origin to the point of destination – for example, from a Netflix server to your home. Another way to describe latency is that it measures the delay in the broadband signals between networks.

The following are the primary kinds of delays in broadband signals:

- Transmission Delay. This is the time required to push packets out the door at the originating end of a transmission. This is mostly a function of the kind of router and software used at the originating server. This can also be influenced by packet length since it takes longer to create and send long packets than it does to create many short ones. These delays are caused by the originator of an Internet signal (like Netflix).
- Processing Delay. This is the time required to process a packet header, check for bit-level errors, and figure out where the packet is to be sent. These delays are caused by the ISP of the originating party. There is an additional processing delay any time a packet is transferred along the way to a

new ISP. There is also processing delay each time that a packet passes through electronics between the originating ISP and the terminating ISP.

- Propagation Delay. This is the delay due to the distance a signal travels. It takes longer for a signal to travel from Tokyo to Arizona than it takes to travel from Los Angeles to Arizona. This is why the companies that perform speed tests try to find a nearby server to eliminate delays that are due to distance. These delays are mostly a function of physics and the speed at which light signals can be carried through fiber.
- Queueing Delay. This measures the amount of time that a packet waits at the terminating end to be processed. This is a function of both the terminating ISP and also of a customer's router, computer, and software.

Total latency for a given broadband connection is the combination of all of these delays. As can be seen, latency can be introduced anywhere along the path between the originator and the receiver of a broadband signal.

The technology used in the first-mile or last-mile has the biggest impact on latency. The big web companies like Netflix and Google, which generate most of the content on the web, purposely place their network hubs in data centers that are located in places that minimize the first-mile latency.

A few years ago, the FCC did a study of the various last-mile technologies and measured the following ranges of performance of last-mile latency, measured in milliseconds (ms): fiber (10-20 ms), coaxial cable (15-40 ms), and DSL (30-65 ms). These are measures of the average latency between a home and the first node of the local ISP network. It is these latency differences that cause people to prefer fiber. The lower latency on fiber makes a connection feel faster. If somebody were to make two simultaneous side-by-side connections – one on fiber and one on a cable network - it's likely that the user would say the fiber connection is faster.

Latency is the primary reason that some technologies 'feel' slow to users. For example, cellular latencies vary widely depending upon the exact generation of equipment at any given cell site. 4G cellular latency can be as high as 100 milliseconds – which is one of the reasons that it feels slower to visit a website on a cellphone.

The next biggest factor influencing latency is the network path between the originating and terminating end of a signal. Every time that a signal hits a network node, the new electronics must examine the packet header to determine the route and pause to perform other checks on the data. The delays of hitting network routers or changing networks are referred to in the industry as hops, and each hop adds latency. The longest path of a signal in the broadband world comes from the path used for high-orbit satellites that are over 20,000 miles above the Earth. In the FCC tests, satellite latency was measured to be as high as 650 milliseconds.

The delays from slow latency are manifested as poor performance. When latency gets above 100 milliseconds, a customer will begin experiencing trouble with real-time applications on the web. High latency can make it hard to stream live sporting events. High latency makes it hard to maintain a connection to a school or work server from home. High latency can make it hard to connect to a voice-over-IP call or to participate in a Zoom session. It can even be hard to shop online and do other routine web events if the latency delay is too long.

A lot of complaints about Internet performance are due to latency issues. It's sometimes hard to diagnose latency issues that can appear and reappear from one second to the next as the routing of data coming to a given customer changes. What is clear is that the lower the latency, the better the performance of the broadband connection.

Jitter. Jitter is the variance in the delays of signals being delivered through a broadband network. Jitter occurs when the latency increases or decreases over time. The broadband signal coming into a home is incredibly erratic. From millisecond to millisecond, the amount of data hitting the home network varies widely. Measuring jitter means measuring the degree of the variance of this network chaos.

Jitter increases when a broadband network gets overwhelmed, even temporarily. Delays are caused in any network when the amount of data being delivered to any point in a network exceeds what can be received and processed. There are a few common causes of increased jitter:

- Not Enough Bandwidth. Low bandwidth connections experience increased jitter when packets from the outside world exceed the capacity of the broadband connection. This effect can be a double whammy for somebody with a slow broadband connection because the network is already slow, and the increased jitter slows things down even more.
- Hardware Limitations. Networks can bog down when outdated routers, switches, or modems can't handle the volume of packets. Other issues like old or faulty cabling can cause delays and increase jitter.
- Network Handoffs. Jitter can increase at any network bottleneck. The most common bottleneck in homes is the device that converts incoming broadband to WiFi. Even the slightest hiccup at a bottleneck can negatively impact the speed of the entire network.

All of these factors help to explain why old technology like DSL performs even worse than might be expected. Consider a home that has a 25 Mbps download connection on DSL. If an ISP were to instead deliver a 25 Mbps connection on fiber, the same customer would see a significant improvement in performance even at the same download speed. A fiber connection would avoid the kind of jitter that is inherent in antiquated DSL hardware. We tend to focus on speeds, but a 100 Mbps connection on a fiber network will typically have a lot less jitter than a 100 Mbps connection on a cable company network. Customers who try a fiber connection for the first time commonly say that the network 'feels' faster – they are noticing the reduced jitter.

High jitter can be deadly to real-time connections – most people won't care if higher jitter means it takes a little longer to download a file. But high jitter can play havoc with real-time events like a Zoom call or a TV signal during a big sports event. It's easiest to notice jitter when a real-time function hesitates or fails. A home might have plenty of download bandwidth, and yet a spike in jitter can drop an online connection.

ISPs have techniques that can help to control jitter. One of the more interesting ones is to use a jitter buffer that grabs and holds data packets that arrive too quickly. It may not feel intuitive that slowing a network can improve quality. But recall that jitter occurs when there is a time delay between different packets on the same transmission. There is no way to make the slowest packets arrive sooner – so slowing down the fastest packets increases the chance that Zoom call packets can be delivered evenly.

Fully understanding the causes of jitter in any specific network is a challenge because the causes can be subtle. It's often hard to pinpoint a jitter problem because it can be present one millisecond and gone the next. But jitter is something that should be talked about more. A lot of the complaints people have about their broadband connections in rural areas are made much worse by high jitter.

Oversubscription. Even when the latest and best technology is deployed, speeds can vary widely in real life due to something called oversubscription. Oversubscription comes into play for any technology where customers share bandwidth somewhere in the network. Oversubscription is why a home broadband connection might get worse when many neighbors are using broadband at the same time.

The easiest way to understand the concept is with an example. Consider a passive optical fiber network. The most commonly deployed fiber technology for the last decade has been GPON, where up to 32 homes share 2.4 gigabits of download bandwidth (in a neighborhood node called a PON).

If an ISP sells a 100 Mbps download connection to 20 customers on a 2.4 gigabit PON, then in the aggregate, these customers can use as much as 2 gigabits of download data (20 customers X 100 Mbps), meaning this sample PON has unused capacity. In this example, every customer is guaranteed to be able to use the full 100 Mbps connection. However, if an ISP instead sells a gigabit connection to 20 customers, then there are 20 gigabits of potential customer usage that have been pledged over the same 2.4 gigabit physical path. The ISP has sold more than eight times more capacity to customers than is physically available, and this particular PON has an oversubscription ratio of eight to one.

When people first hear about oversubscription, they are often aghast – they think an ISP has done something shady and is selling more bandwidth than can be delivered. However, ISPs understand how customers use bandwidth, and they take advantage of the real behavior of customers in deciding on an oversubscription ratio. ISPs know that a home subscribing to a gigabit connection almost never uses the full bandwidth capacity. A home doesn't use much bandwidth when people are asleep or away from home. A gigabit subscriber might spend the evening watching a few simultaneous Netflix video streams and barely use any bandwidth. The ISP is relying on the normal behavior of its customers in determining a safe oversubscription ratio.

Most of CCG's ISP clients using GPON say they average a 40% to 50% utilization rate – meaning all of the customers on a PON collectively only use about 40% - 50% of the 2.4 gigabits of capacity at any given moment. The extra capacity is there for those times when a neighborhood gets busier than normal. We know from working with hundreds of ISPs that every customer on a GPON network can be given gigabit speeds, and the network will still deliver full speeds to customers more than 99% of the time.

To stick with this same example, even if the ISP using GPON gets too busy, it would only happen for a short time. For example, if a few doctors lived in this neighborhood and were both downloading big MRI files at the same time, the neighborhood might temporarily cross the 2.4 gigabit available bandwidth limit. However, broadband transactions happen quickly for a gigabit customer, and the overuse of the bandwidth does not last long. Even in this example, most neighbors of the doctors wouldn't see a perceptible difference in performance.

Oversubscription is different for business customers. Businesses might use steady bandwidth, such as connecting VLANs to multiple branches, using software platforms in the cloud, using cloud-based VoIP,

etc. An oversubscription ratio that works in a residential neighborhood might not work in a business neighborhood. An ISP gets to know its customers and decides how to configure the PON in a business neighborhood according to the characteristics of the businesses in that neighborhood. There are a number of ways that an ISP can make sure that business customers get enough broadband.

The above example describes oversubscribing a fiber network. All broadband technologies must contend with oversubscription issues. Anybody who uses a cable company for broadband can remember a decade ago when cable broadband slowed to a crawl when homes first started watching Netflix in the evening. The cable company networks were not designed for steady video streaming and had hundreds of homes sharing the same neighborhood node. It became routine for the bandwidth demand for a neighborhood to significantly surpass the network capacity, and when that happened, the whole neighborhood experienced a slowdown. Since then, cable companies have reduced the number of households sharing each neighborhood node to reduce oversubscription problems.

One of the major reasons that DSL and fixed wireless networks have slow speeds is from oversubscribing the neighborhood nodes. There is often far more demand from customers than the bandwidth being delivered to a neighborhood.

Oversubscribed networks became a big issue during the pandemic. The issue became the upload link instead of the download link. The upload link in a neighborhood gets overloaded when multiple people simultaneously connect to tasks that require uploading, like working or schooling from home. It was widely reported across the country during the pandemic that people had trouble making and keeping connections to work and school servers and Zoom calls. This didn't just happen with older technologies like DSL, and there are many reports of this happening on the networks of the big cable companies. Customers were rightfully upset if they were buying 100 Mbps or larger download speeds and still couldn't reliably work from home.

To make the issue even more complex, the sharing of bandwidth at the neighborhood level is only one place where oversubscription comes into play in a network. Any other place inside the ISP network where customer data is aggregated and combined can cause the same oversubscription issues. The industry uses the term chokepoint to describe any place in a network where bandwidth can become a constraint. There are a minimum of three chokepoints in every ISP network, and there can be many more. In addition to a chokepoint in the neighborhood node, there is also always a chokepoint in any network at the point where all of the neighborhood nodes come together in the core. The other big chokepoint is the connection point to reach the Internet, and it's possible for a company to not have enough bandwidth to the outside world to satisfy the aggregate demand of all customers collectively. During the pandemic, many ISPs suddenly found themselves having oversubscription problems at multiple chokepoints.

Other Issues That Affect Broadband Speeds

The primary issue affecting broadband speeds is the specific broadband technology being deployed and the way it is deployed. Any network can experience problems if it is configured poorly. It's easy to think that fiber networks are immune from these issues, but that's not always true.

Sections II.C. and II.D. below have a more detailed description of the various broadband technologies. The range of expected download speeds available on the various technologies are as follows:

- DSL delivered on one copper pair can deliver speeds as fast as 25 Mbps for a mile or two from the DSL transmitter, assuming the copper is in good condition and other factors are ideal. There are older and slower types of DSL deployed that might have maximum speed capability of 3 Mbps, 6 Mbps, or 12 Mbps. DSL configured to use two copper pairs can deliver twice as much speed as basic DSL. We've seen ISPs that are combining multiple copper pairs of wires to get speeds as fast as 100 Mbps download. But the faster the speed being configured on DSL, the shorter the distance before the speed starts to degrade.
- High-orbit satellite broadband can deliver speeds as fast as 75-100 Mbps in ideal conditions. Satellite broadband speeds are slower for customers without a full view of the open sky – like customers with trees around their homes or who are located near hills and mountains. The primary problem with high-orbit satellites is the delay (latency) since the signal that has to travel over 20,000 miles each way to and from the satellite.
- Fixed point-to-multipoint wireless technology is evolving rapidly. Technology from just a few years ago can deliver reliable download speeds up to 100 Mbps. There are claims from vendors for newer radios that can deploy speeds up to a gigabit, although most engineers think it's likely that top speeds will be half that in a real-life network. The primary issue with fixed wireless is that the speed delivered varies by customer. Customers who have an unimpeded path to the radio tower can get the best broadband performance, but performance degrades with any impediments in the radio path, such as trees or weather. Speeds also vary with the distance between a customer and the tower. ISPs can overcome distance by using more power or larger channels, but at some distance, the broadband will significantly degrade.
- A hybrid-fiber coaxial system (used by cable companies) can deliver fast download broadband speeds. Networks using the DOCSIS 3.0 standard can deliver download speeds up to around 400 Mbps. Networks that have been upgraded to DOCSIS 3.1 can deliver speeds of up to 1.2 Gbps. Cable companies are using an upgrade called a mid-split to increase upload speeds to 100-200 Mbps. The newest technology that is just now entering the market uses the DOCSIS 4.0 standard and is touted as being able to deliver symmetrical speeds of multiple gigabits.
- Fiber networks can deliver the fastest broadband speeds today. Fiber networks with the older BPON technology are limited to speeds of about 200 Mbps. The most widely deployed technology is GPON, which can deliver speeds up to a gigabit. The newest XGS-PON technology can deliver download speeds as fast as 10 Gbps.
- FWA cellular broadband that uses cellular frequencies for home broadband can deliver speeds today up to 300-400 Mbps download. The big limitation of this technology is the distance between the customer and the tower. The fastest speeds are available within a mile of a tower. By the third mile from the tower, the current technology struggles to deliver 100 Mbps download speeds. Cellular carriers are experimenting with the use of C-Band spectrum, which several claim could double or possibly triple speeds – but distance will still be an issue.

There is an even bigger difference between technologies for delivering upload speeds. Fiber is the only current technology that can deliver symmetrical speeds – the same speeds up and down. All of the other technologies have slower upload speeds. Some of this is restricted by technology standards. For example, there is a maximum upload speed possible on a cable network that is cooked into the specifications for the technology. Other technologies have the ability to set a range of upload speeds, and both DSL and fixed wireless providers almost always choose to provide more download speeds since that is of the highest importance to most users.

C. Competing Broadband Technologies

This section of the report looks at the various broadband technologies used in the county today.

Technology is Improving. Technology constantly evolves, and most broadband technologies are better now than just a few years ago.

Consider fiber-to-the-home (FTTH). This study discusses the use of XGS-PON, which can deliver 10 gigabit speeds to homes and businesses. While this technology has been around for a few years, the technology was originally too expensive and cutting-edge to be considered by most ISPs. AT&T and Vodaphone built enough of the technology that the price of the hardware dropped to be comparable to widely used GPON technology. Last-mile FTTH is now a 10-gigabit technology rather than a 1-gigabit technology.

Last-mile fiber technology continues to evolve. There is an industry consortium headed by CableLabs that is currently creating specifications for the next generation of last-mile passive optical networks, called CPON, that will use 100-gigabit lasers.

Cable company technology has improved over the last five years. During that time, a lot of urban areas saw the upgrade to DOCSIS 3.1 with download speeds of up to 1.2 gigabits. Cable companies are implementing other upgrades to improve speeds. There is an upgrade called a mid-split that can be used to improve upload speeds. The biggest cable companies have implemented this improvement in multiple markets and are seeing upload speeds between 100 Mbps and 200 Mbps. Several large cable companies are experimenting with DOCSIS 4.0 technology that will allow for multi-gigabit speeds for both upload and download speeds.

There have been big improvements in fixed wireless technology. Some of this improvement is due to the FCC providing more spectrum for rural fixed wireless. During the last three years, the agency has approved the CBRS spectrum, which is now being routinely used in rural deployments. The FCC also approved the use of the 6 GHz WiFi spectrum in 2021 and recently modified the rules to allow the spectrum to be widely used. There have also been big improvements in the radios. There are vendors today that are claiming the ability to deliver near-gigabit speeds using fixed wireless in ideal conditions.

Cellular broadband speeds have gotten much faster across the country as cellular carriers have introduced additional bands of spectrum. Cellular broadband speeds over the last five years have improved in cities from 20 Mbps to well over 100 Mbps. The transition to faster cellular speeds is spottier in rural areas. Cellular FWA technology delivers broadband speeds up to 300-400 Mbps.

Three years ago, the low-orbit satellites from Starlink were just hype, but Starlink now has over 5,000 satellites in orbit and well over one million customers.

DSL technology over copper has even gotten better. There are new versions of G.Fast that are being used to distribute broadband inside apartment buildings with speeds up to 500 Mbps – for short distances.

The following will look at each of these technologies except fiber, which is discussed in the next section of the report.

DSL over Copper Wires. Telephone companies in the county that still use copper wires deliver broadband using DSL (Digital Subscriber Line). The copper networks were mostly built between the 1950s and early 1970s. The copper networks were originally expected to have an economic life of forty years and have now far exceeded the economic life of the assets. The copper networks are deteriorating as a natural process of decay due to sitting in the elements. Even more importantly, the copper networks have deteriorated due to neglect by the big telcos that started to cut back on the maintenance of copper in the 1980s as the companies were deregulated from some of their historical obligations.

DSL works by using frequency on the copper that sits just above the frequencies used for telephone service. There are distinct kinds of DSL standards, each of which has a different characteristic in terms of the amount of bandwidth that can be delivered and how far the signal will travel. The most efficient forms of DSL can deliver up to 24 Mbps service over a single telephone wire. Most of the DSL in the county is of older varieties and delivers slower speeds.

The most important characteristic of DSL is that data speed delivered to customers decreases with the distance the signal travels. The general rule of thumb is that most types of DSL can deliver a decent amount of bandwidth for about two miles over copper – that's miles of copper wires, not two miles as the crow flies. DSL signal strength is also affected by the quality of the copper – newer copper and larger gauge copper wires mean better bandwidth.

Hybrid Fiber Coaxial Network. Cable companies use a technology called Hybrid Fiber Coaxial (HFC). Hybrid refers to the fact that an HFC network uses a fiber backbone network to bring bandwidth to neighborhoods and a copper network of coaxial cables to deliver service to customers. HFC networks are considered lean fiber networks (meaning relatively few fiber strands) since the fiber is only used to deliver bandwidth between the headend core and neighborhood nodes. At each node is a broadband optical receiver that accepts the fiber signal from the headend and converts it into a signal that is sent over coaxial cable to reach homes and businesses.

The coaxial copper wires in most HFC networks are aging, and much of the coaxial networks were built in the 1970s. Coaxial cable networks exhibit signs of aging sooner than telephone copper networks because the wires act as a huge antenna, and older networks attract a lot of interference and noise that make it harder to transmit signals through the wires.

An HFC system delivers customer products differently than an all-fiber network. For example, in an HFC network, all of the cable television channels are transmitted to every customer, and various techniques are then used to block the channels a given customer doesn't subscribe to.

There is a distance limitation on coaxial cable. Unamplified signals can't be transmitted more than about 2.5 miles over a coaxial network from a network node. Amplifiers are needed to boost the signal strength, starting as close as a few thousand feet from the core. Modern cable companies try to limit the number of amplifiers on a coaxial route to five or fewer since adding amplifiers reduces broadband speeds.

In an HFC network, all of the customers in a given node share the broadband in that node. This means that the number of customers sharing a node is a significant factor - fewer customers in a node means a stronger and more reliable broadband signal. Before cable systems offered broadband, they often had over 1,000

customers on a node. But today, the sizes of the nodes have been "split" by building fibers deeper into neighborhoods so that fewer homes share fiber for a given neighborhood.

The amount of bandwidth available to deliver broadband at a given node is a function of how many "channel slots" of video the cable company has dedicated to broadband. Historically, cable networks were designed to deliver only cable TV. Technology upgrades were developed to layer on broadband, which consisted of finding ways to create empty channel slots that no longer carry TV programming. Most cable systems have undergone a digital conversion, done for the purpose of freeing up channel slots. In a digital conversion, a cable company compresses video signals and puts multiple channels into a slot that historically carried only one channel.

The technology that allows broadband to be delivered over an HFC system follows a standard called DOCSIS (Data Over Cable Interface Specification) created by CableLabs. Most of the large cable companies upgraded about a decade ago to the DOCSIS 3.0 standard, which allows them to bond together enough channels to create broadband speeds as fast as about 400 Mbps download. By now, most big cable companies have upgraded their networks a second time to a new standard, DOCSIS 3.1, that theoretically could produce broadband speeds as fast as 8–10 Gbps if a network carried only broadband and had zero television channels. Since there are still a lot of TV channels on most cable systems, most cable companies have increased the maximum broadband speeds to between 500 Mbps and 1.2 Gbps using DOCSIS 3.1.

One limitation of a DOCSIS network is that the standard does not allow for symmetrical data speeds, meaning that download speeds are much faster than upload speeds. This is an inherent design characteristic of DOCSIS 3.0 and DOCSIS 3.1, where no more than 1/8 of the bandwidth can be used for upload. Most cable companies have allocated even less than the allowable bandwidth to upload. Poor upload speeds became an issue for many customers during the pandemic, and cable companies are searching for ways to increase the upload bandwidth.

One of the interesting design parameters of a cable network is the use of radio frequencies to transmit data, meaning a cable network can best be described as a captive radio network kept inside copper coaxial wires. As such, the signals inside a coaxial system share the same characteristics as any wireless network. Higher frequencies carry more data bits than lower frequencies. All of the signals are subject to interference if external frequencies leak into the cable transmission path.

The DOCSIS specification for cable broadband sets aside the lowest frequencies in the system for upload bandwidth – the frequencies between 5 MHz and 42 MHz. This happens to be the noisiest part of cable TV frequency – it's where outside sources like appliances or running engines can cause interference with the signal inside the cable network.

The DOCSIS 3.0 specification, released in 2006, allows for other parts of the spectrum to be used for upload data speeds, but very few cable companies took advantage of the expanded upload capability. The DOCSIS 3.0 standard allowed a mid-split option to increase the frequency for upload to 85 MHz or a more aggressive high-split option to assign all of the bandwidth up to 204 MHz for data upload. DOCSIS 4.0 is going to offer an even wider range of upload speeds, as high as 684 MHz of spectrum.

Several of the big cable companies are currently implementing the mid-split option to increase upload speeds. This can mean replacing some of the key components of the network, including neighborhood

nodes, amplifiers, and power taps. It could even mean replacing cable modems. Cable companies are clearly listening to customer complaints about the lack of upload bandwidth and also want a way to fight back against speed claims from fiber providers.

CableLabs has developed a new DOCSIS 4.0 standard that was released in March 2020. The DOCSIS 4.0 standard allows for a theoretical transmission of 10 Gbps downstream and 6 Gbps upstream. A few cable companies have started to deploy networks that include some of the DOSCSIS 4.0 standard, but it will still be a few years until fully standard-compliant hardware is available.

A bigger issue is that the copper in cable networks is aging in the same manner as telco copper. There are already portions of many cable networks that underperform today. Increasing the overall bandwidth of the network might result in the need for a lot of copper replacement. And that is going to create a pause for cable company management. While the upgrade to DOCSIS 3.1 was expensive, it's going to cost more to further upgrade to DOCSIS 4.0. At what point does it make sense to upgrade to fiber rather than undertake another costly upgrade on an aging copper network?

When the DOCSIS 4.0 technology was announced in 2020, most of the CTOs of the big cable companies were quoted as saying that they didn't foresee the implementation of the new standard for at least a decade. But the problems their networks experienced during the pandemic had a lot of them rethinking the timeline. A few cable companies like Cox, Midco, and Altice have announced plans to convert properties to fiber rather than tackle this upgrade. Charter is building a huge amount of fiber as part of implementing broadband grants.

A Primer on Wireless Technologies. All technologies that use wireless spectrum to transmit data share some key characteristics that define both the strengths and weaknesses of broadband delivery. Wireless broadband technologies include fixed wireless, cellular, outdoor WiFi, and satellite technologies – all are wireless and differ by the frequencies of spectrum used and the location of the radio transmitters. The following is a description of some of the basics that apply to any wireless technology.

Frequency**.** Wireless technologies use electromagnetic waves to transmit data. The primary characteristic of a given frequency is the length of the radio wave. Radio waves can be as long as a football field or as short as a subatomic particle. As an example, the length of a radio wave used for an FM radio station broadcasting at 90 kHz is about ten feet long. Some of the higher frequencies now used for cell phones are only a few millimeters long.

Frequency is measured in units called hertz, which quantifies the number of times per second (oscillation rate) that a radio wave is transmitted. One hertz equals one cycle per second. The frequencies defined as radio frequencies vary between 9 kilohertz (kHz), or 9,000 cycles per second – which would be long radio waves, up to 300 gigahertz (GHz), or 300 billion cycles per second, which would be extremely short waves. In the middle of this range are the kilohertz (kHz) frequencies that transmit at millions of cycles per second. The entire electromagnetic range extends far beyond radio waves to include things like light waves and X-rays.

How Digital Radios Transmit Data. At the simplest level, there are two ways that radio waves can transmit data. Both methods vary the radio waves by creating differences in the signal. A digital radio receiver software interprets these differences as a series of 1s and 0s – the basis for all digital communications.

One basic method is amplitude modulation (AM). A radio using this method will vary the strength of the radio signal from moment to moment to represent digital 1s and 0s. The other basic transmission technique is frequency modulation (FM). A radio using this technique will alter how often radio waves are transmitted, with changes in the spacing of the transmissions interpreted as 1s or 0s.

Modern radios use far more complex transmission patterns to transmit data but are still based on the two basic transmission methods. For example, QAM (Quadrature Amplitude Modulation) can transmit more data by modulating the amplitude of two or more radio waves simultaneously, providing a much greater opportunity to introduce the tiny differences that represent the digital 1s and 0s.

In general, the higher the frequency, the greater the amount of data that can be transmitted. This is because higher frequency means more radio waves in a given time span, which translates into more opportunities to create 1s and 0s.

Characteristics of Radio Frequencies**.** The characteristic of any specific frequency is determined by nature. For example, the radio waves used for AM radio travel easily through obstacles like buildings. AM radio signals can also travel great distances – I remember, as a kid in Appalachia, listening late at night to a radio station in Chicago. Other frequencies are unable to penetrate obstacles, with an extreme example being the millimeter-wave frequencies used by Verizon a few years ago to demonstrate gigabit-speed cellphones. These radio waves are short and are blocked if the body of a user is between the cellphone and the transmitting tower.

The key characteristics that determine the usefulness of any specific frequency for transmitting data are distance, power, channel size, the nature of the upload/download links, and interference.

> Distance. All radio transmissions disperse over distance. In simple terms, this means that the path of a radio transmission widens with distance. This is most easily understood with the following simple diagram that shows how a radio signal spreads from a tower. A receiver placed right at the tower would easily be able to receive the full transmitted signal. But as the receiver is placed further from the tower, not as many transmitted data bits reach the receiver.

One example of this that is familiar to most people is the large dishes placed along major highways that are part of microwave radio systems. The microwave signal is tight and densely packed at the transmitting tower, but the receiving tower needs a large dish to gather the signal that was sent. The signal may originate at a centimeter wide but disperses to several meters wide after 10 miles.

Power. The FCC determines the power level that can be used for any wireless application. To put it simply, increasing the power of a wireless transmission will increase the distance of the transmitted signal. The FCC restricts the power to reduce the risk of radio signals interfering with each other. A good example is the AM radio transmissions mentioned above. The reason I was able to listen to a Chicago radio station late at night is that the FCC allowed some stations to increase the power in the evening after competing local stations stopped transmitting for the day.

Channel Size. A wireless transmission path for sending data doesn't use a single frequency but a range of frequencies. The most commonly used spectrum is WiFi. The 2.4 gigahertz WiFi band includes the full range of frequencies between 2401 – 2484 GHz. The FCC has divided the 2.4 gigahertz band into eleven channels of approximately 20 megahertz in width. For example, channel 3 uses frequencies from 2411 – 2422 GHz. This contrasts significantly with the newest WiFi spectrum in the 6 Gigahertz spectrum band, where the largest channel is 160 megahertz wide. Everything else being equal, a larger channel means the capacity to transmit more data on a single channel.

Uplink/Downlink. The method used for handling two-way radio transmissions impacts the amount of data that can be transmitted. This isn't an issue for one-way transmissions like AM radio or broadcast TV, which transmit signals but don't receive them. However, communications links require a signal path in both directions. There are two different technologies used to create a two-way communication path.

- Frequency Division Duplexing (FDD) uses separate frequencies for the uplink and downlink path.
- Time Division Duplexing (TDD) uses one frequency for the links in both directions. The signal can be shared since the two links use different time slots. A TDD radio fluctuates rapidly between a burst of send and a burst of receiving.

Interference. Interference is any phenomenon that can reduce the efficiency of a radio link. There are many sources of interference.

- Natural Interference. This is caused when naturally occurring events like solar flares, northern lights, and other electromagnetic activity interfere with radio transmissions. While not natural, interference can also come from man-made noises from engines and other devices.
- Internal Interference. The most common source of radio interference comes when factors inside of a network cause interference. The radios used for broadband are complex, and there are many reasons why a radio might cause internal interference. It's also common for incompatible hardware at towers to cause interference.
- External Interference. There are numerous ways that external factors can disrupt radio transmissions:
    - Co-channel Interference is when more than one radio is operating at the same frequency. FCC rules are created to minimize such interference for licensed

frequencies, but co-channel interference is common with unlicensed frequencies when multiple wireless ISPs use the same channels at the same time in a market.

- Adjacent Channel Interference comes when a radio transmission on neighboring channels uses some of the same frequencies. Radios are often not precise devices and can transmit in frequencies slightly outside the desired channel. The channels in WiFi overlap and share some frequency with neighboring channels – two nearby locations using adjacent channels will interfere with each other.
- Spurious Emissions come when radios transmit frequencies far outside of the intended range.
- Intentional Interference. This comes from jamming that is intended to cripple a specific radio transmission.

The FCC's Role in Regulating Spectrum**.** The use of radio frequencies is highly regulated around the world and in the U.S. by the Federal Communications Commission (FCC). The FCC began regulating spectrum after the passage of the Radio Act of 1927, which was enacted to bring order to the overcrowding and interference in the AM radio band. This law established the basis for the way that spectrum is still regulated – establishing blocks of spectrum and licenses for use that are intended to serve the public interest. Under this regulatory scheme, the FCC assigns frequency in specific bands for specific uses. The agency decides who can be licensed to use spectrum and the operating characteristics, like the level of power allowed for various uses. The FCC also regulates, monitors, and approves devices that use spectrum.

Over time, the FCC developed two models for regulating spectrum. One is a market approach that licenses spectrum to a specific license holder for a fixed number of years. During the life of the license, the user has ownership rights in the spectrum. The most widely used licensed spectrum is the various bands used to deliver signals to cell phones. The other model is a commons approach of opening a spectrum for anybody to use without a license. The most common use of unlicensed spectrum is WiFi, which is used in the homes and offices of most broadband users. There is a more recent FCC model that sits between the two regulatory methods, where spectrum can be shared by multiple users only under specific rules and circumstances.

Fixed Wireless Technology. This technology is used by a large number of wireless ISPs (WISPs). The key to making this technology work is to use multiple bands of wireless spectrum to maximize the bandwidth to each customer based on local conditions. There are several current frequencies of spectrum that can be used for this purpose:

- WiFi: WiFi is a marketing term used to create a public-friendly term that was easier to remember than the 802.11 series of names. The FCC has currently set aside three swaths of frequency for WiFi: 2.4 GHz, 5.7 GHz, and 6.0 GHz. In a point-to-multipoint network, these three frequencies are often used together. The most common way is to use the higher 5.7 and 6.0 GHz to reach the closest customers and save the lower frequency for customers who are farther away.

  In practical use, in wide-open conditions, these frequencies can be used to serve customers up to about 6 miles from a transmitter, although WISPs often deliver slower speeds for a greater distance.

The WISP industry is counting on 6 GHz spectrum to improve broadband performance. The FCC authorized the use of the spectrum in 2020, but only on a limited basis and at low power. The FCC recently approved full-power use of outdoor 6 GHz spectrum under the control of an automated frequency coordination (AFC) system. This is a process that coordinates and balances the use of the 6 GHz spectrum in any given location with any pre-existing users of the spectrum. This means the spectrum won't be usable everywhere, but it should be available in most rural markets. The biggest benefit of the 6 GHz spectrum is the large channels that might support wireless speeds as fast as 1 Gbps in ideal conditions.

- CBRS Spectrum - 3.5 GHz: In 2019, the FCC approved the use of the 3.5 GHz spectrum band known as the Citizens Broadband Radio Service, or CBRS. This is a huge swath of spectrum covering 150 MHz of spectrum between 3550 and 3700 MHz.

  The FCC has set aside 80 MHz of this spectrum for public use, similar to WiFi, and auctioned the remaining spectrum of 70 MHz in June 2020. In all cases, this spectrum is shared with the military, which always gets priority to use the spectrum.

  The public spectrum also must be shared among users in the public space – something that will be monitored by an authorized SAS administrator. The FCC has named five administrators: Amdocs, CommScope, Federated Wireless, Google, and Sony. It's expected that the cellular carriers will heavily use the free public spectrum to deliver 5G, so in many places, this spectrum might be too busy to allow for a point-to-point application. However, in rural markets, the public spectrum might go unused, in which case it would be available to boost the speeds for fixed wireless broadband.

  There are already rural ISPs using the public portions of the spectrum for fixed wireless service. This spectrum sits in the middle between the 2.4 and 5 GHz WiFi bands used for fixed wireless today and has great operating characteristics.

There are several factors that are critical for the successful deployment of point-to-multipoint radios for rural broadband:

- Using Multiple Frequencies. The newest radios are much improved over radios from just a few years ago because they use spectrum bands including 2.4 GHz, 3.5 GHz, 5.0 GHz, and CBRS spectrum. Having more spectrum bands matters because each frequency band has different operating characteristics in terms of distance and ability to penetrate obstacles. Using multiple frequencies provides an increased opportunity to find a workable solution for each customer in the service area.
- Adequate Backhaul. The best fixed wireless coverage comes when there is fiber at the transmitter that supplies the needed bandwidth. Customer broadband speeds are diminished if a tower doesn't receive enough bandwidth – lack of backhaul bandwidth is the primary reason many WISPs deliver slow speeds.
- Terrain/Topology. There are often physical barriers like hills or heavy woods that can limit or block customer bandwidth. Most spectrum used for fixed wireless broadband requires a good line-of-sight, meaning that there must be a clear, unimpeded visual path between the tower and the customer. Customers who live in valleys or behind hills often cannot get signal. If the signal must pass through trees to reach a customer, the strength of the signal is diminished.

- Height of the Tower. The taller the transmitting radio, the better because the high placement of the antenna provides a better opportunity to look down on homes without having to pass through trees.

There are a few other issues to consider with fixed wireless:

- When there is more than one WISP operating in the same market, there is interference when WISPs try to both use the same channel.
- Interference translates into slower broadband speeds. The biggest drawback of using unlicensed spectrum is the fact that other WISPs can use the same frequencies, and by being unlicensed, there is no entity that can settle disputes between WISPs. The WISP environment in crowded markets is often described as the Wild West, where a WISP grabs channels and spectrum to make its own signals better to the detriment of other WISPs. This results in a never-ending wrestling match for frequency and means that customer speeds go up and down.
- Compared to fiber technology, a wireless radio system has a short, expected life. Most radios have to be replaced every seven years or less.
- Wireless equipment is often not eligible for federal or state grants.

Geostationary Satellite Broadband. Viasat (which was formerly marketed as Exede or Wildblue) and HughesNet provide broadband using geostationary satellites (GEO). The technology is called geostationary because the satellites sit in a parked location over 22,000 miles above the Earth. For both, the availability depends upon a customer having a clear line of sight from a satellite dish at a customer location to a satellite.

The most limiting aspect of GEO satellite broadband is latency, which means a delay in the signal. Latency comes from the distance to and from a satellite. The latency on GEO satellites can make it hard or impossible to do real-time transactions on the web. GEO satellite latency can be as high as 900 milliseconds, and a latency above 100 milliseconds creates a problem with real-time applications such as streaming video, voice-over-IP, gaming, online education, or making connections to corporate WANs (for working at home). Any website or service that requires a constant connection will perform poorly, if at all, with a satellite connection. Satellite broadband also comes with tiny data caps, meaning a customer is highly limited by the amount of data they can send or receive during a month.

Low Earth Orbit Satellites. The newest satellite technology places satellites in orbit between 300 and 800 miles above the Earth. Low-orbit satellites have one major benefit over geostationary satellites. By being significantly closer to the Earth, the data transmitted from low-orbit satellites have a latency of around 35 milliseconds—about the same as experienced in a cable TV broadband network. This is much better than the current latency for high-orbit satellites. The low-orbit satellites can easily support real-time applications like VoIP, video streaming, live Internet connections like Zoom, and distance learning.

One of the most interesting aspects of the technology is that a given satellite passes through the horizon above a given customer in about 90 minutes. This means that there must be a large fleet of satellites so that there is always a satellite in the sky over a customer.

Starlink has over 6,100 satellites in orbit. The company hit over two million customers worldwide at the end of 2023. Starlink claims it will eventually launch 30,000 satellites and will need over 11,000 to complete the first constellation.

Starlink promises faster speeds for businesses with the HP business antenna. This antenna has a 35% better field of view, is less sensitive to hot weather, handles rain better, and melts snow faster. The company now claims the following speeds on its website:

	Download	Upload
Residential	25 – 100 Mbps	5 – 10 Mbps
Business	40 – 220 Mbps	8 – 25 Mbps
RV	5 – 50 Mbps	2 – 10 Mbps

Interestingly, the speed claims above from the Starlink website are a lot slower than what was promised as recently as September 2022. For example, residential customers in 2022 were told that download speeds would be between 50 – 200 Mbps with upload speeds of 10 - 20 Mbps. Customers have been saying online that speeds are getting slower – something that is validated by Ookla speed tests.

4G Hotspots. All of the major cellular companies sell a home broadband product using 4G LTE, which is popularly referred to as a hotspot. This technology uses the traditional spectrum that has been used to deliver broadband to cell phones. Cellular data speeds get significantly slower as the distance between a cell tower and a customer increases. While customers living close to towers report speeds in the range of 50 Mbps, speed tests show that customers living further from towers can get speeds as slow as a few megabits per second.

5G Home FWA Broadband. Since 2021, cellular carriers have been deploying a new generation of home cellular broadband products. The cellular carriers are calling this new product FWA (fixed wireless access). Adoption of the new home broadband products is growing quickly. At the end of the second quarter of 2024, T-Mobile, Verizon, and AT&T added almost 10 million customers to this technology.

The FWA technology is using the new cellular spectrum that each company has labeled as 5G. The technology being used for the product is still 4G LTE, and the 5G name is a marketing way to distinguish these products from the older hotspot technology.

There are some natural limitations of the new technology. The strength of the broadband signal and speeds depends upon the distance between a customer and a cell tower – the speeds get progressively slower as the distance between a tower and a customer increases.

Carriers claim speeds in the FCC maps that range from 100 Mbps to 300 Mbps download. CCG has done extensive research on the FWA product, and we have found that the fastest speeds are only available to customers located near the transmitting cellular tower. If speeds near the cell tower are 300 Mbps, then after a mile the speeds might top out at 100 Mbps. And after two miles, speeds will be 50 Mbps or slower.

The cellular carriers are selling this product to monetize the excess capacity at cell towers. However, the primary product for these companies is selling broadband to cell phones, and both T-Mobile and Verizon warn customers that the speeds will be throttled and slowed any time there is a lot of demand at a cell tower for cell phone bandwidth. Customers have reported that in the worst cases, the bandwidth almost disappears.

Cellphone Broadband. Some households elect to use their cell phones as the only source of home broadband and don't buy a home landline broadband connection. Cellular companies operate two side-by-side cellular networks – one labeled as 4G LTE and the other as 5G. Not all cell sites, particularly in rural areas, have been upgraded for 5G delivery. The difference between the two networks is the spectrum being used. A customer must have a 5G-enabled phone to receive the 5G spectrum. A recent survey by Deloitte showed that about 60% of U.S. cell phones are now 5G enabled.

There is a gigantic difference between cellular broadband speeds in major cities and the surrounding rural areas. Cellular data speeds are faster in cities for several reasons. First, there are more cell sites in cities. Since the data speed on a cell phone is a function of how far the customer is from a cell site, urban cellular customers get fast speeds because they are usually within a mile of a cell site. Rural customers can easily be miles from the nearest tower. Cellular carriers have also introduced additional bands of spectrum in urban areas that are not available outside cities.

The biggest problem with using cell phones for broadband is the tiny monthly data caps. Anybody using a cell phone for home broadband is, by definition, a light broadband user.

D. The Network Design

Evaluating the Network Options

In our evaluation of Vermillion County, we considered the design and construction of an all-fiber broadband network. In the design work, we completed a fiber-to-the-premise network design for the parts of the study area that do not have wireline service (cable/fiber) capable of reaching 100 Mbps download speed and 20 Mbps upload speed, and which do not have a funded obligation to construct a wireline broadband network capable of those speeds.

Our evaluation considered the following criteria that are necessary elements of a broadband solution:

- A review of the existing broadband providers' current deployments and funded broadband deployment obligations.
- The type of construction required in each area: plowing, boring, and presence of rock, aerial installations.
- Bandwidth capacity.
- Cost of the network.
- Expected lifecycle of the technology.
- Resiliency and redundancy of the network.

Before tackling the design, we needed to research to understand the study area better. Some of this investigation was described earlier in the mapping section of the report. We started by analyzing the broadband mapping information from the FCC, which provided us with a snapshot of where ISPs claim service today. We focused on areas where ISPs do not claim fast broadband, but we also looked at the rest of the county to see if we agreed with the claims made by the ISPs. For example, we looked for inconsistencies between the technologies reported to the FCC and the claimed speeds. We also looked at a full year of Ookla speed test data to see how the customer experience matches ISP claims. All this work culminated in a broadband map for the county that defines the areas that don't have adequate broadband.

Our work with the mapping identified all of the ISPs operating in the county, and we attempted to interview each ISP. These were technical discussions asking about the current broadband networks and to see if the ISPs would share any plans for network expansion. We wanted to learn if ISPs have won any grants to fund expansion. Finally, we tried to determine if each ISP was interested in working with the County to improve broadband.

After the ISP interviews, we traveled to the county to conduct a field review. Before the trip, we made a list of 56 areas we specifically wanted to examine to investigate the presence of specific technology from specific ISPs, collecting over 70 images of existing broadband and wireless infrastructure. We used a cellular GIS mapping service to identify and geo-reference the work done by our field team so that we could locate the findings from the field review on a map. This allowed our field team to snap pictures of the equipment or cable used at each location. The goal of the field team was to validate if the information reported by ISPs was correct regarding areas served and the technology being used. This work allowed us to draw boundaries around areas with good broadband coverage to delineate where the areas without broadband started.

Before starting the design, we made a last pass to determine if ISPs have won any recent grants or broadband subsidies to build faster broadband. This included reviewing state broadband grant awards and federal grants and subsidies like RDOF, E-ACAM, ReConnect, Connect IL, etc.

Fiber Network Design

The design process started with primary assumptions, fiber architecture, and optical equipment decisions. These assumptions are discussed in more detail below.

FTTP Architecture:	Centralized Split Passive Optical Network (PON)
Fiber Type:	Armored fiber cable
Aerial Fiber Placement:	Hung on existing utility poles 18” below the neutral
Buried Fiber Placement:	Buried conduit with cable.
Cable Fill Factor:	1.5 fibers for every existing service location
Huts / Cabinets:	6 Hut Sites and 12 Equipment Cabinets
Internet Backbone:	Existing connections from providers
Fiber Drop:	Consideration of Aerial and Buried Fiber Drops
Network FTTP Equipment:	XGS-PON (10 Gigabit symmetrical technology)
Premise FTTP Equipment:	XGS-PON (10 Gigabit symmetrical technology)
Percentage Buried Fiber:	70% Aerial and 30% Buried

We analyze the unserved areas and determine that the most efficient fiber network would be to define 17 distinct serving areas for construction and serving customers.

Currently, two primary technologies- passive and active- are used for last-mile fiber networks. Finley chose a passive network for several reasons, which are discussed below. We also include a comparison of active and passive fiber technology.

Overall Design Criteria

A high-level map of the designed network is included in Exhibit I.

The design of fiber networks and the associated electronics is straightforward. The goal is to define the fiber size that must be built along each road and street in the study areas. However, every network design differs in the details of how the network will be deployed, the method of construction, geography, topography, the number of customers, and the long-term goals of the ISP.

Our goal in the design is to create a cost estimate for constructing a network that is accurate enough for ISPs to make business decisions or file for a grant. The cost estimates will always get refined later when it's time to construct a network and when engineers walk and examine every foot of the planned network.

The network design started by locating every potential customer on a map to see where we need to bring service. The number of potential customers in the telecom industry is called "passings." We utilized Vermillion County GIS address data and compared it to the FCC mapping fabric to create the most accurate map. This allows us to visualize and determine how many locations are residential, business, or community anchor institutions.

As described elsewhere in this report, we considered two scenarios. Scenario 1 assumes that all locations claimed as being served by licensed wireless technology will still be eligible for BEAD grants. Scenario 2 assumes these same locations would not be eligible for BEAD grants. As of the date of writing this report the Illinois Broadband Office has not published that determination.

	Scenario 1	Scenario 2
Residential Passings	4,143	1,492
Businesses	144	35
Total	3,906	1,527

This network utilizes a centralized PON architecture for high-level design purposes. PON stands for passive optical network and is most easily described as having one laser in the network core that serves a neighborhood cluster of customers. In a centralized PON, each customer has a fiber connection from the service location to the PON cabinet, where optical splitters are utilized to serve up to 64 customers. In this design, we used a splitter capable of serving 32 customers to reduce optical loss and retain a higher level of bandwidth available per customer.

One of the interesting aspects of a modern PON network is that the technology can also be used to create a dedicated broadband path to any given customer – meaning that the network can take advantage of the best attributes of an active network to be able to serve large business customers, cell sites, or schools.

We also considered future growth when determining the needed network capacity. Years of building fiber networks have taught us that planning for increased fiber utilization over time is prudent. We always think of a fiber network as a hundred-year investment, and there is no way to know what might happen to the local economy many decades from now. The network was designed to accommodate growth, if it ever appears, even decades from now.

The primary way we planned for growth was to multiply the number of locations by 1.5 to determine the fiber cable size required, typically rounding up to the next industry-standard fiber size. We carried this factor throughout the network from the core hub to the customer locations. We would also point out that

PON networks are the most easily expandable networks. Expanding the network at the edge is possible by placing a new cabinet supporting an additional serving area. This kind of expansion can theoretically be extended forever, although the fibers at the core would need to be updated at some point.

There are two major components of a fiber network:

> Backbone Fiber. Backbone fiber is used to connect between network hubs. Our preliminary network design includes four locations that will house the backbone electronics and six new passive optical cabinets to support the distribution fiber network. The purpose of the backbone is to connect each location so that the network can be quickly restored in the case of a fiber cut.
>
> Last-Mile Fiber Network. The last mile fiber network extends from each hut, remote, and PON cabinet location to reach customer locations. The total fiber network, including the backbone fiber, covers 544 miles of remaining fiber network construction for the base scenario and 905 miles for the challenge scenario.

The total cost of the network includes both the backbone and last-mile fiber. Our pricing for the network is based on recently constructed fiber projects in similar areas. For the basis of our cost estimate, Finley utilized similar projects that used standard fiber cable sizes for the fiber network design. The fiber cable sizes were 12, 24, 48, 96, 144, and 288 fibers in a bundle. We always try to design using standard fiber sizes since such fiber is more readily available from contractors and vendors for additional network construction and repair. Also, standard-sized fiber is priced more competitively.
Our design determines the right-sized fiber cable for each route. One of the most significant costs of deploying fiber is the cost of labor needed to splice fibers together, so our goal is not to include unneeded fiber pairs to limit the required number of splices. Every splice in a network also adds a small amount of signal loss, so the ideal network includes the least number of splices.

PON Cabinet placement is based on the total distance between the electronics at the equipment cabinet and customers—the ideal is to keep this distance under twelve miles. This distance limitation led us to create four separate serving areas.

The biggest cost component of deploying fiber is labor. Labor costs vary around the country due to differences in hourly wages. Local wage differences can be a big factor in choosing between the different construction methods. In this study, we have used cost assumptions from other projects recently constructed in your area and around Illinois to estimate the labor, soil/rock conditions, and material rates.

Optical Electronics Design

Two technologies are used today to deliver last-mile broadband to customers. Active Ethernet technology has been widely used for over thirty years, and passive optical network (PON) technology has been used for over fifteen years. These are both mature technologies that are widely used and well-understood.

Finley Engineering is technology-neutral, and we considered the pros and cons of the two deployment technologies in our analysis.

Passive Optical Network (PON) Technology

PON technology is most easily described as having one laser in the network core that serves a neighborhood cluster of customers. That means one laser at the core communicating with a neighborhood laser at each customer, or to put it another way – one laser to many customers.

The industry standard for passive optical networks has been GPON (Gigabit PON) for the last fifteen years. The GPON technology delivers a 2.4 gigabit data stream for download and 1 gigabit for upload to a neighborhood of up to 32 customers. The newest PON technology that is starting to see widespread use is XGS-PON technology. This new technology can deliver 10 gigabits of both download and upload bandwidth to a cluster of customers. A neighborhood cluster is called a PON in the industry, and with GPON, the typical size of a PON has been set at 32 customers. With XGS-PON, the neighborhood PON can include up to 128 customers. An ISP deploying XGS-PON to a cluster of 32 customers would provide four times More download bandwidth and ten times More upload bandwidth than GPON.

The current vendors for PON equipment include Alcatel-Lucent, Adtran, DZS, Nokia, Juniper, and Calix. The following are the primary pros and cons of using PON technology.

PON Advantages

- No electronics in the field. PON uses passive splitters to distribute the bandwidth over the fiber to the customers. The PON distribution network has only two active components – the Optical Line Terminal (OLT) and the Optical Network Terminal (ONT). The OLT sits in an environmentally controlled hut or building, and the ONT sits on the side or inside of the home.
- Less field maintenance and More reliability. Because PON uses passive splitters in the field, there are fewer powered network elements in the distribution network. This equates to less maintenance, fewer field personnel required, More reliability, and fewer managed network elements in the distribution network. A PON network also means less land and rights-of-way required due to less need for large powered huts.
- Less fiber is needed. PON uses significantly fewer fibers than an active system. A PON network can carry up to 128 customers on the fiber leading to the neighborhood. In GPON technology, most ISPs configure the network to have 32 customers in a PON. There is not yet an industry-wide consensus for the ideal size for an XGS-PON cluster. The one fiber carrying the traffic from many customers differs drastically from an active network that requires one fiber between the core and each customer. Less fiber means lower construction costs, less loading on poles, quicker fiber installations with less splicing, and smaller fiber management systems.
- Higher density electronics. Because PON electronics has only one optical port for many customers, the PON chassis in the OLT can serve a large number of customers in a small space. This means less space for electronics, less power usage, less air conditioning, and reduced backup power requirements.
- Ability to still use active Ethernet. Most PON manufacturers offer the option to serve some customers on active Ethernet in the same chassis by using a separate core card.

- Location Flexibility There are many more options for locating passive devices and placing them close to customers. Network owners can deploy large, centralized splitter sites and widely distributed tiny splitter cabinets.
- Takes the best advantage of oversubscription. All the customers in a neighborhood node share the bandwidth delivered to the node. This is more efficient bandwidth use than sending a dedicated amount of bandwidth to each customer.
- Network Expansion. The Most important benefit of PON is that it's far easier to accommodate future growth. Fiber networks are expected to last more than fifty years, and with a PON network, it's easy to add new homes in a neighborhood or a whole new subdivision or neighborhood that appears in an unexpected place. A PON network can be expanded for small expansion by adding new splitters. A new hut can be added to the network for major expansion, allowing for huge outward expansion. This drastically differs from an active network where an individual fiber is needed from the core to reach each new house in existing neighborhoods.

PON Weaknesses

- Distance Limitation. Customers must be within 12 miles of the OLT core electronics. This can present a challenge in large rural networks.
- More Complex Engineering. Because of distance limitations and splitter requirements, a PON network requires an engineering plan to place electronics and splitters. This is not a major issue since industry engineers are well-versed in designing PON networks.
- More customers are affected by a single fiber cut. Cutting one neighborhood fiber can knock More customers out of service.

Active Ethernet (Active E**)**

In an Active E network, one fiber goes from the core electronics directly to each customer. The primary vendors in the Active E equipment market are Cisco, Calix, Adtran, and Nokia-Alcatel-Lucent. Since PON equipment has won a much greater market share than Active E equipment, this part of the industry has declined for a few years. The following are the pros and cons of Active Ethernet.

Active Ethernet Strengths

- Greater distance. Where a PON has a 12-mile limit between the core electronics and the customer, an active connection can reach over 50 miles.
- Less engineering and planning. Since every fiber run is a home run between the electronics chassis and the customer, less engineering and planning are needed to design and deploy an AON network. Engineering means just planning one fiber per passing.
- Pure IP Network. The active Ethernet network delivers pure native IP, which could be plugged directly into customer modems or switches.
- Can deliver greater bandwidth. Lasers that can deliver speeds greater than 10 Gbps are available. Such lasers can be expensive but easy to integrate into an active network.

Active Ethernet Weaknesses

- Higher Cost. Active Ethernet typically costs around 15% More to build than a passive network. This comes from needing More fiber and More lasers.
- Uses More fiber than PON. With one fiber home run per customer, Active networks require significantly More fiber. This means larger fiber bundles to the same number of electronic chassis.

This affects capital costs, pole loading, conduit, hand-hole sizing, etc. Larger fiber bundles require larger field huts to handle the larger fiber entrance. In a densely populated area, the size of the fibers can be unwieldy.

- Less dense electronics. Since there is a core laser for every customer connection, the electronic chassis supports fewer customers in the same rack space. This means a larger chassis and More rack space, which equates to more air-conditioned space and More and larger power and backup power at the electronics locations.
- More powered network elements. There are more field locations that require power. This means more failure points in the network, More field huts, More power, More battery backup, and More generators.
- Expensive growth after construction. This may be the biggest drawback. Adding new customers in the middle of an active network can be expensive because that means somehow bringing more fibers to an area where all fibers are in use.

The Components of a PON Network

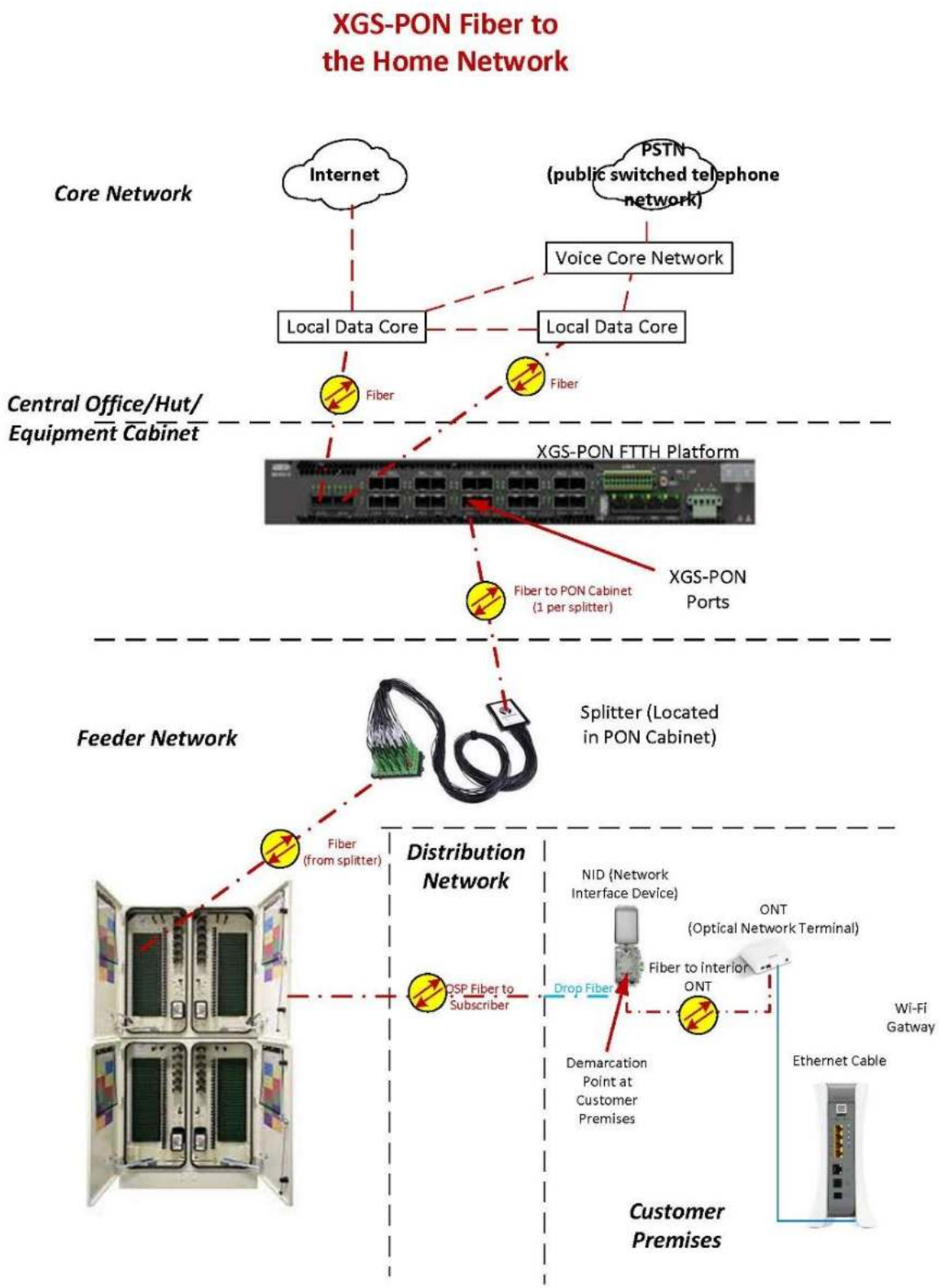
The following diagram shows the basic components of a PON fiber network. A description of each component follows the diagram.

A PON network can be designed in numerous configurations, but all designs include the same key elements. All networks start at a network core where the connection is made to the Internet. At this core, the ISP inserts the signals for the various products being delivered to customers. The following diagram shows the configuration of the network that originates with one of the hub sites and ends at a customer premise.

From the core, there are direct fibers to the optical line terminal (OLT), which is the device that provides a light source for customers. These OLTs can be located in the same location as the fiber core or spread around the city in neighborhood nodes, huts, or large cabinets.

There is one fiber leaving an OLT for each "PON," which is the local network consisting of up to 32 customers. These fibers go to splitter cabinets, where each fiber is then split into 32 separate fibers that go to customers. The splitter cabinets can be located at the same location as OLT electronics or can be placed deeper into the network to be closer to customers. The name passive for the technology comes from the fact that the splitter site doesn't require electronics or power – the term splitting is just what it sounds like – one fiber from the OLT is spliced and split into many individual fiber paths. The paths between the splitter and each customer are home runs, meaning that there is a single dedicated fiber between a splitter site and each customer.

Connection to the Internet. Ideally, a last-mile network will have access to more than one feed to the open Internet. It's not unusual in rural areas for the needed connections to be limited. An important aspect of any network design is to try to find the needed redundancy.


XGS-PON Fiber to the Home Network
Core Network
Internet
PSTN (public switched telephone network)
Voice Core Network
Local Data Core
Local Data Core
Fiber
Fiber
Central Office/Hut/ Equipment Cabinet
XGS-PON FTTH Platform
XGS-PON Ports
Fiber to PON Cabinet (1 per splitter)
Feeder Network
Splitter (Located in PON Cabinet)
Fiber (from splitter)
Distribution Network
NID (Network Interface Device)
ONT (Optical Network Terminal)
Fiber to interior ONT
OSP Fiber to Subscriber
Drop Fiber
Wi-Fi Gatway
Ethernet Cable
Demarcation Point at Customer Premises
Customer Premises

Optical Line Terminal (OLT). The electronics used to light the fiber to customers are called optical line terminals (OLTs). OLTs must be powered, so each OLT location must contain the equipment needed to provide power, including batteries and other backup power, to keep the network functioning in case of a power outage.

An OLT uses circuit cards, each serving 128 and 256 subscribers. Multiple cards can be installed in each OLT chassis, and multiple chassis can be installed in a remote hub site, making it easy to scale the network to accommodate future growth. Multiple vendors provide an all-inclusive PON solution that combines the cabinet and FTTP equipment solutions. All vendors meet industry standards and are priced similarly.

PON Splitters. The next component on the network diagram is a PON splitter. This device can split one fiber to connect up to 32 customers. On the diagram, you can see that there is only one fiber between the OLT and the GPON splitter. This is the place in the network where significant fiber can be saved since one fiber coming into the splitter can serve up to 32 customers. The splitters do not require power, which is why they are referred to as passive. The splitters can be located anywhere in the network where fiber splits are needed to reach customers. Generally, some splitters are located in the central office core or at the various network nodes, but many are located in small neighborhood cabinets closer to customers.

PON Cabinet. Associated with a splitter cabinet is a PON cabinet. The purpose of the cabinet is to arrange and manage the fibers coming into or out of the splitters to make it easy to identify which fiber serves which customer. The primary purpose of the PON cabinet is to accumulate customer connections at strategic points, with the design goal of ensuring that no fiber in the network needs to be larger than 288 fibers. Below is a picture of a typical PON cabinet site. This site includes both a PON equipment cabinet and a splitter cabinet.

Fiber Drops. The local distribution fibers are built to reach every customer location from a PON cabinet site. Our design provides a place to add fiber to reach each location in the serving area, even though not all customers will buy the service. A fiber drop is built from the street to connect customers to the fiber network outside a customer premise building. The customer drop is a two-fiber cable fusion-spliced to a single fiber of the main-line cable. These splices are housed in a splice case sized for each location depending upon the number of homes or businesses that can be served.

At the Customer Location. The piece of customer electronics used to serve customers is referred to in the industry as an ONT (Optical Network Terminal). This electronic device contains a laser that connects back to the OLT in the huts or the central office. The ONT receives optical light signals from the fiber network and converts the signal to traditional Ethernet on the customer side of the device.

Historically, ONTs were only placed outside buildings in a small enclosure and powered by tapping into the electricity after the power meter. But today, there is also an ONT that can be placed indoors and is powered by plugging it into an outlet, much like the cable modems used by cable companies. The cost of the two kinds of units is identical.

Some companies still put the ONT outside of the home to give their technicians 24/7 access to the units. Other providers are electing internal units since they are protected from the weather. The industry is split on this choice, but internal units are becoming the Most predominant choice for new construction. One of the major contributing factors that favor indoor ONTs is that ISPs are tying the ONTs to indoor WiFi routers to provide good wireless connectivity within the home.

ONTs are available in multiple sizes and can be categorized into units designed to serve homes and small businesses and units designed to serve large businesses. The study assumes that the smaller unit will be used for most customers, including most small businesses. These units provide one to four Ethernet streams, which is sufficient for most customers.

Historically, many last-mile fiber networks were designed with battery backup for the ONT. The batteries were installed to power telephones in case of a power outage. Old copper-based phones received power from the copper line and would function when the power was out. However, no power is delivered with fiber, and customers need some battery backup to maintain phone service. In 2015, the FCC ruled that every voice provider must offer an optional battery backup solution for customers who buy telephone service not delivered on copper.

Regardless of the type of ONT (indoor or outdoor), it is necessary to drill through the side of the home to bring the fiber into the premise. ISPs have widely differing ideas on the best way to do this, but most ISPs look for the installation method that requires the least work inside the customer's premises.

Aerial Versus Buried Fiber

The preliminary design for Vermilion County assumes that fiber would be aerial where there are existing poles and buried where there are no existing poles. Buried fiber costs more, and we assume that ISPs will strive to build the least expensive network possible.

Generally, but not always, buried fiber is more expensive than aerial fiber. This is particularly true for fiber drops between the road and the home.

Two primary cost drivers affect all fiber construction:

Access Density. This refers to the number of connections that will be made to a fiber. There is a significant cost for preparing fiber to connect to customers. The more customers there are in a neighborhood, the higher the cost of preparing the cable to make the needed connections.

Labor Costs. Hourly labor rates vary regionally and often between urban and rural construction in the same region.

There are also specific cost drivers unique to buried and aerial fiber:

Major Cost Drivers for Buried Fiber Construction.

Condition of the Substrate. The number one factor that affects the cost of burying fiber is the condition of the substrate – the soil that is three to four feet below the surface. All burying techniques are the least costly when the substrate is Mostly soil with few other impediments. However, when a road was first constructed, many rights-of-way were filled with rocks or other materials. Cobble is a substrate that includes small rocks of six inches or less. Construction is harder if the original contractor used large boulders to fill the ditches when creating a street or road. Some locations have surprising impediments – we know of a project where somebody buried an old tractor in the right-of-way that made it impossible to bore – the contractor had to excavate and remove the tractor. In the worst cases, the substrate comprises native rock that has never been excavated. It can easily cost ten times or more per foot to bore through rock than through softer substrate.

The Chosen Construction Method. The lowest construction cost would be achieved using the lowest-cost construction method for each segment of a fiber project. However, contractors don't like to combine multiple construction methods in the same local project unless there is no alternative. Each construction method requires different heavy equipment and crews with different talents. This means that a contractor will sometimes spend More to build some portions of a network as a trade-off for trying to accommodate various construction techniques.

The Major Cost Drivers for Aerial Fiber Construction

Conditions of Existing Poles. The condition of the existing poles determines the make-ready costs. Almost every fiber route has some make-ready – make-ready can be as simple as trimming a few trees or as costly as replacing a substantial number of poles. The conditions that drive high-make-ready costs include poles that are too short to accommodate a new fiber, poles that have deteriorated and have to be replaced, and poles where the existing attachers did not follow industry standards to allow enough space for the next attacher.

Network Design. Several aspects of network design impact fiber cost. Fiber routes with larger-count fibers usually have higher material and splicing costs. The fiber bundles for an active Ethernet fiber design will contain more fibers than a network using passive optical electronics.

Aerial Fiber Construction Basics. Aerial fiber construction is the process of adding fiber onto poles. The method of putting any wires on poles is highly regulated.

Pole Regulation**.** A wide variety of owners own utility poles. The largest owners of poles in the country are electric companies since they built the first poles in Most communities. There are places where a telephone company will own Most of the poles. There are some communities where the local government owns the poles.

Congress gave the FCC the authority to regulate poles in Section 224 of the Telecommunications Act of 1934. The FCC established basic rules for attaching to poles but initially took a light-touch regulatory approach and allowed various parties that shared poles to negotiate a joint-use agreement that defined the rules and fees for sharing poles. The FCC rules followed nationally accepted standards for poles, which associations of engineers have developed. The standards were created to make it safe for technicians to work on poles, particularly during or after storms. The national standards defined things like the minimum distances required between different types of wires. The joint-use agreements also defined the fee for pole attachments due to the pole owner. As might be imagined, the joint-use agreements differed across the country.

In response to the widespread deployment of networks by cable companies, Congress passed the 1978 Pole Attachment Act. The Act assigned regulation of poles to the Federal Communications Commission (FCC). The 1978 Act intended to set affordable rates and terms for cable companies to use the poles since some pole owners made it impractical for a cable company to get onto the poles. Interestingly, the 1978 Act applied only to poles owned by investor-owned electric or telephone companies – the new rules did not apply to poles owned by state and local governments, cooperatives, or railroads.

The 1978 Act gave States the right to 'reverse preempt' the FCC and establish state-specific pole attachment rules and rates. At the end of 2022, there were 23 states, including Illinois, which assert jurisdiction over poles.

Pole Attachment Agreements. Anybody who wants to hang a new wire on a pole must first sign a pole attachment agreement with the pole owner. A pole attachment agreement is a contract that specifies the specific rules for connecting with the pole owner. For example, the pole attachment agreement will describe the paperwork process needed for hanging a new wire. The pole attachment agreement also specifies the various rates and costs associated with being on a pole.

In some markets, there may be several different pole owners, and a new attacher must have a separate agreement with each pole owner. Pole owners may require attachers to meet specific requirements before attaching to any poles. For example, a pole owner may require an attacher to be registered as a carrier at the state regulatory commission. A pole owner may require a monetary deposit before any work on poles is allowed.

Space Between Wires. Section 23 of the National Electric Safety Code defines the clearances required for wires hanging on poles. The standard clearances are intended to provide safe working conditions for pole technicians. Most of the cost and the controversy associated with adding fiber onto poles is finding a way to add fiber to a pole while continuing to meet the spacing and clearance codes. A highlight of the key clearance distances is as follows:

- Bottom clearance. The bottom wire on a pole must be at least 4.8 meters (15.5 feet) above any area with vehicular traffic. The bottom wire must be at least 2.7 meters (9 feet) above areas with only pedestrian traffic. The rules have many exceptions, such as requiring higher clearances for crossing a railroad track. Many pole owners expect higher clearances; the above numbers are the minimum national requirements.
- Safety Space. National codes require a Communication Worker Safety Zone of forty inches between the lowest electric wire and the next highest wire under the electric wire. This zone was created to keep technicians working on non-electric wires away from high-voltage electric wires.
- Within the Communications Space. Most pole owners require a gap between different attachers in the communications space of 12 inches – meaning the space between the telephone company and a cable company or a fiber provider.

One key aspect of the spacing requirement is that the distance between wires is supposed to be the same across the whole span of two wires between adjacent poles. If you've ever looked up at poles, you'll notice that the wires sag between poles. The sag is intentional and allows wires to move without breaking during heavy winds. A new attacher is expected to match the sag of the existing wires so that the spacing is the same along the whole distance between poles.

Make-Ready. The construction can become complicated when there is insufficient space to add the proposed fiber. This initiates a set of processes that the industry calls make-ready, which is shorthand for making the pole ready to add the new fiber—two aspects of make-ready cause problems for a fiber attacher: cost and time.

The cost issue comes from a regulatory decision that the new pole attacher must pay the full cost of making a pole ready to attach a new fiber. This often seems unfair when the problems on existing poles come from past attachers who didn't follow national standards. For example, a cable company may have added coaxial wires on a pole in the 1970s, which violated the clearance rules, and that means there isn't room for the new attacher. New attachers are unhappy when they must pay to correct for poor past construction done by others.

The cost of getting onto a pole can be extreme. For example, if no space can be created for a new fiber attacher, the new attacher is expected to pay for the cost of building a taller pole and ILving the existing wires to the new pole. That can be costly, and we've seen estimated costs as high as $30,000 to connect to a single new pole.

The FCC recently attempted to make it easier to get onto poles. They created a class of poles they labeled as 'red-flag' poles. These are poles that an electric company has already flagged as needing to be replaced, or which is clearly nearing the end of economic life. The new rules say that a new attacher only has to pay a fraction of the cost to replace a red-flag pole. ISPs are not sure this ruling will help much in real life practice since pole owners are probably going to be reluctant to admit that poles fit into the red-flag category.

Slow Pole Processes. One of the biggest complaints of ISPs building aerial fiber is that pole owners take too long. A lot of that is due to the regulatory rules associated with the make-ready process. Sometimes, adding fiber to poles is easy if there is enough room for a new fiber. But it can get complex, and construction might involve moving the wires of multiple attachers. It might mean constructing a whole new taller pole if there is no solution for creating more space.

Unfortunately, the changes needed to accomplish the make-ready can take a long time. Some pole owners give each existing attacher a chance to move its own wires (which is then billed to the new attacher). Or the pole owner may dictate that it will make changes for everybody. But the process of notifying other attachers and coordinating work can take a while. If there are multiple attachers involved, the rules usually allow each attacher to do the work sequentially, which means giving each attacher a fixed time to make the needed changes. It's not unheard of for it to take as long as a year to complete the make-ready work for a single complex pole.

The problem with the additional time for make-ready is that a new attacher can't add fiber to a given route until all the poles are updated and ready. Consider a street with twenty poles in a row where Most have no make-ready or only minor make-ready - but a few require a lot of work. The new attacher can't run fiber down this street until all poles are ready. Imagine this happening with groups of poles all over a market, and it's easy to see how make-ready can delay fiber construction.

Hanging Aerial Fiber. There are two different types of fiber to match the two primary methods of hanging fiber. Catenary fiber is intended to be attached to some sort of supporting structure. Catenary fiber is attached to either a messenger wire (strand), which is a metal cable that is strong enough to support the fiber or is lashed onto existing wires that are already on a pole, such as existing telephone company wires.

The second type of fiber is self-supporting, meaning it doesn't need to be attached to a messenger wire. The most common kind of self-supporting fiber is ADSS (all-dielectric self-supporting) fiber that is typically used in the power space. ADSS is rigid with a strong, non-conducting outer sheath since the fiber in the power space is not allowed to conduct electricity as a safety measure. There is another kind of self-supporting fiber called figure-8 fiber, which has the messenger wire and the fiber prewrapped into the same bundle to speed up the installation process.

Buried Fiber Construction Basics. There are several different techniques used to bury fiber. The different construction methods are chosen to meet two criteria. The first is customer density, and other methods are used in streets with dense housing versus roads with far fewer customers per mile. The More important consideration is the condition of the soil and substrate under highways. Burying fiber can be extremely labor-intensive and expensive in soil that contains a lot of rock. The engineering analysis includes the following types of construction:

> Trenching. Trenching fiber is digging an open ditch and laying the fiber into the open hole. Trenching is usually chosen in two circumstances. This is often the least expensive way to bury conduit and fiber in places with an open stretch of right-of-way without driveways or other impediments. It's often less expensive to dig a quick ditch with a backhoe or ditch witch than to bore through an area. The second use of trenching is in greenfield areas of new construction, where the conduit can be put into the ground before the homes or businesses are built.

Trenching is the messiest and most disruptive type of fiber construction since it excavates the ground deeply enough to place the fiber. Most contractors would not choose to do this in a residential neighborhood because of the mess and inconvenience for homeowners. Trenching is also not chosen for areas where the contractor expects to uncover major rocks. Trenching is also more likely to hit other existing utilities if done with a backhoe.

The trenching process is straightforward. The path for the fiber will be excavated to the proper depth. The conduit or shielded fiber cable is laid in the trench, and the trench is refilled with backfill dirt – done carefully so as not to damage the fiber. The contractor will pack down the construction area, clean up and remove any excess dirt or mud, and restore the right-of-way to the original condition as needed. This might mean laying sod or gravel.

Plowing. Cable plowing is a construction method that uses a heavy vehicle called a cable plow to bury fiber or small conduits directly into the ground as the plow drives along the right-of-way. Fiber plowing is done almost exclusively when burying fiber cable along a route where the fiber will be placed in unpaved rights-of-way, such as along a country road. The right-of-way must be open and not wooded to allow access to the cable plow. A cable plow is a large, heavy vehicle similar to a bulldozer. The plow is on treads instead of wheels to navigate various terrain conditions. Having a heavy vehicle is important because the force of the plow is used to force a path in the right-of-way as the plow drives forward.

The plow is configured so that a fiber reel is mounted on the front of the plow and situated so that it can turn as fiber is removed from the reel. Behind the plow is an arm with a blade that is extended into the ground, and a narrow trench is dug as the plow is moved forward. Some cable plows use a vibrating blade, while others use a heavy static blade. The fiber is unwound from the reel as the plow moves forward and is inserted into the trench, just behind the blade, as the plow moves forward. The fiber used with a cable plow has a tough sheath that can easily withstand the plowing process. There are fibers built that are particularly suitable for the plowing process.

Boring. Boring fiber is referred to by several different names - horizontal boring, trenchless digging, or directional drilling. The technique can construct a fiber network underneath rights-of-ways, streets, driveways, and sidewalks without disturbing much of the surface.

Boring uses specialized equipment that deploys a heavy carbide drill bit to create a temporary underground hole large enough to pull through one or more conduits. The boring technique can be used anywhere a contractor wants to place a conduit. This would be boring along a residential street to bring fiber to homes, underneath yards to bring fiber from the street to a home, or underneath driveways and other impediments involved in trenching or plowing of fiber.

Boring is almost always the most expensive construction method. It's time-consuming to bore a hole, pull a conduit into the hole, and pull fiber into the conduit. Boring involves digging holes in the right-of-way or cutting holes in concrete to insert the boring machine – and these areas must be restored to their original condition after the construction is done.

Microtrenching. Microtrenching is a construction method that cuts a narrow and relatively shallow trench in a street or sidewalk into which to place fiber. Microtrenching is often less costly than boring.

Microtrenching involves cutting a hole in the street or sidewalk that is 1.5 to 2 inches wide and typically 12 to 14 inches deep. The cutting is done using a heavy-duty saw that is mounted under a heavy work vehicle. The vehicle moves slowly down the street, and as the saw cuts into the street, the material being removed from the road is vacuumed into a trailing vehicle for removal. The cutting process is loud, but it doesn't create a lot of debris or initial mess.

It's possible to do the entire microtrenching process on a given street in one day. But it's more typical to stretch this out over two or three days. The microtrenching process typically requires closing a street (or at least one lane of a street) to provide the needed access for the microtrenching vehicles and crews. Microtrenching crews in cities will deploy full safety protocols of using cones to block off areas from vehicles and using flag personnel to direct traffic as needed. Since the top of the trench is only an inch or two wide, cars can safely drive over the trench during the construction process.

After the construction is complete, the contractor will blow fiber through the conduit. Blowing fiber means shooting or propelling a small ball through the conduit that pulls along the fiber wire. Modern fiber-blowing techniques can bring fiber along the street and also into each access device. Once the fiber reaches the handhole, a technician connects the fiber to the handhole in the same manner as would be done with other buried fiber techniques.

E. Cellular Broadband

We learned through our interviews that cellular coverage in the rural parts of the county is possibly even worse than broadband coverage. We heard there are many areas with poor or no cellular coverage. A cell tower can typically provide broadband for 2-3 miles surrounding a tower and voice services up to 5-6 miles. In both cases, the signal decreases in strength as the distance between the tower and a customer increases. The broadband available to a cellphone (or hotspot) is much stronger for a customer within a mile of a tower compared to a customer three miles or more from the same tower.

Signal strength also varies because of other factors. The signal strength is generally significantly stronger outside a home than indoors (which is why many rural folks have to go outside to make a cellular call). Cell strength is diluted when connected to somebody in a moving vehicle. Like all wireless technologies, there are also cellular dead spots created by impediments in the terrain, such as hills.

The FCC wants to address the lack of rural cellular coverage. On August 29, 2024, the FCC released a Second Report and Order[20] that officially kicked off the process of launching the 5G Fund for Rural America. The FCC says in the order that there are 14 million Americans without access to 5G, and they are providing a $9 billion subsidy fund to bring better rural cellular coverage.

[20] https://docs.fcc.gov/public/attachments/FCC-24-89A1.pdf

The idea of the 5G Fund has been around for a while. The idea was floated to create a $4.5 billion fund in 2019, and in 2020, the FCC announced it would increase the fund to $9 billion and use a reverse auction to allocate the funding. The 2020 effort came to an abrupt halt when it became clear to the FCC that the maps of coverage provided by the largest cellular carriers were highly inaccurate. The FCC has taken steps to make better maps, and cellular carriers must now report cellular coverage data to the FCC twice a year in a process that parallels the collection of broadband data that this report has discussed. In this new order, the FCC says that it believes the cellular maps are now adequate to enable the launch of the 5G Fund.

The funding will be awarded using a reverse auction that is only open to cellular carriers. The 5G Fund can be awarded to areas of the country that don't have at least one carrier with a 5G mobile wireless speed of at least 7/1 Mbps, is not in an urban area, and contains at least one home or business and some portion of a road. In practical terms, that means funding for a rural area that has no 5G today (just 4G LTE) or where 5G speeds are slower than 7/1 Mbps. Areas that don't have any 5G today will get extra weighting in the reverse auction.

There is a further nuance that eligible areas can't already be getting a benefit from an existing FCC cellular subsidy. There has been a rural subsidy paid to cellular providers for years from the Universal Service Fund through the Mobility Fund Phase II that has been providing up to $500 million per year of support to rural cellular carriers. Unfortunately, the FCC's cellular map doesn't identify the areas that are currently being subsidized.

There will likely be adjustments and changes made to the existing FCC maps before an auction. For example, both T-Mobile and Dish are required to meet build-out requirements due to negotiated agreements with the FCC. This expansion has not been completed, and it seems likely that the FCC will remove expansion areas from the 5G Fund map.

Winners of the 5G Fund reverse auction must upgrade 40% of the area in each state by the end of 3 years, 60% by the end of 4 years, 80% by the end of five years, and 85% by the end of six years. Completion means achieving a median broadband speed of at least 35/3 Mbps with a minimum cell edge speed of 7/1 Mbps (meaning at the edge of the cellular coverage areas). It also means offering at least one service that includes a minimum monthly data allowance equal to the average U.S. subscriber data usage. That's going to mean a data cap at some amount of data usage and possibly also a limit on voice and texting.

$765 million of the fund will be reserved for tribal areas. $900 million will be used as a 10% award additive to anybody willing to guarantee the use of Open RAN technology.

Service areas will consist of hex-9 coverage areas aggregated into census tracts. Bidding will be done by bidders asking for the dollars of subsidy wanted per square kilometer.

Concerns About the 5G Fund Plans

There are a number of concerns about the 5G Fund as proposed by the FCC.

Are the Maps Accurate? The Rural Wireless Association (RWA), which represents smaller cellular companies, sent a letter to the FCC that claimed the FCC cellular maps are still highly inaccurate. Another

complaint from RWA is that the FCC cellular reporting only looks at cellular coverage at homes. RWA argues that in rural areas, this is measuring the wrong thing – home cellular coverage is important, but rural cellular coverage should be measured along the roads where people drive every day. The current map shows no coverage data for areas between homes.

No Specific Public Map Challenge. The FCC is not pausing to give citizens and local governments a chance to challenge the cellular map. In fact, the FCC might only issue the final map of areas eligible for the funding 30 days before the auction begins.

This is a big oversight. If the RWA is right about poor maps, then the public should be given a chance to make sure that areas without adequate cellular coverage are included in the 5G Fund. In the recent order, the FCC said that the public and local governments have had enough time to challenge the maps since the FCC started the BDC mapping process a few years ago. However, practically no local governments have considered the issue, and the public likely knows almost nothing about the FCC challenge process.

The methodology needed to challenge the maps is not easy. Speed tests to challenge can only be taken using the FCC speed test app[21]. There must be a lot of tests in a given geographic area for tests to be considered. Speed tests must be taken either from a stationary place outside (like pulling over along the side of a road) or inside a home. Only the outdoor tests count for the 5G Fund. To be done right, speed tests must be done using phones from each of the major carriers, meaning AT&T, T-Mobile, Verizon, and Dish, along with any smaller local carrier that offers 5G in an area.

It's virtually impossible to challenge a carrier that has overstated coverage areas. For example, we've seen rural areas where the only carrier that reports coverage is Dish, and the company has a miniscule customer base. It's probably not easy in many rural areas to even subscribe to Dish in order to take the speed tests needed for the challenge.

It's unlikely that many county governments have undertaken a formal effort to organize the needed speed tests. Even if they did, any challenge had to have been taken in the last year to be relevant.

The FCC has asked for comments. Doug Dawson of CCG Consulting, and hopefully many others, filed comments that asked the FCC to give local governments a chance to prove poor cellular coverage if it's not clear on the current FCC maps. If the FCC rushes forward without a challenge process, then any inaccuracies in the maps will result in areas not getting the needed new towers. If the FCC moves forward without a challenge period, then any area where the maps show erroneous coverage might not get another shot at improved cellular coverage for a decade or more.

Another dismaying part of the order is that the FCC might issue the eligible area map only 30 days prior to the start of the bidding.

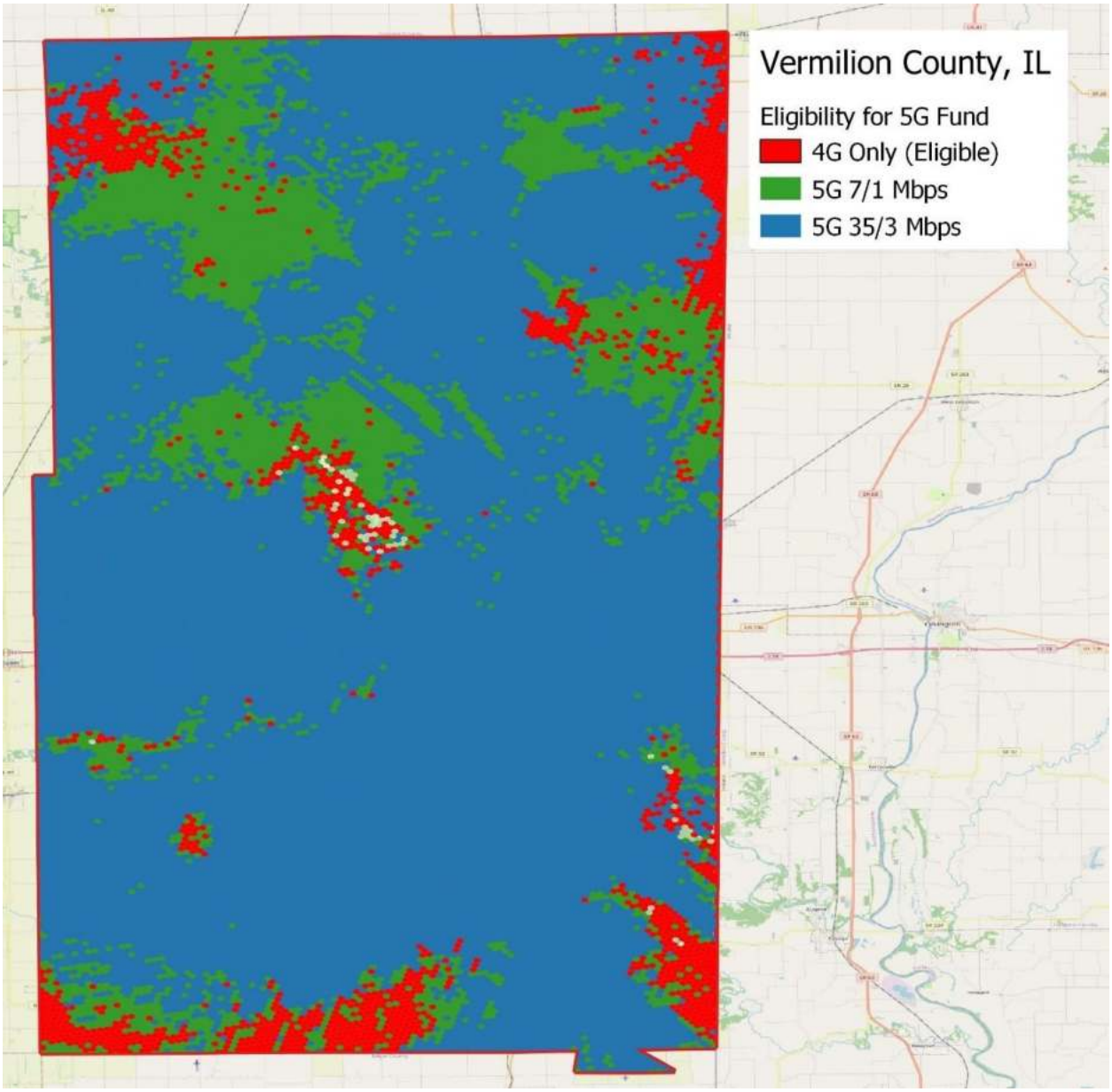
Below is a cellular coverage map we created for Vermilion County using the most current FCC mapping data. In this map, the areas shown in red would be eligible for 5G funding. It looks like there is a chance to get a new cell site in the center of the county. The other areas in red are all along the county border and spill into neighboring counties. It's likely that some of these areas would also be eligible in the 5G Fund.

[21] FCC Speed Test App. https://www.fcc.gov/consumers/guides/fcc-speed-test-app-tip-sheet

What Can the County Do? First, the County should consider the map below. If you think the red areas are the only places that need better cellular coverage, then no further action is needed.

However, if you think that more of the county has poor cellular coverage, you need to reach out to your national politicians to ask them to get the FCC to slow down the 5G Fund process. You would want elected officials to ask the FCC to allow for a 5G map challenge. That's the only way the County could show a bigger need than is shown by the map.

If there is a Map Challenge. There are ways for the County to help get better cellular coverage. The FCC only considers speed tests collected through the FCC app – not speed tests taken on other speed test websites. Unfortunately, the FCC requires a lot of speed tests in a given neighborhood before the FCC will consider the results. That means a cellular map challenge would require getting a lot of folks to take the FCC speed test in rural areas where the cellular coverage is poor. This also means getting folks who subscribe to different carriers to take the test. At a minimum, you're going to want AT&T, T-Mobile, and Verizon customers to use the FCC app. The County would need to organize a mass FCC speed test effort.


Vermilion County, IL
Eligibility for 5G Fund
4G Only (Eligible)
5G 7/1 Mbps
5G 35/3 Mbps

III. FINANCIAL PROJECTIONS

A. Financial Assumptions

This section of the report looks at financial projections that were made to estimate the business plan for an existing ISP to bring fiber to the unserved and underserved parts of the county. There are several reasons why we undertook the financial analysis.

First, the analysis lets us look at whether an average ISP can afford to build in rural areas. That's not an automatic given, and in some rural areas, the cost of the network is so high that it's hard for any ISP to justify operating, even with grant funding. That leads to the second reason for the analysis – to try to quantify the amount of grant that is needed to make the network expansion work. This is an important analysis because grants don't cover the full cost of constructing a network, so the ISP accepting the grant must also pay for a share. For example, the upcoming BEAD grant might finance up to 75% of the cost of the network, meaning an ISP must fund 25% - our goal is to understand if an ISP can make a reasonable business case if they win a 75% grant. More importantly, the chances of winning grants increase if an ISP can request less than the fully available amount – so we calculate what we call a breakeven amount of grant, which is the lowest amount of grant needed to make a business case.

Finally, the analysis explores what we call a sensitivity analysis. In doing this, we explore the impact of changing key variables in our projections. For example, we will quantify the impact of having the interest rate be 1% higher than expected. We hope that ISPs will find the incremental impacts to be valuable information.

This section of the report looks at the detailed assumptions that were made in creating the financial business plans. The business plan assumptions represent our best estimate of the operating characteristics of such a business. As a firm, CCG has assisted hundreds of ISPs that provide rural broadband, and this has given us a lot of insight into how rural ISPs operate. We believe that the financial results shown in these models are characteristic of similar operations elsewhere, and we believe our assumptions are realistic.

We analyzed two scenarios for this study. First, we looked at a scenario where we adjusted the FCC BDC map to what we believe is a more accurate representation of the county's broadband based on available data and the field review, referred to as the base scenario. The second scenario assumes the county will win the map challenge it submitted and reclassifies the challenged locations as grant eligible, referred to as the challenge scenario. We looked at the impact of constructing both scenarios at prevailing labor rates. These are labor rates that are mandated for contractors working on federal and state grant projects and are higher than the local market rates. For example, the upcoming BEAD grants suggest the use of prevailing wages since the funding that created the grants is considered a jobs bill. The authors of that legislation want the workers who build networks to benefit from the government funding.

Incremental Analysis. All of the projections were made on an incremental basis. This means that the studies only consider new revenues, new expenses, and new expected capital costs. This is the most common way that businesses of all sorts look at potential new ventures since an incremental analysis answers the question of whether any new business line will be able to generate enough revenue to cover its costs.

It's important to understand what an incremental analysis shows and does not show. An incremental analysis is basically a cash flow analysis. It looks at the money spent to launch and operate a new venture and compares those costs to the revenues that might be generated from the venture.

An incremental analysis is different from a prediction of what the accounting books of a new venture might look like. For example, if one of the existing ISPs in the area were to undertake one of these business plans, they would allocate some of their existing overhead costs to the new venture for accounting purposes. The classic textbook example of this is that some of the existing costs of the general manager of the ISP would be allocated to the new venture in the accounting books. However, the salary of the existing general manager is not considered to be an incremental cost in the analysis since that salary is already being paid by the existing ISP business. If these studies were to show an allocation, we would not be showing the true incremental cash impact of pursuing the new opportunity.

Our analysis all starts with the assumption that existing ISPs would bring the new broadband. The incremental costs would be significantly higher if a new ISP were created just to bring broadband to your rural areas.

Timing. Timing is critical to any business plan. The faster that a business can start generating revenues, the sooner it can cover costs. These studies are somewhat conservative in the roll-out assumptions. There is an additional timing issue to consider in Illinois. Construction is sometimes restricted in parts of the winter, so many contractors do not build fiber in the winter months.

Following are the major milestones as predicted by these forecasts:

- Financing. All the forecasts assume that the financing is available in January 2025. This is illustrative only and could be changed to any other future date.
- Construction. Fiber construction is assumed to last for three years. We assume that it will take four years to connect all of the customers.
- First Customer. We've assumed that the first customer will be added to the network in October of the first year.

Pricing Strategy. We assumed a simple rate structure for broadband. For example, our analysis includes only three broadband speed tiers for residential or business customers. Rates were discussed extensively in the Rate Study section of the report.

Following are the residential broadband products available in the county today:

Provider	**Technology**	**Download**	**Upload**	**Price**
Frontier	DSL	Best Effort	Best Effort	$54.99
AT&T	DSL	5 Mbps	1 Mbps	$60 + $10 router
	DSL	10 Mbps	1 Mbps	$65 + $10 router
	DSL	25 Mbps	5 Mbps	$65 + $10 router
	Fiber	300 Mbps	300 Mbps	$65
	Fiber	500 Mbps	500 Mbps	$75
	Fiber	1 Gbps	1 Gbps	$90
	Fiber	2 Gbps	2 Gbps	$155

	Fiber	5 Gbps	5 Gbps	$255
	Hotspot	25 Mbps	3 Mbps	$35 - $55
	Fixed Cellular	100 Mbps	20 Mbps	$60
Comcast	Cable	150 Mbps	5 Mbps	$66.00 + $15 router
	Cable	300 Mbps	5 Mbps	$86.00 + $15 router
	Cable	500 Mbps	5 Mbps	$96.00 + $15 router
	Cable	800 Mbps	15 Mbps	$106.00 + $15 router
	Cable	1 Gbps	35 Mbps	$116.00 + $15 router
	Cable	1.2 Gbps	35 Mbps	$126.00 + $15 router
Sparklight	Cable	100 Mbps	20 Mbps	$55 + $12.50 router
	Cable	300 Mbps	20 Mbps	$65 + $12.50 router
	Cable	600 Mbps	30 Mbps	$85 + $12.50 router
	Cable	1 Gbps	50 Mbps	$95 + $12.50 router
Conxxus	Fiber	20 Mbps	5 Mbps	$55 + $5 router
	Fiber	100 Mbps	10 Mbps	$65 + $5 router
	Fiber	300 Mbps	30 Mbps	$75 + $5 router
	Fiber	1 Gbps	100 Mbps	$85 + $5 router
	Fiber	2.5 Gbps	2.5 Gbps	$134 + $5 router
	Fiber	5 Gbps	5 Gbps	$199 + $5 router
Pavlov Media	Fiber	1 Gbps	1 Gbps	$69.99
	Fiber	2 Gbps	2 Gbps	$79.99
	Fiber	5 Gbps	5 Gbps	$99.99
	Fiber	8 Gbps	8 Gbps	$134.99
Surf Internet	Fixed Wireless	5 Mbps	1 Mbps	$54.95
	Fixed Wireless	10 Mbps	1 Mbps	$64.95
	Fixed Wireless	15 Mbps	2 Mbps	$84.95
	Fixed Wireless	25 Mbps	3 Mbps	$104.95
	Fixed Wireless	50 Mbps	5 Mbps	$99.95
MF Wireless	Fixed Wireless	50 Mbps	5 Mbps	$85
	Fixed Wireless	100 Mbps	10 Mbps	$100
	Fixed Wireless	150 Mbps	20 Mbps	$125
Rise Broadband	Fixed Wireless	5 Mbps	Best Effort	$81.95
	Fixed Wireless	10 Mbps	Best Effort	$81.95
	Fixed Wireless	15 Mbps	Best Effort	$81.95
	Fixed Wireless	20 Mbps	Best Effort	$86.95
	Fixed Wireless	25 Mbps	Best Effort	$86.95
	Fixed Wireless	50 Mbps	Best Effort	$96.95
Nextlink	Fixed Wireless	25 Mbps	Best Effort	$49.95 + $8.99 router
	Fixed Wireless	35 Mbps	Best Effort	$59.95 + $8.99 router
	Fixed Wireless	50 Mbps	Best Effort	$69.95 + $8.99 router
	Fixed Wireless	100 Mbps	Best Effort	$79.95 + $8.99 router
	Fixed Wireless	200 Mbps	Best Effort	$94.95 + $8.99 router
	Fixed Wireless	300 Mbps	Best Effort	$109.95 + $8.99 router
	Fixed Wireless	400 Mbps	Best Effort	$124.95 + $8.99 router
	Fixed Wireless	500 Mbps	Best Effort	$139.95 + $8.99 router

WATCH Comm	Fixed Wireless	10 Mbps	1 Mbps	$59.99
	Fixed Wireless	15 Mbps	1 Mbps	$69.99
	Fixed Wireless	25 Mbps	5 Mbps	$79.99
	Fixed Wireless	50 Mbps	10 Mbps	$99.99
	Fixed Wireless	100 Mbps	20 Mbps	$120.00
Verizon	Hotpot	50 Mbps	4 Mbps	$20 - $110
	FWA Cellular	300 Mbps	20 Mbps	$45 - $60
T-Mobile	Hotspot	25 Mbps	3 Mbps	$20 - $50
	Cellular FWA	100 Mbps	20 Mbps	$65

In the forecasts, we used $60 as the starting price for broadband. The $60 starting price is in line with many of the providers in the county. The starting product for Comcast is $81, however the company pushes most customers to sign up for the 300 Mbps at $101. The starting price for Sparklight is $67.50. Conxxus offers 100 Mbps fiber at $70. AT&T offers 200/200 Mbps for $65 on its fiber network. T-Mobile FWA is priced at $65. In the analysis, the $60 rate is only a starting point, and we considered the impact of an ISP charging both higher and lower rates.

The $60 rate would be a significant discount from some of the rural technologies in play today. For example, Nextlink broadband using licensed spectrum at 100 Mbps starts at $88.94. Starlink prices start at $120. WATCH Communications offers 100 Mbps licensed fixed wireless at $120. MF Wireless offers licensed fixed wireless at 100 Mbps for $100. Surf Internet offers 50 Mbps for $99.95. Other satellite broadband and hotspots have stingy data caps, and customers can spend a lot per month if they use a normal amount of household broadband.

The forecasts assume some rate increases over time. Rates must be increased to keep up with expense inflation. The model is conservative and assumes that rates increase 5% every fifth year, which works out to a little less than 1% per year. The big cable companies have been raising rates every year for the last decade.

Rates Used in This Study

Telephone Rates

The studies assume a single residential telephone product – a telephone line with unlimited long-distance for $20.00. The product includes a full package of features like voice mail, caller ID, etc. These rates don't include taxes on the telephone service, such as the tax that supports 911. The average revenue for business customers is estimated at $55. This higher revenue reflects the fact that businesses often buy multiple phone lines. Unlimited long-distance will be welcome in households that have poor cellular coverage since the telephone companies still charge long-distance rates for calling outside of the local area. The unlimited calling plans today usually include Canada, Mexico, and even some other international locations.

Cable TV Products

We did not include cable TV in the feasibility assessment. Millions of households nationwide have been dropping traditional cable every year and are instead using streaming video services. Even should an ISP

decide to bring a TV option, there is little margin on the product, so adding cable TV would make little difference to the financial analysis.

Broadband Products

The four speeds below are arbitrary, and an ISP might use these prices but a different set of speeds. This structure uses a $15 price step between tiers. The broadband products are all assumed to have symmetrical download and upload speeds. Most ISPs charge higher rates to businesses, and the studies assume a $20 additive to business rates. The financial models assume that the data products don't have data caps and provide unlimited broadband usage to customers.

	Price	Percentage
Residential Fiber Broadband		
100 Mbps	$ 60.00	40%
250 Mbps	$ 75.00	40%
500 Mbps	$ 90.00	17%
Gigabit	$105.00	3%
Business Fiber Broadband		
100 Mbps	$ 80.00	30%
250 Mbps	$ 95.00	40%
500 Mbps	$110.00	25%
Gigabit	$125.00	5%

Managed WiFi. ISPs have found that the biggest quality problems with home broadband are due to obsolete or poorly placed WiFi routers in the home. A poor WiFi router translates to a poor broadband experience. Many ISPs are now offering managed WiFi. This product places carrier-class WiFi routers in the home that are placed and operated by the ISP. High-quality routers and the placement of multiple routers for larger homes usually mean better broadband coverage throughout the home. ISPs often assist customers when adding a new device to the wireless network. The managed WiFi routers provide a secondary benefit to an ISP because they provide a network monitoring location inside the home, meaning that the ISP is more easily able to pinpoint problems.

The studies assume a monthly rate for managed WiFi of $5.00 for residences and $10.00 for businesses. It's further assumed that 70% of residents would buy this product and 60% of businesses.

Large Broadband Products. There are entities in the market that buy larger bandwidth products. The studies are conservative and predict modest revenues in this category. In the county, the larger bandwidth products would be sold to cellular towers, schools, and a handful of large businesses.

Cell towers are an interesting challenge. In some parts of the country, we have clients with rural fiber networks that get almost every cellular tower as a customer. But we have other similarly situated clients that get none of this business. Cellular carriers like to buy large volumes of connections from a single regional provider, and they often already have long-term contracts for large areas. The new opportunity for cell towers will be for small cell sites. These are smaller cellular transmitters that are placed on utility poles or light poles and that bring improved cellular service into neighborhoods.

Network Capital Costs. The telecom industry uses the term capital costs to describe the cost of assets required to operate the business. The capital expenditures predicted in these models reflect the results of the engineering analysis described in Section II of this report.

Below is a summary of the specific capital assets needed for each base scenario. Capital for broadband networks includes several broad categories of equipment, including fiber cable, fiber drops, fiber electronics, huts and buildings, and customer devices like WiFi modems. In addition to capital needed for the network, there are operational capital costs for assets like furniture, computers, vehicles, tools, inventory, and capitalized software.

Our goal in the forecasts is to be realistic but a little conservative. For the past decade, the prices for components in the industry have been stable, and we've been able to make estimates that got within 5% of the cost of building a network. It's harder to estimate the cost of the network today because of inflation.

We started our analysis by using the most current component costs we know about. Some of these costs are already 20% higher than costs from a year ago.

Below is a summary of the cost to build the needed fiber network for two scenarios. In the first scenario, areas served today by licensed wireless technologies are considered eligible for BEAD grants (4,247 locations). In the second scenario, areas served by licensed wireless technologies are not eligible for BEAD grants (1,527 locations).

	Scenario 1	Scenario2
Fiber	$11,985,120	$32,667,434
Drops	$ 1,193,491	$ 3,366,019
Electronics	$ 1,057,556	$ 2,982,076
Operational Assets	$ 159,155	$ 221,098
Total	$14,395,322	$39,236,627
Passings	1,523	4,287
Cost per Passing	$9,452	$9,152

The cost per passing is largely driven by customer density. In both scenarios there are approximately six homes and businesses per mile of fiber needed in the unserved areas. We've worked in other counties in the state with only three homes per mile of fiber, and the resulting cost per passings was double and much harder to finance with a grant.

There are ways that an ISP can lower the costs shown above. The biggest savings can come from an ISP that is able to construct some of its own network since the above costs assume that external contractors build the network – and outside labor charges include a profit mark-up. One of the easiest ways to save money would be to use employees to build drops and do installations instead of contractors. We've been seeing that many contractors are charging a premium price to build drops in today's market because they would rather use these technicians to build fiber in some other market.

Customer Costs. Residential Fiber Electronics Costs: The assumed cost for the customer electronics (ONT) includes the installation labor. The cost is the same for both scenarios. Our assumption is:

$785 for an ONT and installation at prevailing wage.

It might be possible that installations could cost less if they were done by ISP personnel and not contract laborers. Our analysis assumes that most businesses use the same ONT electronics used to connect to homes. Only larger businesses would require a larger ONT with more data ports. We've assumed that a WiFi modem is included in the cost of the ONT. This is a middle-of-the-road price, and there are both more expensive and less expensive ONTs available.

Fiber Drops: Fiber drops are the fiber that connects from the street to a customer premises. We have included conservatively high costs for fiber drops. The assumption has been made that with the volume of drops needed plus the anticipated speed of network deployment, the drops during the first four years of the project would be installed by external contractors. It would be possible to build drops for less using ISP staff, but the huge volume of installations during the first four years is probably more than what company personnel can handle. The prices below are the same for both scenarios.

$1,282 for drops at prevailing wage.

One of the biggest factors in determining drop costs is the average distance from customers to the road. In the rural parts of the county homes are further from the road in the rural areas compared to the towns and cities.

Customer Penetration Rates. One of the most important variables in the assessment is the customer penetration rate or the percentage of the homes and businesses in the county that will buy broadband service.

The analysis looks at customer penetration rates in several different ways. The base scenario begins with what we call expected rates. We used an expected penetration rate of 60% to begin our analysis. We think this is a conservative penetration rate because a fiber provider would win a large majority of customers over time. We also look at a range of other penetration rates to demonstrate the impact of penetration rates on financial performance. We normally expect this to be the most important variable.

Expense Assumptions

Expenses are the recurring costs of operating the business once it's built. The forecasts represent our best estimate of operating expenses and are not conservative. As mentioned earlier, expenses are estimated on an incremental basis, meaning that the forecasts only consider new expenses that are needed to open a new market. In an incremental analysis, we don't show a share of the costs of the accountant who would be keeping the books if that position already exists and is on the payroll. An incremental study would assume, for example, that an existing ISP is already paying for positions like an accountant and not include those costs in the analysis.

The two scenarios differ significantly due to the economy of scale for existing ISPs to add a new market. An existing ISP is already going to have the processes in place to be an ISP. It will already have the

software needed to take orders and bill customers. It will already have the systems in place to track inventory and customer locations. It will already have functions like network monitoring, responding to customer troubles, and numerous other systems in place. An existing ISP will have an executive team in place that will operate the business and handle accounting, human resources, insurance, legal, etc. It's unlikely that adding the customers from this project would drive an existing ISP to hire any new people for the backoffice functions. If an ISP is already operating in your area, it's likely that they would only add technicians in trucks and customer service representatives.

Following are a few of the most important expense assumptions.

Inflation. We've used an annual inflation rate of 2.5%. That has been the average historic inflation rate over the last several decades. We know there are years when inflation will be higher. If inflation stays higher than the historical average, an ISP will typically raise rates to compensate.

Employees: Labor is one of the largest expenses of operating a broadband network. The models assume that an ISP will need to hire additional staff to take care of the new customers. We have assumed salaries at market rates with an annual 2.5% inflation increase for all positions. We've assumed that the benefit loading is 40% of the basic annual salary. That would cover payroll taxes and other taxes like workers' compensation, as well as employee benefits. At a minimum, expanding an ISP to cover the county will require the following incremental new employees:

Customer Service Representative. This is the staff that takes new orders and answers customer questions about billing, services, etc. The We've assumed the business will require the following new positions:

Scenario 1	2 new CSRs
Scenario 2	1 new CSR

Install/Repair Technician. These technicians provide maintenance and repair calls. The technicians would maintain both network electronics and facilities as well as customers. We've assumed the business will require the following new positions:

Scenario 1	2 new outside technicians
Scenario 2	1 new outside technician

We assumed that construction contractors would build the fiber network. We've also assumed that customer installations will be outsourced during the construction process and for a year after. However, once the bulk of customers has been added, the forecasts assume that the ISP will do future installations.

Start-Up Costs: To be conservative, there are some start-up costs included in each scenario. There are one-time expenses associated with launching a new business or new market, and rather than listing them all, we have included them as start-up costs.

Sales and Marketing Expenses: Every scenario will require a significantly high customer penetration rate to be successful. We used the assumption that there would be a marketing effort to sign customers. We've assumed an average cost of $100 in sales and marketing costs for each new customer added. It is likely that well-known local ISPs could spend less on marketing.

Delivery of Products: The studies assume that a wholesale basic telephone line can be purchased wholesale at $6.00 per month. A line with unlimited long-distance is assumed to cost $9.00. It's possible to buy telephone lines for less than these estimates. The studies assume there is no cable TV product.

Maintenance Expenses: There are a number of routine maintenance expenses that the new business would incur on an incremental basis. These include:

- Vehicle expenses to maintain the vehicles required for the field technicians.
- Computer expenses to support the computers used by employees.
- Tools and equipment expenses.
- Power expenses to provide power to the network.
- General maintenance and repair of the outside plant network and the electronics to repair damaged or nonfunctional electronics.
- Internet Backbone. Since this is an incremental analysis, we have shown only incremental increases in the cost of Internet bandwidth.

Software Expense: ISPs typically maintain a complex software system called BSS/OSS (billing and operational support systems). This software provides a wide range of functions: taking orders, provisioning new customers, tracking customer equipment, tracking inventory, creating customer bills, and tracking customer payments (or nonpayment). Since most such software is billed to providers on a per-customer basis, we have assumed an expense for this maintenance.

Billing: Billing costs are shown as the incremental cost used to bill customers. We assumed that there would be some mix of mailing paper bills, charging bills to credit cards, and charging bills directly as debits to bank accounts.

Taxes: The model assumes that if a commercial ISP operates the business, there will be state and federal income taxes. These taxes would not apply to a municipal business or a non-profit.

We have assumed no property taxes on assets. There are a few jurisdictions in the country that charge property taxes on fiber networks, but most of the country doesn't.

The forecasts do not include any taxes assessed to customers. For example, this business would charge and collect various sales and telephone taxes. The models don't show these taxes, and the assumption is that the taxes would be collected and sent to the tax authorities on the customers' behalf. The expenses are treated as a passthrough on the ISP books rather than a revenue or expense.

Overhead Expenses: The forecasts include minor overhead expenses. Since this is an incremental model, it does not include allocated expenses such as an allocation of the general manager's salary. However, there are incremental costs attributable directly to the new business. This would include things like legal expenses, accounting audit expenses, consulting expenses, business insurance, and other similar expenses that are related to entering a new market.

Depreciation and Amortization Expense: The forecasts include both depreciation and amortization expense. These are the expenses recognized by writing off assets over their expected accounting lives. For example, the depreciation rate for a vehicle is 20% per year (it is written off over five years). The cost of

a new vehicle is depreciated monthly to write off the asset over five years or sixty months. All hard assets are depreciated except land. Depreciation rates are set according to the expected life of the assets—something that is usually determined to comply with IRS rules and accounting standard practices. Soft assets like software are amortized using the same process as depreciation.

B. Financial Results

We created the financial analysis for two purposes. First, this is the only way to understand the amount of grant funding that might be needed by ISPs that want to bring broadband to the grant-eligible areas. We also want to demonstrate there is the possibility of operating profitably in the unserved areas.

We always try to be conservative when creating financial forecasts. By conservative, we mean that an actual business plan ought to perform a little better than what we are projecting.

It is never easy to summarize the results of complicated business plans and make them understandable to the nonfinancial layperson. The following summary shows a few key results of each scenario that we think best allow a comparison of the numbers between scenarios. A table of all the financial results is included in Exhibit II, which makes it easier to compare scenarios.

There are a few key assumptions in the base analysis:

- We assume that the network would be constructed and owned by existing ISPs.
- We assume ISPs would build an all-fiber network using XGS-PON electronics capable of delivering 10 gigabit broadband.
- Construction costs assume 70% aerial and 30% buried fiber.
- The base study assumes a 60% market penetration, meaning that 60% of customers would buy broadband on the new network. We also looked at other scenarios.
- We use broadband rates that start at $60.
- We've assumed that non-grant funding would consist of 85% loans, financed at 6.0% for 25 years, and the remainder from ISP equity.

All of these assumptions affect the amount of grant funding that is needed. We also analyzed other scenarios in the sensitivity analysis to understand how changing key variables impact the financi8al results.

Scenario 1

This scenario assumes that all locations served by fixed wireless technology today are eligible for the BEAD grants (4,287 locations).

	No Grant	Breakeven Grant
Asset Costs	$ 39.2 M	$ 39.2 M
Grant	$ 0.0 M	$ 20.9 M
Equity	$ 6.7 M	$ 3.0 M
Bank Debt / Bond	$ 37.9 M	$ 17.0 M
Total Financing	$ 44.5 M	$ 40.9 M

Penetration Rate	60%	60%
Cash after 5 Years	($ 1.27 M)	$ 0.40 M
Cash after 10 Years	($ 9.41 M)	$ 0.58 M
Cash after 15 Years	($17.84 M)	$ 0.47 M
Cash after 20 Years	($25.95 M)	$ 0.69 M

The number above shows that building fiber is not feasible without substantial grant funding. The second column shows that a grant of $20.9 million is needed for this scenario to break even – meaning that the revenues from the project would cover operating costs. This grant equals 53% of the cost of total assets. The BEAD grant will cover grants that ask for up to 75% of the costs of the assets, so an ISP should easily be able to find an acceptable grant in the county.

Sensitivity Analysis

The simple summary above is based on a single set of assumptions. In the following sensitivity analysis, we look at how changing some of the assumptions changes the financial projection of a fiber business built using grant funding.

Customer Penetration Rate

The most significant variable affecting the success of a fiber project is usually the customer penetration rate – the percentage of customers that buy broadband. The numbers below show the breakeven amount of grant required at customer penetration rates between 55% and 75%.

	50%	55%	60%	65%	70%
Asset Costs	$ 38.3 M	$ 38.8 M	$ 39.2 M	$ 39.7 M	$ 40.1 M
Grant	$ 25.4 M	$ 23.1 M	$ 20.9 M	$ 18.6 M	$ 16.3 M
Equity	$ 2.2 M	$ 2.6 M	$ 3.0 M	$ 3.4 M	$ 3.8 M
Bank Debt	$ 12.4 M	$ 14.7 M	$ 17.0 M	$ 19.4 M	$ 21.7 M
Total Financing	$ 39.9 M	$ 40.4 M	$ 40.9 M	$ 41.4 M	$ 41.9 M
Cash after 5 Years	$ 0.40 M	$ 0.39 M	$ 0.40 M	$ 0.39 M	$ 0.39 M
Cash after 10 Years	$ 0.58 M	$ 0.55 M	$ 0.58 M	$ 0.53 M	$ 0.49 M
Cash after 15 Years	$ 0.46 M	$ 0.43 M	$ 0.47 M	$ 0.45 M	$ 0.37 M
Cash after 20 Years	$ 0.54 M	$ 0.56 M	$ 0.69 M	$ 0.73 M	$ 0.68 M
% Grant to Assets	74%	59%	53%	47%	41%

This table shows several important trends. The key takeaway is that the percentage of grant funding required decreases with higher expected customer penetration rates. This is because the extra revenue from having more customers helps to pay to operate the broadband business. Another trend is the slight increase in the cost of assets as the penetration rates go higher due to having to construct more customer drops and provide more customer electronics.

Note again that each result shown on the table represents the breakeven scenario – which shows the least amount of grant necessary to make a given scenario viable. Even using our conservative assumptions shows that with an expected penetration rate of 50% that an ISP could make this work with a 75% grant, which is the cap under BEAD. Our experience is that somebody who builds a rural fiber network will likely eventually get a substantial penetration rate, assuming customers find the prices to be affordable. We know a number of rural ISPs that have achieved penetration rates from 70% to as high as 90%.

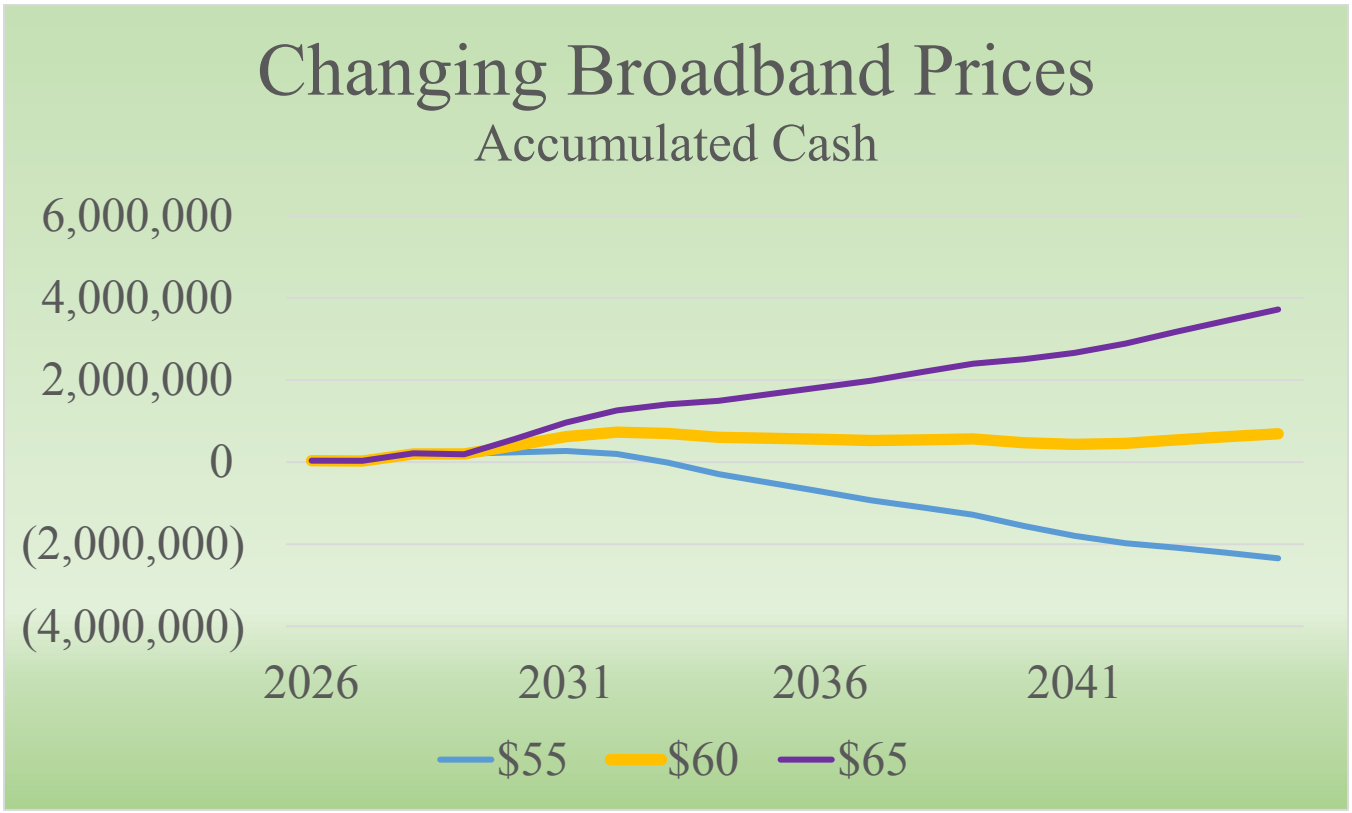
Changing Broadband Prices

We looked at the impact of changing broadband prices. Increasing broadband prices by $5 per month (changing the base rate from $60 to $65) increased cash flow over 20 years by just over $3 million. This means that a $1 change in broadband prices changes the 20-year cash flow by over $150,000 annually. This is a significant sensitivity. Decreasing rates by $5 had a similar impact and lowered cash over 20 years by 3 million.

This high sensitivity means several things for an ISP.

- An ISP should be careful about lowering rates. For example, if a future marketing plan suggests cutting rates to gain customers, the long-term impact of lower rates could be devastating for cash generation.
- This also means that an ISP can raise rates (to the extent possible in the market) to help make up for other shortfalls.

The following graph shows the wide swings in financial performance due to changing prices upward or downward by $5. The yellow line represents the base case with broadband rates at $60.



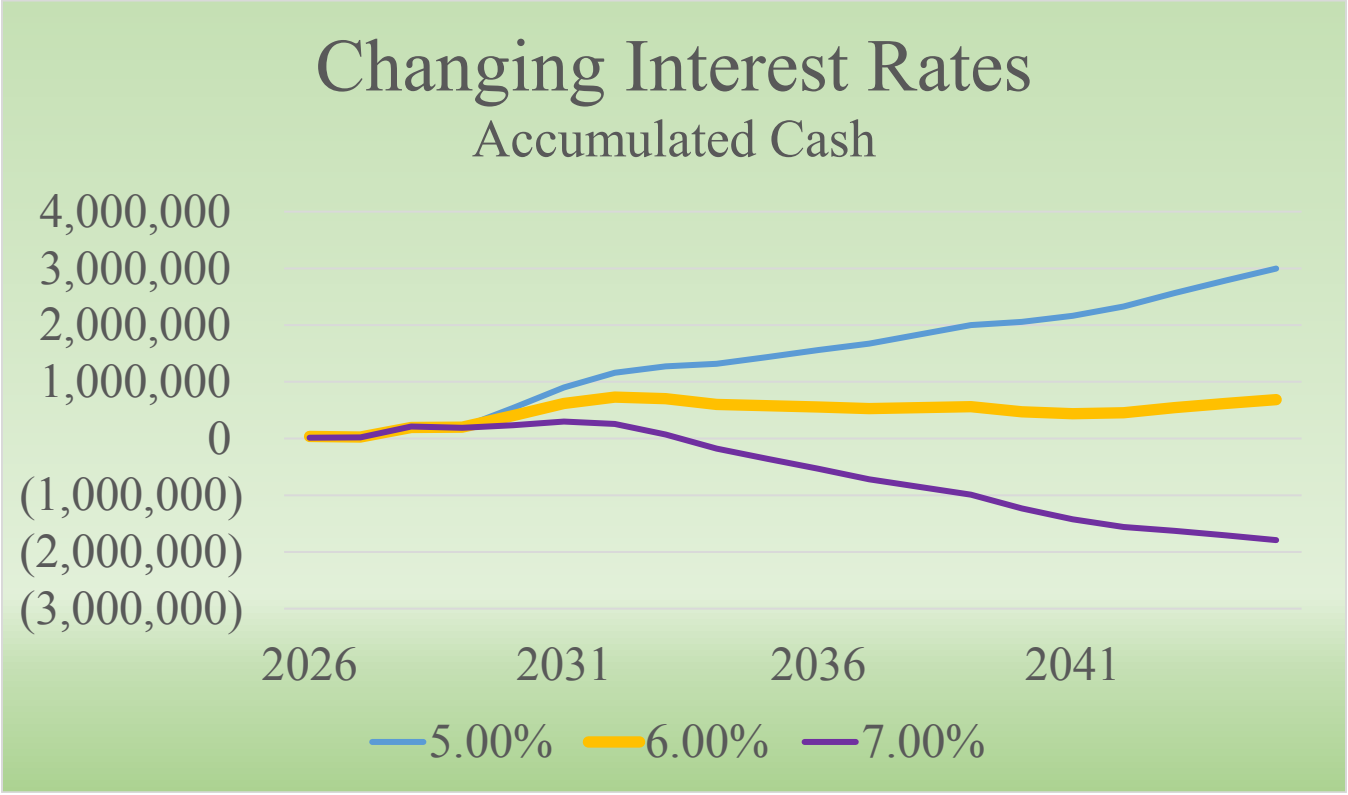
Changing Financing Terms

We looked at the impact of changing the various financing parameters.

Interest Rate. Our base study assumed an interest rate of 6.0%. We looked at a scenario that lowered the interest rate by 100 basis points, or 1% (in this case, lowering the interest rate from 6% to 5%). Lowering the interest rate by 100 basis points improves cash flow by almost $2.3 million over twenty years. The impact of increasing the interest rate to 7% was similar and decreased cash flow by $2.4 million over twenty years.

This result provides a warning that anybody planning a new fiber network during a time of financial uncertainty should keep a close eye on interest rates and be cautious about proceeding if interest rates are too high. If an ISP must finance at a high interest rate, it should make sure that the loan can be refinanced in the future if interest rates drop.

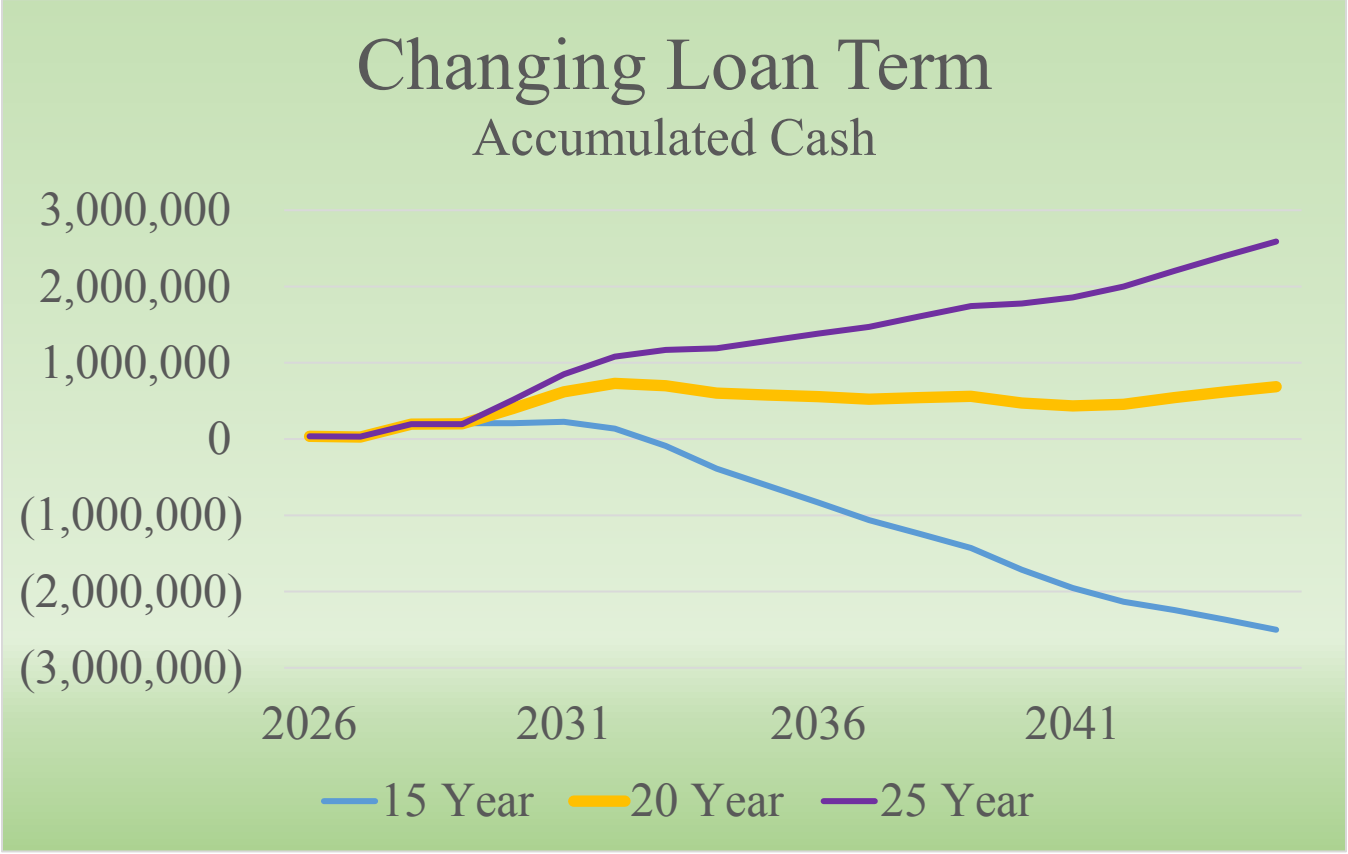
The graph below shows the impact on accumulated cash for a 5%, 6%, and 7% interest rate.



We should note that another way for ISPs to perform better than shown on these graphs is to invest more cash equity and reduce the amount of debt. There are a number of ISPs funded by venture capital that plan to use equity to support BEAD grants.

Loan Term. Loan term refers to the number of years of payments on a loan. The base scenario assumed a 25-year loan term. Changing the loan term changes cash flow since it changes the annual debt payments - much like what happens with longer or shorter-term home mortgages. We looked

at the impact of increasing the loan term to 30 years. This increased cash over 20 years by almost $1.9 million. We also looked at decreasing the loan term to 20 years, which decreased cash over 2- years by $3.1 million.



Refinancing the Loans. An ISP borrowing money at today's high interest rates is likely counting on the possibility of someday refinancing the loan if interest rates drop. We looked at a scenario where the original loans are refinanced after five years at a 4% interest rate. This is not a prediction that rates will be lower by then but is a way to quantify the impact if refinancing becomes possible.

Refinancing increased cash flow over 20 years by about $3.6 million. It's likely that any ISP that borrows at current interest rates will try to refinance the project at the earliest opportunity.

Inhouse Construction. As discussed in the report, it is more expensive to build drops with contractors than with in-house technicians. We looked at a scenario where the ISP would use internal staff to build drops and complete installations. In this scenario, the ISP would hire two additional installers for just the first four years of the contract. After that, existing technicians could build the occasional drops needed.

Using internal labor reduces the labor costs for the drops and installations. Using in-house technicians drops overall asset costs by over $3 million. This would also lower the amount of grant and other funding needed for a project – and makes the project more feasible.

$1 Million Cost Overrun. We looked at the impact of spending $1 million more on assets than is budgeted. We've assumed that a cost overrun would reduce cash flow by almost $1.4 million over twenty years.

A More Optimistic Scenario
The base scenario includes a number of conservative assumptions. In this scenario, we changed some of the key assumptions to produce a more optimistic scenario:

- We increased the starting broadband price by $5 to $65.
- We increased the loan term by 5 years to 30 years.
- We show the debt being refinanced to 4.0% interest after five years.

This three changes increased cash over twenty years by $6.5 million. This may be the most important result of the study because it shows ISPs that the assumptions they make can have a huge influence on the amount of grant funding needed to be successful.

Other Scenarios

We also looked at a few alternate business structures. These scenarios were examined at the base 60% penetration rate. The results would also vary with greater or fewer customers.

ISP Leases the Network
In this scenario, the County would fund, build, and own the network and lease it to an ISP to operate. The ISP would earn any extra profits. This scenario turns out to be difficult to make work in rural areas. These results show that if the lease is set so that the County is made whole, then the ISP will likely lose money over time. The biggest challenge of this business plan is to find an ISP that would guarantee the government's debt payments. An ISP could do better than shown by raising rates, but it's hard to imagine an ISP that would be interested in this scenario in a rural area.

	At Breakeven Grant	
	County	ISP
Asset Costs	$ 39.1 M	$ 0.1 M
Grant	$ 20.9 M	$ 0.0 M
Equity	$ 0.0 M	$ 0.3 M
Bank Debt	$ 17.6 M	$ 2.1 M
Total Financing	$ 38.5 M	$ 2.4 M
Cash after 5 Years	$ 0.31 M	($0.23 M)
Cash after 10 Years	$ 0.57 M	($1.42 M)
Cash after 15 Years	$ 0.42 M	($2.09 M)
Cash after 20 Years	$ 0.20 M	($1.33 M)

Open-Access
In an open-access scenario, the County would pay for the network, including customer electronics. Customer connections would be sold to ISPs at a rate between $35 and $55 dollars per customer per month, depending upon the broadband product. The ISP would sell to customers and would incur some small capital costs for things like WiFi routers inside customer homes.

	At Breakeven Grant	
	County	ISPs
Asset Costs	$ 39.0 M	$ 2.1 M
Grant	$ 20.9 M	$ 0.0 M
Equity	$ 0.0 M	$ 0.4 M
Bank Debt	$ 16.7 M	$ 2.7 M
Total Financing	$ 38.5 M	$ 3.1 M
Cash after 5 Years	($ 0.27 M)	$ 0.23 M
Cash after 10 Years	($ 2.06 M)	$ 0.37 M
Cash after 15 Years	($ 3.79 M)	$ 0.50 M
Cash after 20 Years	($ 5.31 M)	$ 1.66 M

As the numbers above show, this scenario loses money for the County while one or more ISPs are collectively slightly profitable. These losses are fairly easy to understand:

- The County would be making nearly the same capital investment as in the retail scenarios.
- The County would still need to employ a small staff of technicians to care for the fiber network and the electronics. This adds to the cost of operating the business.
- The County would collect the smaller open-access loop fees instead of the much larger retail revenues. This means the County must cover nearly the same debt with a much smaller revenue stream.

There has been a lot of discussion nationwide about how open-access should be the preferred business model for cities and counties. Our analysis shows that this is a lot easier to make work in cities than in counties due to the cost per passing to build the network. This business also has a significant economy of scale, meaning the greater the number of customers the more chance of success.

Scenario 2

This scenario assumes that locations served by licensed wireless spectrum, and with claimed FCC speeds of at least 100/20 Mbps are not eligible for BEAD grants (1,527 locations).

		Breakeven
	No Grant	Grant
Asset Costs	$ 14.4 M	$ 14.4 M
Grant	$ 0.0 M	$ 9.9 M
Equity	$ 2.6 M	$ 0.8 M
Bank Debt / Bond	$ 14.6 M	$ 4.5 M
Total Financing	$ 17.1 M	$ 15.2 M
Penetration Rate	60%	60%
Cash after 5 Years	($ 0.32 M)	$ 0.29 M

Cash after 10 Years	($ 3.21 M)	$ 0.45 M
Cash after 15 Years	($ 6.27 M)	$ 0.44 M
Cash after 20 Years	($ 9.30 M)	$ 0.45 M

This shows that building fiber in this smaller grant footprint still requires substantial grant funding. The breakeven grant of $9.9 million represents 70% of the cost of total assets at prevailing wages. Breakeven is defined as a scenario where the project never runs out of cash – so the breakeven grant is the lowest amount of grant funding needed for the project to always be cash-positive. ISPs would be reluctant to do a project that never does better than breaking even, so a typical ISP will expect more grant funding than shown above.

Sensitivity Analysis

Customer Penetration Rate

The most significant variable affecting the success of a fiber project is usually the customer penetration rate – the percentage of customers that buy broadband. The numbers below show the breakeven amount of grant required at customer penetration rates between 50% and 70%.

	50%	55%	60%	65%	70%
Asset Costs	$ 14.1 M	$ 14.2 M	$ 14.4 M	$ 14.6 M	$ 14.7 M
Grant	$ 10.7 M	$ 10.1 M	$ 9.9 M	$ 8.3 M	$ 7.3 M
Equity	$ 0.6 M	$ 0.8 M	$ 0.8 M	$ 1.1 M	$ 1.3 M
Bank Debt	$ 3.7 M	$ 4.3 M	$ 4.5 M	$ 6.2 M	$ 7.3 M
Total Financing	$ 15.0 M	$ 15.2 M	$ 15.2 M	$ 15.6 M	$ 15.9 M
Cash after 5 Years	$ 0.30 M	$ 0.32 M	$ 0.29 M	$ 0.30 M	$ 0.29 M
Cash after 10 Years	$ 0.41 M	$ 0.53 M	$ 0.45 M	$ 0.52 M	$ 0.49 M
Cash after 15 Years	$ 0.32 M	$ 0.56 M	$ 0.44 M	$ 0.57 M	$ 0.54 M
Cash after 20 Years	$ 0.22 M	$ 0.61 M	$ 0.45 M	$ 0.69 M	$ 0.66 M
% Grant to Assets	76%	71%	70%	57%	50%

This table shows several important trends. The key takeaway is that the percentage of grant funding required decreases with higher customer penetration rates. This is because of the extra revenue from having more customers help to pay to operate the broadband business. You can note an interesting phenomenon, in that the amount of needed grant decreases if the ISP can achieve customer penetration rates higher than 60%. Once revenues solidly cover operating costs, a greater share of revenue flows into bottom line profits.

Using our conservative assumptions, this table shows that at penetration rate a little higher than 50% is needed to stay under the BEAD cap of awarding 75% grants. As the penetration rate increase, the amount of grant required to break even decreases.

Another trend is the slight increase in the cost of assets as the penetration rates go higher due to having to construct more customer drops and provide more customer electronics.

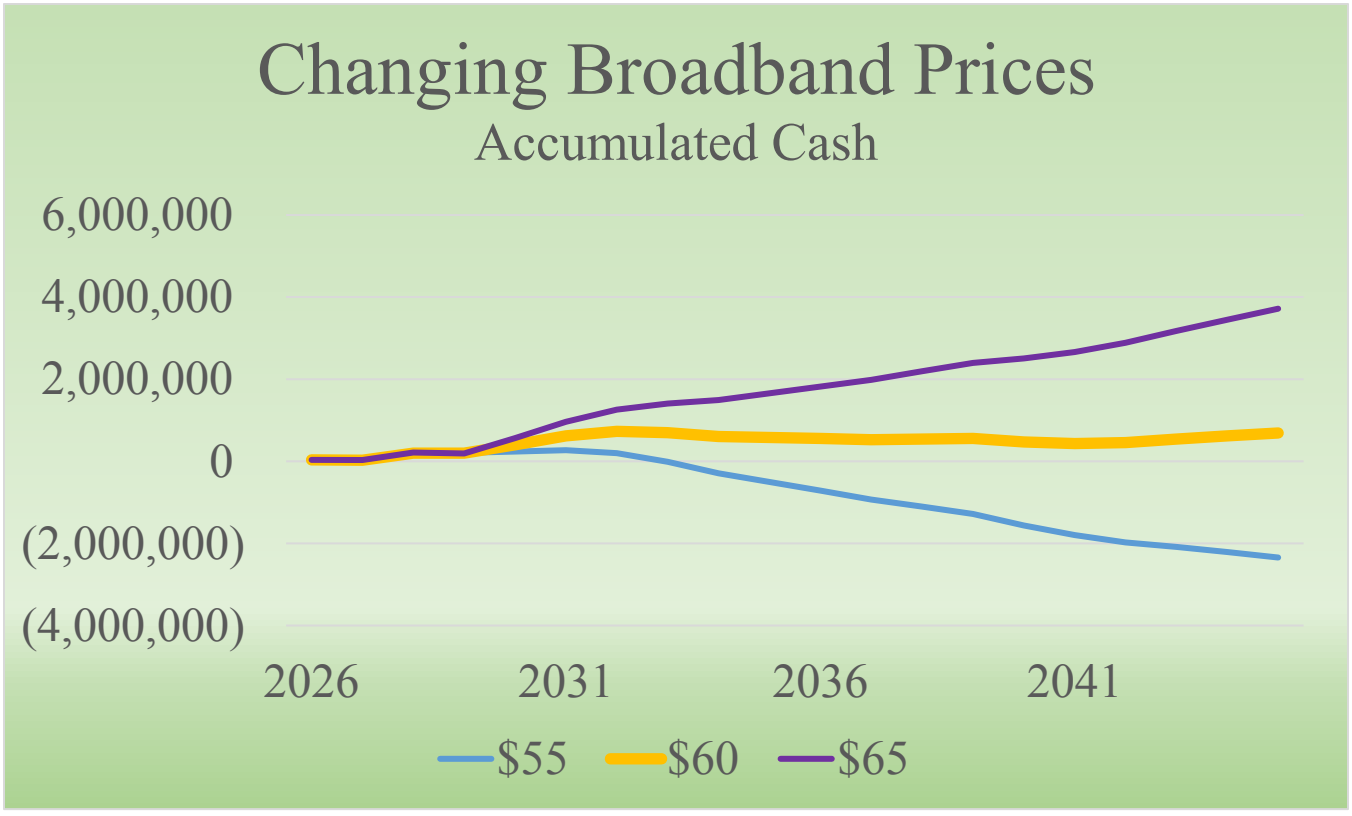
Changing Broadband Prices

We looked at the impact of changing broadband prices. Increasing broadband prices by $5 per month (changing the base rate from $60 to $65) increased cash flow over 20 years by just over $1 million. This means that a $1 change in broadband prices changes the 20-year cash flow by over $50,000 annually. This is a significant sensitivity. Decreasing rates by $5 had a similar impact and lowered cash over 20 years by 1 million.

This high sensitivity means several things for an ISP.

- An ISP should be careful about lowering rates. For example, if a future marketing plan suggests cutting rates to gain customers, the long-term impact of lower rates could be devastating for cash generation.
- This also means that an ISP can raise rates (to the extent possible in the market) to help make up for other shortfalls.

The following graph shows the wide swings in financial performance due to changing prices upward or downward by $5. The yellow line represents the base case with broadband rates at $60.



Changing Financing Terms

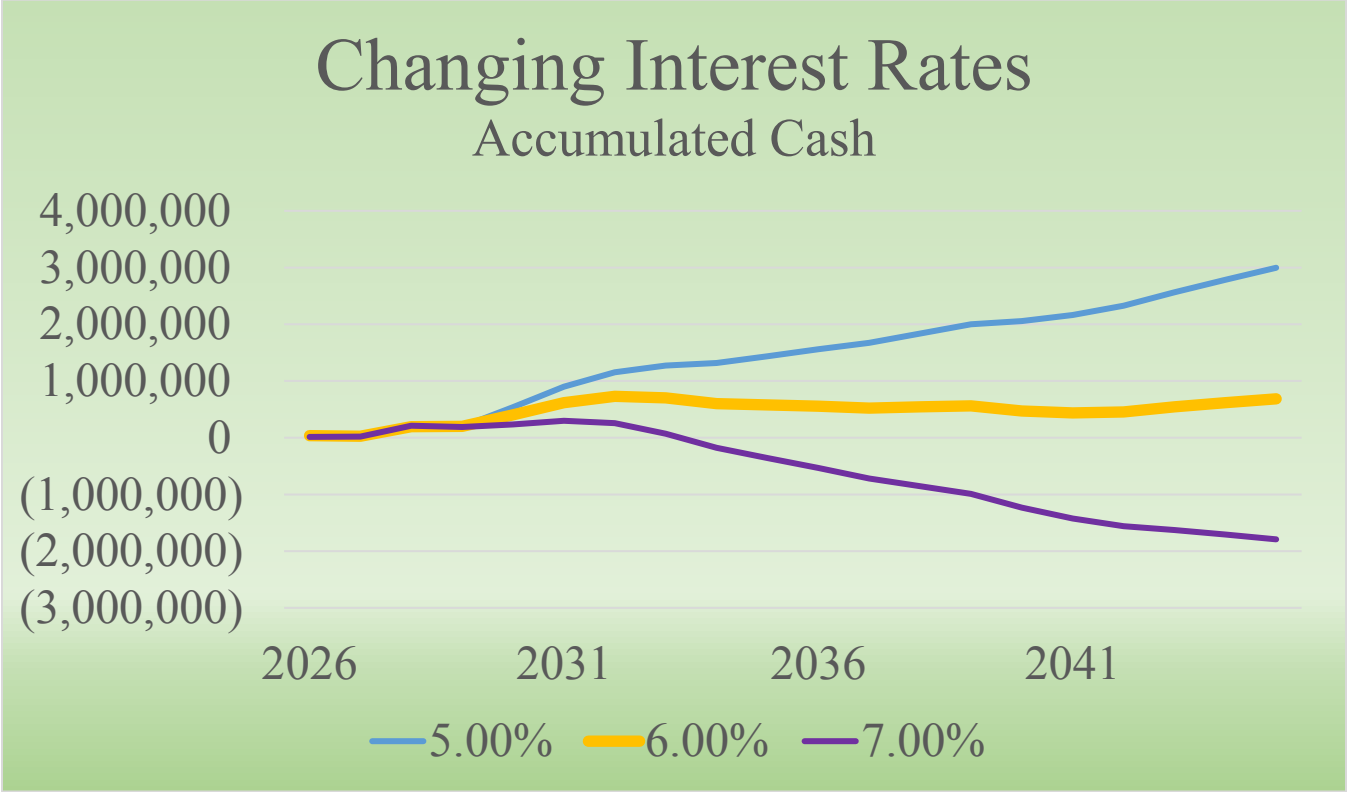
We looked at the impact of changing the various financing parameters.

Interest Rate. Our base study assumed an interest rate of 6.0%. We looked at a scenario that lowered the interest rate by 100 basis points, or 1% (in this case, lowering the interest rate from

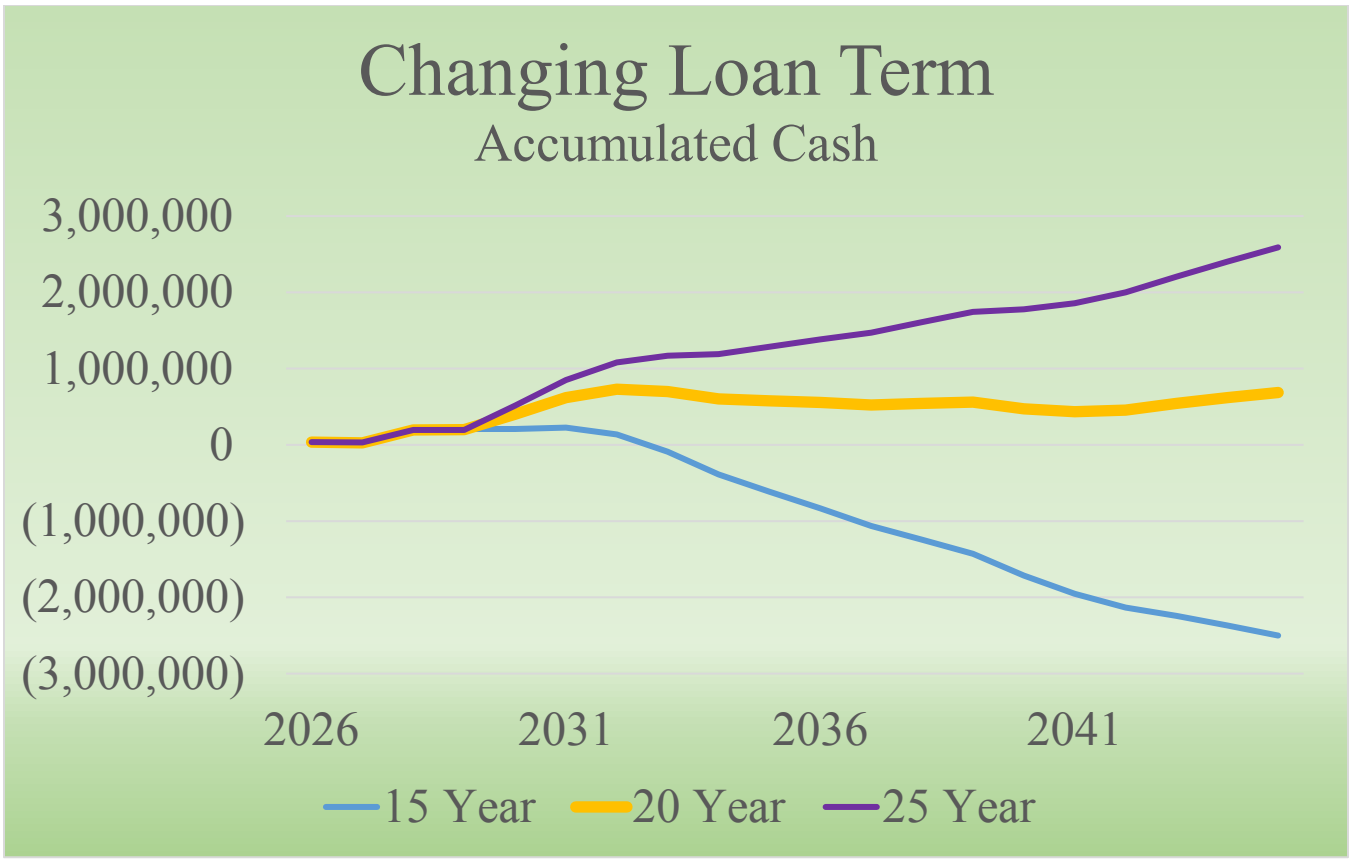
6% to 5%). Lowering the interest rate by 100 basis points improves cash flow by around $620,000 over twenty years. The impact of increasing the interest rate to 7% was similar and decreased cash flow by $670,000 over twenty years.

This result provides a warning that anybody planning a new fiber network during a time of financial uncertainty should keep a close eye on interest rates and be cautious about proceeding if interest rates are too high. If an ISP must finance at a high interest rate, it should make sure that the loan can be refinanced in the future if interest rates drop.

The graph below shows the impact on accumulated cash for a 5%, 6%, and 7% interest rate.



Loan Term. Loan term refers to the number of years of payments on a loan. The base scenario assumed a 25-year loan term. Changing the loan term changes cash flow since it changes the annual debt payments - much like what happens with longer or shorter-term home mortgages. We looked at the impact of increasing the loan term to 30 years. This increased cash over 20 years by almost $500,000. We also looked at decreasing the loan term to 20 years, which decreased cash over 2-years by $860,000.



Refinancing the Loans. An ISP borrowing money at today's high interest rates is likely counting on the possibility of someday refinancing the loan if interest rates drop. We looked at a scenario where the original loans are refinanced after five years at a 4% interest rate. This is not a prediction that rates will be lower by then but is a way to quantify the impact if refinancing becomes possible.

Refinancing increased cash flow over 20 years by about $950,000. It's likely that any ISP that borrows at current interest rates will try to refinance the project at the earliest opportunity.

Inhouse Construction. As discussed in the report, it is more expensive to build drops with contractors than with in-house technicians. We looked at a scenario where the ISP would use internal staff to build drops and complete installations. In this scenario, the ISP would hire two additional installers for just the first four years of the contract. After that, existing technicians could build the occasional drops needed.

Using internal labor reduces the labor costs for the drops and installations. Using in-house technicians drops overall asset costs by over $950,000. This would also lower the amount of grant and other funding needed for a project – and makes the project more feasible.

$1 Million Cost Overrun. We looked at the impact of spending $1 million more on assets than is budgeted. We've assumed that a cost overrun would reduce cash flow by almost $1.4 million over twenty years.

A More Optimistic Scenario. The base scenario includes a number of conservative assumptions. In this scenario, we changed some of the key assumptions to produce a more optimistic scenario:

- We increased the starting broadband price by $5 to $65.
- We increased the loan term by 5 years to 30 years.
- We show the debt being refinanced to 4.0% interest after five years.

This three changes increased cash over twenty years by $2 million. This may be the most important result of the study because it shows ISPs that the assumptions they make can have a huge influence on the amount of grant funding needed to be successful.

Other Scenarios

We also looked at a few alternate business structures. These scenarios were examined at the base 60% penetration rate. The results would also vary with greater or fewer customers.

ISP Leases the Network

In this scenario, the County would fund, build, and own the network and lease it to an ISP to operate. The ISP would earn any extra profits. This scenario turns out to be difficult to make work in rural areas. These results show that if the lease is set so that the County is made whole, then the ISP will likely lose money over time. The biggest challenge of this business plan is to find an ISP that would guarantee the government's debt payments. An ISP could do better than shown by raising rates, but it's hard to imagine an ISP that would be interested in this scenario in a rural area.

	At Breakeven Grant	
	County	ISP
Asset Costs	$ 14.3 M	$ 0.1 M
Grant	$ 9.9 M	$ 0.0 M
Equity	$ 0.0 M	$ 0.1 M
Bank Debt	$ 4.4 M	$ 0.7 M
Total Financing	$ 14.3 M	$ 0.8 M
Cash after 5 Years	$ 0.31 M	($0.11 M)
Cash after 10 Years	$ 0.38 M	($0.34 M)
Cash after 15 Years	$ 0.31 M	($0.43 M)
Cash after 20 Years	$ 0.22 M	($0.16 M)

Open-Access

In an open-access scenario, the County would pay for the network, including customer electronics. Customer connections would be sold to ISPs at a rate between $35 and $55 dollars per customer per month, depending upon the broadband product. The ISP would sell to customers and would incur some small capital costs for things like WiFi routers inside customer homes.

	At Breakeven Grant	
	County	ISPs
Asset Costs	$ 14.4 M	$ 0.1 M
Grant	$ 9.9 M	$ 0.0 M
Equity	$ 0.0 M	$ 0.1 M
Bank Debt	$ 5.2 M	$ 0.6 M
Total Financing	$ 15.1 M	$ 0.7 M
Cash after 5 Years	($ 0.16 M)	$ 0.04 M
Cash after 10 Years	($ 1.63 M)	$ 0.33 M
Cash after 15 Years	($ 3.32 M)	$ 0.86 M
Cash after 20 Years	($ 5.05 M)	$ 1.36 M

As the numbers above show, this scenario loses money for the County while one or more ISPs are collectively slightly profitable. These losses are fairly easy to understand:

- The County would be making nearly the same capital investment as in the retail scenarios.
- The County would still need to employ a small staff of technicians to care for the fiber network and the electronics. This adds to the cost of operating the business.
- The County would collect the smaller open-access loop fees instead of the much larger retail revenues. This means the County must cover nearly the same debt with a much smaller revenue stream.

There has been a lot of discussion nationwide about how open-access should be the preferred business model for cities and counties. Our analysis shows that this is a lot easier to make work in cities than in counties due to the cost per passing to build the network. This business also has a significant economy of scale, meaning the greater the number of customers the more chance of success.

What Conclusions Can We Draw from the Financial Analysis?

There are a few important conclusions to draw from the financial analysis:

Perhaps the most important statistic in the study is customer density, meaning the number of customers per mile of fiber. In both scenarios, there are roughly six homes and businesses for each mile of constructed fiber. As the analysis shows, that is enough density to make BEAD grants viable at levels significantly below the 75% maximum grant. This is important because the grant office is using the cost per passing as a key element in scoring grant applications. We've worked in other counties, including in Illinois, where the cost per passing is two or more times higher than in Vermilion County.

Our base assumptions are conservative, and we looked at various scenarios that are more attractive. Factors like a higher customer penetration rate and higher broadband prices produce results significantly better than shown in the result summaries just above.

There doesn't look to be any true partnership opportunities for the rural areas where the County would own the network and work with ISP partners. This is not surprising in rural areas where the operating costs are high and the margins low – there is not enough cash generated to support two partners.

C. Funding for Broadband Networks

The biggest challenge for many broadband projects is finding funding. This section of the report looks at the various ways that other communities have been able to fund broadband networks. The following discussion covers both commercial bank financing and bond financing. There are a number of different financing options to consider. The report examines the following:

- Federal and State Infrastructure Grants
- Private Financing (loans)
- Public Financing (bonds)
- Loan Guarantees
- Customer Financing
- Digital Equity Grants

Federal and State Infrastructure Grants

There are several federal broadband grant programs that might benefit from this project.

Broadband Equity, Access, and Deployment Program (BEAD) Grants

This is the official name of the $42.5 billion grant program approved by Congress in November 2021. Illinois received over $1.04 billion in grant funding through this program. This grant program was established by the Infrastructure Investment and Jobs Act. Congress established the following high-level requirements for this grant program. Detailed rules were defined by a Notice of Funding Opportunity.

- Every State Has a Separate Timeline. The money will go from NTIA to the states, and the states will administer the grants. NTIA is mandating some of the grant rules, but states have the discretion to customize the grants to fit local conditions. There has been a detailed process for states to get access to the funding. For example, states had to reach out to stakeholders in all portions of the state. States must conduct a challenge process to the maps used to define grant eligibility. Funding flows once the NTIA approves a state's plan and final eligibility map. As of September 1, 2024, only Louisiana and Montana have begun their grant processes, with most states likely to start the generally year-long application process in late 2024. Awards are expected to be approved toward the end of 2025, with the bulk of grant funding likely to start flowing to winning applicants in 2026.
- The Grant Application is Complicated. This is the most complicated set of rules ever for a broadband grant.
- Definition of Broadband. Grants must adhere to two key definitions of broadband. *Unserved* locations are those that have no broadband options of at least 25/3 Mbps. *Underserved* locations are those with speeds between 25/3 and 100/20 Mbps. Grants must cover all unserved locations, and if there isn't enough then funding might not cover all underserved areas. The federal rules say that all unserved places must be served, no matter how remote. Funding for anchor institutions is allowed after all underserved locations are covered.
- Preference for Fiber. Although various technologies are eligible for BEAD funding, NTIA considers fiber-to-the-premises (FTTP) projects as "priority broadband projects," with hybrid fiber-coaxial cable (HFC), licensed fixed wireless (LFW), and digital subscriber line (DSL) technologies qualifying as eligible "reliable broadband service." Unlicensed fixed wireless

(ULFW) and low earth orbit (LEO) satellite service that meets programmatic speed and latency standards are "other broadband technologies" eligible for funding. Whichever technology is deployed, projects must be able to deliver speeds of at least 100/20 Mbps and have latency less than or equal to 100 milliseconds.

- 5-Year Grant Program. States have five years to disperse the funds but are pushing for networks to be built sooner – this includes one year to complete the grant application process and an additional four years for winning applicants to complete their builds.
- Other Uses of the Grants. Grants don't have to all go for broadband to unserved and underserved areas. Grants can be made to connect eligible community anchor institutions. States can use the money for data collection, broadband mapping, and planning. Funding can go to serve qualifying multi-family apartments with WiFi or low-cost broadband. For states which can cover all eligible locations with BEAD funding, any remaining balance can be used for digital equity initiatives addressing other aspects of the digital divide – such as adoption, affordability, or digital literacy.
- Eligible to All. BEAD doesn't give priority to any class of grant applicants. The grants can't exclude tribes, cooperatives, non-profit organizations, public-private partnerships, private companies, public or private utilities, public utility districts, or local governments from eligibility.
- Several Grant Priorities. States must give priority to grants that are deployed in counties with persistent poverty. Projects that will deliver more than the minimum speeds will be given priority. Projects that are shovel-ready will be given priority. Projects that pledge to pay Davis-Bacon prevailing wages will get priority. However, all of these considerations take second fiddle to the program's stated preference for fiber.
- Challenge Process. Before the grant application process opens, incumbent ISPs, local governments, and non-profits can challenge the validity of homes and businesses identified as either having or lacking access to 100/20 Mbps or 25/3 Mbps. Notably, the NTIA can override states in their challenge process decisions.
- Grants up to 75%. In general, grant applicants must provide at least a 25% match for the cost of the project. Matching funds can include federal CARES and ARPA funding. Match can also come from state grants. Grant applicants willing to take less than 75% will have an advantage; those applicants requiring a waiver to the 25% match requirement face uncertainty and the possibility of lost points in application scoring.
- Requires Two 9's Reliability. Deployed technology must meet two 9's reliability – meaning that it can be out for two days per year and still be considered adequate.
- Low-Price Option. Grant recipients must provide at least one low-cost broadband option for eligible households and would have been required to participate in the FCC's Affordably Connectivity Program (ACP) had Congress not allowed the program to lapse. The federal legislation says that the grants can't be used to regulate rates in any manner.
- No Middle-Mile. Interestingly, any fiber built along highways must include access points at "regular and short intervals." This money is not intended for middle-mile fiber.
- Plenty of Paperwork. Grant recipients must file complicated semiannual reports tracking the effectiveness of the grant funding.

BEAD Initial Proposal

Before any state can proceed with its BEAD program, the NTIA requires thorough planning, policy consideration, and program design. Each state's resulting Initial Proposal includes two volumes. The Illinois Office of Broadband (IOB) posted both draft volumes for public comments in August 2023. The

state incorporated many public comments into the draft Initial Proposal submitted to the NTIA for approval in December 2023.

IP Volume I

Among its contents, Volume I of the Initial Proposal details how the state will engage various stakeholders to validate the eligibility of homes, businesses, and community anchor institutions for BEAD funding. The NTIA approved IOB's Volume I in February 2024. This report covers the following Volume I issues:

- Status of current grant funding that has already been used in a state to bring broadband to unserved and underserved locations.
- A list identifying the remaining unserved and underserved locations.
- A list of the community anchor institutions that don't yet have good broadband.
- A description of the state's map challenge process where local governments and ISPs can challenge the accuracy of the broadband maps to define areas eligible for BEAD grants. The map challenge has already been completed.

IP Volume II

In Volume II, IOB details various aspects of how it plans to run its BEAD grant program. This report includes the following Volume II topics:

- The specific objectives of a state's BEAD grant plan.
- A description of how the state assisted local and regional broadband planning efforts.
- A description of the local coordination process where a state was supposed to reach out to all corners of the state to get feedback on the BEAD grants.
- The specific plan of how the BEAD grant process will be structured. This includes defining the grading scale that will be used to choose grant winners.
- A description of how some BEAD funds will be used for non-deployment purposes and how grant winners will be selected. Non-deployment uses of BEAD include grants for activities like cybersecurity training, promoting telehealth, improving digital literacy skills, etc.
- Description of how a state will monitor the implementation of grants.
- Description of how a state will track the jobs created by the grants.
- Description of how the BEAD winners will use a diverse and highly skilled workforce.
- Description of how the funding process will give priority to minority and women-owned businesses.
- Description of the steps a state has taken to reduce the cost and the barriers to infrastructure construction and deployment.
- Description of how a state will assess the impact on climate by the projects.
- Description of the requirements for ISPs to offer low-income rate plans.
- Description of how a state will make sure that ISP rates are affordable for the middle class.
- Descriptions of how a state will use the first 20% of BEAD funding.
- Description of any waivers that a state plans to use for situations where state laws conflict with BEAD requirements, such as not allowing grants to be awarded to local governments.
- Description of a middle-class affordability plan.

Illinois BEAD Grant Plans

Following is an overview of the proposed rules for the Illinois BEAD grant program.

- As required by BEAD, the Illinois Office of Broadband (IOB) is emphasizing fiber construction over other technologies.

- IOB will award BEAD grants in stages:
    - A pre-qualification process took place in Summer 2024 to engage potential BEAD applicants regarding their financial, operational, managerial, and technical qualifications.
    - IOB assigned all eligible homes and businesses into project area units (PAUs). Each PAU is a hexagon approximately two miles in diameter, contains both unserved and underserved locations, and is designed to promote efficiency in the BEAD grant application process. PAUs are the basic building block by which applicants will propose network expansion and IOB will award BEAD grant funding.
    - Three waves of application submission, review, and selection

Wave 1

- The first wave of grants will focus on hard-to-serve PAUs. Only applications that include a sufficient ratio of hard to serve areas (versus other eligible areas) will be considered.
- Priority broadband projects will be identified, and applications that include overlapping areas will be identified.
- Overlapping applications will be de-conflicted, and provisional winners will be selected as follows:
    - All qualifying applications will be scored using the scoring rubric.
    - The applications will then be ranked based on the scoring rubric score.
    - If a lower ranking applicant conflicts with a higher-ranking applicant the lower ranking applicant will be asked to remove the conflicting area. Once removed the lower ranking applicant will be rescored.
- The state will only award a non-priority broadband project in "Wave 1" if there are no fiber projects covering the same area.
- Applications not considered provisional winners in Wave 1 will advance to Wave 2.

Wave 2

- Wave 2 will include all of the PAUs not considered provisional winners in Wave 1.
- Priority broadband projects will be identified and the same process as Wave 1 will be followed for any conflicting areas.
- Only in areas where a fiber network is either not proposed or deemed too expensive will alternative technologies be considered
- If there are eligible locations and a fund balance following Wave 2, IOB will hold a third wave that repeats the Wave 2 steps.

BEAD Grant Scoring

The Illinois grant scoring has a maximum score of 100 points:

- Grant Funding Requested (30 Points). Points will be assigned based on how much the application's required BEAD outlay deviates from the reference cost published by the state. More points will be assigned to applications with lower BEAD outlay compared to the reference cost. See subsection C below for more details.
- Match Funding (20 Points). More points will be assigned to the degree of nonstate match over 30%, as a greater non-state match signifies more "skin in the game" and the financial risk assumed by the applicant. See subsection B below for more details.

- Affordability (15 Points). Applicants will be scored based on the price they offer for either 1/1 Gbps or 100/20 Mbps: 1/1 Gbps for priority broadband projects and 100/20 Mbps for other broadband projects.
- Fair Labor Practices (15 Points). Applicants will be scored based on their demonstrated record of compliance with federal labor and employment laws and the submission of a project labor agreement.
- Local Support (5 Points). Points based on the breadth and depth of community support for the project. Factors for community support are as follows:
    - Degree of "personalized" letters that reflect a broadband spectrum of community members,
    - Degree to which the project fits into an existing community strategic plan,
    - A recent survey that provide meaningful results regarding level of need, gaps, and project support,
    - Evidence of community outreach efforts to gauge interest in the project,
    - Other community feedback that shows compelling need and project support.
- Local Coordination (5 Points). Points based on financial investment by community members and organizations. Factors for consideration include:
    - The degree of match funding from community-based members and institutions.
    - In-kind resource commitments from community-based members and institutions.
    - Evidence to support verification of pledge.
- Speed of Network and Technical Capabilities (4 Points). Points based on the performance levels and scalability of networks. To receive full points the application must be capable of providing speeds of 1/1 Gbps.
- Speed of Deployment (3 Points). Applicants are awarded higher points for deployment plans faster than 48 months.
- Open Access and Use of Existing Network (3 Points). Points are based on the provision of open access and use of existing networks.

  Factors for consideration of open access include:
    - Details regarding open access policy.
    - A clear description of wholesale services and rates.
    - Identification of retail ISP partners and status of contract negotiations.

  Factors for consideration for using an existing network include:
    - Clear identification of network assets being leveraged.
    - Clear description of non-network resources and assets being contributed.

Key BEAD Rules about the Role of the County

A county government can help prospective BEAD applicants win 10 points in the BEAD scoring, which is 10% of the total grant points possible. The 10 points come from:

- Five (5) points if the county and community support the proposal.
- Five (5) points if the county provides 'meaningful' financial support to a grant applicant.

This gives the county a big role in choosing winners and losers by providing or not providing support. The county can also influence the grant winners by providing local grants to some ISPs.

ARPA State and Local Fiscal Recovery Funds (SLFRF)

Before the BEAD Program and its $42.5 billion mandate to achieve universal coverage across the country, the American Rescue Plan Act (ARPA) gave states and local governments an opportunity to leverage truly unprecedented amounts of federal funding for broadband access.

APRA's State and Local Fiscal Recovery Fund (SLFRF) includes a whopping $350 billion in federal funding directly to states, counties, cities, towns, and townships. The purpose of this funding is to provide state and local governments with the necessary resources to:

- Fight the pandemic and support families and businesses struggling with its public health and economic impacts.
- Maintain vital public services, even amid declines in revenue.
- Build a strong, resilient, and equitable recovery by making investments that support long-term growth and opportunity.

Broadband is among the various pressing eligible uses of these funds. We know of numerous county governments that are providing some ARPA funding for local projects. This funding must be allocated before the end of 2024 and spent before the end of 2026.

This could be the source of funding that a county might consider using if it wanted to contribute a matching grant to one or more BEAD applicant(s). The Illinois BEAD grant rules give ISPs extra grant points for winning local financial support. However, among certain factors that need to be considered, the county must obligate the funding to a likely BEAD grantee (contingent on eventual award selection) by the end of 2024.

State Infrastructure Grants

States were given $10 billion from the ARPA Capital Projects Fund to use for broadband infrastructure. This is the source of funding for many of the state broadband grant programs around the country, including in Illinois.

Connect Illinois

In 2019, Illinois launched its first statewide broadband grant program. The resulting $400 million Connect Illinois Broadband Grant Program included $100 million in state funding and then added $300 million in ARPA funds. Following three rounds of grants stretching from February 2020 to July 2024, the state received over $1.6 billion in funding requests and is administering approximately 75 grant-funded projects that have added over $150 million in matching funds to extend fiber broadband to more than 50,000 Illinois homes, businesses, and community anchor institutions.

Round 3 of Connect Illinois allowed for a maximum grant award of $10 million. Priority was given to projects that provided 50% or more of eligible total project costs in nonstate matching, but most applications averaged around 30 percent in matching funds. The projects must be completed within three years of being awarded the grant. The Connect Illinois program will serve as the foundational program for the IIJA BEAD funding.

Project Requirements
To ensure a statewide reach and address various broadband access issues of the digital divide, Connect Illinois accepted applications across three categories:

- *Broadband Access* for Illinois homes, businesses, and community anchor institutions in unserved and underserved areas.
- *Broadband Innovation* for economic development and related applications; and
- *Urban broadband* for expanded access or innovation in qualified Illinois cities or metropolitan areas of 75,000 or more residents.

Eligibility Details
Eligible applicants for this program included an incorporated business or partnership, a political subdivision, a nonprofit organization, a cooperative association, or a limited liability corporation organized to expand broadband access.

Additional Information
Applicants must submit a detailed project narrative describing how the award will be executed. The project narrative should include enough information for DCEO to understand the project's scope and the budget, including a detailed breakdown of the costs associated with each budget line and any additional detail to enable DCEO to manage the grant agreement activity against the planned project performance.

Given certain shortcomings of the collective federal broadband funding landscape, it's likely that BEAD funding alone will fall short for large states like Illinois. States may seek to leverage alternative state or federal funding to ensure that all homes and businesses have access to affordable, reliable, and high-performance broadband.

The following programs have contributed to broadband deployment in the past and may continue to complement investment toward universal broadband access in the future.

ReConnect Grants

In the 2017 Farm Bill, Congress created a grant program called ReConnect. The program awarded $200 million in grants, $200 million in loans, and $200 million in a combination of grants and loans in 2019. Congress reauthorized an additional $600 million to be awarded in 2020. There was a round of ReConnect in 2022 for $1.2 billion and another in September 2022 for $2 billion. The USDA's Fifth Round of the ReConnect program closed on May 21, 2024.
The following is a highlight of the rules for the latest ReConnect grants:

- Speeds. The grants provide funding for areas with broadband speeds under 25/3 Mbps along with areas under 100.20 Mbps. The grants do not automatically adhere to the FCC mapping data, but an applicant needs to be prepared to demonstrate why an area is eligible.
- Eligible Entities. Almost anybody is eligible, but preference is given to tribes, local governments, non-profits, and cooperatives (including for projects involving partnerships that include those entities).
- Must be Rural. Grant-serving areas must be rural and remote. There is a ReConnect mapping tool that defines if an area is eligible. To be eligible for funding, a grant area must be "15 minutes or more drive time from an urban area of 2,500-9,999 people; 30 minutes or more from an urban area of 10,000-24,999 people; 45 minutes or more from an urban area of 25,000-49,999 people; or 60

minutes or more from an urban area of 50,000 or more people." Additionally, there is a density test.
- Economic Need. The grants favor bringing broadband to Socially Vulnerable Communities.
- Prefers Open-access. Retail rates must be affordable and non-discriminatory. There are grant points awarded to those willing to offer "wholesale rates," which is another way of describing open-access.
- Strong Labor Standards. While the grant doesn't require Davis-Bacon prevailing wages, there are grant points awarded for agreeing to pay prevailing wages.
- Net Neutrality. Applicants must be willing to adhere to net neutrality.

HUD Community Development Block Grants (CDBG)

Grants under this program can be used to build fiber or wireless networks in areas lacking broadband access. Any grant application must meet all three of the following objectives:
- The project must benefit low- or moderate-income neighborhoods
- The project must eliminate slums/blight.
- The project must demonstrate urgent need.

The last criterion is fairly easy to demonstrate in any community without adequate broadband. The big hurdle for many grant applicants is the second objective of eliminating blight. We've seen an argument made that improving broadband improves incomes, which ultimately improves impoverished communities. For example, luring tenants to closed storefronts with good broadband meets this test.

The CDBG grants have wide latitude in considering grant applications and can be used in the following ways that benefit broadband:
- The acquisition, construction, reconstruction, rehabilitation, or installation of public facilities and improvements (which include fiber or wireless infrastructure improvements).
- The acquisition, construction, reconstruction, rehabilitation, or installation of distribution lines and facilities of privately-owned utilities, which includes the placing underground of new or existing distribution facilities and lines.
- Digital literacy classes as a public service.
- Economic development – grants/loans to for-profit businesses, particularly businesses that focus on broadband/Internet access and technology.

The CDBG program also makes block grants to states, which then administer state grants. These state grants must still follow the same federal guidelines for eligibility as listed above.

It's hard to use this money to support a widespread network that serves different neighborhoods, but it can be useful to supplement other grants to serve low-income neighborhoods.

Private Financing

Most commercial ISPs rely on traditional private financing, meaning loans. Some of the largest, publicly traded ISPs raise money through corporate bonds or use equity. Following are some key challenges that ISPs must navigate to get bank financing:

Equity: Most forms of private financing require some equity. Equity means that the borrower brings some sort of cash or cash equivalent to the business as part of the financing package. The amount of equity

required will vary according to the perceived risk of the venture by the lender. The higher the risk, the more equity is required.

Equity can take a number of different forms:

- Cash: Cash is the preferred kind of equity, and lenders like to see cash infused into a new business – cash that can't be pulled out of the business and which doesn't earn interest.
- Preferred Equity: A stock corporation (like an LLC or C Corp) can raise equity by selling some form of preferred stock that acts as equity. A buyer of preferred equity usually earns some guaranteed interest rate on the equity investment, but the payments are not usually guaranteed like they are for bank loans. If the business gets into a cash crunch, it must pay bank loans and other forms of debt before paying preferred equity interest.
- Assets: It's possible to contribute assets as equity. For example, a new fiber venture might be seeded by having one of the partners contribute an existing fiber route or another valuable asset to the business. In such a case, the contributed asset often must be assigned a market value, often appraised by an independent appraiser.

Bank Loan Basics: The banking industry does not like to finance long-term infrastructure projects. This is one of the primary reasons why the country has had such an infrastructure deficit. Until the 1960s, banks funded projects like power plants, electric and water systems, telephone networks, and other long-term revenue-generating assets. Various changes in banking laws require banks to maintain larger cash reserves, which makes them less willing to make long-term loans. Banks have also increased their expectations over time to favor loans with a higher interest rate. Many attribute this to the fact that giant publicly traded banks have captured most of the banking market. Banks don't like long-term loans since the interest rates get locked in for many years, possibly depriving the banks of earning more on their own equity.

Most banks prefer not to make loans with a term much longer than 12–15 years, and a broadband project might not generate enough cash in that time period to repay the loans.

Banks are also averse to start-ups and prefer to make loans to existing businesses that already have a proven revenue stream. It's extremely hard for a first-time borrower to be able to borrow the kind of money needed to build a broadband network.

Collateral. The biggest issue that borrowers have in getting a bank loan is the requirement for collateral, which is the assets a borrower pledges to a bank if the project fails. Banks like hard collateral like buildings, vehicles, shares of stock, and things they know they can readily sell for a reasonable price. Banks don't like broadband networks as collateral because even a little bit of web searching shows them that failed fiber networks are sometimes sold for pennies on the dollar. Fiber networks have little intrinsic value – all of the value of an ISP comes from the paying customers on a network.

It's important to understand the implications of collateral. Communities often ask an ISP operating nearby to build fiber in their town. What they fail to realize is that the ISP might have to pledge the entire business as collateral in order to secure the loan – meaning that if the new venture fails, the ISP could lose the whole existing business.

Return on Bank Equity. Banks don't only consider the interest rate when making loans. A bank concentrates on its return on equity and will consider a combination of factors like interest rates, upfront

and monthly loan fees, the likelihood that a borrower will pay a loan off early, or borrower default. A bank will look at a dozen financial parameters before making an offer of interest rate and term – based on meeting the bank's targeted return on bank equity. There is a misperception that interest rates are negotiable, but the same project offered to multiple banks is likely to get a nearly identical financing package offered by all banks.

Federal Loans

Rural Utility Service (RUS): This is a part of the Department of Agriculture and is the only federal agency that makes direct loans for broadband projects. The Rural Broadband Access Loan and Loan Guarantee Program (Broadband Program) furnishes loans and loan guarantees to provide funds for the costs of construction, improvement, or acquisition of facilities and equipment needed to provide broadband in eligible rural areas. These loans can't be used for any town with a population of over 20,000. The RUS acts much like a bank and follows similar lending practices. I like to describe the RUS as a bank from the 1950s because its lending rules were set by Congress to loan money for rural electrification and have never been modernized.

RUS makes broadband loans and loan guarantees to:

- Finance the construction, improvement, and acquisition of facilities required to provide broadband, including facilities required for providing other services over the same facilities.
- Finance the cost of leasing facilities that are required to provide broadband if the lease qualifies as a capital lease under Generally Acceptable Accounting Procedures (GAAP). The financing of such a lease will be limited to the first three years of the loan amortization period.
- Finance the acquisition of facilities, portions of an existing system, and/or another company by an eligible entity, where acquisition is used in the applicant's business plan for furnishing or improving broadband. The acquisition costs cannot exceed 50 percent of the broadband loan amount, and the purchase must provide the applicant with a controlling majority interest in the equity acquired.
- Finance pre-loan expenses, i.e., any expenses associated with the preparation of a loan application, such as obtaining market surveys, accountant/consultant costs for preparing the application, and supporting information. The pre-loan expenses cannot exceed 5% of the broadband loan, excluding any amount requested to refinance outstanding telecommunication loans.

RUS is allowed to make loans to a wide range of entities. Borrowers can be either non-profit or for-profit and can be one of the following: corporation, limited liability company (LLC), cooperative or mutual organization, Indian tribe or tribal organization as defined in 25 U.S.C. 450b, or state or local government, including any agency, subdivision, or instrumentality thereof. Individuals or partnerships are not eligible entities.

To be eligible to receive a loan under this program, the entity must:

- Submit a loan application. The loan application requires a lot of work, including pre-engineering, surveys, mapping, financial business plan models, environmental impact studies, and other things, which make the application expensive to prepare externally.
- Agree to complete the build-out of the broadband system described in the loan application within three years from the date the borrower is notified that loan funds are available.
- Demonstrate an ability to furnish, improve, or extend broadband in rural areas.
- Demonstrate an equity position equal to at least 10% of the amount of the loan requested in the application.

- Provide additional security if it is necessary to ensure financial feasibility as determined by the administrator. (For anyone other than large borrowers, this means pledging the whole existing business as collateral).

In practical terms, RUS loans are administered as follows:

- The rules say that a project needs at least 10% equity, but this is often expanded to be anywhere from 20% to 40% at the discretion of the RUS. In effect, the RUS acts as a bank, and it will require enough equity so that the projected revenues can cover debt payments.
- The loan terms are generally in the range of 12 years, but the RUS can choose to extend to 20 years for fiber projects. This is much shorter than the terms available on bond financing, meaning the annual payment would be higher under an RUS loan than with a bond.
- It is exceedingly hard to get a project funded for a start-up business. The RUS typically wants the whole company of the borrower pledged as collateral. Thus, the bigger and more successful the existing company, the easier it is to meet the RUS loan requirements.
- Their collateral requirements are overreaching in other ways that make them hard to work with for municipal projects. For example, if the project is going to share fiber with some existing network, such as one built by a school system, they would want that asset as collateral. Many borrowers find the RUS collateral demands to be impossible to meet.

The RUS loan fund is often large, and there have been many times over the last decade when the balance to be lent sat at more than $1 billion. Congress generally adds additional funds to the RUS pot each year. The RUS also has some discretion, and it has the power to include some portion of a loan as a grant that doesn't have to be repaid. This is something that can't be counted on, but we know of projects where the borrower only had to pay back 80% of what they borrowed. The RUS interest rate tends to be lower than bank rates during periods when bank interest rates move higher.

Servicing an RUS loan requires significant paperwork for drawing down funds and significant annual reporting requirements.

Other Bank Loans

There are two specialty banks that specialize in making broadband loans that should be mentioned. The first is CoBank. This is a boutique bank that is owned collectively by telephone cooperatives. CoBank historically made loans to cooperatives but has branched out to the other parts of the industry.

CoBank is cautious and only takes on loans that look to have a high chance of success. This means it rarely loans to a start-up and prefers existing ISPs with a long history and a strong balance sheet. CoBank loans are generally at market interest rates, similar to bank rates. CoBank also wants significant collateral. Finally, CoBank loans are rarely longer than 15 years and often for shorter terms.

The other industry bank is RTFC, which is a bank owned by electric cooperatives. RTFC rarely lends to anyone other than a cooperative but could be the source of funding if a local government is partnering with a cooperative. Borrowers must typically join the cooperative as a condition of borrowing.

Loan Guarantees

Another way to help finance broadband projects is through federal loan guarantees. A loan guarantee is just what it sounds like. Some state or federal agencies provide a loan guarantee, which is very much like getting a co-signer on a personal loan. These programs guarantee to continue debt payments in the case of

a loan default and greatly lower the risk for a lending bank. In return for the lower risk, the banks are required to offer a significantly lower interest rate.

These guarantees are not free. There is an application process to get a loan guarantee in much the same manner as applying for a bank loan or a grant, which means a lot of paperwork. The agency making the guarantee will want a fee equal to several interest "points" upfront. To some extent, this process works like insurance, and the agency keeps these fees to cover some of the cost of defaults. If they issue enough loan guarantees, then the up-front fees can cover eventual losses if the default rates are low. These points are a payment to the agency for issuing the guarantee and are not refundable.

There are several federal agencies that might be willing to make loan guarantees for telecom projects. The following agencies are worth considering:

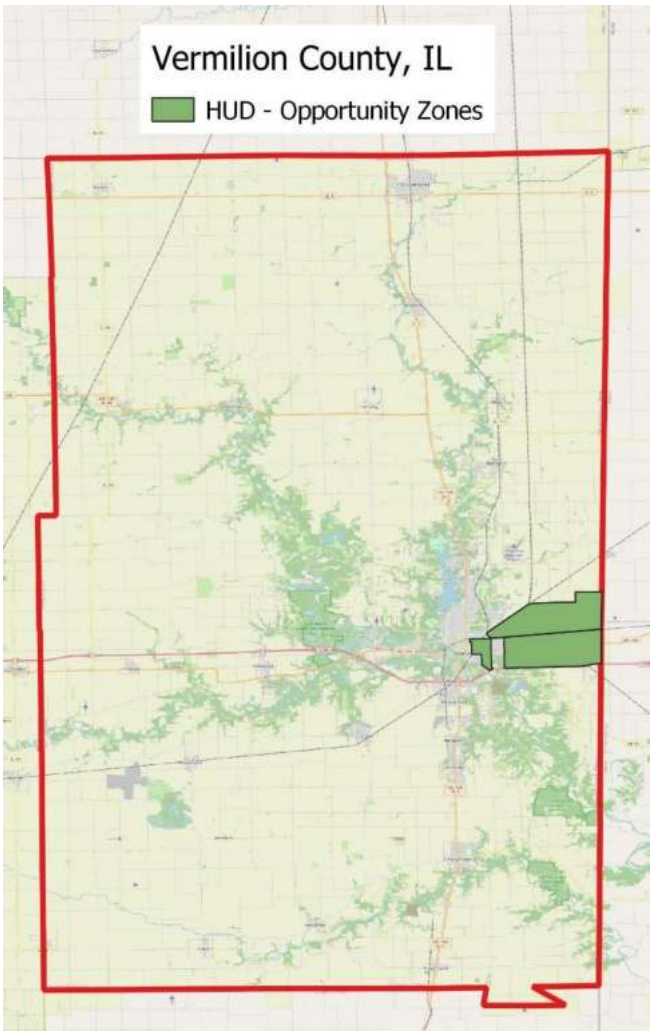
HUD 108 Program: The Department of Housing and Urban Development has a loan and loan guarantee program that is allotted for economic development. There is both federal loan guarantees as well as money given to the states to administer. While these loans and loan guarantees generally are housing-related, the agency has made loan guarantees for other economic development projects that can be shown to benefit low- or moderate-income households. If enough of a fiber project can be said to benefit low-income residents, then these loans can theoretically be used for a fiber project.

Small Business Administration 504 Loan Program: This program by the SBA provides loans or loan guarantees to small start-up businesses. These loans or loan guarantees must be made in conjunction with a bank, with the bank providing some loan funds directly and with the SBA loaning or guaranteeing up to 50% of the total loan.

USDA Business and Industry Guaranteed Loans (B&I): The Department of Agriculture provides loan guarantees through the B&I program to assist rural communities with projects that spur economic development. Such a project must, among other things, provide employment and improve the economic or environmental climate in a rural area. These loan guarantees are available to start-up businesses. The program can guarantee up to 60% of a loan over $10 million or greater percentages of smaller loans.

Opportunity Zones

Congress created a new investment opportunity as part of the 2017 Tax Cuts and Jobs Act. The Act created Opportunity Zones in which investors can get special capital gains treatment and other tax breaks for investing in qualified infrastructure within an opportunity zone. Each state governor designated specific opportunity zones. There are three Opportunity Zones in the western part of Vermilion County, shown on the map below.



Qualified investments made inside an Opportunity Zone can get special tax treatment. The first benefit is that capital gains tax can be deferred from past investments if the gains are reinvested inside of an opportunity zone. For example, if an investor had a capital gain from the sale of a property, they could invest those gains in an Opportunity Zone project and defer the original capital gains taxes until as long as 2047. Investors have until 2026 to make such investments.

An investor also gets capital gains tax forgiveness on new investments made inside an opportunity zone if that investment is held for at least ten years. Most of the opportunity zones include sizable areas of low-income residents, and a qualified investment must meet a test of benefiting that community in some significant way. A fiber network that will bring broadband to all the homes in an opportunity zone would meet that test since there are many demonstrable benefits of fiber.

The other benefit of using opportunity zone financing is that the interest rates can be favorable. Interest might be set far below market rates and some principal might be forgiven if there is enough benefit accruing to the lender.

An ISP building a network in the applicable locations could get at least part of the funding from one of the many Opportunity Zone funds that have been created to invest in qualified investments. This portion

of the financing portfolio would have a lower interest rate and might not have to pay back the full cost of the investment.

New Market Tax Credits

The New Markets Tax Credit (NMTC) Program was established in 2000 as part of the Community Tax Relief Act of 2000. The goal of the program was to spur revitalization efforts of low-income and impoverished communities across the United States and Territories. Most of rural America qualifies for new market tax credit financing. New market tax credits are normally used to fund only a small portion of a project.

The NMTC Program works by giving big tax credits to investors who are willing to invest in infrastructure projects in qualifying communities. The tax credits are so lucrative that often, the other terms for accepting the funding are modest. The tax credit equals 39% of the investment paid out—5% in each of the first three years, then 6% in the next four years, for a total of 39%.

The Community Development Financial Institutions (CDFI) Fund and the Department of the Treasury administer the program. Treasury allots credits in a complicated way, with the simplest explanation being that there are entities each year around the country that are awarded tax credits, and these entities work as brokers to allot the credits to specific projects. The credits are often purchased by large banks or other firms that invest in infrastructure.

In practice, these funds act like a mix of loans and credits to the recipient. For instance, a community that received these funds might have to pay some modest amount of interest during the seven years of the tax credit and then have a balloon payment for the principal. It's possible for some of the principal to be excused, making this look like a grant.

Public Financing

The two primary mechanisms used for the public financing of broadband are revenue bonds and general obligation bonds. There are some major benefits of using bond financing. First, the term of the bond can match the expected life of the assets, and it is not unusual to find bonds for fiber projects that stretch to 25 or 30 years. It's also possible to finance a project completely with bonds, meaning that no cash or equity is needed.

Bonds often, but not always, have lower interest rates than commercial debt. The interest rate is dependent upon several factors, including the creditworthiness (bond rating) of the borrower as well as the perceived risk of the project. In recent years, when commercial interest rates were low, the rates for municipal bonds were similar to bank loans. But there have been times when bond rates are higher than bank rates.

For municipal entities with a good credit rating, it is easier to sell bonds than to raise commercial money from banks. Sometimes bonds require a referendum, but once bonds are approved, there is a ready market for selling the bonds. The traditional source of public money used to finance telecom projects is through the issuance of tax-exempt municipal bonds, meaning the buyers of the bonds don't have to pay federal and/or state income taxes on the revenue from the bonds.

Customer Financing

We know of broadband projects where customers contributed some of the funding.

Property (or Other Kind of Tax) Revenues. It is possible to obtain some or all of the cost of a broadband network through a pledge of future tax revenues. That pledge can then support a bond. This is different than most bonds for a broadband network, where the network would be secured by revenues of the broadband venture. A pledge of some other kind of tax revenue is one of the easiest ways to get a bond. Following are a few examples of this kind of financing:

- Lyndon Township, Michigan: This is a township of about 1,000 homes that voted to raise property taxes to fund a fiber network. The township then partnered with a local broadband cooperative to provide services. The project is a win/win for citizens. Property taxes increased by about $25 per month per household. The township provides inexpensive access to the cooperative, which offers attractive customer rates. This area had no broadband before the project.
- UTOPIA, Utah: UTOPIA is a consortium of a number of small towns in Utah that banded together to get fiber. Many of the member towns have pledged property tax revenues to fund part of the cost of the network.
- Cook County, Minnesota: Cook County funded about half of its fiber network using a federal grant awarded from the Stimulus funding program in 2008. The County held a referendum and used a sales tax increase to finance bonds to pay for the remaining matching funds needed to build the project.

Direct Customer Contributions: It's also possible to fund some project costs through direct contributions from potential customers. This has never been done on a large scale because it would be exceedingly difficult to get a lot of residents to agree to write a check to fund a network. But there are some examples to consider:

- Contribution to Aid in Construction: Most utilities have a program where they will agree to extend their network to customers if those customers agree to pay the cost of the connection. We are aware of numerous cases where small pockets of rural homes raised the needed money to get connected to a nearby broadband network.
- Ammon, Idaho: This is the only municipal attempt at funding a network in this way. The City of Ammon will connect customers to a fiber network if they contribute $3,500 up-front to cover the cost of construction.

Digital Equity Grants

Beyond investment in universal broadband access, the Infrastructure Investment and Jobs Act (IIJA) created two new grant programs to address digital equity and inclusion. This section of the IIJA recognizes that providing broadband access alone will not close the digital divide. There are millions of homes that lack computers, and the digital skills needed to use broadband. The grant programs take two different approaches to try to close the digital divide.

The State Digital Equity Capacity Grant Program will give money to states to distribute through grants. The stated goal of this grant program is to promote the achievement of digital equity, support digital inclusion activities, and build capacity for efforts by States relating to the adoption of broadband. The Act allocates $1.5 billion to the states for this program. The NTIA was slow in getting this program running,

and recently, $840 million in funding was released to cover from 2022 through 2024. This includes $23.7 million for Illinois, with roughly $16 million in additional funds anticipated for 2025 and 2026.

States must apply for this funding by May 28, 2024, and the NTIA will start awarding money to states at the end of August 2024. Illinois and other states have already told the NTIA how they would use the funding. Illinois is likely to open its State Digital Equity Capacity Grant Program in Fall 2024, with funding available to winning applicants in early 2025.

The second new grant program is called the Digital Equity Competitive Grant Program. These are grants that will be administered by the NTIA and awarded directly to grant recipients. The budget for this grant program is $1.25 billion, with $250 million per year to be awarded from 2022 until 2026. However, the NTIA has also been slow in launching this program, releasing the first $750 million NOFO in July 2024 in advance of a September 23, 2024, application deadline. These grants can be awarded to a wide range of entities, including government entities, non-profit foundations and corporations, community anchor institutions, education agencies, entities that engage in workforce development, or a partnership between any of the above entities.

IV. Other Issues

A. How to Find ISP Partners

Examples of Public-Prive Partnerships (PPPs)

There is a wide variety of public-private partnerships that can be created between a government entity and an ISP. There are many ways that revenues, profits, and risks can be shared between partners. The following discussion examines the most common forms of PPPs.

PPPs initially arose internationally as a way to finance infrastructure needs that local, regional, or national governments could not pay for upfront or finance from taxes, bonds, or other methods of raising government money. Over the last fifty years, governments collectively in the U.S. have been unable to fund the needed level of infrastructure - and PPPs were often formed to help finance the infrastructure deficit.

There are three major ways that a fiber PPP can be structured depending on who pays for the network. A fiber network could be mostly funded by the government, mostly funded by a commercial entity, or funded jointly by both.

PPP Funded Mostly by the Government. This scenario means that a government takes all of the financial risks of building a network and then hands the operations to somebody else. This is the arrangement that is in place in the Google Fiber partnership with Huntsville, Alabama. Reports are that Google Fiber is responsible for the costs inside the customer premises and the City for the rest. There are similar partnerships between Ting and Charlottesville, VA, and Westminster, MD. CenturyLink has reached a similar arrangement with Springfield, MO.

PPP Funded Mostly by the Commercial Provider. There are many examples where a commercial provider has built a fiber network with some upfront assistance from a community. In most cases, the parties don't think of these arrangements as a partnership.

For example, ISPs often ask for some concessions when building a fiber network. The first few markets for Google Fiber are reported to have this arrangement. It's widely believed that Kansas City granted major concessions to Google Fiber to get them to build fiber there. The City might have provided concessions like free rights-of-way, expedited permitting, use of city land for placing facilities, etc.

Another common form of this kind of partnership is happening this year as local governments are providing grants to ISPs using the American Rescue Plan Act funding. The municipalities rarely get an ownership share in the business for these kinds of contributions.

For this kind of arrangement to be considered a traditional PPP, a municipal entity would have to get something in return for the concessions they make to an ISP. This could be almost anything that is perceived to be of value. It might be free or reduced telecom prices provided to government buildings or fibers connecting government locations together. It could also be the ISP agreeing to help a city meet some social goal, such as building in poorer parts of a city that a commercial ISP

might otherwise not have considered. In some rare cases, this might mean that the local government takes an ownership share in the business.

PPP Funded Jointly. When a municipality and an ISP both contribute significant cash or hard assets to a venture, it's clearly a PPP. The following are a few examples of the different ways such partnerships can be structured.

- Zayo partnered with Anoka County, Minnesota to build a middle-mile fiber network throughout the county. This is a suburban county just north of the twin cities. Both entities made a significant cash contribution to the project, plus the two parties together pursued and received a grant to help pay for the network. The County received access to a 10-gigabit network connecting all of its facilities, and Zayo received connections to all of the major business districts. Zayo owns the network, but each party has affordable access to the whole network as needed. Each party is also allowed to build outward from any point on the jointly built network at their own cost.
- Nashville, Tennessee, partnered with a commercial ISP to build fiber to city buildings and commercial districts. Both parties made capital contributions. The City eventually sold its interest in the network but still retains fiber to most city buildings.
- There are dozens of small cities where a city built an initial fiber network to connect to schools, water systems, etc., and now allows commercial providers to build fiber spurs from the city-owned ring. The financial arrangements for this vary widely. Sometimes the two parties just swap access to various locations on each other's network, and in other cases, each pays to lease access on the other's network. However, both parties share some parts of the network, portions of which each has funded.
- Several of the Public Utility Districts (PUDs) in Washington built fiber into business and residential neighborhoods and allow ISPs to build fiber extensions onto the network to reach customers.
- Google Fiber recently announced a partnership with West Des Moines, Iowa, in a network that can best be described as open-access conduit. The City is building empty conduits along every street and will also extend the conduit to each home and business. The network will be available to any ISP, and Google Fiber is the first announced network tenant. Google will pay to pull fiber through the conduit, and the company says it plans to serve the whole city. The City recently made a similar arrangement with Mediacom. In this partnership, the City tackled the most expensive part of the network, but ISPs still have to make a sizable investment to pull fiber to reach customers.
- There are hundreds of examples of government entities that have built fiber routes jointly with a commercial partner. This is referred to in the industry as fiber sharing, and generally, each contributor to the fiber route gets some specific number of fibers for their contribution. For example, this is common practice for school system fiber networks.

There are several kinds of contributions that a government can make to somebody else's fiber network. This could include cash, real estate, excused fees, or sweat equity. Governments can allow a commercial provider to use parcels of land or give them an existing building. Excused fees might mean not charging for something that would normally be due, such as permitting fees or property taxes. The government could excuse payments for poles, conduits, existing fiber, or towers. It could mean the commercial provider might not need to pay taxes or fees for some period of time, as is often done in many economic development projects. Sweat equity is assigning value to the time contributed by a city. For example,

we've seen a city assign extra employees for free for tasks like the permitting process during a major fiber construction project.

There are almost unlimited ways to model and form a public-private partnership. The underlying requirement is that the business must be profitable for the private commercial partner. Commercial providers expect a healthy rate of return on any investment they make in the business. Most commercial companies won't invest in a business that doesn't return at least a 20% to 30% return on their investment.

There are hundreds of examples of Public-Private Partnerships. The ones that get the big press are when Google Fiber or other large ISPs create a partnership with a city to bring fiber. But there are myriad smaller partnerships. Perhaps the easiest way to demonstrate the different kinds of PPPs is to take a look at a wide variety of PPPs that have been formed in one small region in northwest Colorado.

PPPs in Northwest Colorado

The opportunity for partnerships was created when the local governments partnered together with an ISP to build a middle-mile network called Project THOR. The overall partnership include three counties, four municipalities, a local consortium of anchor institutions, a health care district, and NWCCOG – the regional economic development agency. Local communities were invited to take advantage of the network.

The original purpose of the network was to provide reliable middle-mile fiber. The entire region had been plagued by multi-day outages of the CenturyLink network – the incumbent telephone company in the region. The outages were devastating and knocked out 911 service, hospitals, public service networks, cellular service, businesses, and residents across the region – often for days at a time.

The THOR consortium created a PPP partnership with Mammoth Networks, a regional commercial ISP, to build and operate the network. Project THOR brings two advantages to the region. First, the network is designed to carry up to 400 Gbps – much more capacity than any existing middle-mile routes in the region. Mammoth Networks was also able to string together routes that provide diversity for each city to protect against fiber cuts. A single fiber cut on the Project THOR middle-mile routes won't interrupt service to any of the member communities.

The initial network was put together with some constructed fiber, dark fiber leased from the Colorado Department of Transportation, and lit fiber routes from Strata, Comcast, and Zayo. The THOR consortium has plans to eventually replace all lit fiber with its own constructed fiber. The State of Colorado Department of Local Affairs funded the construction of fiber within each member community to reach key anchor institutions like hospitals, 911 centers, and public safety. The State also funded half of the electronics for the network.

The completed THOR network is shown on this map:

The communities are free to use the THOR network in any way they see fit. The network terminates at a meet-me center created in each community. Following are a few examples of public-private partnerships that have been created to take advantage of the THOR network.

- In Moffat County, the City of Craig, population 9,000, created a partnership with Mammoth Networks to extend fiber to reach the major anchor institutions in the City.
- In Moffatt County, the Yampa Valley Electric Cooperative partnered with THOR to win a federal ReConnect grant to extend rural fiber-to-the-home.
- Rio Blanco County pursued grants to build last-mile fiber networks. The County formed a partnership with THOR and Mammoth Networks to build last-mile fiber in the Towns of Meeker and Rangely, each with a population of around 2,500. The towns had almost no broadband options before the project. The County owns the network and has a concessionaire relationship with two ISPs to serve the residents and businesses in the towns.
- In Summit County, the City of Breckenridge formed a PPP partnership with ALLO, a large ISP from Nebraska. In this partnership, the City and ALLO each paid for a part of the fiber network, which is now operated by ALLO.
- In Eagle County, the City of Glenwood Springs, population 10,300, has operated a municipal fiber network since 2002 that served businesses and anchor institutions. In conjunction with the completion of the THOR network, the City invested in citywide last-mile fiber. The City also formed a partnership with nearby Eagle, Colorado (population 7,500) where Eagle funded a fiber network, and Glenwood Springs will operate it. This is an example of a public-public-partnership.

- In Eagle County, THOR partnered with Forethought, a local ISP, to build a series of microwave towers to cross the mountains to bring the first broadband ever to the tiny town of Red Cliff, population 279.
- Pitkin County is using the THOR backbone network to support a new network of wireless towers throughout the county. These were funded with public safety grants. Much of the county had zero cellular coverage, and these towers are being used to bring both wireless broadband and cellular service to rural areas.
- In Pitkin County, the City of Aspen partnered with THOR and Mammoth networks to build fiber to reach sixteen anchor institutions including public safety and the hospital. The effectiveness of the THOR network was demonstrated a few days after this anchor institution network was activated. There was a major outage on the CenturyLink fiber in the region, but the 911 Center in Aspen, as well as hospitals in Granby and Kremmling stayed connected while the rest of the area lost broadband.
- In Routt County, the City of Steamboat springs partnered with Thor and Mammoth network to build a fiber network to anchor institutions and to also lease out to local ISPs to reach businesses.

There are numerous other examples from around the country that show the power of local PPPs. We don't know of another region that has embraced PPPs to the same extent as this part of Colorado.

The Best Characteristics of an ISP Partner

Experience. Finding partner ISPs with a history of success is one of the most important characteristics to look for. For example, there are several investor-driven ISPs that want to invest and operate broadband networks but are not currently serving customers. This isn't to say that such a group can't have an experienced team and be a good partner, but it's a higher risk to work with an ISP that doesn't currently have customers, along with all of the processes and systems that come with being an operating ISP.

There are a few stories in the industry of public/private partnerships that went awry because of the lack of experience by the ISP partner. In the following two examples, the ISP management team was made up of folks with industry experience but who had never worked together as a team before.

- The first example is Utopia in Utah. This is a collaboration of small towns that are working together through the Utopia organization to create an economy of scale. State law in Utah doesn't allow towns, cities, or counties to establish and operate a retail ISP, so Utopia works as an open-access network where local governments fund the network, Utopia operates the network, and various ISPs compete for the retail business from customers.

  Utopia started by hiring an external management team that had not worked in an open-access environment before. Several things went wrong – the networks were late in getting constructed and came in over budget. The ISPs did not sell as aggressively as the business plan had projected. Utopia ran out of cash before construction was complete and almost folded, but the business was eventually saved through several rounds of refinancing and is now large enough to be financially stable. It took a decade before the business finally reached success. More importantly, it took a new management team that understood how to operate an open-access network.
- Another example is Lake County, Minnesota. This is one of the northernmost counties in the state. There are 11,000 residents in 2,100 square miles. The project was funded through a combination of a $10 million federal grant and a low-interest rate government loan for $56 million. The County

borrowed over $7 million in bonds and also made direct loans to the new business. The project roll-out went disastrously, and the project ran out of money before getting many customers connected. The project went underwater financially and didn't make enough money to cover debt payments. In 2019, the County sold the network to an ISP for $8.4 million. The federal government had to write off about $40 million in debt, and the County must continue to make payments on the original bonds plus eat the internal loans made to the project.

Experience Working with Local Government. Priority should be given to ISPs that have worked with local governments before. CCG has witnessed a number of public-private partnerships where the two parties became frustrated with each other over time. This is due to two factors – frustration with the government decision-making process and a difference in goals and expectations.

Commercial ISPs can quickly become frustrated with the local government decision-making process. Most local governments have a specified legal process that must be followed to make certain kinds of decisions. This might mean listing a topic for a public meeting and waiting for public comments on the issue. Commercial ISPs are used to making decisions quickly and don't like the drawn-out processes that governments require. Government entities get frustrated as well since their commercial partners push them to make decisions too quickly.

A more fundamental issue arises in public-private partnerships over time due to a fundamental difference in goals. The issue commonly arises when the two parties don't thoroughly discuss their long-term goals before a partnership begins. Commercial ISPs are usually mostly focused on cash flow and profit margins. If an ISP has invested equity in a broadband network, it becomes unhappy if the business doesn't meet the expected earnings goals. Governments often have a separate set of goals – serving every household, offering low-priced broadband to low-income houses, or providing subsidized broadband to non-profits and anchor institutions. In many cases, these kinds of fundamental differences can't be overcome and eventually result in the dissolution of the partnership.

The difference between the government and a commercial ISP often surfaces when there is a discussion of rates. Local governments often push back against rate increases – particularly in election years. Governments generally push ISP partners to provide low rates and often want an ISP to provide subsidized rates for low-income households and even free service to groups like non-profits.

These kinds of issues are less likely to be a huge problem if the ISP has worked successfully with other local governments. A government entity that is working with an ISP that has not partnered in this manner before should have an in-depth discussion upfront about expectations. It's a lot easier if the two parties decide upfront that they aren't compatible instead of after the partnership has been launched.

Financial Strength. Government entities often have a hard time judging the financial strength of a partner. Unfortunately, most public/private partnerships are not made with large, well-financed ISPs. The more typical partnerships are with telephone companies, electric cooperatives, or fiber overbuilders. It's typical for commercial ISPs of this type to overstate their financial security – and they may even believe what they say in doing so. But there are a few fundamental things about ISPs that a local government should understand:

- All ISPs, except possibly the largest ones, have a natural borrowing limit. There is only so much debt that bankers and other lenders will lend. By definition, when an ISP nears that lending limit,

it means that bankers think the company is pushing its financial limitations. Any ISP that has borrowed to its limit can't afford to make financial mistakes, and that means the partnership and all its other ventures need to perform as expected. It's not unusual to see a budding partnership be dependent upon obtaining financing, and it's common for the ISP to fail to get the hoped-for funding.

- The biggest issue with ISPs and borrowing is collateral. Banks don't look at fiber networks as good collateral for loans because there is little value in repossessing a fiber network. This means the only good collateral that most ISPs have is the value of their existing company. Even surprisingly large ISPs might have to pledge their entire company to borrow a sizable amount of money to build an expensive network. It's often necessary for owners of ISPs to make personal guarantees on loans, meaning that both their business and their personal assets are on the line with a new fiber project. ISPs are unlikely to disclose to a government partner the details of how they raise money – among other reasons, they fear public disclosure laws and don't want their personal financial position discoverable as a public record.

Capacity to Grow. One of the hardest things to judge is the ability of an ISP to grow quickly. A traditional ISP, like a telephone company, may have a lot of customers – but they acquired them slowly over the decades. ISPs often get stressed to the breaking point when they try to grow too quickly. It's not unusual for an ISP to somehow assume that existing middle and upper management can handle a growth scenario while still handling existing responsibilities.

Just because a company is a great ISP doesn't mean that the company is going to be great at growing. Unfortunately, there is no way to judge this unless the ISP has already been growing prior to the creation of the partnership.

Fair Recognition of Value. One of the important attributes of a good partnership is the full and fair recognition of the value that each party brings to the partnership. Local governments should be wary of a partner that overvalues what they bring while undervaluing the contribution from the local government. A local government can create value for a public/private partnership in a number of ways:

- Funding. Any amounts paid towards funding a broadband network are valuable. Governments often don't know how to set a value for cash contributions – something that commercial partners routinely figure out. It's been my experience that ISPs don't value government funding as much as they do other funding sources. This is because government funding doesn't come with the same stringent strings and responsibilities. A local government is not likely (or even able) to require things that a bank might require, such as collateral or a lien on a partner's assets. If an ISP gets into financial trouble, the first entity they will try not to pay is a government partner. This can be dealt with in creating a partnership agreement, but to some degree, which requires a government to think like a bank.
- Anchor Tenant. Government entities often make good anchor tenants – which means they guarantee to buy services from a new ISP with a long-term contract. It's typical for a government entity to be one of the largest broadband and telecom customers on a network.
- Other Assets. Governments often have other assets that can benefit a partnership. This could be land for placing equipment; It could be a building to create a central office or a storefront. It might mean towers, empty conduits, or spare existing fiber that can be used to defray the cost of constructing a broadband solution. The value of such assets should be set according to what the partnership would pay to get the same thing from a third party.

- Easier Construction Processes. Local governments can play a significant role in the construction process. They might have to approve permits for rights-of-way. They might be the entity that locates existing utilities. They might require inspection of construction work sites during and after construction. They might require things like traffic management during construction. Before tackling a major fiber construction project with a partner, a government should review these processes with an eye toward streamlining them to make it easier to build fiber. The caveat of relaxing the rules for a fiber partner will mean relaxing the rules for everybody else.
- Contributed Labor. A government can contribute labor. Using the last example above, a government could agree to conduct permits, locating, or some other service for free as a way to contribute to launching a partnership project.
- Tax Abatements. Tax abatements have always been a tool for economic development. Governments often have it within their power to excuse certain taxes to entities that bring something of economic value to the community. For example, it's common to forego property taxes to lure a business to locate in the community. There are numerous taxes and fees that might impact a new broadband network, such as property taxes, sales taxes, or right-of-way fees that a government might be willing to waive to help a new network get established.

The bottom line is that a government can bring significant value to a partner, and that contribution should be valued fairly. Even when a government brings tangible value, such as contributing funding, it's not unusual for an ISP to undervalue that contribution. It's even more prevalent for an ISP to not assign a realistic value to the more intangible contributions.

How do You Find Potential Partners?

Almost every partnership we know of has come about through one of the following processes:

- Request for Information (RFI). It's typical for communities that want broadband to issue an RFI aimed specifically at soliciting potential ISP partners. An RFI typically describes the situation in the community, typically describes whatever work has already been accomplished (such as this feasibility study) and describes the role the local government wants to take in a partnership.

  The RFI then asks ISPs to describe themselves and their capabilities. The RFI probably won't go as far as to request a specific solution but rather asks the ISPs to discuss how they might tackle broadband issues in the community.

  An RFI is generally the first step in determining which ISPs might be interested in partnering. After the RFI, the process typically moves to one of the two processes described below.

- Request for Proposal (RFP). An RFP is typically a lot more in-depth. In addition to asking ISPs to introduce themselves, an RFP might ask for specific proposed solutions. It might go deeper in detail and ask about the financial strength of the ISP partner and ask how they operate in other markets.

- Direct Negotiation. It's routine for governments to interact directly with potential ISP partners rather than go through an RFI or RFP. This might involve a local government reaching out to ISPs in the area, or it might be in response to an ISP making an unsolicited proposal to a local government to bring broadband.

Comparing the Three Options. It's worth considering these processes from the perspective of an ISP. ISPs are leery of public records laws. They are often highly reluctant to provide financial information, customer lists, or other information that they feel is confidential. They don't trust that local governments will fight to keep such information confidential. ISPs are even more unwilling to spell out specific details of their business plan and how they will approach a broadband market – they don't want that information to be available to their competitors.

Many ISPs are not willing or able to respond to an RFI or an RFP that asks for lengthy written responses to a lengthy list of questions. Vendors that sell equipment and services are used to the idea of making proposals and usually have a pile of pre-prepared canned responses to the typical questions they are asked by a prospective customer. An ISP might never have been asked to make a proposal in the specific and detailed way that might be needed to respond to an RFI or an RFP. There are ISPs that refuse to participate in an RFI or RFP for this and related issues.

ISPs prefer direct discussions where nothing is put into writing during the negotiation stage. That's the same process that ISPs typically use when they partner with other ISPs – they sit and talk out the pros and cons and mutually decide if there is a potential for a partnership. As often as not, such discussions end up with the realization that a partnership is not a promising idea, and the parties amicably go their separate ways with nothing that was discussed put into writing.

Here is the process that we have found to be effective:

> For most local governments, the best first step is to invite known ISPs for a high-level discussion about whether any kind of partnership makes sense. This process might involve several meetings where an ISP might come back with ideas, followed by a meeting where the local government reacts.
>
> The RFI process is a better approach if there are no local ISPs to consider. For example, we worked with a geographically isolated community where there was no local ISP candidate within fifty miles. An RFI made sense since the community didn't have a wish list of local ISPs to consider. An RFI also might make sense for larger communities. In this case, we define larger to mean that the cost of the project is large – perhaps more than $25 million. We've known communities that found an ISP partner through an RFI that they would never have otherwise found.
>
> An RFI should ask for basic information only. That might include asking an ISP to provide its history, talking about the products it normally sells, and talking about the management team. While a local government might have a hundred questions for a prospective partner, the ISP is going to be a lot happier if the details of their business are not put into writing at the early stage of meeting and negotiating.

Establishing Compatible Goals. At some point during the initial stages of the process, it's vital for both sides to thoroughly discuss their goals for the project. Misalignment of goals is the number one issue that plagues public-private partnerships eventually. Both parties need to fully hear, understand, and be fully comfortable with the goals of the other partner.

Goals can be stated simply and don't have to be complicated. Goals for a local government might be things such as serving the entire community, not needing to subsidize the project, keeping rates low, and so forth. The goal for an ISP might be to generate a specific target of cash flows or profits. It wouldn't be unusual for an ISP partner to eventually want the option to buy the business. However, an ISP might have the opposite intention and be hoping to flip and profit from the business in a few years.

It's important for local government to fully understand an ISP's goals. This is one situation where a local government might want to discuss these goals with a consultant or somebody with broad industry experience. It's not unusual for two partners to be using different jargon when discussing financial issues, and it's vital to fully comprehend what an ISP is telling you about their goals.

An alignment of goals is a make-or-break issue for a potential partnership. Many of the differences that a local government and an ISP might have can be negotiated, but you can't negotiate a difference in philosophy. If an ISP has a goal that a local government can't accept, such as selling the network in ten years, then our advice is to not pursue the partnership. When an ISP tells you a goal of this nature, they mean it.

How to Rank Potential Partners. There are hundreds of questions that a local government might ask an ISP that might range from important questions like, "Can you bring funding to this project?" to questions with less impact, such as, "What's your process of disconnecting customers who don't pay?"

We advise prospective partners (government or otherwise) to place their questions into three categories: 1) make-or-break questions, 2) questions that might disqualify a potential partner, and 3) all other questions.

Every community will have its own list of make-or-break questions based on its own priorities and expectations. Make-or-break questions might be things like 1) "How much funding can you bring to the project?" or 2) "Are you willing to serve everybody in the community?"

The first two categories of questions are the important ones that should be used to qualify and rank potential partners. Other less critical questions are important but shouldn't be addressed until it looks like both sides are serious about moving forward. You choose a partner based on the most important aspects of the relationship – the other facts can be filled in when a partnership is on the table.

Several techniques can be used to rank potential partners. Most rankings are done by compiling the rankings by individual members of a review team. The most important questions might get weighted somehow to have the biggest impact on the composite answer. A ranking process is aimed at creating a numerical value that reflects the composite opinion of those doing the ranking. Numerical rankings should not be so rigid that this is the only way to choose partners – but it's an important step.

Defining the Roles of Each Partner. It's vital to define the specific roles and responsibilities of each partner. Ideally, this should be done before formalizing the partnership arrangement.

CCG has often used a technique that seems to work ideally in defining a partnership. It starts with a list of all the tasks needed to launch and operate the upcoming broadband business. The level of detail usually becomes readily apparent. For example, if it's clear that the ISP is going to have 100% of the interactions

with customers, then having a task called "Interface with customers" would be sufficient rather than listing all of the various ways that somebody might interface with customers.

The items on the list would include financial and other contributions as discussed earlier, issues having to do with the construction of the new network, issues having to do with governance, and issues having to do with operating the business.

The responsibility for each task must be assigned. The choices for each task are 1) the task is the responsibility of the government, 2) the task is the responsibility of the ISP, 3) the task is a joint responsibility of both parties (in which case that needs to be fully described), or 4) the task is the responsibility of some third party (like an outsourced vendor). This kind of checklist can quickly show if the two parties are aligned and agree on the responsibilities or if there are tasks where the two sides have different views.

Making this checklist serves two purposes. It's a great tool for getting both parties to acknowledge the specific roles of each partner. It also serves as a template for developing a contract between the partners.

Maintaining Local Control. One of the biggest challenges faced by local governments in partnerships with ISPs is the question of maintaining some local control to ensure long-term responsiveness to local needs.

One of the best ways to tackle this question is for the local government to make a list of aspects of the businesses where they would hope for some local control. It's likely that a list will include major aspects of operating the business, such as setting rates, installation intervals, business hours, priorities of repairing customers after an outage, etc. A good thought experiment is for the local government to change hats and look at these same issues from the perspective of the ISP that wants to operate a profitable business. This exercise often highlights that there are some tasks where ISPs must have control.

One of the stories we tell about politics and local control concerns Bristol Virginia Utilities, which was one of the first cities to enter the broadband business. The business was operated by the municipal electric utility. The bonds were fully backed by the electric utility, but since the City had to approve any bond issue, the City reserved the right to set and approve rates. A few years after launching the business, and during an election year, the City Council voted to slash all the rates by 15%. The utility warned them this would put the business underwater, and as was warned, the utility was unable to meet a bond payment due six months later. The City got the message and raised the rates to a higher level than the original rates to correct the shortfall. The City also changed its ordinances so that no future city council could change rates.

There are numerous other examples of negative ways that local governments have meddled in a new broadband business. Politicians might make promises to constituents on behalf of the ISP. Politicians often press the ISP to give special rates to friends or to forgive bad debts for a constituent. It's not unusual for politicians to go further and interfere in things like personnel decisions. It's important to have clearly defined boundaries and lines so that an ISP can say no to meddling.

ISPs are highly wary of ceding any control to a government entity. ISPs know that a partnership with a local government can change drastically after an election. There are plenty of examples of a council or board that changed from pro-broadband utility to anti-broadband after an election. Political changes can

put a huge strain on the business relationship, even if there are no control issues. ISPs know that the local government they partner with today may not be the same in the future.

This is not to say that a local government shouldn't have any say in running the business. One of the more obvious aspects of maintaining control depends upon who funds the network. A local government is going to get little or no say in how to operate a network that includes significant funding from a commercial ISP. If an ISP brings money to a project, they will not risk letting the local government tell them how to operate the business.

But even funding doesn't always determine control. Many ISPs will only partner if they can make all the business decisions – even if the government funds the network. This is why you must ask all of the questions before creating a partnership.

The only surefire way for a local government to have control is to fund and operate the network. It's going to be difficult to find an ISP partner that will want local government to influence business decisions once the business is operating.

Specific Partnership for BEAD Grants

As mentioned earlier, the County can help prospective BEAD applicants win up to 8 points in the BEAD scoring, which is 10% of the total grant points possible. The 10 points comes from:

- 5 points if the County and community support the proposal.
- 5 points if the County provides 'meaningful' financial support to a grant applicant.

This gives the County a big role in choosing winners and losers by providing or not providing a letter of support. The County can also influence the grant winners by providing local grants to some ISPs.

Letter of Support. We see counties taking a wide range of different approaches for deciding which ISPs get a letter of support. Some counties don't want to be in the business of picking winners and losers and give a letter of support to everybody who asks for one. This means that no ISP gets any advantage in the grant scoring

Most counties have a preference for who will win the BEAD grant. They might prefer fiber over wireless technology. They might prefer local ISPs that already operate in the county versus an ISP they don't know. A county might have a preference for large national ISP or small ones for various reasons.

Counties also need to make the effort to make sure that some ISP plans to cover all parts of the county. One of the primary goals of the BEAD grants is to bring a broadband solution to every unserved and underserved household. ISPs might only have plans to serve part of a county, so a county might need to provide letters of support to multiple ISPs for different parts of the county.

Counties that only want to support some ISPs need to go through something like the process described earlier to pick their favorite ISP. That could mean:

- An informal process of talking to ISPs before providing letters of support.
- A more formal process like an RFI or an RFP that asks ISPs to describe their plans for the BEAD grants.

Local Grants. Many counties are providing local grants to act as matching funds for larger grants like BEAD. Many counties have determined that this kind of process requires a more formal process. For example, a county might decide it needs to go through an RFP in order to award a local grant.

A local grant is also going to require a contract between the county and an ISP that will define the specific ISP obligations that must be met to earn the grant. The contract also generally defines how the ISP will get paid – usually based upon performance. If a county is using ARPA funding for the grant, then the ISP has to agree to meet all of the federal obligations that come with use of the ARPA funding.

B. Benefits of Broadband

This section examines the overall community benefits of having good broadband.

Improved Education

Schools today want to be able to assign computer-based homework but can't when many students don't have good home broadband. An increasingly common practice in places with adequate broadband is to have students watch video content at home as homework and then discuss it later in the classroom. That frees valuable classroom time from watching videos in class. The whole education process is increasingly moving to the web, and kids without access to the web lack the tools that their peers take for granted.

It's getting exceedingly hard to raise kids in a home without adequate broadband. The issue is not just data speeds but also the total amount of downloaded data that even elementary school students need to do homework. This is one of the major problems with satellite broadband, which has speeds up to 50 Mbps, but with tiny data caps and high latency, the satellite broadband is often inadequate for doing homework. The same is true with cellular hotspots, and we've heard horror stories of homes with kids with astronomical broadband bills for using broadband hotspots for homework.

The pandemic showed how hard it could be to connect to a school or the office from home. A connection between a student and a school is typically activated through the creation of a VPN (virtual private network). This is a dedicated bandwidth connection that is carved out of the Internet path – like the path that is created for a student or adult working at home. The connection remains open for as long as the connection to the school WAN is open. One of the important aspects of a VPN is that it carves out upload bandwidth as well as download bandwidth. All broadband technologies other than fiber have much less capacity to tie up upload streams.

There are characteristics other than broadband speeds that matter. Both VPN connections and video conferencing require reasonable latency (delay) to maintain a connection. Doing schoolwork from home also means using a significant amount of bandwidth during a month, and that raises the issue of data caps and overage charges.

Education is not only for K-12. Adults are using broadband to train for new job skills or to take advanced courses online. There is a huge range of undergraduate and advanced degrees that are offered mostly online. Online training courses require decent broadband speeds but also low latency when the training is done in real time.

The U.S. Bureau of Labor Statistics reported in 2021 that the average American baby boomer held 12.3 different jobs between the ages of 18 and 52. It's much harder to measure a change in careers, meaning a change to doing something drastically different than prior jobs, but researchers have looked at the data and said that most people change careers at least several times during their work life. The above statistics don't tell the whole story because many people are now working well past 65 years of age, including many older workers starting a new career.

Many new jobs and careers today require online training. New employees are often expected to complete online training courses at the start of a new job. Many out-of-work adults pursue online training to learn a new career. Anecdotal evidence suggests that taking training or educational courses from a distance (across the country) requires more bandwidth since it's harder to hold a VPN session when the bandwidth varies.

The biggest group of online learners (outside of the COVID-19 crisis) are students pursuing a post-secondary education online. There are almost 20 million college and graduate students across the country, many of whom routinely have a part of a college curriculum online, even if they attend live classes. Secondary education had already been in the process of migrating online before the pandemic. Eduventures estimates that the percentage of students already tackling an online degree before the pandemic was 29% of those pursuing an associate degree, 42% for a bachelor's degree, 27% for a master's degree, and 3% of those working towards a doctorate. The National Center for Education Statistics (NCES), an agency within the U.S. Department of Education, says that over 60% of students pursuing a bachelor's degree now take some of the coursework online, as do about 55% of graduate students.

There was another major study performed by NCES to look at what is being called the homework gap,[22] That study compared test scores for 8th-grade students both with and without a home computer. The results showed:

- On tests of reading comprehension, students who have a computer at home had an average score of 268 compared to a score of 247 for students without a computer.
- In tests for mathematics, students with a computer at home scored 285, while those without it scored 262.
- In testing science, students with a computer scored 156 compared to 136 for students without a computer.
- In testing competency in information and communication technology, students with a home computer scored 152, compared to 128 for students without a home computer.

Another survey[23] released by the Pew Research Center looked at the problems uncovered when we sent kids home to learn. 93% of parents in the survey said that K-12 children received some online learning during the pandemic. That alone is big news because it means that 7% of students didn't partake in any online learning.

[22] https://nces.ed.gov/pubs2017/2017098/index.asp

[23] https://www.pewresearch.org/fact-tank/2021/10/01/what-we-know-about-online-learning-and-the-homework-gap-amid-the-pandemic/

30% of the parents that assisted students with online learning said that it was somewhat difficult to use the technology needed to take classes from home. The households that struggled varied by demographic. Low-income homes were twice as prone to struggle with technology, with 36% of low-income homes reporting the problem. Rural areas (39%) had more problems with technology and the Internet than other groups like urban (33%) and suburban (18%). But even one in five suburban kids – areas that likely have the best broadband – struggled with technology and the Internet.

About one-third of parents said that children experienced technology issues that were obstacles in completing schoolwork. 27% of parents said students struggled to do homework on cell phones. 16% said students did not have access to computers. 14% said that kids left home to use public WiFi to complete schoolwork and homework. 46% of low-income homes had the biggest technological obstacles compared to 31% of homes with mid-range incomes and 18% of homes with higher incomes.

Black teens were the most heavily disadvantaged during the pandemic. 13% of Black students said they were regularly unable to complete homework due to technical issues compared to 4% for white teens and 6% for Hispanic teens.

Household incomes affected the ability to complete schoolwork. 24% of teens from households making less than $30,000 annually said that the lack of a dependable computer or internet connection sometimes hindered them from completing schoolwork, compared to 9% of students living in homes making more than $75,000 annually.

Impact on Housing

Numerous studies show that homes without broadband are worth less than similarly placed homes with broadband. Realtors have been reporting across the country that broadband is at or near the top of the wish list for most homebuyers today. There are common news stories about people who buy a rural home and are shocked to find that broadband is not available.

CCG Consulting has interviewed hundreds of real estate agents who work in rural areas, and we have been told how difficult it is to convince people to move to rural places that don't have good broadband. Without a broadband solution, the rural parts of the county will become a less desirable place to live in over time.

Improved Medical Care

Telemedicine is becoming a routine part of healthcare. Telemedicine requires both a solid upstream and downstream connection and often requires more bandwidth than a connection to a school or office. In the past two years, telemedicine visits have skyrocketed. During March and April of 2021, the billings for telemedicine were almost $4 billion, compared to only $60 million for the same months just before the pandemic. By all industry accounts, the high level of telemedicine visits has continued as the pandemic ebbed.

The biggest benefit of telemedicine is being able to talk to a specialist without having to make a long trip to some distant city. Another common use of telemedicine is for non-intrusive assistance for things like counseling. Patients can make scheduled appointments without major disruption to work schedules.

A growing area of telemedicine is the use of medical telemetry devices, which can monitor patients after they've had medical procedures. For example, Saint Vincent Health System in Erie, Pennsylvania, has been using these technologies and has lowered the readmission rates of patients after surgery by 44%. CoBank sponsored a trial in Georgia a few years ago for rural diabetes patients that showed significant improvement when patients were monitored daily and could communicate easily with doctors.

Amazon invested $3.9 billion in 2023 to buy a healthcare company that concentrates on telemedicine. The company says that it's time to shake up the medical industry as a way to lower costs.

According to a report released by McKinsey & Company[24], we are on the verge of seeing a major shift toward health care performed in the home. The report says that as much as $265 billion in annual fees to Medicare and Medicare Advantage could shift to homes by 2025. This is significant because telemedicine and patient monitoring are a big part of home health care.

The report cites several changes in the healthcare industry that are contributing to the trend for more in-home healthcare:

- 40% of patients who have used telemedicine say they expect to keep using it in the future. It's a big burden on working families to try to get to a doctor's office during the workday, and telemedicine makes it easier for many families to seek health care.
- There are new technologies that make it easier to deal with remote patients. As an example, 20% of all medical practices in April 2021 were using devices that allow for electronic patient monitoring.

Working at Home

A lot of jobs can be done at home today, even if only part-time. But people without adequate home broadband can't participate in this part of the economy. Increasingly, companies are willing to hire people who work out of their homes. The beauty of such jobs is that they can be done from anywhere. Working from home is one of the fastest-growing parts of the national economy. After years of experiments with telecommuting, companies have seen that employees are often more productive from home due to missing the various distractions that are in the work environment.

The COVID-19 crisis highlighted the need for good home broadband when as many as 30% of the nationwide workforce was sent home to work in March 2020. Across the country, employees who live in rural areas have been unable to work from home due to inadequate broadband.

Working at home requires an encrypted VPN connection for most corporate and government WANs, in the same manner as described above for connecting to school WANs. Working at home is also becoming synonymous with communicating by video conference as an alternative to face-to-face meetings. This requires a dedicated 1 – 3 Mbps connection for both upload and download – again, something that is a challenge for somebody working from home with a slow Internet connection.

[24] https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/from-facility-to-home-how-healthcare-could-shift-by-2025

Both VPN connections and video conferencing require reasonable latency (delay) to maintain a connection. This makes it impossible to reliably maintain real-time connections over satellite.

U.S.A Today reported on the results of the fifth annual survey of the State of Remote Work[25] conducted by Owl Labs and Global Workplace Analytics in 2021. The nationwide survey was done at a time when almost one-fourth of workers continued to work at least partially from home.

The survey showed a strong desire among employees to work from home, at least part-time. Here are a few of the most interesting findings from the survey:

- A little more than half of all employees would choose to work full-time from home. 74% of those interviewed said that working at home made them happier.
- Almost half of the workers said they would take a 5% pay cut to continue to work remotely, at least part-time.
- 91% of those working at home say they are as productive or more productive than when in the office. 55% say they work more hours at home than when they are in the office.
- Almost one-fourth of employees said they would quit their jobs if they couldn't work remotely. For context, this survey was done at a time when employees were quitting jobs at historic rates.
- A lot of employees changed jobs during the pandemic. 90% of them were looking for a better career. 88% also wanted a better work-life balance. 87% were looking for less stress. 84% wanted more flexibility for where they work, and 82% wanted more flexibility for when they work.
- The ability to work from home convinced millions of people to relocate during the pandemic. Two-thirds of employees who relocated were between the ages of 26 and 40. 63% of employees who moved from urban areas to rural areas were in this age group. More than half of those who moved from suburban to rural areas were also in the younger age group.

The results from this survey are similar to other surveys taken over the last few years. It seems that many people got a taste of working from home and decided that they liked it more than going to the office every day. A lot of employers are starting to demand that workers return to the office, and many have been reporting an exodus of employees who don't wish to come back.

This has a lot of implications for rural and suburban communities. Many people want to get away from the stress of urban life and lead a more relaxing lifestyle – but they need good broadband to do so. Remote workers can't tolerate mediocre broadband and need reliable broadband that enables them to always connect. 56% of younger workers said they would love to incorporate virtual reality and virtual meetings into the workday – something that will require fast upload and download speeds.

From an economic development perspective, work-from-home employees provide a huge economic boost to rural communities that have been aging and slowly losing population over time. Employees making good salaries provide a huge boost to local economies. For years, rural communities offered big tax incentives to try to attract new employers. It costs a lot less to attract one hundred remote workers than to lure a traditional employer that will bring a hundred jobs.

[25] https://www.usatoday.com/story/money/2021/11/11/workplace-survey-remote-pay-cut-covid/6367601001/

Taking Part in the Modern World

Households with good bandwidth routinely use broadband for things like watching videos on services like Netflix, talking to friends and family on services like Zoom, playing video games (most of which have moved online), taking online courses, or just browsing today's video-rich Internet. Many of the businesses that people routinely interact with (utilities, insurance companies, shipping companies, doctors, etc.) assume that people have broadband. Many people's social lives, for better or worse, have moved to the web. It is common now to have friends all over the country based on some shared interest instead of based on geographic proximity. Homes without broadband can't participate in the many activities and services available on the web.

Taking part in the modern world has grown to mean a lot more than just watching videos. Consider some of the following ways that a lot of households routinely use bandwidth:

- Security. Millions of homes now have video cameras at the front door or elsewhere on their property that they can view remotely. A video camera requires a 1 – 3 Mbps upload connection for low-resolution cameras and up to 16 Mbps upload for an HD-quality camera.
- Machine-to-Machine Traffic. Our devices often connect with the Internet without human intervention. Our computers and smartphones automatically upgrade software and apps. Many homes use services that automatically back up files and records in the cloud. Numerous appliances and devices in our home periodically connect with the cloud, whether providing updates or making sure the connection is still live. Many cars now communicate with the cloud when they get into range of a home broadband connection to provide a log of all car sensors and to upload driving data that can later be used by the car owner.
- Online Everything. Many routine functions have moved to the web – we can't begin to make a full list of things that are now online. This includes functions like applying for a job, applying for government benefits, making insurance claims, making reservations for a restaurant, banking, and a slew of other activities. Homes without broadband are being left out of numerous activities that everybody else takes for granted. Many of these functions can be done using a cellphone, but unfortunately, many of the rural places with poor broadband also have poor cellular coverage.

Keeping Talent at Home

An issue we often hear about in rural communities is what is called the "rural brain drain." Most rural counties don't have enough good-paying jobs to keep recent graduates at home, and so a large percentage of each graduating class migrates to larger cities and towns to pursue careers. One of the promises of reliable broadband is the ability to create new jobs and to provide the opportunity for people to either work at home or to create new businesses that allow them to stay where they want to live.

Entrepreneurship.

Many communities have success stories of companies that started in a home before becoming significant employers in the community. Many communities have developed business incubator sites to support and promote startup businesses. Good home broadband is essential for a startup ecosystem.

Economic Development

Many communities claim huge economic development benefits from building fiber. Communities often tout fiber as part of the package used to attract new businesses and industries. An example is Lafayette, Louisiana, which leveraged fiber to attract several major companies that engage in computer animation – and much of the animation and special effects for movies are now created there. One of the biggest claims for the benefits of municipal broadband is detailed in a study by Bento J. Lobo that quantifies the benefits of fiber in Chattanooga, Tennessee, to be $2.69 billion over ten years.[26]

But economic development successes don't have to be that dramatic. The pandemic has convinced millions of people that they no longer need to live in major cities. Almost every rural community that CCG is working with has seen some influx of people looking to live in smaller and less hectic communities. A giant piece of the new economy is folks who can work from home – and many of them can work from anywhere. Traditional economic development efforts would normally be thrilled to attract a new business with a hundred high-paying jobs. The same economic benefit can be achieved by attracting the same number of highly paid workers who work outside their homes.

Ubiquitous or Expanded Public WiFi

Many communities provide some WiFi access to citizens in places like libraries, city halls, parks, or other commonly used public spaces. A community with a fast broadband network can offer WiFi in many more places. This ability comes at a time when outdoor hotspots have improved significantly, and it's a viable idea to provide wide WiFi coverage.

This idea also comes with a word of caution. Many cities have been sold on the idea that they can generate enough revenue from public WiFi systems to cover the cost of the network. We have never heard of a WiFi network that was able to generate enough revenue to cover costs. We recommend looking at WiFi as an awesome public benefit but not as a profit center.

More Efficient Businesses

One of the biggest beneficiaries of fiber broadband is the business community. CCG has conducted interviews with businesses all over the country both before and after they got fiber broadband. Universally, we find that fiber allows businesses to take advantage of all of the many online tools. Many of the benefits come from better upload speeds because businesses can be far more restricted by poor upload speeds than residents. The following are some of the most important ways that businesses use broadband. Faster, low-latency broadband makes it easier to do most of the following:

- Communicating with Customers. Businesses routinely have portals that make it easy for customers to place and track orders and communicate with the business. Inadequate broadband means lower sales. The old days of calling purchasing agents are slowly passing away, and most commerce between companies is becoming automated – which improves accuracy and speeds up the ordering process. A business that operates a busy e-commerce ordering site needs enormous amounts of bandwidth to make sure that all customers have a successful purchasing experience.

[26] https://assets.epb.com/media/Lobo%20-%20Ten%20Years%20of%20Fiber%20Infrastructure%20in%20Hamilton%20County%20TN_Published.pdf

- Communicating with Vendors. Businesses also routinely use the portals of their own vendors and suppliers to buy whatever they need to operate.
- Communicating with Other Branches of the Company. Many businesses are part of larger corporations and maintain open data connections to communicate with other parts of the company and with headquarters. It's not unusual for a business to operate a constant VPN connection back to the parent company.
- Working in the Cloud. It's now common for companies to work in the cloud using data that's stored somewhere offsite. This can be in one of the big public clouds like the ones offered by Amazon, Google, Microsoft, or a private cloud provided by a business. Working in the cloud is one of the biggest drivers of the need for business bandwidth. Much of the routine software that companies use now works in the cloud, meaning that employees retrieve and save documents and data constantly to and from the cloud servers. A company that relies on the cloud comes to a halt when the Internet connection isn't working. This is leading businesses to seek broadband connections from more than one ISP.
- Security Systems. Businesses often have their security monitored by offsite firms. Security today also means the use of numerous video cameras used to monitor the inside and outside of a business. Video cameras can require significant upload bandwidth.
- Sending and Receiving Large Data Files. Most businesses report that the size of data files they routinely transmit and receive has grown significantly larger over the last few years.
- VoIP. Many businesses now provide voice communications between their various branches using Voice over IP. A reliable VoIP system needs to have guaranteed dedicated bandwidth that won't vary according to other demands for bandwidth within the business.
- Communicating via Video. We've finally reached the time when employees routinely communicate via video conferences like Zoom. We saw a huge surge in this during the pandemic as students and employees increasingly used video conferencing services, but these services had already started to become routine for businesses before the crisis.
- Collaborative Software. While many businesses still rely on email, many have gone to more advanced communications systems that let parties connect in a wide variety of ways. Businesses are using collaborative tools that let multiple employees from various locations work on documents or other materials in real time. This software requires a steady upload and download data path.
- Supporting Remote Employees. Supporting employees who work from home is a major new requirement for many businesses. Communicating with remote employees is done by creating a virtual private network (VPN) connection with each employee. For a business, this means establishing both a dedicated upload and download link for each remote employee. These connections can vary between 1 – 3 Mbps per second in both the upload and download directions.
- Data Backup. Companies are wary of hacking and ransomware and routinely maintain several remote copies of all critical data to allow them to restore data after a problem.
- Internet of Things Sensors. Companies of all sizes now routinely use devices that include sensors that communicate with the Internet. Common uses of sensors might be for burglar alarm systems or manufacturing equipment. A lot of office equipment like printers, copiers, postage machines, and others only function when connected to the Internet.

Smart Government

Over the years, the idea of a smart government has evolved. A decade ago, the vision was to have a city full of surveillance cameras to cut down on crime and smart traffic systems to eliminate traffic congestion. But over time, the vision has expanded. Consider some of the following smart government applications:

- Environmental Monitoring. Sensors are used to monitor air, water, and noise pollution.
- Smart Watering Systems. This means using sensors to then water public parks and lands only as needed and only with as much water as needed. This reduces labor and saves water.
- Parking Management. Smart monitors can keep track of open parking spaces to make it easier for the public to park. Smart systems can also increase revenues from parking fees. Monitors can also identify illegal parking that might block first responders.
- Smart Lighting. Smart lighting can save money by turning lights on and off as needed. Smart lighting also identifies broken or burned-out lights.
- Waste Management. Public trashcans can signal when they need to be emptied. Some communities are also considering the idea of waste pickup on demand for businesses that generate a lot of waste.
- Outdoor WiFi. Communities are providing powerful and temporary WiFi networks to support street fairs, parades, and other outdoor events.
- Smart Traffic. It turns out that smart traffic systems are a lot harder to make work than once imagined. But we are seeing cities like Pittsburgh that are using software to reduce traffic congestion during rush hour by as much as 40%. Cities are automating public transportation to be more efficient.
- Smart Law Enforcement. Video is becoming a big part of law enforcement, and having a broadband network makes this easier and more functional. Many jurisdictions have gone to a virtual arraignment where prisoners don't have to be transported from jail to court to make an appearance before a judge. With broadband everywhere, this can be expanded to work from anywhere. We know courts during the pandemic that now allow virtual witnesses. Broadband sites around the community can make it easier for police to upload files from personal cameras. For example, the community can create numerous high-bandwidth hotspots in places that are convenient for squad cars. Files can be automatically uploaded by parking near these locations. Many communities are also partnering with citizens to create surveillance networks based on Ring security cameras. Emergency 911 systems are being expanded to allow for transmitting information to first responders, like a floor plan of a building that is on fire.

Smart Water Systems

It's been estimated that as much as 50% of drinking water is lost to leaks in some cities, with even good systems losing as much as 20% of water. A smart water system starts by placing numerous sensors throughout a water network to gather information on water flow and pressure. Once engineers understand the normal water flow in a system, they can spot deviations and drops in water pressure and pinpoint new leaks.

Another big improvement is to upgrade to more accurate water meters that are connected to broadband. Engineers have estimated that as many as 40% of the meters used to serve high-volume commercial customers underreport the amount of water being used and consequently underbill for water usage.

Smart Grid

The smart grid concept encompasses a number of technologies used to improve the local power grid. Most of these technologies can be improved by better broadband.

- Smart Meters. Accurately measuring electric consumption gives customers the ability to monitor and change electric consumption easily.
- Load Controls. This allows the utility to understand usage by neighborhood. It allows utilities to turn off a customer's air conditioning at times of peak usage.
- Integrating Renewable Power. The characteristics of renewable power are far different than generated power. Smart grid technology helps to seamlessly integrate solar, wind, and generated power.
- Controlling Devices. The grid operator can monitor and control transformers, reclosers, and any other field electric device. This saves on truck rolls, speeds up outage repairs, and makes the grid more efficient.
- Monitoring the Network. Electric companies have historically monitored the performance of substations to identify when neighborhoods lose power. However, a ubiquitous fiber network can effectively pinpoint power outages to the exact homes that have lost power and can significantly speed up restoring outages.

Resiliency

Having a widespread fiber network provides an alternative source of broadband for key anchor institutions like hospitals, schools, the 911 center, and fire stations. This can also be a vital benefit to large employers. Connecting the important parts of a community to more than one ISP can help ensure that critical services don't go offline.

There are examples of fiber networks that stay connected when other networks fail. As an example, the municipal fiber network in Lafayette, Louisiana, was the only network that didn't go dark during Hurricane Katrina. Both the telephone and cable TV companies went dark for several days. Part of this reason is that fiber wires are smaller, lighter, and stronger than some other kinds of wires - fiber doesn't break as easily from falling limbs. Fiber doesn't carry electricity, and the loss of electrical power is often the reason that other networks go dead.

Specific Industries

Every part of the economy has unique and specific uses for broadband. The following are two examples that we think are germane to the county. We could make a similar list for dozens of major industries, so the following are just a few examples of how various industries have adopted software and processes that require broadband.

Agriculture Goes Digital

CCG has interviewed farmers who say that they feel more like an IT professional than a farmer since modern farms have automated many functions that need broadband connectivity, including the following:

Controlling Equipment and Machinery. Almost all farm equipment used for plowing, seeding, weeding, and harvesting is now available as self-driving units. Broadband is required to direct the equipment precisely where to operate. Many farms still send along a person to make sure the equipment does what it's supposed to, but we already see farms where the equipment works autonomously. There are also many other forms of automated equipment, like corn dryers, watering systems, etc. that have been automated and can be controlled by the farmers from anywhere.

Tracking Soil Conditions. Many farms now do an annual census of soil conditions to identify the nutrients and other important aspects of each part of every field. These censuses are done using tractors or drones and can develop terabyte-sized files that must be loaded into the cloud to be analyzed by agronomists. We are getting close to having 24/7 field monitoring through sensors scattered around fields.

Monitoring Herds. Livestock farms are the most advanced in terms of automation. Dairy farmers track the status of each cow in detail in order to keep cows in top health to produce the most milk.

Tracking the Market. Farmers have gotten sophisticated and can directly sell their crops on worldwide markets, which means staying abreast of crop prices across the world market.

Supporting Farm Workers. Farmers who need seasonal labor are in competition with other farmers since there is a shortage of workers. Farmers that can provide broadband so that workers can stay in touch with their families have a better chance of finding the help they need. There are also online forums for finding workers.

Smart Factories

New factories have become highly sophisticated in terms of automation, which usually requires connections to cloud software. Some of the ways that smart factories need broadband include:

Controlling Robots. Modern factories have automated as many manufacturing processes as possible. Moving materials around the factory, assembling, packing, and shipping are automated as much as possible. The workforce in a modern factory is there to perform the functions that can't be automated and to maintain the automated equipment. Many of the instructions that control machinery come from the cloud in real time.

Controlling Manufacturing Processes. Processes that involve the mixing of chemicals and other complex processes have been automated as much as possible. This allows for precisely following the detailed steps needed for chemical processes, which allows for the manufacture of complex drugs and other chemicals and materials that can't be done manually.

Customization of Products. Smart factories are adept at customizing products and tracking each permutation of a project from start to shipping.

Supply Chain Management. Factories are saving a lot of money by not having to warehouse raw components and materials. The goal is to have components show up at the factory only when needed. This requires a highly sophisticated ordering and shipping program.

EXHIBIT I: NETWORK DESIGN

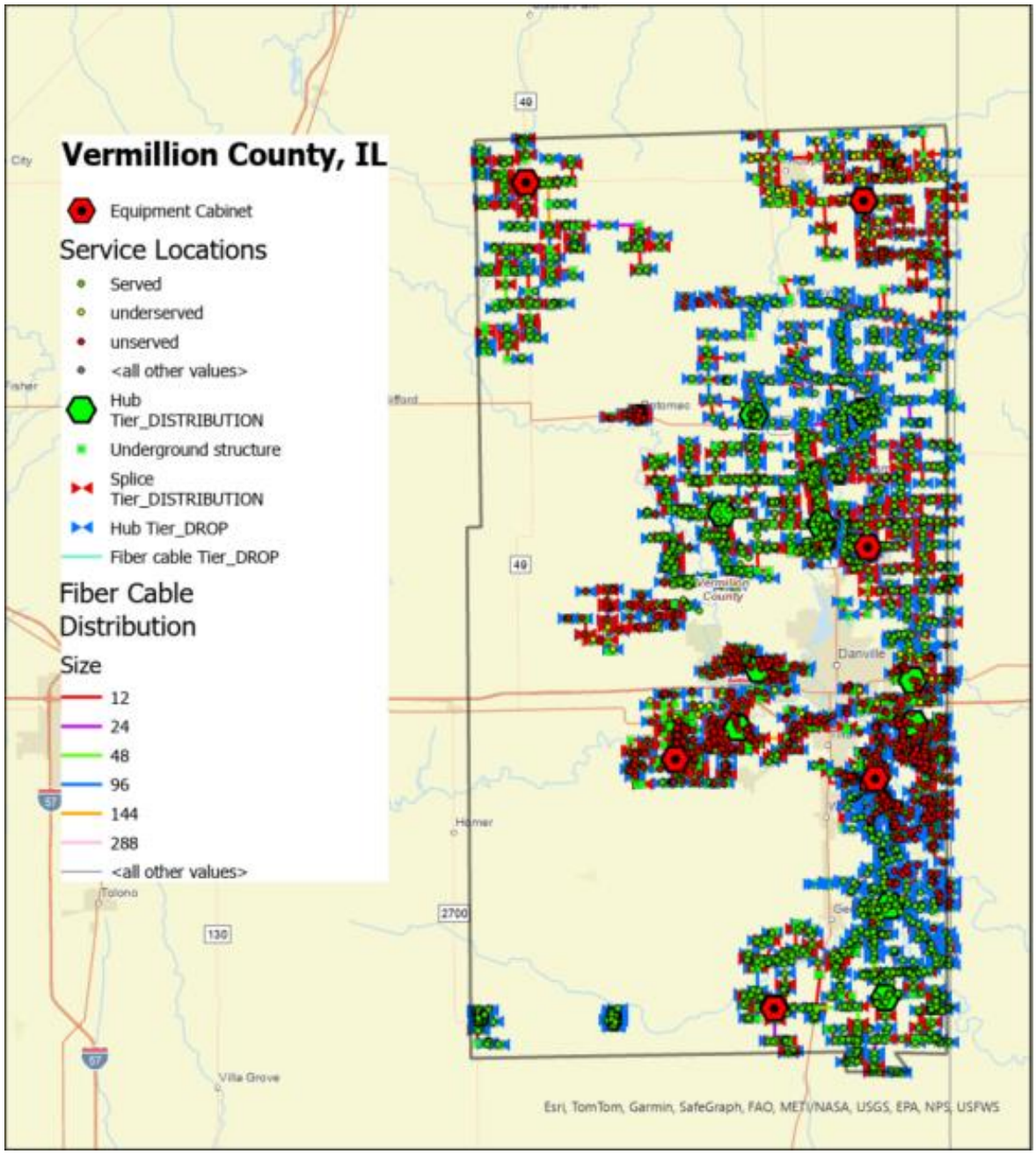


EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Year 4 Assets	Take Rate	Loan	Equity	Grant	Total Financing	Year 5 Cash	Year 10 Cash	Year 15 Cash	Year 20 Cash
	Wireless Areas are BEAD Eligible										
1	**Base 60% Penetration**	$39.2 M	60%	$37.9 M	$ 6.7 M		$44.5 M	($ 1.27 M)	($ 9.41 M)	($17.84 M)	($25.95 M)
2	**60% Penetration Breakeven**	$39.2 M	60%	$17.0 M	$ 3.0 M	$20.9 M	$40.9 M	$ 0.40 M	$ 0.58 M	$ 0.47 M	$ 0.69 M
3	**50% Penetration**	$38.3 M	50%	$37.7 M	$ 6.7 M		$44.5 M	($ 1.63 M)	($11.57 M)	($21.80 M)	($31.85 M)
4	**50% Penetration Breakeven**	$38.3 M	50%	$12.4 M	$ 2.2 M	$25.4 M	$39.9 M	$ 0.40 M	$ 0.58 M	$ 0.46 M	$ 0.54 M
5	**55% Penetration**	$38.8 M	55%	$37.8 M	$ 6.7 M		$44.4 M	($ 1.46 M)	($10.49 M)	($19.81 M)	($28.89 M)
6	**55% Penetration Breakeven**	$38.8 M	55%	$14.7 M	$ 2.6 M	$23.1 M	$40.4 M	$ 0.39 M	$ 0.55 M	$ 0.43 M	$ 0.56 M
7	**65% Penetration**	$39.7 M	65%	$37.9 M	$ 6.7 M		$44.6 M	($ 1.07 M)	($ 8.34 M)	($15.83 M)	($22.97 M)
8	**65% Penetration Breakeven**	$39.7 M	65%	$19.4 M	$ 3.4 M	$18.6 M	$41.4 M	$ 0.39 M	$ 0.53 M	$ 0.45 M	$ 0.73 M
9	**70% Penetration**	$40.1 M	70%	$38.0 M	$ 6.7 M		$44.7 M	($ 0.91 M)	($ 7.30 M)	($13.90 M)	($20.08 M)
10	**70% Penetration Breakeven**	$40.1 M	70%	$21.7 M	$ 3.8 M	$16.3 M	$41.9 M	$ 0.39 M	$ 0.49 M	$ 0.37 M	$ 0.68 M
	Based on Line 2										
11	**Higher Interest Rate**	$39.2 M	60%	$17.3 M	$ 3.1 M	$20.9 M	$41.3 M	$ 0.24 M	($ 0.36 M)	($ 1.23 M)	($ 1.79 M)
12	**Lower Interest Rate**	$39.2 M	60%	$16.7 M	$ 2.9 M	$20.9 M	$40.5 M	$ 0.54 M	$ 1.44 M	$ 2.06 M	$ 3.00 M
13	**20-Year Term**	$39.2 M	60%	$17.3 M	$ 3.1 M	$20.9 M	$41.3 M	$ 0.21 M	($ 0.62 M)	($ 1.72 M)	($ 2.50 M)
14	**30-Year Term**	$39.2 M	60%	$16.8 M	$ 3.0 M	$20.9 M	$40.7 M	$ 0.51 M	$ 1.28 M	$ 1.77 M	$ 2.59 M
15	**Refinance**	$39.2 M	60%	$17.0 M	$ 3.0 M	$20.9 M	$40.9 M	$ 0.60 M	$ 1.90 M	$ 2.93 M	$ 4.28 M
16	**Higher Prices**	$39.2 M	60%	$16.8 M	$ 3.0 M	$20.9 M	$40.6 M	$ 0.57 M	$ 1.65 M	$ 2.50 M	$ 3.72 M
17	**Lower Prices**	$39.2 M	60%	$17.3 M	$ 3.0 M	$20.9 M	$41.2 M	$ 0.24 M	($ 0.50 M)	($ 1.56 M)	($ 2.34 M)
18	**$1M Cost Overrrun**	$40.3 M	60%	$18.1 M	$ 3.2 M	$20.9 M	$42.1 M	$ 0.32 M	$ 0.06 M	($ 0.47 M)	($ 0.69 M)
19	**Inhouse Drops Breakeven**	$35.9 M	60%	$18.6 M	$ 3.3 M	$16.1 M	$38.0 M	$ 0.33 M	$ 0.41 M	$ 0.37 M	$ 0.68 M
20	**More Optimistic Scenario**	$39.2 M	60%	$16.6 M	$ 2.9 M	$20.9 M	$40.4 M	$ 0.78 M	$ 2.96 M	$ 4.91 M	$ 7.23 M
	Lease Network										
21	**County**	$39.1 M	60%	$17.6 M		$20.9 M	$38.5 M	$ 0.31 M	$ 0.57 M	$ 0.42 M	$ 0.20 M
22	**ISP**	$ 0.1 M	60%	$ 2.1 M	$ 0.3 M		$ 2.4 M	($ 0.23 M)	($ 1.42 M)	($ 2.09 M)	($ 1.33 M)
	Open Access										
23	**County**	$39.0 M	60%	$16.7 M		$20.9 M	$38.5 M	($ 0.27 M)	($ 2.06 M)	($ 3.79 M)	($ 5.31 M)
24	**ISPs**	$ 2.1 M	60%	$ 2.7 M	$ 0.4 M		$ 3.0 M	$ 0.23 M	$ 0.37 M	$ 0.50 M	$ 1.66 M

		Year 4 Assets	Take Rate	Loan	Equity	Grant	Total Financing	Year 5 Cash	Year 10 Cash	Year 15 Cash	Year 20 Cash
	Wireless Areas Not BEAD Eligible										
25	**Base 60% Penetration**	$14.4 M	60%	$14.6 M	$ 2.6 M		$17.1 M	($ 0.32 M)	($ 3.21 M)	($ 6.27 M)	($ 9.30 M)
26	**60% Penetration Breakeven**	$14.4 M	60%	$ 4.5 M	$ 0.8 M	$ 9.9 M	$15.2 M	$ 0.29 M	$ 0.45 M	$ 0.44 M	$ 0.45 M
27	**50% Penetration**	$14.1 M	50%	$14.5 M	$ 2.6 M		$17.1 M	($ 0.44 M)	($ 3.95 M)	($ 7.64 M)	($11.36 M)
28	**50% Penetration Breakeven**	$14.1 M	50%	$ 3.7 M	$ 0.6 M	$10.7 M	$15.0 M	$ 0.30 M	$ 0.41 M	$ 0.32 M	$ 0.22 M
29	**55% Penetration**	$14.2 M	55%	$14.5 M	$ 2.6 M		$17.1 M	($ 0.39 M)	($ 3.59 M)	($ 6.96 M)	($10.31 M)
30	**55% Penetration Breakeven**	$14.2 M	55%	$ 4.3 M	$ 0.8 M	$10.1 M	$15.1 M	$ 0.32 M	$ 0.53 M	$ 0.56 M	$ 0.61 M
31	**65% Penetration**	$14.6 M	65%	$14.6 M	$ 2.6 M		$17.2 M	($ 0.27 M)	($ 2.85 M)	($ 5.59 M)	($ 8.28 M)
32	**65% Penetration Breakeven**	$14.6 M	65%	$ 6.2 M	$ 1.1 M	$ 8.3 M	$15.6 M	$ 0.30 M	$ 0.52 M	$ 0.57 M	$ 0.69 M
33	**70% Penetration**	$14.7 M	70%	$14.7 M	$ 2.6 M		$17.2 M	($ 0.20 M)	($ 2.46 M)	($ 4.87 M)	($ 7.22 M)
34	**70% Penetration Breakeven**	$14.7 M	70%	$ 7.3 M	$ 1.3 M	$ 7.3 M	$15.8 M	$ 0.29 M	$ 0.49 M	$ 0.54 M	$ 0.66 M
	Based on Line 26										
35	**Higher Interest Rate**	$14.4 M	60%	$ 4.6 M	$ 0.8 M	$ 9.9 M	$15.3 M	$ 0.26 M	$ 0.21 M	($ 0.02 M)	($ 0.22 M)
36	**Lower Interest Rate**	$14.4 M	60%	$ 4.5 M	$ 0.8 M	$ 9.9 M	$15.1 M	$ 0.34 M	$ 0.69 M	$ 0.87 M	$ 1.07 M
37	**20-Year Term**	$14.4 M	60%	$ 4.6 M	$ 0.8 M	$ 9.9 M	$15.3 M	$ 0.24 M	$ 0.13 M	($ 0.16 M)	($ 0.41 M)
38	**30-Year Term**	$14.4 M	60%	$ 4.5 M	$ 0.8 M	$ 9.9 M	$15.2 M	$ 0.33 M	$ 0.65 M	$ 0.79 M	$ 0.96 M
39	**Refinance**	$14.4 M	60%	$ 4.5 M	$ 0.8 M	$ 9.9 M	$15.2 M	$ 0.34 M	$ 0.80 M	$ 1.09 M	$ 1.40 M
40	**Higher Prices**	$14.4 M	60%	$ 4.5 M	$ 0.8 M	$ 9.9 M	$15.1 M	$ 0.36 M	$ 0.84 M	$ 1.16 M	$ 1.52 M
41	**Lower Prices**	$14.4 M	60%	$ 4.6 M	$ 0.8 M	$ 9.9 M	$15.3 M	$ 0.24 M	$ 0.07 M	($ 0.28 M)	($ 0.63 M)
42	**$1M Cost Overrrun**	$15.4 M	60%	$ 5.6 M	$ 1.0 M	$ 9.9 M	$16.5 M	$ 0.21 M	($ 0.07 M)	($ 0.53 M)	($ 0.96 M)
43	**Inhouse Drops Breakeven**	$13.5 M	60%	$ 5.2 M	$ 0.9 M	$ 8.4 M	$14.5 M	$ 0.27 M	$ 0.33 M	$ 0.26 M	$ 0.23 M
44	**More Optimistic Scenario**	$14.4 M	60%	$ 4.4 M	$ 0.8 M	$ 9.9 M	$15.1 M	$ 0.45 M	$ 1.20 M	$ 1.80 M	$ 2.45 M
		0.9									
	Lease Network										
45	**County**	$14.3 M	60%	$ 4.4 M		$ 9.9 M	$14.3 M	$ 0.31 M	$ 0.38 M	$ 0.31 M	$ 0.22 M
46	**ISPs**	$ 0.1 M	60%	$ 0.7 M	$ 0.1 M		$ 0.8 M	($ 0.11 M)	($ 0.34 M)	($ 0.43 M)	($ 0.16 M)
	Open Access										
47	**County**	$14.4 M	60%	$ 5.2 M		$ 9.9 M	$15.1 M	($ 0.16 M)	($ 1.63 M)	($ 3.32 M)	($ 5.05 M)
48	**ISPs**	$ 0.1 M	60%	$ 0.6 M	$ 0.1 M		$ 0.6 M	$ 0.04 M	$ 0.33 M	$ 0.86 M	$ 1.36 M