Broadband Feasibility Report

Farmington Electric Utility System

December 10, 2020

Finley Engineering
CCG Consulting

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EXECUTIVE SUMMARY

Finley Engineering and CCG Consulting submit this final Broadband Feasibility Report that provides our findings and recommendations for bringing better broadband to the electric service territory of the Farmington Electric Utility System.

The original scope of the study was to look at two specific broadband opportunities. The first was bringing broadband to the entire FEUS service area. The second looked at bringing broadband to only the rural areas – something FEUS wanted to consider because a federal grant (the Rural Digital Opportunity Fund, or RDOF) was available to that would help pay for the rural buildout. We looked at the impact to FEUS for accepting or not accepting the federal grant.

After the draft of this study was circulated, in early December 2020 the FCC completed a reverse auction to award the RDOF grants. In that auction FEUS won a grant for $3.18 million to serve a portion of the rural service area. However, grants were also awarded to CenturyLink and Windstream to serve other portions of the FEUS rural service area. This report has been updated to discuss the impact of these grants. The revised study now also shows the financial opportunity for bringing fiber broadband to only the denser urban portions of the FEUS service areas.

This revised report also takes a fresh look at the question of whether FEUS should consider building fiber in the rural portions of the service area. Any decision to move forward in the rural areas now has to contemplate what CenturyLink and Windstream might do in the rural areas. It's no longer clear to us if there is any reasonable option for building much fiber in the rural parts of the service area. There is a more in-depth discussion of this topic at the beginning of the Recommendation section below.

The first phase of the study was to look at the need for broadband in the area. We tackled that task in two ways. We communicated with residents and businesses through surveys, speed tests, and interviews to understand broadband needs. Finley Engineering also drove extensively through the area to identify the facilities used to provide existing broadband.

One of our most important findings is that the broadband offered by the current ISPs is not as good as they advertise and not as good as reported to the FCC. For example, we found a large percentage of the Comcast customers are receiving speeds far slower than the basic speed of 150 Mbps download that Comcast advertises. While there are several reasons why speeds are slower, the primary one is that Comcast has not upgraded basic design problems in the network. The company has upgraded to the latest DOCSIS 3.1 electronics, but the configuration of the local network makes it impossible to deliver the speeds that Comcast is advertising. In addition, except for some customers in the city, most of the customers using CenturyLink DSL are getting slow speeds. This is mostly due to the use of outdated DSL technology and copper wires that have outlived their useful life.

We were asked to specifically identify the broadband gaps in the area. We went about this in a number of different ways. For example, we compare the broadband situation in the area to other places in the US and in New Mexico. We discuss the various broadband gaps we witnessed during our research and our public outreach. This includes things like the urban / rural gap where homes and businesses outside of city areas have few, or even no, broadband options. We discuss the homework gap where students without home broadband don't perform as well in school. We discuss the computer gap where homes without computers

don't do as well as homes with them. We look at the broadband speeds available in the area today and compare them to other places.

Finally, we created our own version of a broadband map showing the speeds we think are available in the county today – which differs significantly from the FCC maps that overstate the broadband coverage. Unfortunately, the faulty FCC maps are used by the FCC when determining the areas that are eligible for federal broadband grants. We discuss steps that you might consider taking to correct the FCC maps.

The next phase of the study quantified the cost of bringing broadband to the area. Finley Engineering tackled this task by separately estimating the cost of building fiber to the rural areas and the city areas. Our original investigation showed that the cost of all assets needed to build and operate a fiber network for the rural areas is $64.5 million. The cost to build fiber in the urban areas is $64.5 million for a combined cost of $122.7 million.

There are key variables which can have a significant impact on financial performance. We looked at over thirty scenarios to better understand the impact of changes in variables like the customer penetration rates, prices, interest rate on debt, the length of bond borrowing terms, the cost of assets, etc.

Our financial analysis allowed us draw conclusions about the viability of the various scenarios. Our conclusions are as follows:

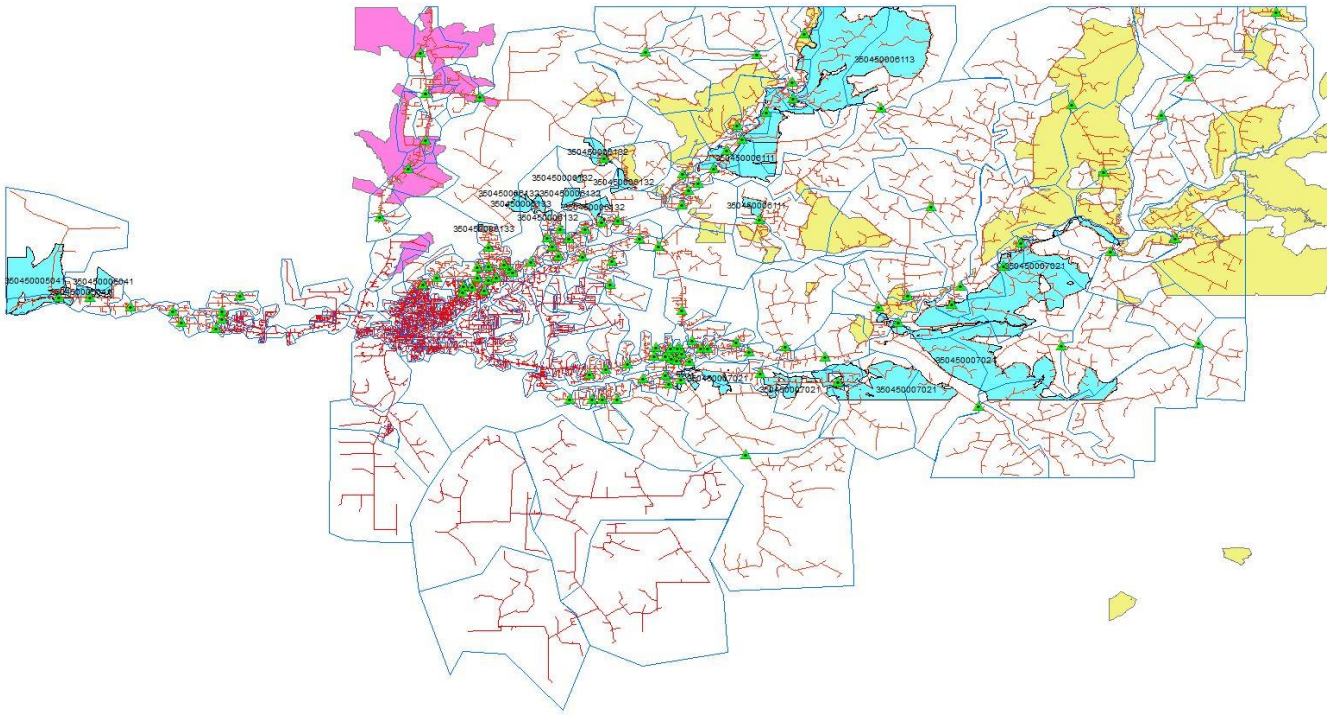
- In the original analysis, we concluded that it was a reasonably safe business plan to build fiber everywhere. Our conclusion was the same regardless of whether FEUS won the RDOF grant of around $9.5 million. The key factor that led us to this conclusion is the low breakeven penetration rate of 35% in the city and 56% in the rural areas. Subject to FEUS undertaking surveys to judge the public's desire to buy better broadband, we think those are likely achievable penetration rates for anybody building a fiber network.
- In the revised analysis, we come to the same conclusion for building only in the urban areas. If that is the only areas that get fiber, the breakeven penetration rate is 40% - again something that that seems reasonably achievable, subject to better understand customer demand for broadband.
- We can no longer recommend building in the rural parts of the service area. At a minimum, you'll not want to build in areas where CenturyLink or Windstream have won grant funding – at least until some future time when you understand what that means for those areas in terms of new broadband infrastructure. More work is needed to see if there is a coherent business plan that can be put together for reaching the parts of the rural areas where FEUS won grant funding.

We conclude the report by providing a list of specific recommendations for the utility to consider after getting this report. The most important recommendation is to undertake a statistically valid survey to understand the likely customer penetration rate for a broadband business, since that is the key variable identified by our analysis. But there are numerous other steps you must undertake in order to make the decision to enter or not enter the broadband business.

FINDINGS

Following are our primary finding:

The RDOF Auction Produced Unexpected Results. The original estimate of the available funding from the Rural Digital Opportunity Fund auction was around $9.5 million in the rural areas within the FEUS service territory. FEUS was awarded a grant of $3.18 million, to be collected over ten years to cover some of the rural area. But unexpectedly, both CenturyLink and Windstream won funding to build gigabit broadband in other parts of the service area. This initial report considered building fiber to the entire FEUS service area. This report has been modified to show the opportunity for building fiber only to the urban areas along with a strategy for how to consider the rural opportunity.



= Farmington RDOF Grant Award Census Block Groups
= Windstream RDOF Grant Award Census Block Groups
= CenturyLink RDOF Grant Award Census Block Groups

As can be seen by the above map of the FEUS service area, Windstream (Yellow) won grant funding to bring gigabit broadband in a big portion of the rural area. CenturyLink (purple) won grant funding for parts of the northwest corner of the FEUS service area. The areas covered by the grant won by Farmington (blue) don't make an automatically coherent service area. For example, completing those builds would require building through areas won by Windstream.

Existing Providers and Market Rates. The incumbent telephone company in and around Farmington is CenturyLink. The incumbent cable provider in Farmington is Comcast/Xfinity. From the surveys we see customers buying fixed wireless service from Advantas Internet, Sacred Wind, Commnet Wireless,

Sivadnet, and NTUA. Rural homes are also using cellular broadband or cellular hotspots for home broadband. Most homes and businesses can buy satellite broadband from Viasat and HughesNet. Rural customers can also buy cable TV from DirecTV or Dish Networks. We looked at the key products and prices currently offered by the existing broadband providers.

Quality of Broadband. The broadband inside the city limits of Farmington is typical of what is available in rural county seat cities. Comcast offers broadband service with speeds up to 1 gigabit, but the speed tests show a surprising number of Comcast customers with speeds under 100 Mbps. CenturyLink offers two levels of DSL – a technology that uses one pair of copper wires and that delivers speeds under 20 Mbps and a version that uses two pairs of copper wires that can deliver speeds up to 50 Mbps. In many cases, the speeds delivered on CenturyLink are far slower than the theoretical maximum. CenturyLink seems to be serving at least a few customers using fiber – this might be limited to businesses and apartment complexes.

Broadband outside the city limits is a different story. In rural areas the options for customers are very slow DSL, with speeds as slow as only a fraction of 1 Mbps, fixed wireless that has speeds of perhaps 15 Mbps or slower, satellite broadband that can have decent speeds but extremely high latency, or cellular hotspots that have a low monthly data cap. We heard from rural customers who reported they didn't have any broadband options.

It's worth noting that any problems with the quality of broadband were magnified during the COVID-19 pandemic as employees and students tried to function from home. Many rural residents have been unable to connect to work or school servers. Even in the city, many homes struggled with broadband connections that have slow upload speeds that make it hard for multiple people to work at home at the same time.

The Residential Survey. We conducted an online residential survey and got 443 respondents. The results are not statistically valid, meaning the survey is most useful as a way to understand sentiment rather than hard statistics. Here are a few key results of the survey:

- We got 50 responses from people that don't have broadband, and 2/3 of those live in rural areas and report that they have no home broadband option.
- The average price for home broadband was cited as $73 per month, which we think is a realistic number for the market. 28% of the respondents said that broadband is too expensive, which is much lower than what we normally see.
- 79% of respondents said that somebody works from home, including 28% who have somebody working full time from home. Note that the survey was taken during the pandemic, but this is still the highest number we've ever seen.
- 49% of respondents have school-age students and 43% of them say that the broadband is not adequate to connect to schools.
- 73% of respondents supported the idea of getting a community fiber network.

Speed Tests. The speed tests uncovered perhaps the biggest broadband gap in the market – customer speeds for the major ISPs are mostly slower than what's being advertised.

- Comcast. The speeds reported on the speed tests are often much slower than what Comcast advertises. 58% of speeds tests showed speeds under 100 Mbps, 29% show speeds under 50 Mbps, and 12% show speeds under 35 Mbps – all slower than the advertised speed of 150 Mbps. A little

over half of Comcast respondents have upload speeds under 10 Mbps and most of the rest are under 20 Mbps.

- CenturyLink. The speeds on DSL are mostly slow, as would be expected due to the technology. 51% of customers have download speeds under 10 Mbps, with a lot of customers with speeds less than 1 Mbps and 2 Mbps. 17% of customers have speeds over 20 Mbps, provided by a DSL technology that uses four copper wires to the home – this is only available in some areas of the city. 56% have upload speeds under 1 Mbps, with 85% of customers have upload speeds under 10 Mbps.

The Study Area. The study area is the same as the area covered by the electric utility. Finley engineering looked at network costs in two parts – inside and outside the city limits of Farmington, but the financial analysis was done for the entire study area.

Fiber Network Design. Finley Engineering considered several technologies before designing a reasonably efficient network for each of the scenarios studied. A detailed description of the fiber technologies considered in in Section II.C. of the report. The chosen network design uses Passive Optic Network (PON) technology on fiber to bring gigabit broadband to every home and business in the service area. The network design also allows any large customers to be serviced using Active Ethernet technology that can deliver dedicated bandwidth up to 10 gigabits per second in speed.

The fiber network is designed to go on poles where other utilities are on poles and to be buried underground where other utilities are currently buried. The network design is robust. The fiber network is designed to provide fiber for every home and business in the county today and well as capacity for future expansion or growth. The extra capacity could be used for numerous reasons such as supporting electric smart-grid, supporting smart-city applications, or for providing for new housing and business growth.

Passings is the broadband industry term used to define the number of potential customers in the service area. For residential broadband that means residential living units such as single-family homes or the number of apartment units in an apartment building. A business passing is a business that can subscribe to broadband, which requires counting standalone businesses as well as the businesses inside of multi-tenant buildings that hold multiple businesses.

Finley counted passings using GIS and meter data provided by the utility as follows:

	Rural	Urban	Total
Residential	14,662	15,961	30,623
Business	400	3,172	3,572
Total	16,062	19,133	34,195

Miles of Fiber Construction. The study designs a fiber network to pass every home and business in the study area. Not every road in the rural areas gets fiber, such as some roads that service oil rigs but no residents. In the original analysis, Finley Engineering identified the following road miles of fiber required to bring fiber everywhere.

	Miles	Cost	Cost / Mile
Rural Area	1,221 miles	$ 52,917,044	$ 43,339
Urban Area	574 miles	$ 47,265,178	$ 82,344

Total	1,795 miles	$100,182,222	$ 55,812

Asset Costs. Below is a summary of the cost of the assets needed by the end of the sixth year in the original analysis. Note that these assets represent an assumed 50% penetration rate in the urban area and 60% in the rural areas. The needed investment would be higher or lower with more or fewer customers due to the cost of fiber drops and customer electronics that are only installed for subscribed customers.

	Rural	Urban	Total Area
Fiber	$52,917,044	$ 47,178,178	$100,182,222
Drops	$ 2,861,919	$ 2,570,580	$ 5,398,710
Electronics	$ 7,389,304	$ 7,906,549	$ 15,115,428
Operational Assets	$ 1,329,916	$ 1,247,787	$ 2,002,692
Total	$64,498,183	$ 58,990,094	$122,699,052
Cost per Passing	$4,282	$3,083	$3,588

Our Approach to the Financial Analysis. We used the following approach in estimating the revenues and costs for operating a new fiber network for each of the three scenarios:

- A base model was created for each operating model. We arbitrarily chose a 50% market penetration (the percentage of customers using the network) within the city limits of Farmington and a customer penetration rate of 60% for serving the rural area. We don't know how many customers a new fiber business might win and chose these penetration rates as typical, yet conservative estimate based upon many other markets we have worked in.
- All financial models cover a 25-year period. All projections include projected financing costs for borrowing the money needed to build and launch the network.
- We believe the engineering cost estimates are conservatively high.
- All studies include an estimate of future asset costs that are needed to connect future customers and to maintain and upgrade the network over time. We've assumed that electronics wear out and need to be replaced periodically during the studied time frame.
- Products were priced at a modest discount from the existing prices of products sold in the market today. The expectation is that the internet speeds offered on the network will be significantly faster than the speeds available today.
- The estimates of operating expenses represent our best estimate of the actual cost of operating the fiber business and are not conservative. Most operating expenses are adjusted for inflation at 2.5% per year.

Key Financial Study Results (revised for actual grant award). The assumptions used in creating the various business plans are included in Section III.B of the report. The results of the financial analysis are included in Section III.D of the report. A summary of the financial results is included in Exhibit II. Following are the key financial findings of our analysis. These results from the original study have been modified to reflect the actual amount of RDOF grant award of $3.18 million.

- Operating a Fiber Broadband Business Is Feasible. The original study showed that it is feasible to profitably operate a fiber broadband business that covers the entire FEUS study area. Even without a grant, that study showed that a fiber business might generate a cash flow over 25 years of as much as $67 million. However, until the rural grant situation and opportunity is understood, we are no longer recommending building in the whole rural area. However, fiber still makes sense in

the urban areas and make sense in some subset of . With a customer penetration of 50%, a fiber business in the urban areas would generate as much as $37.9 million over 25 years.

- The Breakeven Penetration Rate Seems Achievable. The required breakeven for the business is relatively low. The breakeven penetration rate for the urban areas is 40%, meaning that the business would always be solvent and have cash as long as it won that many customers in the market. By looking at the success of other fiber overbuilders, we judge this penetration rates to likely be reasonably achievable but recommend considering a market survey before moving forward.
- The Business Is Sensitive to a Few Key Variables. All the scenarios are sensitive to changes in a few key variables including interest rates, prices, loan terms, and capital costs.

Funding Options. The study assumes that a new fiber network would be paid for using municipal bonds. We looked at the opportunity with and without grant funding.

San Juan County Has Been Harmed by FCC Policy. There are FCC policies which have blocked some of the rural areas from being eligible for federal broadband grants. The FCC determines places that have good broadband through a process of collecting broadband data from existing ISPs. ISPs report broadband customers and speeds twice a year by Census block. Census blocks are small geographic areas determined by the US Census Bureau that normally cover 40-60 homes or businesses (but can cover more). ISPs are supposed to report the fastest broadband speeds available to customers. There is also an odd rule that says that if even one customer in a Census block can get a fast speed, say 25 Mbps, then the ISP can claim the whole Census block as having that speed.

The biggest issue with current FCC mapping is that CenturyLink has overstated broadband coverage in some rural Census blocks and is claiming it can deliver broadband speeds of 25/3 Mbps. We don't believe that many, or possibly any, of the customers in the affected Census blocks can buy broadband at that speed or faster. If the overreporting for these areas can be corrected, there might be significant future federal grants that could help to pay for building broadband in these areas (just as were offered this year with the rural RDOF grants). There are steps that can be taken to overcome the incorrect reporting.

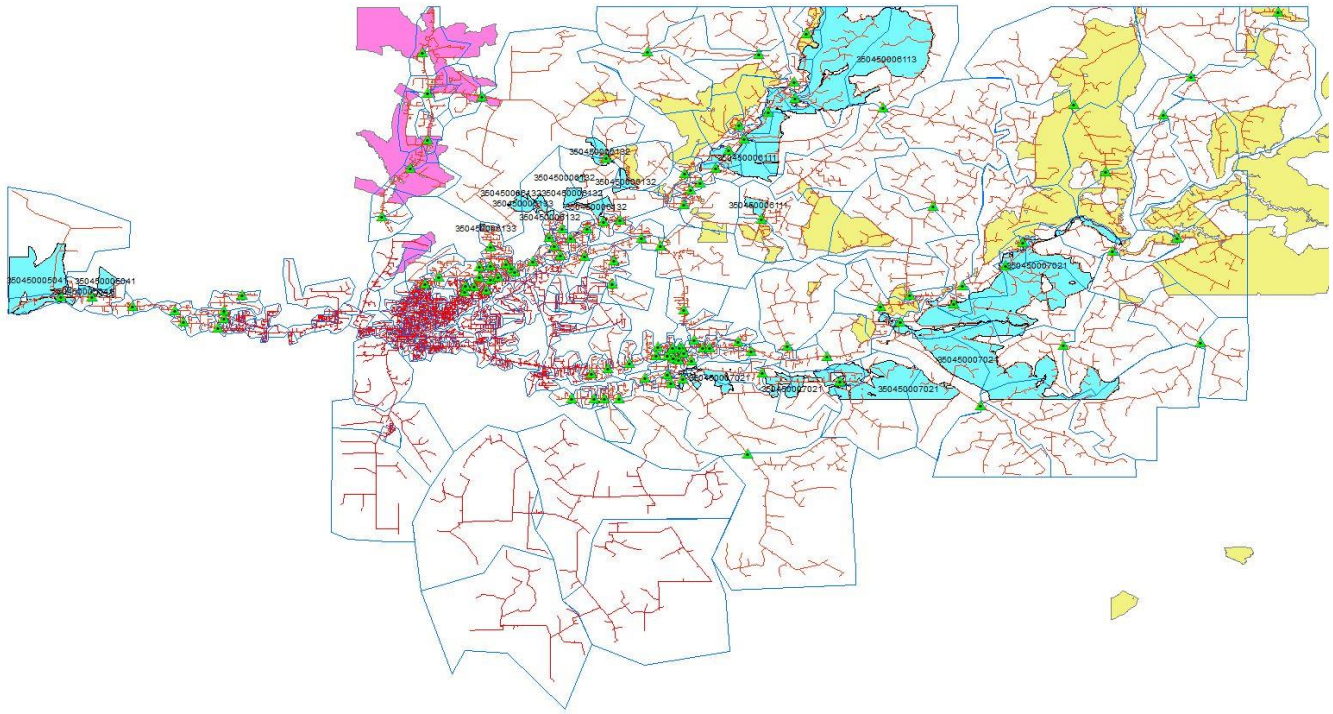
RECOMMENDATIONS / NEXT STEPS

Following is a list of recommendations that come from our analysis of the broadband landscape in and around Farmington. This is one of the longest lists of recommendations that we've ever made, but that is driven by the fact that the area has some significant broadband gaps, particularly in the rural areas. You don't have to go very far outside of Farmington to find homes and businesses with no good broadband options. Even within the two cities there are complaints about broadband reliability and price.

One of the first things you should do with the following list is to understand each recommendation and then prioritize the recommendations. It's impossible to tackle everything on this list in a short period of time, so setting priorities can define the items that you think are the most important to tackle first.

Decide About Accepting the RDOF Grant

The decision to accept the RDOF grant got more difficult due to significant awards being made to CenturyLink and Windstream to bring gigabit broadband to parts of the rural FEUS service territory. FEUS was awarded $3.18 million in grants to cover a portion of the county, with funding also going to the two incumbent telcos to build the rest.



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The fact that grant funding went to big telcos complicates any decision. These big telcos have taken federal funding in the past to build better rural broadband and then didn't follow through and build what those

grants required. A case in point is CenturyLink that accepted money in 2015 to improve rural broadband in the areas around Farmington to speeds of at least 10/1 Mbps. The investigation conducted for this project shows that rural broadband speeds do not meet that speed threshold. We don't know if CenturyLink just made a half-hearted attempt at improving rural DSL speeds of if they did nothing – but they didn't comply with the requirements of the previous federal grant. We see the same situation all across the country in areas where CenturyLink, AT&T, Frontier, and Windstream accepted funding in that same 2015 grant program.

FEUS can see from the work we did for this project that the full amount of RDOF grant in the rural areas, estimated to be around $9.5 million, is not nearly enough money to build fiber in the rural areas. If somebody like FEUS was already going to build fiber, then the RDOF grant would have made it a little easier to make a fiber project work. That makes the big telco grant awards so puzzling. Are CenturyLink and Windstream really going to accept relatively small grants and make the additional large investment needed to bring gigabit broadband?

This report is being updated soon after the RDOF grant awards, so there are still a lot more questions than answers. One of the biggest speculations is that grant winners might try to substitute some less costly technology, such as fixed wireless to fulfill the grant requirements. This would hopefully not be allowed by the FCC. There is other speculation that the big telcos will just take the grant money and largely pocket it, as they've done in the past. But these (and many other rumors) are just speculation. We'll know more when grant winners file grant long forms in several months, but we may not really know what CenturyLink and Windstream plan to do until years from now as the build-out requirements for the rural areas kick into effect. Only then will you know if they are really going to build gigabit broadband in the areas surrounding FEUS.

For now, our recommendation is that FEUS should not consider building to the rural area where the two telcos won funding. It's never going to make sense for two providers to compete with fast networks in rural places. The results of the grant have reduced the FEUS decision to a different set of options than were covered by this report.

Unfortunately, your decision isn't as simple as building where the two telcos didn't get a grant. Part of the consideration to build in the rural area includes building to locations that are not covered by the grants. An examination of the map above shows that there is no easy way to reach much of the rural area without building through areas won in the grant process by Windstream. The way this grant was awarded makes it hard for FEUS or Windstream to put together a reasonable business plan for serving the rural area.

FEUS is still faced with the decision of accepting or not accepting the smaller RDOF grant. Part of that decision is to take a hard enough look at the engineering data to see if the grant awards create a coherent enough service area that makes any sense. Finley Engineering is doing that analysis and will get back to FEUS with their conclusions. But when looking at the grant map, both CCG and Finley are doubtful that a reasonable business case can be made in the rural area. If either of the telcos makes significant improvements in rural broadband, it's likely going to be hard for FEUS to be profitable in the rural area.

FEUS is not alone with this dilemma. We see similar situations all over the country where the areas that got grant awards are not in one coherent service area but mixed in with grant awards given to other. If

FEUS decides to not accept the grants you won't be alone. The above map might provide a good reason to ask for no penalties for not accepting the grant award.

Meanwhile, we've added the financial analysis to the report for building just the urban parts of the FEUS serving area. We've known all along that this could be done profitably, and now we've created the financial models to prove so. The breakeven penetration rate for the urban areas is 40% - meaning that FEUS would need to eventually get 40% of the customers to use a new fiber network. In our experience that sounds like an achievable goal, but there are a few more steps to take, detailed below, that you'd want to take before making the decision to move forward.

Steps Needed to Decide to Move Forward

There are some clear next steps that you should take before deciding to move forward with a fiber business plan. Each of these will be discussed immediately following this item. The short-term tasks you should tackle:

- Conduct a statistically valid survey to understand the likely residential customer penetration rates in both the city and rural areas. The two rates are likely to be different.
- Engage in a customer education process to solicit feedback from the public on the idea of building fiber.
- Gather more information about potential bond financing.

Conduct a Statistically Valid Residential Survey

The biggest concern that every ISP has about a new market is knowing if they can get enough customers to be successful. Communities differ widely in the willingness of people to subscribe to broadband. For example, we've worked in rural communities in just the last few years where the demand for rural broadband varied between 65% and nearly 90% - and it's vital for an ISP to understand where your community fall within that wide range. The willingness of people in a city willing to buy broadband can vary even more. The primary techniques used to understand market demand is a statistically valid survey. That will provide a prediction within a relatively narrow range of the potential demand.

There are a few factors that are vital to get an accurate and believable survey. First, the questions asked must be unbiased and can't lead respondents into answering in a given way. It's also important for a survey to be random if you want the results to represent the whole County. For example, since the goal is to predict broadband penetration rates, it's just as important to hear from those who don't want broadband as it is to hear from those who do.

It's also essential to have confidence in the survey results and this speaks to the accuracy of the answers obtained in the survey. Most business and political surveys are designed to provide an accuracy of 95% plus or minus 5%. That accuracy would mean that if you were to ask the same questions to 100% of the people in the area that the results should not vary by more than 5% from what was obtained in the survey. That is a high level of accuracy, but other levels of accuracy are possible by varying the number of completed surveys. For most communities, a survey with between 350 and 380 completed surveys will produce this desired accuracy. In your case, you might want to consider separate surveys for the city areas and the rural areas.

Educate the Public

The utility and the City are going to want feedback from the community before undertaking such a large project. One important aspect of community engagement is to provide useful information to the public to help them better understand broadband issues. It also means providing basic information that explains broadband in ways the public can understand. 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 study, or meetings could be more generic and be aimed at explaining broadband issues. It's worthwhile to have elected officials at public meeting so they can directly hear the kinds of issues that households have due to lack of broadband. It's vital to advertise heavily to drive attendance at meetings. CCG and Finley Engineering have been to a community meeting where only one resident attended, and to other meetings that were standing room only in a large room.
- Broadband Web Site. Many communities create a broadband web page. Such a page can be used to educate as well as inform. For example, a common educational feature is to have a lengthy section with responses to "Frequently Asked Questions." It's important that if you create a broadband web site that you keep it current. You want the public to think of this site as a resource.
- Gather List of Broadband Proponents. One important tool is to create a database of local broadband proponents – citizens who say they support fiber. Having 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. It's even more important if you move forward because this is a list of potential customers.
- Broadband Newsletter. Cities often create a newsletter dedicated to broadband. These newsletters are aimed at educating the public on topics related to broadband and also to keep the public informed on the progress of the effort to get better broadband.
- 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 sorts of groups – 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.

Investigate Financing Options

One of the important variables identified in the financial analysis is the interest rate on debt – due mostly to the fact that you are likely to finance much or all of the project using municipal bonds. Our study assumed a bond interest rate of 3% and a bond term of 25 tears. The better you can define those two variables the more accurate ongoing forecasts will be. At a minimum you should be looking at the following:

- Pinning down a likely range of interest rates on bonds would be extremely useful.
- You also should pin down other bond parameters. What debt term (year of the borrowing) are possible? Would a debt service reserve fund be required? How much capitalized interest should you borrow?

- You also have some interesting options to consider. For example, you could borrow and launch the business first in either the rural or the city area and then borrow and build the other area later. There are trade-offs because there is no way to predict future interest rates, but there could be a significant savings on interest expense from not borrowing the money for the whole project at the start.

Identify Staffing Resources

If the utility is going to seriously going to tackle of the question of if you should move forward, you're going to need staff resources to tackle many of the tasks. Finding a broadband solution takes a focused and persistent effort, particularly in this case where the RDOF grant question is pushing a timeline. We've seen the following ways that cities have done this well.

- Dedicate Staff. The communities that have done this the best have dedicated at least one staff person to concentrate on community engagement. The biggest challenge in doing this is usually finding the funding. The person undertaking this task needs to be a big believer and advocate of broadband for it to be successful. This is not a permanent position, but rather somebody dedicated to this effort for some fixed period of time. This is also not a 9 to 5 job with a lot of demands placed on evenings and weekends.
- Volunteers. Volunteers can also be an important part of this effort. There are typically people living in areas with no broadband who are willing to volunteer to help find a solution. We've seen fiber efforts effectively use volunteers to accomplish a lot of needed legwork. Volunteers aren't really free since you'll have to pay to support whatever tasks they are undertaking – but they can save a lot of money and can sometimes accomplish a lot in a short period of time.
- Broadband Task Force. A more formal solution is to create a committee of citizens who are willing to work to get better broadband. A Broadband Task Force is most often composed of citizen volunteers and a few elected officials. These groups meet regularly and work towards finding a broadband solution. It's normal that such a group would report back regularly to the Board or to staff about their progress. Such a group can collectively take on the needed community engagement tasks, and we've seen effective committees do this well. It's not unusual for a Broadband Task Force to solicit help from volunteers.

  Such groups are usually given a budget, but also restrained by needing to have expenditure pre-approved. A task force might use funding to collect data needed to advance broadband. I've seen funding approved for such things as statistically valid surveys, for pledge card drives, and for hiring a consultant to answer their questions.

  We could write pages on the dos and don'ts of operating a successful citizen's advisory group. The one issue I've seen with a task force is if the citizen group has a different vision of the right broadband solution than the government – they are often impatient and want to see results. Most governments have already experienced this in working with citizen groups on other topics. The main keys for success are to make sure that the group has a specific agenda, a specified budget, and the specific authority to meet their goals. Citizen groups can accomplish great things if they are directed to do so – but can stray if not given good direction.

Review Local Policies Related to Fiber Construction

Before building fiber everywhere you should take the time to look at the utility, city, county, state, tribal, and federal issues that might impact building fiber. The utility, the various cities, and the county should coordinate a review of the following kinds of policies to see if there are ways to be friendlier to ISPs. Changing these processes might require new ordinances or new internal procedures. Local governments need to remember than any changes made to accommodate your new fiber build would also then apply to the incumbent ISPs:

- Granting rights-of-ways to construct a network.
- Issuing permits to construct a network.
- Locating existing underground utilities where fiber is to be buried.
- Inspecting and approving that construction followed the permits.
- Requiring things like traffic control during the construction process.
- Requiring other kinds of agreements like franchise agreements or rights-of-way agreements.
- Requiring records of what's been constructed.

Push the Incumbents to do Better

It can be tempting to ignore the incumbent broadband providers when contemplating building fiber, but we've seen examples recently where incumbent providers and local governments have created partnerships to bring better broadband.

This study shows that the Comcast network is not up to snuff and that the speeds being delivered look to be significantly slower in some cases than the speeds being advertised. This is not true of all Comcast markets and we've done studies in cities where the speeds met or exceeded the advertised speeds. It's always worth the effort, particularly based upon the findings of this report to push Comcast to make the needed improvements.

It's also possible to find interest in partnering from CenturyLink. The company is not going to spend any more money investing in its old copper technology. CenturyLink has also largely stopped investing in residential fiber, but they have formed a few partnerships, like one in Springfield, Missouri, that is worth considering.

Lobby for Larger State Broadband Grant Funding

It's going to be a lot easier to fund rural broadband projects in New Mexico if the State steps up and increases the annual amount of broadband funding. The current awards of $5 million per year is one of the smallest state grant programs in the country. While anybody getting grant money from this program will be thankful, it might take literally a few centuries for a grant program of that size to make a dent in the rural broadband gap in the state – which ranks near the bottom among all states.

Increasing broadband grant funding means lobbying state legislators to the problems caused by lack of broadband. Legislators are surely hearing a lot about this during the COVID-19 crisis, but the pressure needs to stay focused on the legislature to give rural broadband a higher priority and more funding. State legislators must hear loudly and often that the current level of funding is not enough if they want to pull the state up from the bottom in the country in broadband.

The state is involved in other initiatives that could benefit the broadband goals of San Juan County. This includes:

- The Governor's Broadband for Education[1] initiative. This effort has the goal of getting fast broadband into every classroom in the state as well as to provide training and advice for securing federal E-Rate funding to help pay for broadband for schools and libraries.
- The state has been coordinating with the New Mexico Telehealth Alliance[2] to leverage federal grant dollars to help support rural healthcare facilities.

Be Prepared to Challenge the FCC Maps

This recommendation is only something to consider if you decide to build into the rural areas. There are additional grants that could be pursued in the rural areas if you pursue the following recommendation.

It appears to us that there are parts of the service area that were not included in the RDOF grants because CenturyLink claimed the areas already have broadband of 25/3 Mbps or faster. While it's possible that a handful of customers in the Census blocks might have these speeds, most of these areas have slow broadband.

CenturyLink might be following the FCC reporting rules if there is at least one customer in each of these Census blocks that could actually receive the 25/3 Mbps speed – however, after our field review we are skeptical in most of these areas that such speeds are available. In order to pursue federal grants for these areas, you're going to have to challenge the FCC broadband maps.

You've already taken the first step to address the problem by having Finley Engineering look at existing broadband deployments in these areas. Finley has picture proof of the age of the equipment and strong opinions about the quality of the remaining copper wires. Finley can provide written proof as well as picture of electronics to help you make the case that these areas don't have good broadband.

The other effective way to challenge the FCC maps is with significant numbers of speed tests. As part of this study you had several hundred customers take a speed test. If you are going to challenge the FCC data, you will want people in the affected areas to take a speeds test. You'd want to gather such tests by address, with the specific goal of overturning the bad data in the existing FCC reporting system.

In continuing the speed tests there a few things to keep in mind. The incumbents might challenge your speed test results, so you need to take steps to collect the data in way to reduce the chances of your data being challenged. Here are a few aspects of administering speed tests that should be considered.

- A speed test needs to distinguish between cellular and landline connections. Rural folks with no broadband connection or those using cellular for home broadband are going to take the test using their cellphone. While these results are interesting, cellular speed tests shouldn't be used in a database used to challenge landline broadband coverage. This means asking those taking the speed test to tell you if they are using a cellphone. However, over time it's usually possible to identify

[1] http://www.broadband4education.nm.gov/
[2] http://www.nmtelehealth.org/

the cellphone test results by looking at the speeds and latency – they should have characteristics that make them distinguishable from landline broadband speed tests.

- Everybody needs to use the identical speed test, because each test measures speed using a different algorithm. We've established the speed test using Ookla and speedtest.net.[3] We think this is the best test in your area. No matter what speed test site you use – all the speed tests should use the same site. Never use the speed test from the incumbents – which might be baked to show good results.
- It's important to somehow get people with no broadband at their home to get into the database. This allows you to map areas with zero broadband coverage. You need to find an easy for such homes to let you know their situation. Perhaps there can be a button on the speed test that asks them to tell you that and then thanks them for "not" taking the rest of the speed test.
- You are going to want to map the results. With enough speed test results you'll paint a detailed picture of the real broadband coverage in San Juan County. One of the challenges of mapping the results is to not be so accurate that you disclose the addresses of every person that took the speed test. Such information can be the basis for an incumbent ISP to challenge the test results.
- There is value in collecting speed tests even where there is broadband. It's never a bad idea, for example, to continue to collect data about Comcast's performance in Farmington. With more speed tests – including addresses – you might be able to define neighborhoods that have the worse broadband.

The last way to challenge the FCC maps is through lobbying of federal elected Representatives and Senators to make sure they are aware of how the poor FCC mapping is specifically hurting San Juan County. There has already been some pressure from Congress to force the FCC to fix the broadband maps, but more pressure could make it happen faster and make sure it's done right.

Get Creative in Seeking Grants

There are numerous broadband grants that can be used for purposes other than building fiber. For example, there are grants that can be used to get more laptops or portable hotspots for students. These grant programs are not always obvious, and it often takes some creativity to turn an existing grant program towards being used for purposes of improving broadband.

Tackle the Other Broadband Gaps

Out study uncovered additional broadband gaps other than the availability gap and the speed gap. Following are some ideas for tackling these other broadband gaps.

Inform the Public About Low-Income Assistance Programs

Both incumbents – CenturyLink and Comcast – have programs that can reduce the price of broadband for customers that qualify. Regardless of their press releases, these companies don't widely advertise the availability of the lower-price plans and many homes that qualify for these plans don't know about them.

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

Somebody could undertake an education campaign to notify citizens about these plans. This would mean having to first understanding each plan in detail – who qualifies and what documentation does a home need to enroll. Armed with that knowledge it would be possible to mount an education campaign to get more subsidized broadband into homes that need it.

Find Broadband Solutions for Public Housing

When communities look harder, it's likely that one of the parts of the community with the worst broadband might be public housing.

Since the utility and the schools already own fiber networks, it is possible to use those assets to bring better broadband to public housing. Many communities now provide free WiFi broadband to public housing, but there are many other possible solutions.

There is one national nonprofit that concentrates on this effort. ConnectHomeUSA[4] has helped communities find broadband solutions for public housing across the country. This organization doesn't currently help any communities in New Mexico, but their stated aim is to help communities everywhere. They work with another nonprofit, EveryoneOn to implement the solutions.

Support Local Affordability Efforts

There are nonprofit organizations around the country that are tackling the affordability issue. One of the more ambitious such efforts is being done by Mobile Beacon.[5] This is a nonprofit that works nationwide to bring low cost mobile broadband to nonprofits organization around the country, and through those local nonprofits brings low cost broadband to low-income people.

There are numerous solutions being used by the nonprofits working with Mobile Beacon. One common effort is to provide portable WiFi hotspots that are can be lent to residents by the libraries. Mobile Beacon had also negotiated a deal with Sprint to provide low-cost cellular broadband to students and others that is priced as low as $10 per month for an uncapped cellular broadband connection – we'll have to see if that deal survived the Sprint T-Mobile merger.

An interesting study[6] was done looking at the impact of bringing broadband to low-income homes for the first time in the Twin Cities in Minnesota through the Mobile Beacon effort.

- 94% of Mobile Beacon subscribers use the internet daily and 82% say they use the internet several hours a day.
- The average home with Mobile Beacon used 41 GB of data per month. Students used an additional 25 GB per month. People looking for jobs used 14 GB more per month.
- The Mobile Beacon broadband had an immediate impact on students. Parents report that students spend an average of more than 4 hours per week doing homework on the Internet.

[4] https://connecthomeusa.org/

[5] https://www.mobilebeacon.org/

[6] Bridging the Gap. https://www.mobilebeacon.org/wp-content/uploads/2017/05/MB_ResearchPaper_FINAL_WEB.pdf

- The new Internet connection allows adults in low-income homes to get training. 32% of adults in the Mobile Beacon program were taking online courses.

Tackling the Broadband Skills Gap. Even if you decide to build broadband, there are many residents of the county that don't possess the basic computer skills needed to take part in the modern digital world. The county should consider finding ways to provide more computer training. This can be done in a wide variety of ways:

- Allow the Schools to be Used After Hours for Training Adults. A number of communities use computer training centers that already exist in schools to hold after-hours training for adults.
- Develop Training Course in the Libraries. A number of communities have developed computer training programs through their libraries.

Find Solutions for the Homework Gap and Computer Gap. It appears to use that there is a sizable homework gap – homes with students that lack either good broadband, computers, or both. The COVID-19 crisis showed that the need to work on this problem now and not wait for a fiber broadband solution. Possible solutions might include:

- Take-Home Computers for all School Kids. The most common solution are schools that send computers home with students. In some school systems these computers can only be used to connect to the school system network, making them homework-only computers. But other school systems have recognized that these might be the only computer in a home and let students and their family use the computer for other purposes. The biggest problem with school-provided computers are students that don't have a broadband connection at home.
- Lending Mobile Hot Spots. There are many communities that are lending mobile hot spots to citizens through the libraries much the same way they lend books. A person can check out a hot spot for some period like a week or 10 days, which will provide broadband that can be used with computers or tablets.

  This program requires two things. First, somebody needs to buy mobile hot spots and be prepared to continue to fund them into the future. You'd also need to partner with one of the big cellular companies to provide free or inexpensive bulk cellular data to power the hot spots. Other communities have been successful in creating such partnerships. It's worth noting that these hot spots will only work where there is cellular broadband available – so you should try to put together a map of where cellular works and doesn't work – much like mapping landline broadband as described above.
- Get Computers into Homes that Need Them. Communities tackle this in two ways. One is to give or lend laptops or tablets to students. Some school districts provide computers to every student while other provide them selectively to students that need them.

  The other alternative is to find a local nonprofit that is willing to tackle the computer issue. Most home and business computers last 3-5 years and nonprofits have found that older computers can be upgraded fairly inexpensively and then placed in homes that need them. Such an effort can be a lot of work, but many communities have found groups willing to tackle the issue.

An example of one such program is the nonprofit E2D[7] (End the Digital Divide) in Charlotte, North Carolina. The organization refurbishes laptops contributed by businesses in the Charlotte area and gives them to students. The organization has taken a several-prong approach to making this happen:

- They solicit used laptops from businesses in the Charlotte area. Most big businesses replace laptops every few years and most of them have been ending up in the landfill. Now a number of businesses send all their used laptops to E2D.
- Used laptops need to be refurbished and E2D started several computer labs in area high schools where they hire students at a decent wage to refurbish the computers and install new software. The purpose of these labs is not only to get the laptops ready to distribute, but they are providing technical training for kids that is helping them move on towards college or a technical career.
- Households that get a new computer also get a live tutorial and technical support to best take advantage of the new laptops.
- Finally, the Charlotte area has a lot of homeless families and there are thousands of homeless kids in the area. E2D has partnered with Sprint to provide mobile hot spots and data plans that are providing broadband access to homeless students and others with no broadband.

Another organization that works nationwide to fund computers is Minneapolis-based nonprofit PCs for People.[8] They provide PCs to households that need them and work with other entities including Mobile Beacon and E2D. Some local nonprofit could connect with PCs for People to find ways to get computers into the hands of the neediest households in the County. A local nonprofit could also mirror what's been done elsewhere.

- Create More Public Hot Spots. The utility, the cities, or the county could fund more public hotspots. Outdoor hot spots are particularly effective since students can sit in cars and use them any time of the day or night. One way to start this process is by extending the WiFi at government buildings to the outside areas surrounding the buildings. To the extent that County buildings already have decent broadband, the concept is to share it with the public. It's particularly easy to make bandwidth available to the public in the evenings when the government offices are closed, and the bandwidth isn't being used – sharing this bandwidth usually adds no cost to what is paid for broadband.

  A more aggressive plan would be to create public hotspots in each rural neighborhood that doesn't have good broadband – the places where citizens need it the most. However, it might be a challenge to find the bandwidth needed to support such hot spots. You might be able to partner with the incumbent ISPs or cellular carriers which might have broadband that isn't otherwise available to the public.
- Reward Businesses for Providing Public Hotspots. We've seen communities that reward businesses for creating good public hot spots. The reward can be anything from public recognition and awards to some sort of break on local taxes and fees.

[7] https://www.e-2-d.org/

[8] https://www.pcsforpeople.org/

I. MARKET ANALYSIS

A. Providers, Products, and Price Research

The incumbent telephone company in and around Farmington is CenturyLink. The incumbent cable provider in Farmington is Comcast/Xfinity. From the surveys we see customers buying fixed wireless service from Advantas Internet, Sacred Wind, Sivadnet, and NTUA. Rural homes are also using cellular broadband or cellular hotspots for home broadband. Most homes and businesses can buy satellite broadband from Viasat and HughesNet. Rural customers can also buy cable TV from DirecTV or Dish Networks.

Following is an analysis of the prices being charged in the area today. We know from experience that prices vary widely by customer for many ISPs. Over the years, customers have purchased bundles or participated in promotional pricing and might be charged differently than their neighbors. It seems almost counterintuitive, but the customers paying the most to incumbent providers are often those that have been with them the longest. The wide variance in rates charged in the community means there is no longer anything that can be considered as a "standard" price in the market. Nevertheless, we wanted to understand the products being offered and the range of prices being charged in the community today for the average prices being charged today for broadband and the other triple play products.

Incumbent Telephone Company

CenturyLink is the third largest telephone company in the country with headquarters in Monroe, Louisiana. Several years ago, the company purchased Qwest, which was formerly Mountain Bell and US West, and was part of the Bell Telephone system. At the end of the second quarter of 2020, the company had 4,638,000 broadband customers. The company has a small number of cable TV customers but has announced that it is phasing out that business line. For most of the areas it covers, the company bundles with DirecTV.

As the incumbent provider, CenturyLink is considered the "provider of last resort" in its service areas. This means that CenturyLink is required to serve all residential and business customers for basic local services, and it must provide facilities to all customers. The rules that govern the way that CenturyLink serves customers are embodied in their "General Customer Services Tariff," which is approved by the New Mexico Public Regulation Commission. This tariff contains all of the regulated products and prices, along with the terms and conditions under which CenturyLink will sell them to customers. The tariff sets forth rules for such customer service procedures as the manner and amount of customer deposits, the rules by which they will disconnect service for nonpayment, and the rules by which they will reconnect service. We'd like to note here that a recent trend is to get states to deregulate many services as competitive and take them out of the tariff.

In 2019 CenturyLink had asked the Commission to deregulate landline telephone services in the state. The company didn't want to stop offering the services but wanted to shed the old regulations put in place at the heyday of the telephone monopolies. Most states have deregulated the big telcos from a lot of the old telephone rules. The New Mexico Public Regulations Commission rejected the request and said that CenturyLink had not demonstrated that there was "effective competition" for residential telephone service. That might sound like a surprising ruling since in most places everybody has shifted to cellular phones.

However, the FCC data shows a lot of areas in the state with little or no 4G coverage for cellular, meaning a lot of houses still rely on a landline.

In recent years CenturyLink invested significant capital in improving data speeds in metropolitan areas. For example, in 2016, the company constructed fiber to pass 900,000 homes in major markets like Seattle, Phoenix, Denver, and the Twin Cities. Since then the company has merged with Level 3 Communications and last year the new CEO announced that the company would not be making any future investment in assets with "infrastructure returns," meaning it's not going to build new fiber to residential customers and is probably not going to invest any more money in its copper networks.

Telephone Rates

CenturyLink's telephone rates were as follows when last tariffed. This does not mean that these are the rates any longer and with a de-tariffed rate, CenturyLink is allowed to charge whatever they want, within reason. The following rates were the last listing of the flat rate option, meaning a telephone line using these rates can make unlimited local calls. There used to be options available for customers who wanted to be able to make and pay for fewer local calls.

	Monthly
Flat Rate Residential Phone Line	$18 - $22
Flat Rate Business Telephone Line	$42 - $45
Business PBX Trunk Lines	$45 - $51

These rates do not include the Subscriber Line Charge which is currently $6.50 for both a business and a residential line and would be added to the above rates. The rates also do not include the Access Recovery Fee (ARC), which is an FCC fee that is currently capped at $1 per month, and CenturyLink could be charging any amount up to and including the $1 rate.

CenturyLink telephone line prices don't include any features. These features are either sold a la carte or sold in bundles and packages. Some of the most commonly purchased features are call waiting, 3-way calling, voice mail, and caller ID. CenturyLink offers dozens of features and they range in price from $2.95 to $8.50 per feature for residential service. These products are also now de-tariffed, and CenturyLink can charge whatever it likes for these products.

CenturyLink DSL

CenturyLink sells high speed Internet using DSL technology. They sell both a bundled DSL product, meaning that you purchase it along with a telephone line, and also a "Pure" product, meaning a customer can buy just DSL (most of the industry refers to this as naked DSL). As discussed above, CenturyLink offers a lot of specials, with special rates available on their web site for new customers. But as typical with most big ISPs, a subscriber's rates will revert to "normal" rates at the end of a special promotion. Following are base list prices for residential DSL. Note that the quoted speeds offered by CenturyLink DSL are "best effort" speeds, meaning they are not guaranteed. In fact, rural customers typically get speeds significantly slower than the advertised speeds.

Residential DSL

Pure DSL is CenturyLink's name for a DSL line that is not bundled with telephone or DirecTV. There is one price for the first year, a higher price for the second year, and after that the customer pays the list price:

	1st Year	2nd Year	List
1.5 Mbps download, 896 Kbps upload	$30.00	$40.00	$42.00
7 Mbps download, 896 Kbps upload	$35.00	$45.00	$47.00
12 Mbps download, 896 Kbps upload	$40.00	$50.00	$52.00
20 Mbps download, 896 Kbps upload	$50.00	$60.00	$62.00
40 Mbps download, 896 Kbps upload	$60.00	$70.00	$72.00

Pure DSL also requires a DSL modem. The charge for this seems to be negotiated and ranges from $1.95 to $6.95.

We don't expect that there is any DSL in the rural areas that would be faster than 10 Mbps. Generally, the faster speeds are available only in the metropolitan markets. It's more likely that rural DSL speeds are slower than 10 Mbps, with some speeds much slower.

CenturyLink Business DSL

CenturyLink no longer publishes business DSL prices. There are no prices on the website and no prices listed in any of their sales literature or tariffs. Basically, CenturyLink will negotiate a price with a business customer based upon both how many other products they purchase as well as how long they are willing to sign a contract.

When CenturyLink last published rates their slowest business DSL ranged from $40.00 per month for a 3-year contract up to $62.50 for a month-to-month product and no contract commitment. But today each customer will negotiate with a salesperson and rates charged in the market are all over the board for the same product.

Cable TV Providers

Comcast Infinity. Comcast is the incumbent cable TV provider in Farmington. Comcast markets and bills using the "Xfinity" brand name. The company offers the traditional triple play of cable TV, internet, and voice services. Comcast is the largest cable TV company in the US with 2019 revenues of nearly $109 billion, and the second largest cable company in the world. They are headquartered in Philadelphia. At the end of the first second quarter of 2020 the company had over 29.4 million broadband customers and around 20.4 million cable customers.

In addition to providing triple-play services, 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), DreamWorks, and the Philadelphia Flyers hockey team and arena. The company now sells cellular phone service. They are also probably the largest seller of smart home services in the country.

Stand-Alone Internet[9]

Comcast offers significant discounts to some new customers. Promotional products eventually revert back to list price, generally within one or two years. Following are the most recent list prices for standalone Internet.

Performance Starter	15/2 Mbps	$ 53.00
Performance Plus	60/5 Mbps	$ 73.00
Blast! Pro	150/5 Mbps	$ 83.00
Extreme	250/10 Mbps	$ 93.00
Gigabit	1,000/35 Mbps	$113.00
Gigabit Pro	2,000/2,000 Mbps	$299.95
WiFi Modem (for all products)		$ 14.00

Comcast raised broadband rates by $3 and the cost of the modem by $1 in December 2019. Industry analysts expect prices to increase annually.

Comcast has data caps. Most broadband products are capped at 1 terabyte of download per month (1,000 gigabytes). There are lower caps that apply to grandfathered legacy products. When customers exceed that cap for a given month (the usage adds together both download and upload data usage), Comcast bills $10 for each additional 50 gigabytes of data used, with a maximum of $50 extra.

Telephone

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

Basic	$30.00
Additional Line	$ 9.95

The basic line is a telephone line with the standard features but no long-distance option. Comcast used to offer a telephone line with unlimited long distance, but that's no longer in their price list. My guess is that they will direct customers to the Comcast cellular service for those wanting unlimited calling.

Cable TV

The following prices are for standalone cable TV. These packages follow the tiers of service required by the FCC. The Limited Basic tier includes the network broadcast channels like ABC, CBS, FOX, NBC, and PBS. The tier also has a number of other channels such as shopping channels

[9] The Comcast rate sheet as of December 2019 is at: https://comcaststore.s3.amazonaws.com/prod/wk/urc/585bc4be5bcd10375b2cf1d8/high_res/UC0000002_sik_high_res.pdf

and a few others – varies by market. The Extra tier includes most of the popular channels that people expect from a cable subscription. Finally, the Preferred tier adds on a number of additional channels and includes every non-premium channel offered by Comcast.

Limited Basic	$32.95
Extra	$70.00
Preferred	$90.00
Set-top box	$10.45
DVR Service	$10.00

Comcast adds the following fees to every cable subscriber.

Broadcast TV Fee	$14.95
Regional Sports Fee	$ 8.25

These fees are controversial since Comcast doesn't mention these mandatory fees when they advertise the cable product. Further, Comcast customer service has repeatedly told the public that the fees are mandated by the government and are a tax that is not set by Comcast. There is currently a lawsuit underway filed by the State of Minnesota that is challenging these fees. Lori Swanson, the Attorney General of Minnesota sued Comcast in 2018 seeking refunds to all customers who were harmed by the company's alleged violation of the state's Prevention of Consumer Fraud Act and Uniform Deceptive Trade Practices Act.

Comcast only started charging separately for these two fees in 2014, but the size of the fees has skyrocketed. In recent years, the company has put a lot of the annual rate increases into these fees, allowing the company to continue to advertise low prices. The Regional Sports fee passes along the cost of regional sports networks. The Broadcast TV fee includes the amounts that Comcast pays local affiliate stations for ABC, CBS, FOX, and NBC.

Comcast argues that breaking out these fees makes it easier for customers to know what they are paying for – but there are numerous examples cited in customer complaints where new customers were surprised at the size of the first bill they receive from the company.

Comcast now also offers a lot of free content for cable subscribers it's labeling as Flex. This is a library of over 10,000 programs that come out of Comcast's big library from owning programming networks. Customers must have a Comcast settop box to reach the content.

The Comcast Bundle

It is important for anybody that wants to compete against Comcast to understand the power of its bundles. The most obvious reason for giving bundles is to entice customers to buy more than one service from the company, and Comcast provides increasing discounts for customers that buy 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 that buy multiple products - particularly products in addition to the triple play – rarely churn and become loyal customers.

One of the most important aspects of the bundles are that they punish customers for dropping a bundled service. Consider the following simplified example of how this works. Suppose that a customer purchased the $73 broadband product and the $70 cable product and is given a $20 bundling discount and charged is $123 for the bundle. If a customer drops either product, the customer loses the entire $20 discount and remaining product reverts list price.

Customers never know what they pay for any given product within the bundle. For example, there are bundles that make it look like a customer is getting telephone service for free. But if the customer breaks the bundle and wants to keep only telephone with Comcast it reverts to the prices above.

This is one of the primary reasons that most competitors to Comcast offer cable TV. Otherwise, if a customer tries to change just their broadband to the new provider but leaves cable TV with Comcast, they are charged a "penalty" for breaking the bundle. Once customers understand the financial consequences of breaking the bundle, many won't change to a competitor since they might not get any net savings.

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. Customers pay by the amount of data used, at $12 per gigabyte. A customer using less than 1 GB of data pays only $12 per month for the connection. For $45 per month customers get unlimited data. Comcast uses the Verizon network to carry the traffic, but the company recently purchased spectrum and is planning on providing the service directly to customers in some markets.

Comcast also provides smart home products under the brand name of 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). It's an impressive suite of products and is all integrated through the Comcast portal.

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.

Dish Network is a large satellite provider and has customers nationwide. The company had around 9.5 million cable customers nationwide at the end of the third quarter of 2019.

Dish Network now also offers an Internet-based cable product branded as Sling TV. This service offers an abbreviated channel line-up and costs less than traditional cable products.

Dish Network has the same pricing nationwide. The standalone price with no discounts is as follows:

190 Channels	$ 79.95
190 Channels +	$ 84.99

240 Channels +	$ 94.99
290 Channels +	$104.99

DirecTV is one of the largest cable providers in the US. The company is now owned by AT&T. The company had 16.8 million cable customers at the end of 2019, down almost 2.4 million customers during 2019. AT&T has decided to end all discount packages, resulting in significant rate increases for many customers who were getting various promotional discounts. DirecTV can be purchased in San Juan County as part of a bundle with CenturyLink.

DirecTV now offers an online version of its programming that was called DirecTV Now but which was recently renamed as AT&T TV.

Current prices after any promotional discounts are:

155 Channels – Select	$ 85.00
160 Channels – Entertainment	$ 97.00
185 Channels – Choice	$115.00
235 Channels – Xtra	$131.00
250 Channels – Ultimate	$142.00
330 Channels – Premier	$197.00

The above rates include increases effective January 2020 that range from $4 to $8 per month.

WISPs (Wireless ISPs)

WISPs (wireless ISPs deploy a technology called fixed wireless where they mount a transmitter on a tower or other tall structure like a water tower. They beam broadband to customers which is received through a dish receiver. The speed that a customer can receive is affected by the distance to the transmitting tower – the further from the tower, the lower the broadband speeds.

Sacred Wind is a private ISP founded in 2006 with headquarters in Yatahey, New Mexico. The company offers a mix of fiber-based broadband and fixed wireless broadband. Sacred Wind has built fiber-to-the-home on the Navaho Indian reservation. Earlier in 2020, the company was awarded grant funding to build fiber in rural parts of Sierra County. The company also recently agreed to work with the Navajo Technical University to deploy fixed wireless technology on parts of the Navajo reservation using an experimental license for 2.5 GHz spectrum.

Standalone Internet is marketed under the name of Eagle Internet. The company's web site doesn't distinguish pricing by technology. It's likely that anybody using the wireless product would be paying one of the two lowest prices. Pricing is as follows.

15 Mbps	$ 75
25 Mbps	$ 85
50 Mbps	$105
75 Mbps	$115
100 Mbps	$120

Prices for broadband are $10 per month lower for customers that buy a telephone line. Telephone is priced as follows:

Basic Line (no features)	$18.00
With 3 Features	$32.90
With 10 Features	$37.90

(Lifeline for tribal members on a reservation can be as much as $34.25.)

Advantas Internet is a local wireless ISP located in San Juan County. They've been offering broadband services for 17 years.

Residential Broadband	
3 Mbps	$44.99
5 Mbps	$49.99
10 Mbps	$69.99
15 Mbps	$79.99

Business prices not advertised

Sivadnet is a wireless ISP with headquarters in Aztec, NM. The company has been in business since 2013.

Residential Broadband	
3 Mbps	$49.99
5 Mbps	$69.99
10 Mbps	$89.99
Install	$50.00
Unlimited data	

Business Broadband	
3 Mbps	$59.99
5 Mbps	$79.99
10 Mbps	$99.99
Install	$50.00
Unlimited data	

Brainstorm Internet is headquartered in Durango Colorado and offers wireless Internet in the area. The company claims 11,000 customers ranging from Grand Junction Colorado to Farmington. Broadband prices are as follows:

3 Mbps	$57 monthly
3 Mbps	$52 – if paid annually
5 Mbps	$70 monthly
5 Mbps	$65 – if paid annually
10 Mbps	$85 monthly

10 Mbps $80 – if paid annually

Upload speeds for all products set at 1.5 Mbps.
Installation fees range from $95 to $195.

Business Internet is priced by customer.

NTUA Wireless is the offered by the Navajo Tribal Utility Authority. The broadband is marketed under the brand name of Choice NTUA Broadband. NTUA reports to the FCC that this service is available in a small portion of the west corner of the electric service territory.

There are two wireless products – the speeds are not specified on the web site. The two prices are $44.99 and $64.99.

Installation is $99.99.
Service Activation is $75.
There is a monthly Service Plan fee of $10.
There is a monthly administrative fee of $2.21.

Choice NTUA also offers a bundle discount for customers buying cellular service, but prices are not specified on the website.

Satellite Broadband.

There are two satellite broadband providers available to homes and businesses in San Juan County. Both Viasat and HughesNet utilize satellites that are parked at a stationary orbit over 20,000 miles above the earth.

There are a few problems that customers consistently report with satellite broadband. Customers complain that satellite costs too much (Viasat claimed in their most recent financial report for June 2019 that the average residential broadband bill is $84.26). 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 satellites parked at over 22,000 miles above earth – that adds time to every round-trip connection to the web. Most real-time web connections, such as using voice-over-IP, or connecting to a school or corporate WAN prefer latency of less than 100 ms (milliseconds). Satellite broadband has reported latency between 400 ms and 900 ms.

The other customer complaint is about the tiny data caps. As can be seen by the pricing below, monthly data caps range from 10 gigabytes to 150 gigabytes. To put those data caps into perspective, OpenVault announced recently that the average US home used 344 gigabytes of data per month in the fourth quarter of 2019, up from 275 gigabytes in 2018 and 218 gigabytes in 2017. They also reported that the average cord-cutting home used 520 gigabytes per month in 2019. 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 (was formerly marketed as Exede or Wildblue) offers broadband from one older and one newer satellite. Following are the products from Viasat:

	Price	Speed	Data Cap
Liberty 12	$30	12 Mbps	12 GB
Liberty 25	$50	12 Mbps	25 GB
Liberty 50	$75	12 Mbps	75 GB
Unlimited Bronze 12	$50	12 Mbps	35 GB
Unlimited Silver 12	$100	12 Mbps	45 GB
Unlimited Gold 12	$150	12 Mbps	60 GB
Unlimited Silver 25	$70	25 Mbps	60 GB
Unlimited Gold 50	$100	50 Mbps	100 GB
Unlimited Platinum 100	$150	100 Mbps	150 GB

Online reviews say that speeds can be throttled as slow as 1 Mbps once a customer reaches the monthly data cap.

HughesNet is the oldest satellite provider. They have recently upgraded their 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. Their packages are as follows:

10 GB Plan	$ 59.99
20 GB Plan	$ 69.99
30 GB Plan	$ 99.99
50 GB Plan	$149.99

These packages are severely throttled after meeting the data caps.

Cellular Data

There are four primary cellular companies in the country—AT&T, Verizon, T-Mobile, and Sprint. As this paper was being written, the courts approved the final challenge to a merger between T-Mobile and Sprint. Part of the merger conditions was that Sprint would provide spectrum that would allow Dish Networks to become the fourth cellular nationwide carrier.

The residential surveys showed that some households in San Juan County that use their cellphone data plans for household broadband. There are several problems with this. First, customer speeds decrease with distance from a cellphone tower. Speeds for rural cellular data generally are not fast.

Following are the nationwide average 4G data speeds for the four carriers, shown for 2017 and 2019. Speeds are improving over time. However, these are nationwide averages and rural customers likely get slower speeds than these averages.

	2017	2019
AT&T	12.9 Mbps	17.8 Mbps
Sprint	9.8 Mbps	13.9 Mbps
T-Mobile	17.5 Mbps	21.1 Mbps

Verizon	14.9 Mbps	20.9 Mbps

All four carriers now offer "unlimited" data plans. The plans for AT&T, Sprint, and Verizon are not actually unlimited and have monthly data caps in the range of 20 – 25 gigabytes per month of downloaded data. These plans might provide some relief to homes that rely on cellular broadband, although there have been reports of Verizon disconnecting rural customers who use too much data on these plans. These plans allow have limits on how much data can be used when tethering from a cell phone for use in other devices, so the plans are not much more useful for home broadband than normal cellular plans. T-Mobile claims to offer unlimited data but begins throttling customers after 50 GB of data usage in a month.

There are two different cellular data standards in use: 3G and 4G. 3G data speeds are capped by the technology at 3.1 Mbps download and 0.5 Mbps upload. There are likely to still be some 3G cellular towers in rural parts of the county. The amount of usage on 3G networks is still significant. GSMA reported that at the end of 2018 that as many as 17% of all US cellular customers still made 3G connections, which accounted for as much as 19% of all cellular connections. Opensignal measures actual speed performance for millions of cellular connections and reported the following statistics for the average 3G and 4G download speeds as of July 2019:

	4G 2019	3G 2019
AT&T	22.5 Mbps	3.3 Mbps
Sprint	19.2 Mbps	1.3 Mbps
T-Mobile	23.6 Mbps	4.2 Mbps
Verizon	22.9 Mbps	0.9 Mbps

Cellular Hotspots. Each of the big cellular companies offers wireless products that are designed to provide home broadband. In the surveys we found numerous homes using each of these products.

Verizon. Verizon's hotspot product has four available pricing tiers based upon the monthly data allowance. The 10 GB plan is $60, the 20 GB plan is $90, the 30 GB plan is $120, and the 40 GB plan is $150. The real price killer is that Verizon bills additional gigabits for $10 each.

Verizon says that broadband speeds average from 5 – 12 Mbps download and 2 – 5 Mbps upload. I recently talked to a customer using this plan who told me that when a customer doesn't agree to pay the overage charges that the broadband throttles to a crawl once the monthly data limit has been reached.

T-Mobile. T-Mobile has six hotspot pricing plans based upon the monthly data usage. The 2 GB plan is $10. The 6 GB plan is $25, the 10 GB plan is $40, the 14 GB plan is $55, the 18 GB plan is $70, and the 22 GB plan is $85. Each plan offers a $5 discount for customers who authorize autopay. The killer with this plan is that speeds revert to 3G speeds when the cap has been met. The plans also include unlimited texting.

It's worth noting that T-Mobile will offer a plan that provides 100 GB of monthly data to qualified students for the next 5 years as one of the promises made in order to merge with Sprint. We don't yet know the definition of eligible households, but the company estimated this at 10 million when it made the merger agreement.

AT&T**.** AT&T has three hotspot plans. That includes 3 GB of data for $25, 10 GB of data for $50, and 18 GB of data for $75. Overage data ranges from $10 for 1 GB with the $25 dollar plan to $10 for 2 extra GB with the 18 GB plan.

These hotspots are some of the most expensive broadband in the world. You have to look at distressed third world countries to see similarly high data prices.

- Verizon plans range from $3.75 to $6.00 per gigabyte. Additional gigabytes are $10 each.
- T-Mobile data prices range from $3.86 to $5 per gigabyte. After hitting the data cap, the company throttles customers rather than provide more expensive data.
- AT&T hotspots are the most expensive and range between $4.16 and $8.22 per gigabyte. Extra gigabytes on AT&T range between $5 and $10 per gigabyte.

B. Surveys / Interviews / Speed Tests

Residential Survey Results

The survey was conducted online using Survey Monkey. It's important to note that an online survey does not produce statistically valid responses. For example, the number of people who took this survey and subscribe to Comcast does not represent the percentage of homes in the community that subscribe to Comcast.

The survey was posted on Farmington's website and was advertised locally. 443 people took the survey. The survey produced some interesting results.

Broadband Customers

89% of survey respondents have some form of home broadband.

The respondents use a wide range of ISPs operating in the area. 57% used Comcast, 30% used CenturyLink, 5% used a fixed wireless provider, 3% use satellite broadband, and 5% use cellular connections for broadband.

For the homes that don't have broadband, 65% said that broadband is not available at their home, 28% said broadband is too expensive, 5% said the Internet they don't buy because the Internet is too slow to use, and 2% said they don't have a computer. These are typical of the responses we see in rural counties all over the country.

Cable TV Penetration

In an interesting response, only 41% of respondents said they buy traditional cable TV at home. That is significantly lower than the nationwide average, which dipped below 60% at the end of the second quarter of 2020. 19% of homes subscribe to Comcast and 22% subscribe to satellite TV (DirecTV or Dish Networks).

38% of respondents say they are cord cutters and only watch online content like Netflix. That's one of the highest percentages we've ever seen in that category, and the nationwide number of cord cutters is thought to be around 20% (nobody has figured out how to count it on a national scale).

Telephone Penetration

Only 19% of homes have a telephone landline. The nationwide landline penetration has dropped into the range of 35% to 40%.

Customer Bills

The survey asked customers what they pay each month for the triple-play services (Internet access, cable TV, and telephone). Here are what customers say they are spending:

Customers buying a bundle of service	$135
Customers buying standalone broadband	$ 73
Customers buying standalone cable TV	$ 70
Customers buying standalone telephone	$ 67

Uses of Broadband

79% of respondents said that somebody in the household uses the Internet to work from home. We note that the survey was taken after the Covid-19 pandemic, which likely inflated this response. That is made up of those that work at home fulltime (28%), those that work several days per week (30%), those that work from home a few times per month (12%), and those that work from home occasionally (9%). These are significantly higher percentages of people that work from home than we typically see. 53% of all respondents said they would work from home more if they had better broadband.

49% of respondents report having school-age children at home. 43% of them said the home broadband is not adequate to support homework.

Satisfaction with Existing Broadband

39% of respondents say they are unhappy with their Internet download speeds at home, while 34% are satisfied.

40% of respondents are not happy with the customer service from their ISP, while 34% are satisfied with customer service.

54% of respondents say that they are unhappy with the value they get from their ISP compared to the price they pay. Only 19% of homes are satisfied with the value they are getting.

Support for a Fiber Network

One of the key questions asked in the survey is if respondents support the idea of San Juan County attracting somebody to build a fiber network. 73% of households support the concept. Another 26% said

they might support the idea but need more information. Only 1% of respondents said they didn't support the idea.

We asked the reasons why respondents support bringing a new network to the town. 46% said they hope for more competition. 42% of households hope for lower prices. 67% hope for faster speeds. 28% hope a new broadband solution would mean better customer service.

Switching Service to a New Network

In probably the most important question of the survey, we asked households if they would buy Internet service from a new fiber network. 66% said they would definitely buy. Another 21% said they would probably buy service and 10% said they would consider buying service. Only 3% said they were unlikely to buy service.

When asked if respondents would buy a landline telephone, only 16% of the respondents said yes with another 10% saying probably. 54% said they were unlikely to buy a landline.

Cellular Service

97% of respondents say that they subscribe to cellular service – that's close to the national average of 95%. 22% of homes said the cellular coverage is not adequate at their homes.

Interpreting the Results of the Survey

It's always a challenge to interpret survey results. It's first important to recognize that an online survey is not statistically valid, meaning you can't take the results from this survey and assume that they are the same answer you would get if you were to ask the questions to everybody in the area. With that said, online surveys are considered a good way to understand sentiment, and many of the questions in this survey are sentiment questions.

> Dissatisfaction with the Incumbents. 39% of respondents are unhappy with download speeds. 40% are unhappy with existing customer service. 54% don't think they get value for the price they pay. This demonstrates a sizable portion of the community unhappy with existing incumbent ISPs.
>
> Support for a New Network. 73% of respondent were in favor of getting a new fiber network in the area. Only 1% of respondents were not in favor of fiber, with 26% of respondents saying they wanted more information. This represents overwhelming support for the concept of bringing faster broadband.
>
> Download Speeds. This seemed to be a predominant issue for respondents. While 39% said they are unhappy with download speeds, 67% of respondents said that getting faster speeds would influence them to change service to a new fiber network.
>
> Price Consciousness. We found it interesting that lower prices ranked third in terms of factors that would influence people to use a new fiber network. 42% citied price as important factor, but 46% cited competition and 67% citied broadband speeds as a reason to consider fiber. I can't think of a

community that we've ever studied where price wasn't one of the top reasons for respondents liking the idea of a new network. This doesn't mean that people in the area aren't price conscious but does tell us that price is not the driving factor in somebody's decision to change providers.

Potential Customers on a New Network. One of the most important reasons to do a survey is to get a feel for the number of households that might buy broadband from a new network. This is one of the questions where it matters that the survey was not statistically valid – meaning that we need to take the results with a grain of salty. However, even an online survey can give us a feel for the popularity of a new network.

66% of all respondents said they would definitely buy from a new network. Another 21% said they would probably buy. 10% said they might buy. We interpret these results as follows:

- Customers who say they will definitely buy probably will. We typically see between 20% and 30% of customers saying they will definitely change to a new network, so your survey result of 66% is far higher than what we typically see.
- We've always found that around 2/3rds of those that say they will "probably" change will also do so. Some won't make the effort to make the change, and some will be lured with low-priced packages aimed to keep them on the current provider. Overall, such respondents have indicated a decent interest in changing providers. In your case, 21% of respondents said they would probably change to a new fiber network.
- The "maybe" respondents are just that. We've always seen that a third of these customers can be gained as customers – but at a cost. This is the part of the market that requires the marketing budget. These customers can be won if you have products and prices they find attractive and if you make the effort to explain the benefits of your network.
- In summary, the responses we got indicate that 83% of the respondents would buy broadband. However, we can't forget that this is not a statistically valid survey and doesn't represent everybody in Farmington.

  Online surveys tend to have what statisticians call self-selection. The people that took the time to go online and respond to the survey were likely those for whole the issue is important. In this case it seems likely that folks who want faster broadband are the ones that took the survey.

  We are not going to interpret these results to mean that 83% of people in your area would buy broadband from a new fiber network. However, this survey does demonstrate a sizable sentiment leaning towards better broadband.

  In our studies we used a penetration rate of 50% in Farmington and 60% in the rural areas. We based this upon our experience in the last two years working in other rural counties. We think the 50% goal for the towns is a solid goal, but one that we wouldn't want to predict any higher without first doing a statistically valid survey. We believe the 60% penetration in the rural areas is conservatively low. We have seen fiber deployment in rural counties in the last few years where 65% to 85% of home bought fiber – with the difference within that range likely due to household incomes. It's conceivable that 85% of rural household would buy better broadband if it came available – that's the national average

penetration rate of broadband. The existing rural broadband products are weak and expensive and it's not hard picturing a lot of people migrating to fiber if it was available.

The only way to really understand the market penetration is with a statistically valid survey, and we are listing that as something to consider in the recommendation section of the report.

Speed Tests

CCG created an online speed test that was published on the FEUS website and advertised locally. Over 200 residents and business in the area took the speed test that reported download broadband speed, upload broadband speed, and latency measured in milliseconds.

The primary purpose of the speed tests is to judge the overall quality of broadband in the market. CCG has conducted similar speed tests in markets where the incumbent cable company delivered faster speeds than advertised and other markets where the speeds are slower. The speed tests were to make a qualitative judgement about the networks of the ISPs operating in the area.

Speed tests are not 100% reliable and don't always deliver a true picture of the broadband being delivered to a given address. However, we've found that when speed tests are administered in mass that we can understand the overall quality of broadband in a community. Following are a few of the criticisms that can be made about an 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 on the market uses a different algorithm to measure speed. In this study we used the speed test from Ookla, which is one of the most popular speed tests. Ookla's algorithm discards the fastest 10% and the slowest 30% of the results obtained. In doing so, the speed test might be masking exactly what drove someone to take the speed test, such as not being able to hold a connection to a VoIP call. Ookla also multithreads, meaning that they open multiple paths between a user and the test site and then average the results together.
- A speed test can report slow speeds due to network issues within the home such as problems with a home WiFi router or faulty wires inside a home. A slow speed test doesn't always mean that the ISP has a slow connection.
- Internet speeds vary throughout the day, and anybody that takes multiple speed tests in the same day will see this. Taking only one speed test might not tell the real story about a given customer.
- Some ISPs use something called "burst" technology. This provides a fast Internet connection for one or two minutes. ISPs know that a large majority of Internet activities are of a 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 time 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.

With the above caveats in mind, following are the results from the speed tests taken for this study:

Comcast

Comcast serves the community with hybrid coaxial technology that brings fiber to neighborhoods and then distributes network connections over coaxial cable to the residence or business. However, the speed tests include two customers with symmetrical broadband that we have to assume are businesses being service by fiber.

We received 156 results of download speeds from Comcast customers, which includes the 2 fiber customers.

Comcast Download Speeds	
0 – 25 Mbps	19
26 – 50 Mbps	26
51 – 75 Mbps	14
76 - 100 Mbps	32
101 – 125 Mbps	16
126 – 150 Mbps	6
151 – 175 Mbps	4
176 – 200 Mbps	7
201 – 250 Mbps	8
251 – 300 Mbps	6
301 – 400 Mbps	7
401 – 500 Mbps	5
501 – 600 Mbps	3
601 – 900 Mbps	1
900+ Mbps	2

We were frankly surprised to see so many customers with slow download speeds. Comcast publicly says that they have upgraded all of their networks to DOCSIS 3.1 and have set the minimum download speeds for new customers at 150 Mbps. The speed tests showed a greater percentage of home with Internet speeds under 100 Mbps than what we've normally seen in other markets.

When Comcast upgraded to DOCSIS 3.1 they unilaterally increased customer speeds in some markets. For example, we did speed tests in a slightly larger city and saw that almost every customer with speed tests showing download speeds over 100 Mbps. But in your market, 58% of the Comcast customers taking the speed test had speeds under 100 Mbps and 72% had download speeds under 150 Mbps. Perhaps the most troubling statistic is that 29% of the customers taking the speed test reported speeds under 50 Mbps, including 12% under 25 Mbps.

There are a few possible explanations for the significant number of relatively slow speeds:

- Comcast may have grandfathered a lot of customers with older products, both speeds and prices. Sometimes cable companies will let customers keep older products and prices, which we refer to as grandfathered. Should the customer ever want to change speeds they must change to the latest minimum product for the market, which in your market is the 150 Mbps product. However, we've often seen older customers given the unilateral speed increases when the technology in a market

is increased. But it's possible that Comcast has, for some reason, allowed a lot of customers in Farmington to stay on older products and speeds.

- It's also possible that Comcast introduced DOCSIS 3.1 but kept customers on older generation cable modems that can't receive the newer faster speeds. There are some well-known markets where Charter has done this, but we've never heard any large-scale complaints about Comcast doing this. It's also possible that Comcast has layered on DOCSIS 3.1 for customers willing to pay for fast speeds but is still maintain a dual system where DOCSIS 3.0 is also still being used. That would allow the company to continue to keep customers on the older technology and speeds. Again, we've never heard of Comcast doing this before, but it's possible.
- There are always some customers who get slow broadband due to old and outdated WiFi modems. This is particularly possible for customers who supply their own WiFi routers. It would be more troubling if Comcast upgraded to DOCSIS 3.1 but left its old outdated WiFi modems in place.
- Finally, a cable network doesn't perform uniformly throughout. There are likely older parts of the cable network in the city that don't function as well as newer areas with newer cable. It's also possible that there are parts of the city where Comcast has kept large node sizes. The technology in a DOCSIS network works such that all of the customers on a node share the broadband. If nodes are too large, then overall speeds are held down. This issue mostly manifests by seeing slow broadband during evening hours when the greatest number of homes are using the network.

We have no way of knowing why there are so many Comcast customers with slow speeds. It's really hard to imagine that nearly 60% of the customers in the market get slow speeds due to old customer WiFi modems – so it's likely that Comcast has some role to play in the slow speeds. This is an issue that the city government might want to pursue in terms of any service promises made by Comcast in franchise agreements.

We received upload test results from 146 Comcast customers.

Comcast Upload Speeds	
0 – 5 Mbps	18
6 – 10 Mbps	61
11 – 15 Mbps	31
16 – 20 Mbps	15
21 – 25 Mbps	1
26 – 50 Mbps	19
400+ Mbps	1

This report discusses the new phenomenon where slow upload speeds present a problem for adults or students trying to work from home, particularly when more than one person wants to work at the same time. 54% of Comcast customers showed upload speeds under 10 Mbps. 85% of customers have upload speeds under 20 Mbps. There is one customer reporting an upload speed of over 400 Mbps – this must be a business customer served by fiber.

The average latency on Comcast was 20 milliseconds This is a relatively low latency for the DOCSIS technology and indicates a network in good working order. This makes it even more of a mystery why so many Comcast customers have slow download speeds.

CenturyLink

CenturyLink delivers broadband to most of the community using DSL. The speed tests show two different varieties of DSL. First is older DSL that delivers bandwidth over a single pair of copper telephone wires. Newer kinds of DSL use two pairs of copper wireless and can offer double the speeds. There also appears to be a few CenturyLink customers served with fiber. These could be business customers. They also might be residential customers in an apartment building where CenturyLink feeds the whole complex with a fiber. It's also possible that the company would have built fiber within the last few years to reach a new residential subdivision.

CenturyLink Download Speeds	
0 – 5 Mbps	18
6 – 10 Mbps	16
11 – 20 Mbps	14
20 – 30 Mbps	6
31 – 40 Mbps	3
41 – 50 Mbps	3
Fiber	7

Over half of CenturyLink customers reported download speeds under 10 Mbps (51%). However, 17% of customers seem to be using the newer DSL technology and have download speeds between 20 Mbps and 50 Mbps.

10% of customers reported download speeds over 50 Mbps and we have to suspect that these customers are served entirely, or partially using fiber. There were two customers who claim to be buying gigabit fiber from CenturyLink, so the company must be selling this in some portion of the city. There were other customers with speeds a little faster than normal DSL. We assume these customers are likely in apartment buildings where CenturyLink brings a fiber to the complex to share among all tenants.

CenturyLink Upload Speeds	
0 – 1 Mbps	35
1 – 2 Mbps	6
3 – 5 Mbps	10
5 – 10 Mbps	2
10 – 25 Mbps	2
25+ Mbps	2

CenturyLink upload speeds are really slow by today's standards but were adequate a decade ago when the DSL technology was introduced. 56% of CenturyLink customers report upload speeds under 1 Mbps. Another 10% have speeds under 2 Mbps. 85% of customers have upload speeds under 10 Mbps.

The latency for DSL customers was 45 milliseconds which is pretty typical for the technology. The two clear fiber customers had a latency of 4 milliseconds. There is a fuller discussion of the significance of latency below.

Advantas Wireless

We got speed test results for 11 Advantas customers. The average download speed was 11 Mbps. The average upload speed is 4 Mbps. The average latency was 39 milliseconds.

HughesNet

We got four speed test results for HughesNet delivered over satellite. The average download speed was 21 Mbps, although the fastest reading was 39 Mbps. The four HughesNet customers reported upload speeds under 1 Mbps. The average latency was 752 milliseconds, far greater than the ideal latency needed to make real-time connections on the web such as to a school server or to watch live video.

FastTrack

We got two speed tests from FastTrack customers. These both appear to be businesses with a fiber connection, with the fastest getting a download speed of 743 Mbps.

We also got a few other speed test results from Sacred Wind, Verizon Wireless, Dish Networks, and Diginet Wireless. The readings were too few to draw any conclusions but were all in line with the technology being used.

Latency

There are a lot of underlying causes for delays that increase latency – the following are primary kinds of delays:

- 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, and it generally takes longer to create long packets than it does to create multiple short ones. These delays are caused by the originator of an Internet transmission.
- Processing Delay. This is the time required to process a packet header, check for bit-level errors and to figure out where the packet is to be sent. These delays are caused by the ISP of the originating party. There are additional processing delays along the way every time a transmission has to "hop" between ISPs or networks.
- Propagation Delay. This is the delay due to the distance a signal travels. It takes a lot longer for a signal to travel from Tokyo to Baltimore than it takes to travel from Washington DC to Baltimore. This is why speed tests are usually created to find a nearby router to ping so that they can eliminate latency due to distance. These delays are mostly a function of physics and the speed at which signals can be carried through cables.
- 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 the customer's computer and software.

Total latency is the combination of all of these delays. You can see by looking at these causes that poor latency can be introduced at multiple points along an Internet transmission, from beginning to end.

The technology of the last mile is generally the largest factor influencing 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: fiber (10-20 ms), coaxial cable (15-40 ms), and DSL (30-65 ms). These are measures of latency between a home and the first node in the ISP network. It is these latency differences that cause people to prefer fiber. The experience on a 50 Mbps fiber connection "feels" faster than the same speed on a DSL or cable network connection due to the reduced latency.

Latency is why cellular wireless connections seem slow. Cellular latencies vary widely depending upon the exact generation of equipment at any given cell site. But 4G latency can be as high as 100 ms. In the same FCC test that produced the latencies shown above, satellite broadband was almost off the chart with average latencies of 650 ms.

A lot of complaints about Internet performance are actually due to latency issues. It's something that's hard to diagnose since latency issues can appear and reappear as Internet traffic between two points uses different routing. But the one thing that is clear is that the lower the latency the better.

Business Questionnaire / Interviews

As part of the study, we conducted in-depth interviews with a number of businesses in the area. We also circulated a business questionnaire to businesses that asked them to tell us their broadband stories. Altogether we heard from twenty-five businesses in the area. This represented a full range of businesses from small to large located both inside and outside the city. The businesses included such fields as manufacturing, health care, oil and gas production, construction, banking, real estate, and retail. We also talked to large government entities in the areas such as the public schools, the junior college, public safety, and local governments. Most of the businesses we interviewed said that we could talk about the kinds of issues they faced but did not want any details of their business to be cited in a public report. Following is what we learned from the interviews and questionnaires:

Here are a few of the things we learned from the questionnaires and interviews:

- The schools have world-class broadband. The schools own the fiber network that provides a 10-gigabit connection between the schools. Connectivity is provided by Brainstorm, an ISP, and Forethought, a cloud provider. The school's primary problem in 2020 has been students without home broadband connectivity. The school has provided iPads for younger students and MacBook Air laptops to older students so that every student has a home computing device. The schools also handed out 400 cellular hotspots to provide home broadband for students without a home broadband connection. This solution is working for most students, although some rural students don't have good enough cellular coverage to support the hotspot. The schools have activated outdoor WiFi around the schools and student or the public can use the broadband by sitting in the parking lots. One unexpected problem for the schools was that elementary-age children ended up spending the day at day care centers that had inadequate broadband which could not be easily solved for multiple students sharing a cellular hot spot.
- Many businesses sent employees home to work during the pandemic and we got universal comments that home broadband was often not sufficient to connect reliably back to the office. Some of the problems employees experienced at home include:
    - People living in rural areas where there was no broadband option or broadband that was too slow to work from home.

  - Inconsistent broadband that varies during the day, meaning that the broadband would inexplicitly go from adequate to inadequate without notice.
  - The inability, even in town, of homes to support more than one or two people at a time working online. This often resulted in family members taking turns with the Internet – a poor solution for everybody involved.
- We talked to several businesses that are served on a fiber network provided by FastTrack. The companies universally praised the fiber broadband as providing reliable service with few interruptions.
- A common complaint made by many businesses is that both Comcast and CenturyLink had frequent outages or slowdowns in service at least several times per week. There a number of specific problems cited due to slowdowns, outages, and inconsistent broadband:
  - Several businesses said that outages almost always resulted in staff unable to complete needed work.
  - We heard that inconsistent broadband meant that it is impossible to rely on security cameras and that there is often a lag to see a feed from a camera or else an ability to check a camera at all due to the fluctuating broadband.
  - We heard from a business that lost phone service during broadband slowdowns and outages since they are connected to corporate voice over IP.
- We talked to three businesses located in rural areas that used fixed wireless broadband. All three businesses struggled with the small amounts of bandwidth available on wireless and with inconsistency in the quality and strength of the connection.
- Businesses reported struggling with upload speeds similar to the feedback we got from residents. For example, businesses said that they could not initiate more than a few Zoom connections companywide at the same time. Several businesses complained about the inordinate amount of time needed to backup data to cloud storage. We talked to several businesses that conduct much of their work in the cloud, and slow upload speeds was limiting their ability to connect multiple employees to the cloud at the same time.
- We heard from several government employees as well as a few businesses that the consumer grade broadband connections they could buy could not provide the level of data security they want.
- All but a few businesses said they felt like they didn't have any choice of broadband provider – they felt the provider they use is the only realistic option for where they are located.
- The library is able to buy a 100 Mbps connection from CenturyLink. However, they have 105 computers that share the bandwidth, so connections get very slow.
- Half a dozen businesses told us that if they had better broadband that they would hire additional staff. They felt that poor connectivity was a limiting factor for their business.

C. Broadband GAP Analysis

A broadband gap is a situation where there some customers with an advantage compared to others in relationship to using the Internet. This report will look at the different kinds broadband gaps as described below.

- The Gap in Broadband Speeds. The broadband speeds vary widely throughout San Juan County.
- The Gap in Broadband Availability. There are homes with no landline broadband available.

- The Gap in Broadband Affordability. In every community there are households 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 look forward to the natural progression of technology that will create new broadband gaps that don't exist today.

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

The Gap in Broadband Speeds

The first step in trying to define the broadband speed gap is to look at the official definition of broadband.

FCC Definition of Broadband

In 2015, the FCC established the definition of broadband as 25/3 Mbps (that's 25 Mbps download and 3 Mbps upload). Prior to 2015 the definition of broadband was 4/1 Mbps, set a decade earlier. The FCC defines 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 take action if broadband is not being deployed in a timely manner. The FCC report the state of broadband to Congress every year.[10] 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 have acknowledged that there are broadband gaps but claim that the broadband situation is improving due to actions taken by the FCC. As you will see in the following report, the annual reports to Congress are largely fictional and don't describe the state of broadband in places like San Juan County.

The FCC didn't use empirical evidence like speed tests in setting the definition of broadband in 2015. They instead conducted what is best described as a thought experiment. They listed the sorts of functions that a "typical" family of four was likely to engage in, and then determined that a 25/3 Mbps broadband connection was fast enough to satisfy the broadband needs of a typical family of four.

The FCC asked the question again in 2018 if 25/3 Mbps was still an adequate definition of broadband. They took no action and decided that 25/3 Mbps was still a reasonable definition of broadband. There were comments filed by numerous parties in that docket that thought that the definition of broadband should be increased.

[10] The FCC report to Congress for 2019 can be found at https://docs.fcc.gov/public/attachments/FCC-19-44A1.pdf.

The FCC Measures Broadband Speeds

Since the FCC is required by law to state an opinion as to the state of broadband deployment, they collect data from ISPs about broadband that is deployed and sold to customers in the US. The FCC collects ISP data using a process called the Form 477 process. The FCC collects data from every landline broadband ISP in the country (they don't require this data from dial-up providers, from satellite providers or from cellular companies). The FCC collects the following data twice per year from every ISP (even though we know there are small ISPs that don't participate).

- ISPs report broadband customer counts by Census Block. Those are finite geographic areas defined by the US Census bureau that typically cover between 60 and 100 homes. In a city, a Census block might be a city block and in a rural area it might cover a large portion of the county.
- For each Census Block the ISP reports the fastest speed available to customers.

After the FCC gathers this data from ISPs, they make it available in the form of databases showing the speeds reported by each ISP in every Census Block. The FCC also maps the broadband data in various ways. The most common maps produced by the FCC show areas that don't have broadband that meets the 25/3 definition of broadband, areas that meet the 25/3 speed, areas that achieve speeds of at least 100/10 Mbps, and areas that have gigabit broadband capability. Many other variations of these maps are also possible.

Unfortunately, the FCC rules mean that the fastest speed available to one customer in a Census Block is available to all customers. For example, if an ISP has one customer in a corner of a Census Block that can buy 100 Mbps broadband, then the FCC interprets that result to mean that every customer in that Census Block can get that same 100 Mbps speed.

To make matters worse, ISPs are supposed to report actual speeds to the FCC, but there is no penalty for reporting any speed number they want. Many ISPs, particularly rural telcos, have been accused of reporting marketing speeds instead of actual speeds. As an example, an ISP might advertise DSL as a speed of "up to 30 Mbps" and then report the 30 Mbps speed to the FCC. In actual practice the DSL speeds might be significantly slower than the advertised speed. Those two factors – reporting by Census Block and reporting by advertised speeds means that the FCC's reported broadband speeds are significantly overstated, particularly in rural America.

One place where coverage is often overstated is rural in areas adjacent to towns and cities that have decent broadband speeds. Homes in the surrounding area are often shown as having the same broadband capabilities as the town even though homes might have no broadband available. This can also happen in rural areas. For example, a big telco might place a DSL cabinet at the opening to a subdivision and provide decent DSL service there. The FCC mapping will show the entire Census Block as having good DSL, even though it is only available inside the subdivision.

The FCC doesn't monitor what is reported and has allowed big reporting errors into the mapping databases. The 2018 Broadband Deployment Report reached the conclusion that the state of rural broadband was improving rapidly. It turns out there was a huge error in the data supporting that FCC report. A new ISP in New York, Barrier Free, had erroneously reported that they had deployed fiber to 62 million residents in New York. Even after the FCC was forced to correct the error, they still drew the same conclusions that broadband was getting better, even though the revised report showed million fewer homes

with good broadband. This raises a question about what defines "reasonable and timely deployment of broadband" if having fiber to 62 million fewer people doesn't change the answer.

Apparently, the ISP is at it again because the FCC is now threatening a fine of $164,000 for BarrierFree for continued overreporting. The FCC says that's the maximum penalty allowed by law. There were supposedly substantial overreporting in both the September 2019 and March 2020 data. To the best of my knowledge this would be the first fine due against an ISP due to false reporting in the 477 process. The FCC has threatened fines against Verizon and a few other ISPs for falsely reporting rural 4G cellular coverage, but I'm not aware of any fines being levied.

The idea of levying fines against ISPs for blatant broadband overreporting is long overdue. There can be huge consequences when ISPs can freely claim broadband coverage that doesn't exist. The biggest current consequence of such overreporting is that it can block eligibility for grants. The FCC used the faulty 477 data when determining the areas that are eligible for the $16.4 billion in RDOF grants that will be awarded in October. I know of counties where no RDOF grants are being offered due to the FCC data falsely showing counties to already have adequate broadband. There are many rural counties where at least some portion of the county has been incorrectly excluded from RDOF grant eligibility due to ISP overreporting of broadband speeds and coverage.

All these factors taken together mean that the FCC broadband databases and maps are full of errors. The broadband speeds reported by ISPs in the city might be reported reasonably correctly, although the speeds reported sometimes reflect marketing "up to" speed instead of actual speeds. This is something that was seen in the speed tests where there were Comcast and CenturyLink customers getting slower speeds than what might be expected. It's more likely for the speeds to be overstated for areas just outside of town.

Following is a series of maps that demonstrate speeds being reported to the FCC in the service areas.

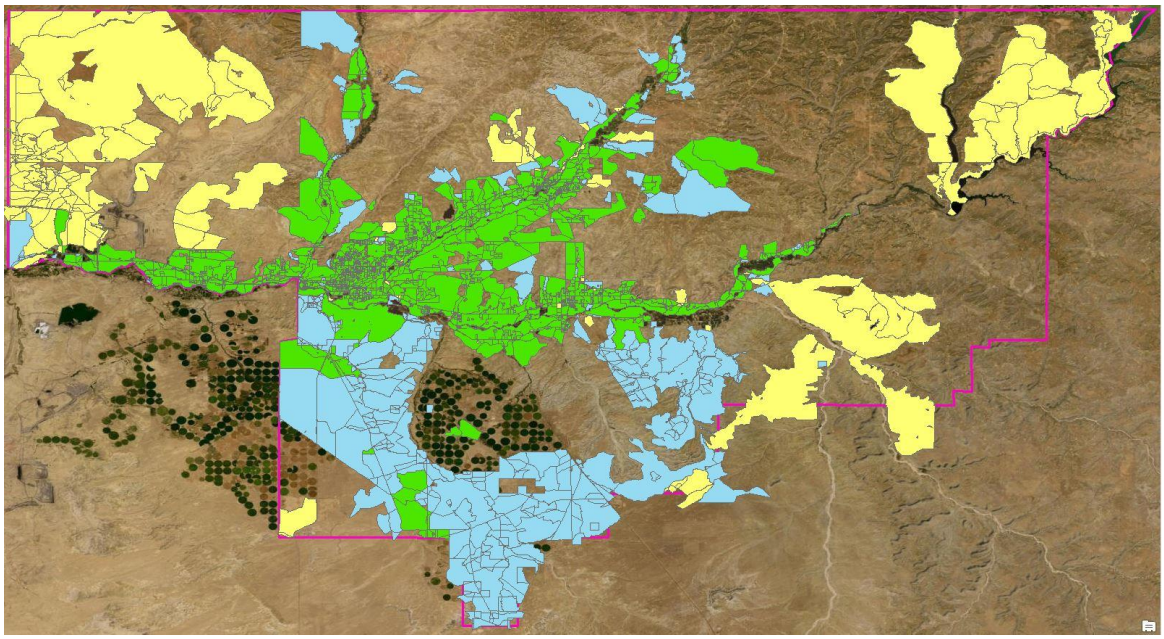
The first map below is a composite of all of the reporting by ISPs in the area. In all of these maps, the red line defines the service area of the utility. The yellow areas are those where the fastest available broadband products have speeds under 10/1 Mbps. The blue areas supposedly have broadband products available between 10/1 Mbps and 25/3 Mbps. The green areas supposedly have broadband products that can deliver speeds greater than 25/3 Mbps.

All Providers FCC Reporting – Data from FCC Form 477 for December 2019

= 10/1Mb Broadband or Less Census Blocks

= 10/1Mb thru 25/3Mb Broadband Census Blocks

= 25/3Mb Broadband or Greater Census Blocks



As mentioned earlier, ISPs are all supposed to report broadband speeds to the FCC using Form 477 that shows the Census blocks where they have customers and the fastest broadband speeds they can deliver in that Census block.

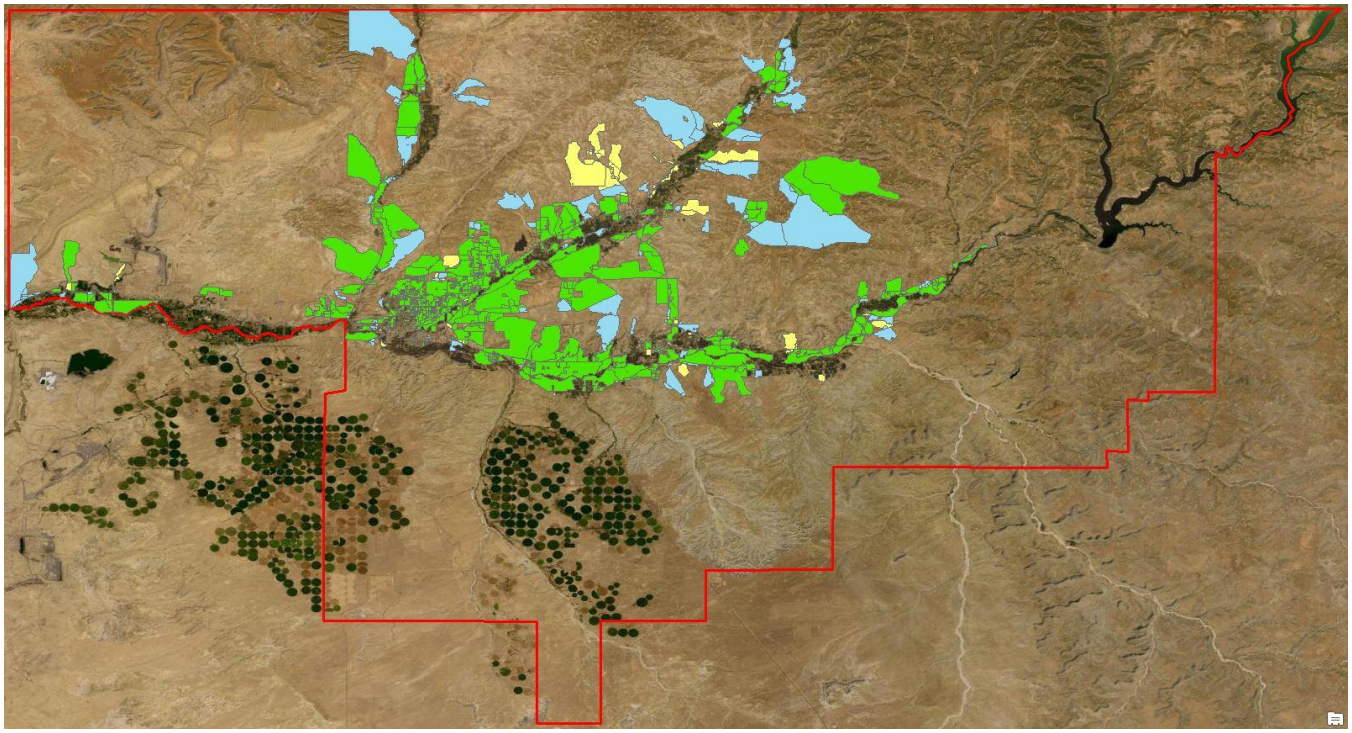
CenturyLink. The following map includes all of the speeds reported by CenturyLink. It's noticeable that they are reporting speeds available greater than 25/3 Mbps for much of the serving area. CenturyLink offers faster speeds anywhere it can deliver the DSL technology that uses four copper wires. The speed tests showed this product delivering speeds between 20 Mbps and 40 Mbps. CenturyLink also has a few customers on fiber.

CenturyLink FCC Reporting – Data from FCC Form 477 for December 2019

= 10/1Mb Broadband or Less Census Blocks

= 10/1Mb thru 25/3Mb Broadband Census Blocks

= 25/3Mb Broadband or Greater Census Blocks



CenturyLink is reporting the following technologies to the FCC:

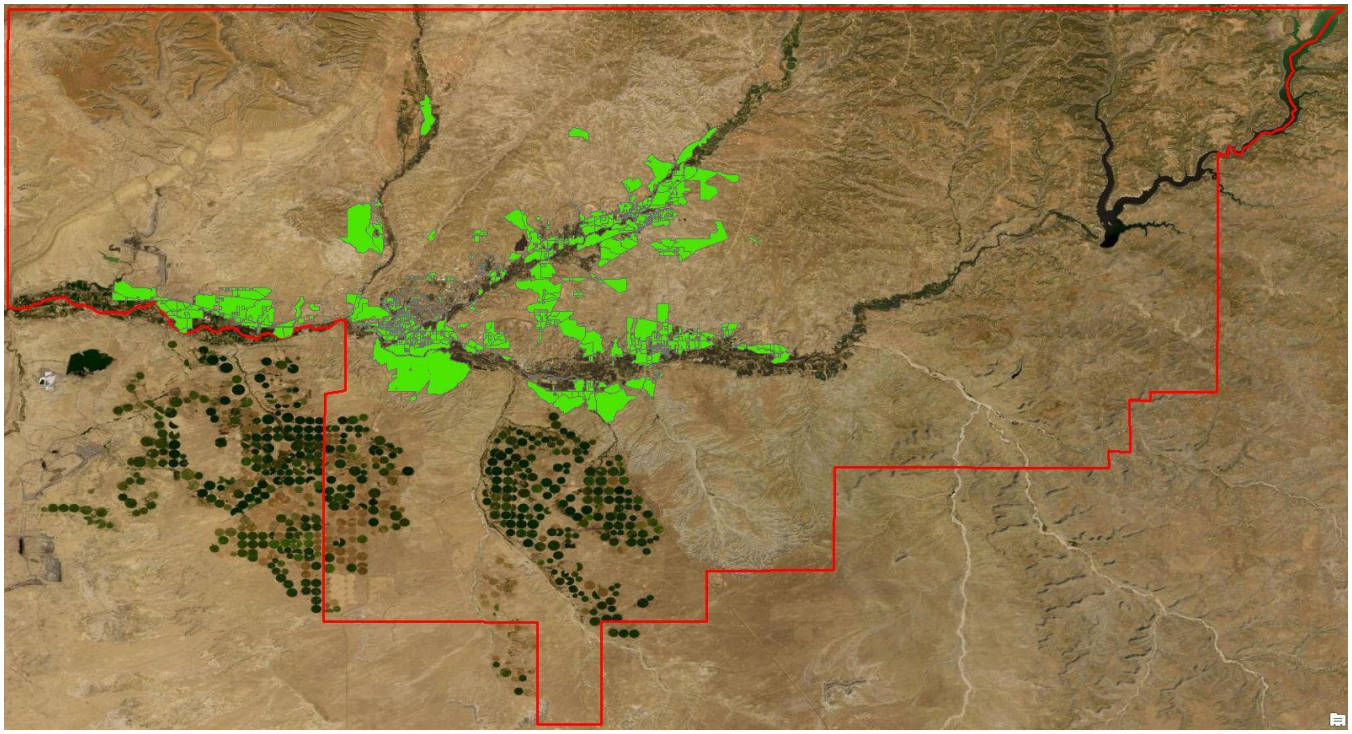
- ADSL or ADSL/ADSL2+ with most maximum speeds reported as available as 1 Mbps download and 0.8 Mbps up. These are the yellow areas of the map.
- ADSL/ADSL2+ speeds reported are 4/1 Mbps or 10/1 Mbps broadband.
- VDSL technology speeds reported as 4/1 Mbps, 10/1 Mbps or 20/2 Mbps broadband speeds.
- VDSL speeds range from 40/5 Mbps broadband to 100/10 Mbps.
- Fiber Optical Carrier speeds reported as symmetrical 1Gbps.

As will be discussed below, we believe that CenturyLink is overstating speeds in the rural areas where they claim speeds greater than 10/1 Mbps and 25 Mbps.

Comcast. Comcast is reporting that speeds greater than 25/3 Mbps are available everywhere they offer broadband service.

Comcast FCC Reporting -Data from FCC Form 477 for December 2019

= 25/3Mb Broadband or Greater Census Blocks

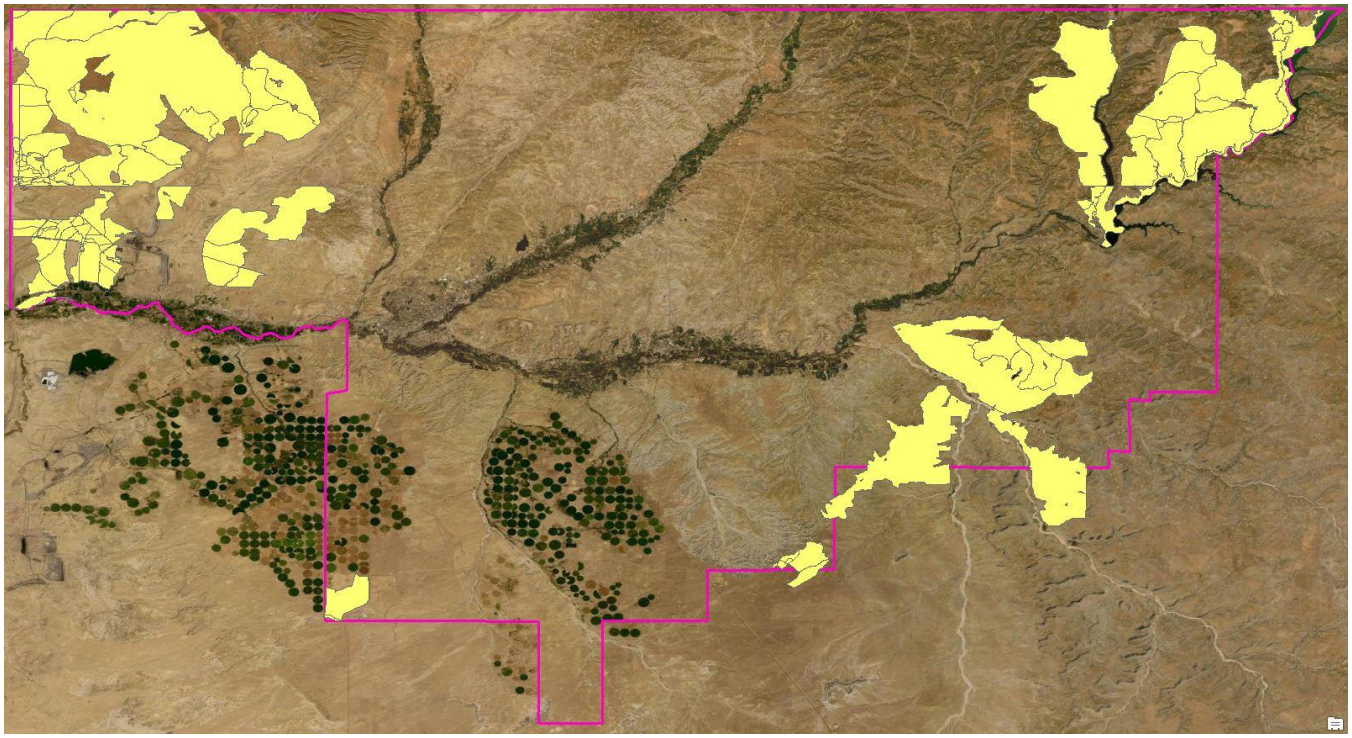


The company is reporting the availability of DOCSIS 3.1 technology everywhere. The company claims speeds are available as fast as 987/35 Mbps everywhere. The biggest problem with the Comcast reporting is nothing that the company is doing wrong, but the FCC reporting rules An ISP is supposed to report coverage in an entire Census block even if they serve only one customer. This leads to the green areas above extending out into rural areas where the company is not serving customers – but they are reporting properly to the FCC.

Commnet Wireless. The company provides fixed wireless broadband. The maximum speeds reported to the FCC are 9/2 Mbps. It's likely that there is coverage shown in the yellow areas where coverage is not available. This is also due to the FCC rules that say an ISP should report Census blocks even if only one customer can buy service.

Commnet Wireless FCC Reporting -Data from FCC Form 477 for December 2019

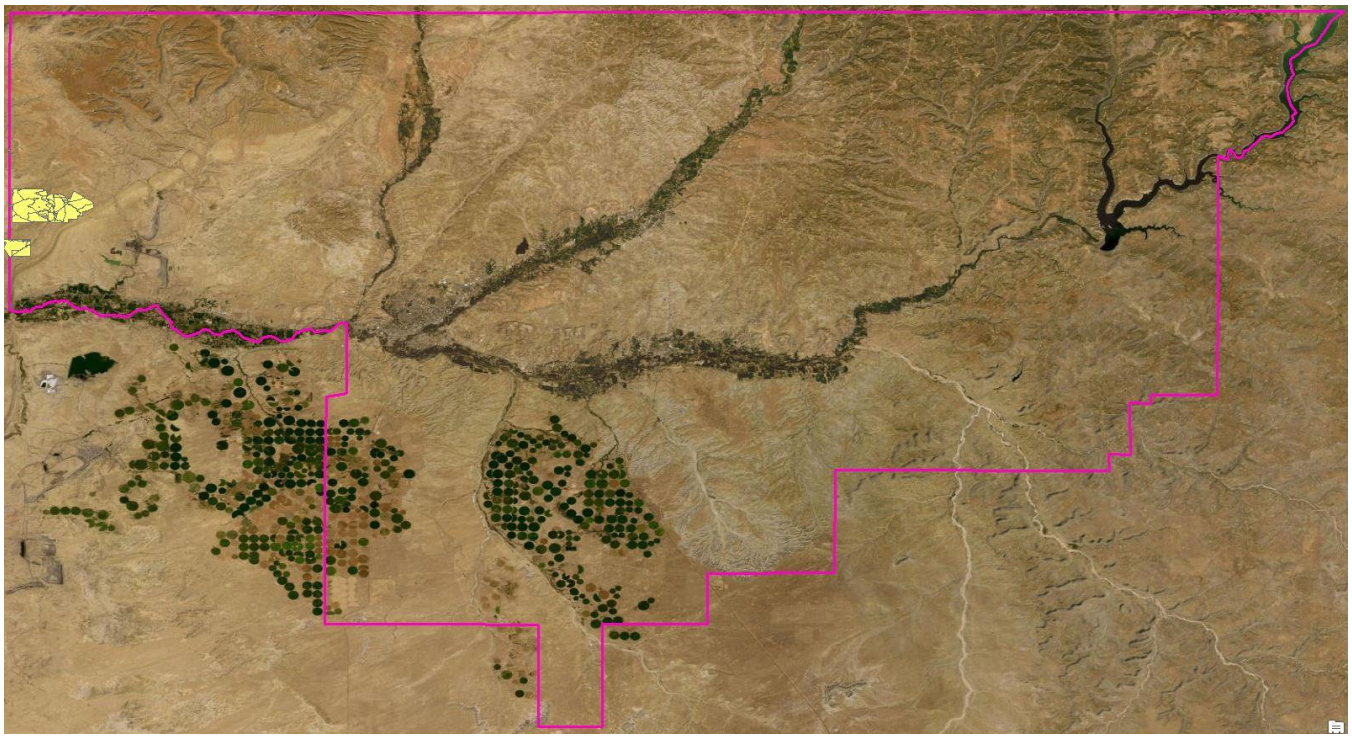
= 10/1Mb Broadband or Less Census Blocks



NTUA Wireless. The company provides fixed wireless broadband in a small portion at the western edge of the service areas. NTUA reports a maximum speed available to customers of 9/2 Mbps.

NTUA Wireless FCC Reporting -Data from FCC Form 477 for December 2019

= 10/1Mb Broadband or Less Census Blocks



Less than 10/1Mb technology is indicated and technology is listed as Terrestrial Fixed Wireless; the max speed reported in all census blocks is 9/2Mb from NTUA Wireless.

Sacred Wind. The company provides fixed wireless in parts of the service area today as well as some DSL broadband over copper.

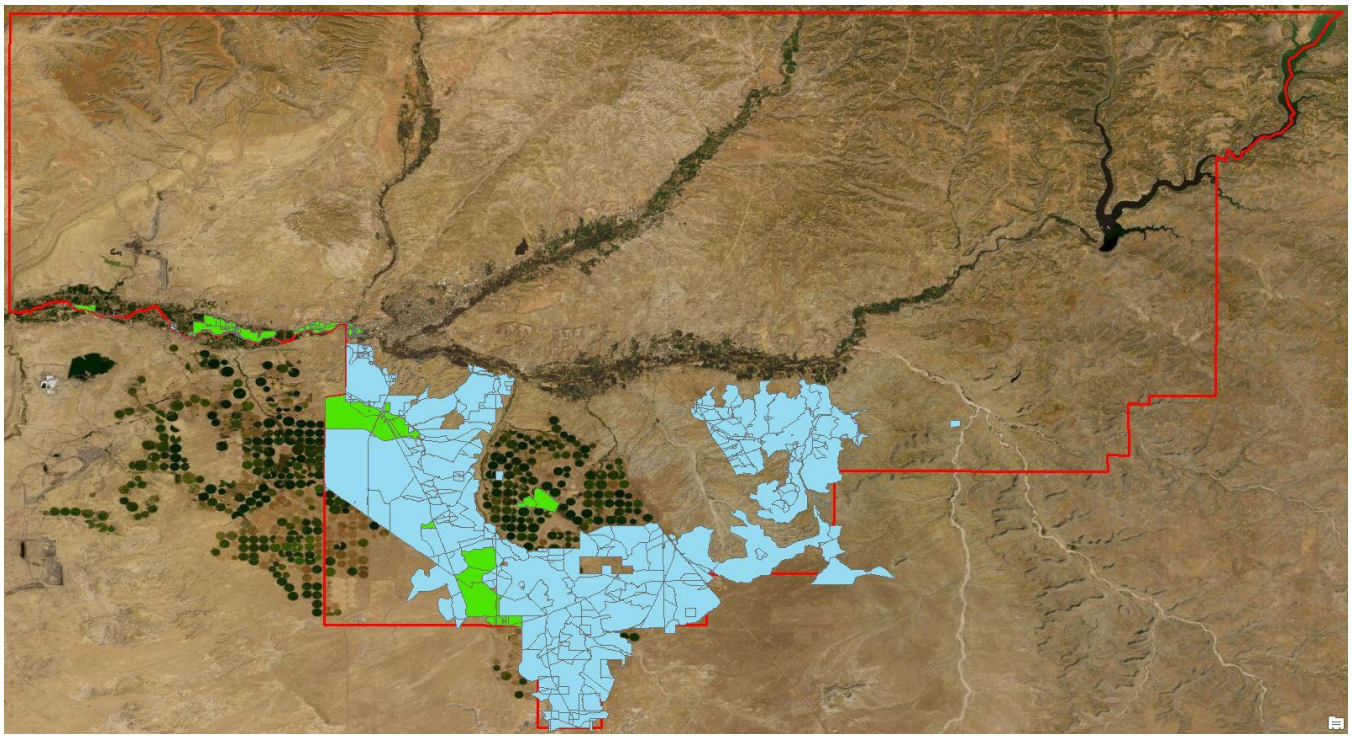
The map below shows the broadband speeds that are reported to the FCC.

The company is reporting fixed wireless technology as being able to deliver speeds of 10/1 Mbps. broadband. These are the blue areas of the map.

Sacred Wind reports using ADSL/ADSL2+ and/or fixed wireless to deliver speeds of at least 25/3 Mbps in the areas shown in green on the map.

= 10/1Mb thru 25/3Mb Broadband Census Blocks

= 25/3Mb Broadband or Greater Census Blocks



The Real Broadband Speeds in the Study Area

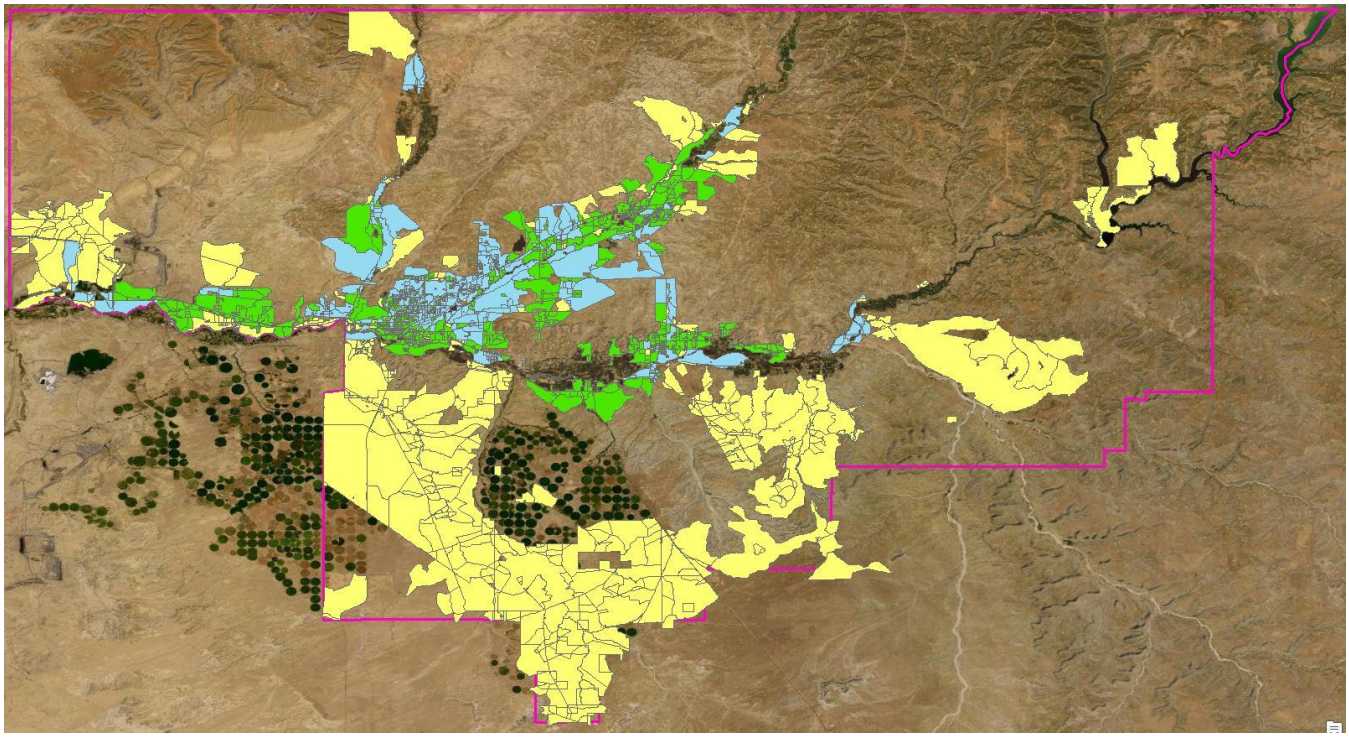
As been discussed earlier, we believe that much of the ISP reporting to the FCC is overstated. The following is a map created by Finley Engineering that shows the broadband download speeds that we think are available in the community.

Finley Analysis of Broadband Available in FEUS Service Area

= 10/1Mb Broadband or Less Census Blocks

= 10/1Mb thru 25/3Mb Broadband Census Blocks

= 25/3Mb Broadband or Greater Census Blocks



Here are the highlights of what how this map was derived:

- The best broadband is available in the FEUS service area mainly along the Hwy 170, Hwy 516, and Hwy 64 corridors. Comcast seems to be delivering speeds greater than 25/3 Mbps (areas in green). In those same areas is where we think CenturyLink offers some DSL faster than 25/3 Mbps.
- CenturyLink reports a lot of rural areas as having broadband speeds greater than 25/3, but we think this mostly does not exist. This is not to say that there aren't a handful or rural customers with faster SL speeds, but we think that is either a small number or even zero.
- Some of the wireless carriers are reporting speeds greater than 10/1 Mbps in the southern part of the service area. We also think there are few, if any customers getting speeds in that range, although it is possible that some do.

Consequences of Inaccurate FCC Maps

It's been CCG's belief for years that the FCC has been hiding behind the bad maps because those maps give them cover from having to take stronger action to fix rural broadband. It's likely that 90% or more of counties in the country have overstated broadband coverage on the FCC maps like what is seen on the map above. If the FCC were to acknowledge how bad the maps are, they would be required by Congressional mandate by Section 706 rules to undertake extraordinary efforts to fix the broadband problems. The bad maps have allowed the FCC to issue a report to Congress every year stating that rural broadband coverage has problems but is improving.

Unfortunately, the speeds reported by the FCC maps have other real-life implications. For example, the FCC constantly cites the statistics from the broadband mapping system when developing various policies or making decisions that impact rural broadband. The FCC is fully aware of the inadequacies of their mapping data, and yet they still cite their own faulty data as proof that broadband isn't as bad in rural America as critics might suggest.

Probably the biggest impact from lousy FCC mapping is that the FCC maps are still used to define where federal and state grants can or cannot be awarded. Since the maps overstate the broadband at many rural homes, those homes are excluded from being upgraded using the grant money. The FCC maps were used to define the areas that needed to be upgraded by the big telcos in the CAF II grant program. That program provided funds in 2015 to upgrade DSL in areas that didn't have speeds of at least 10/1 Mbps. Since then the maps were used again in the CAF II reverse auction where ISPs could get grants to build broadband in rural areas that weren't covered by the original CAF II.

In October 2020, the FCC will be awarding the largest broadband grants ever and will be providing $16.4 billion in grants for selected rural areas that don't have broadband speeds of at least 25/3 Mbps. This grant program has been named the Rural Digital Opportunity Fund (RDOF). There will an additional $4 billion of RDOF grants awarded in 2021. These grants will continue to use the same lousy existing FCC broadband maps.

Unfortunately, parts of the study area are considered by the FCC to have 25/3 broadband, even though the people in those areas have poor, or even no broadband available. This means that for purposes of these grants – the biggest broadband grants ever awarded – that the FCC will use the flawed maps when defining eligibility for the RDOF grant program. That will harm not only your area, but also most of New Mexico and numerous other rural communities.

There are federal grant programs like the ReConnect grants administered by the USDA that allow a grant requester to challenge the FCC mapping data. There are no predetermined ways to undertake such a challenge, and the incumbent providers get to comment on the protests. The best way to challenge the FCC grants is with speed tests. They also can be challenged by on-the-ground observations by a qualified engineer that can show the presence or absence of the technology required to provide rural broadband. Finley Engineering undertook this kind of field analysis.

New FCC Maps Coming

In August 2019, the FCC voted to change the method of collecting data to support its broadband maps. The primary new change is that ISPs have to produce "polygons" (or geographic shapes) that cover areas where they have broadband customers today. The ISP maps can also cover areas without current coverage where an ISP could provide a broadband connection within ten business days of a customer request and without an extraordinary commitment of resources or construction costs exceeding an ordinary service activation fee.

The new polygons will fix some big holes in the current FCC maps. The polygons are going to make a noticeable difference when showing coverage for cable company or fiber-to-the-home networks. Those networks have hard boundaries that stop at the "last home" to have broadband. Today's mapping by Census block doesn't recognize these hard boundaries and routinely counts customers outside these networks as having access to faster speeds. This mapping change will more adequately show the boundaries of cable or fiber-to-the-home networks.

Unfortunately, changing to mapping using polygons is not likely to make a significant change in the rural outside of the city. The polygons might highlight areas better where the telcos have zero customers. But it won't change most of the reporting by the telcos unless they get scrupulously honest with reporting actual speeds. If the telcos continue to report marketing speeds, then the maps for the rural areas might continue to look the same as today.

Unfortunately, while the FCC is changing to the polygons for mapping, they are not requiring the ISPs to report more honestly about broadband speeds. We hear from customers all the time who are being sold a rural DSL product that is marketed to deliver speeds up to 25 Mbps while they are receiving only a few Mbps.

The Technology Gap

To a large degree, the broadband speeds available to customers is dependent upon the technology used to deliver the broadband. Our reports will discuss various technologies in more detail when we describe the engineering cost estimates to bring better broadband to the counties.

The general speeds available on various technologies is 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, 12 Mbps, or 16 Mbps. In the rural areas we see DSL download speeds of a few Mbps down to less than 1 Mbps.
- DSL delivered on two copper pairs can deliver twice the speeds. This technology is usually only deployed using the latest types of DSL and has maximum speeds around 50 Mbps. We see some of this deployed in the city.
- High orbit satellite broadband can deliver speeds as fast as 75 Mbps. The problem with this broadband is that the satellites are so far above the earth that there is a lot of delay (latency) in the signal and it's hard to do real-time web activities like streaming video, connecting to a corporate WAN or a school server, making VoIP calls, or even shopping on some web sites.

- Fixed point-to-multipoint wireless is capable of speeds up to 100 Mbps, although the equipment and configuration of most networks delivers speeds significantly less than this, sometimes as slow as only a few Mbps. The providers outside the city are marketing speeds under 10 Mbps.
- A hybrid-fiber coaxial system (used by cable companies) can deliver fast broadband speeds. Networks using the DOCSIS 3.0 standard can deliver speeds up to around 400 Mbps. Networks upgraded to the most recent DOCSIS 3.1 standard can deliver speeds up to a gigabit. Cable companies typically sell broadband products with speeds a lot less than the theoretical fastest speeds.
- Fiber networks also deliver fast broadband. Fiber networks with the older BPON technology are limited to speeds of about 200 Mbps per system. More modern GPON technology can deliver speeds up to a symmetrical gigabit (same speed up and down). There are newer kinds of fiber-to-the-home technology that offer speeds up to 10 Gbps.

Every technology has some limitations in real-life networks that can produce slower broadband speeds. Consider as example all of the following factors that can affect the broadband speeds delivered over DSL:

- The distance between the customer and the DSL transmitter (called a DSLAM). DSL speed decreases with distance.
- The size of the copper wire serving the customer matters – the larger the gauge of the copper wires the stronger the DSL signal.
- The quality of the copper (copper wire slowly degrades over time, particularly if the copper gets in direct contact with the elements or with longstanding water).
- By the quality of the telephone wiring inside of a home (this varies a lot, particularly for wires that were installed by the homebuilder rather than by a telco).
- The type of DSL electronics used to serve a customer. There are still older DSL technologies in the field that have maximum download speeds of only a few Mbps and newer DSL that can deliver speeds as fast as 48 Mbps.
- The backhaul network used to provide bandwidth to a feed the DSL network. DSL is like most broadband technologies and bandwidth is shared between users in each neighborhood. If the total usage demanded by the neighborhood is greater than the bandwidth supplied to the neighborhood, then everybody gets slower speeds when the network is busy.
- And finally, speeds can be impacted by how a customer gets broadband to devices. For example, an old WiFi router can cut down the speed between what is delivered to the home and what makes it to computers and other devices inside the home.

All these factors mean that DSL speeds vary widely in the field. Two adjacent homes can have a significantly different DSL experience. It's extremely difficult for an ISP to understand DSL speeds for customers since the speeds can very during the day. It's impossible for them guess the speeds that would be available for homes that don't buy their service.

The same sorts of factors also apply to fixed wireless. Customer speeds vary according to distance from a tower, the spectrum used for any given connection, the types of impediments between the tower and the home (speeds are often slower in summer when the leaves are on trees). It's nearly impossible to map DSL and fixed wireless speeds in the field.

The Urban/Rural Gap

The most dramatic broadband and noticeable broadband speed gap is often called the Urban/Rural gap and is due to the big speed difference between broadband speeds offered on most cable TV networks and the DSL and other slower technologies available outside of towns. The "urban" designation used isn't accurate, because any small town that has an up-to-date cable provider network will have significantly faster speeds than speeds available outside of the cable network.

This gap didn't always exist. Both DSL and cable modem technology were developed in the late 1990s, and at first the two technologies delivered nearly the same speeds. For example, in 2001 a customer in a town likely had the option between a 1 Mbps service from either the phone company or the cable company.

Over time the technology improvements provided more speed across the coaxial cables used in a cable network (the copper wires that plug into your TV) than with the much thinner wires used to deliver telephone service. As much as anything, the faster speeds on a cable network were due to the larger amount of wire available in a coaxial cable.

Even as both technologies got faster, the speed offered by both competitors was roughly the same. For example, by 2006 you probably could have bought a 6 Mbps connection in a town from a telco or cable company that had made the needed upgrades. After that time, however, the cable company technology improved a lot more than the telephone company DSL technology, and cable company executives decided they could win the competitive broadband battle by offering faster speeds than telephone companies, at the same price. Since then, the cable companies have unilaterally increased speeds to broadband customers. In Farmington Comcast says they have upgraded the base network in Farmington to roughly 150 Mbps. As the speed tests showed, there are a significant percentage of people getting feeds slower than that target speed. But the speeds on Comcast are still the best overall speeds in the community.

In the industry we talk about the "last home" served by the cable companies, because at every street emanating out from the city there is a last home connected to the cable network, and past that point customers can't buy broadband from the cable company.

Homeowners who live just past the last home are often frustrated when they can't convince a cable company to extend their lines. Cable companies generally have some metric where they won't pay to extend cable unless there is some pre-defined number of homes per road mile. A typical metric would be 20 homes per road mile – if a road has fewer homes, the cable companies won't build. The cable companies have a second issue in that they don't extend their networks past the point where they have to amplify the signal too many times, because that allows interference to enter the network and causes snow and interference on TVs and degraded broadband. Depending upon the specific wiring and technology used, these networks have a limit of 4 – 7 miles of coaxial cable, past which their signal begins to degrade.

We have some dramatic evidence of the urban/rural technology gap. The firm OpenVault tracks broadband usage in the US and around the world. In their latest report that was published in January 2020 the company says that 54% of homes now purchase broadband plans with speeds of 100 Mbps or faster. Another 23.6% of homes are subscribing to broadband between 50-75 Mbps. This means that nearly 78% of homes in the country are subscribing to data plans of at least 50 Mbps, while 54% subscribe to plans of

at least 100 Mbps. OpenVault further says that the average subscribed speed in the US grew significantly between 2018 and 2019 from 103 Mbps to 128 Mbps.

The Business Broadband Gap

Businesses generally have the same issues as residents in terms of limitations of technology. A business operating in a rural area won't have any better broadband options than nearby residences.

However, there are some unique issues affecting business broadband:

- In many towns the original cable company might not have built the cable network to reach business districts. Back in the 1970s and 1980s the cable companies didn't expect to sell enough cable TV service to justify the cost of the network. Now that the cable company is usually the fastest broadband solution in a town, there are often still businesses that are not connected to the cable company networks.
- In towns, if any entities have fiber it's like to be either government locations like schools or some of the largest businesses. The telephone and cable companies are often willing to build fiber to a sufficiently large enough customer. Such fiber availability, if it even exists, is also often limited by how close a business might be to an existing fiber.
- Businesses have drastically different broadband needs. For example, there might be one business with a 100 Mbps connection from the cable company that is satisfied with the service. Next door could be another business that finds the 100 Mbps connection inadequate and that struggles to operate their business because of the broadband.

Microsoft Speed Data

Microsoft is in an interesting position when it comes to looking at broadband speeds. The vast majority of computers in the country download sizable upgrade files from Microsoft. Even many Apple computers are loaded with Microsoft Office products like Word, Excel, and PowerPoint.

Microsoft decided a few year ago to record download speeds of software upgrades. There is probably no better way to measure a broadband connection than during a big file download. Most speed tests only measure broadband speeds for perhaps 30 seconds. There are a lot of ISPs in the country that deploy a technology generally referred to as "burst." This technology provides a faster download for a customer for the first couple of minutes of a web event. It's easy for a customer to know if their ISP utilizes burst, because during a long download, such as one updating Microsoft Office, the user can see the download speeds drop to a slower speed after a minute or two. This burst technology has great benefits to customers since most web activities don't take very long. When customers visit a website, open a picture, or even take a speed test, the customer only needs bandwidth for a short time. The burst technology gives customers the impression that they have a faster download speed than they actually have (or it could be conversely argued that they have a fast speed, but just for a minute or two).

Microsoft measured downloads starting in September 2018, and found:

- The 2018 FCC data claimed that 24.7 million people in the US don't have access to download speeds of at least 25/3 Mbps. In September 2018 Microsoft claimed that 162.8 million people were downloading data at speeds slower than 25/3 Mbps.

- The FCC claimed in 2018 that 65.8% of the people in San Juan County had access to broadband of at least 25/3 Mbps. In September 2018 Microsoft said that only 28.9% of people in the County used broadband of at least 25/3 Mbps. That is an eye-opening difference.

It's important to note that the FCC and Microsoft are not measuring the same thing. The FCC is measuring the percentage of homes that have access and can purchase 25/3 Mbps broadband. Microsoft is measuring the actual speeds of downloads. There are a few reasons why the speeds might be different:

- Some people opt to buy broadband products slower than 25/3, even when faster broadband is available.
- Some households receive slower speeds due to issues in the home like poor-quality WiFi routers.
- The biggest difference is probably due to the ISPs overstating the speeds to the FCC that they make available to the public. As stated elsewhere in this report, the FCC doesn't challenge speeds reported to them by ISPs.

The Microsoft findings have implications beyond rural broadband. The Microsoft measurements showed that a lot of customers in towns and cities also aren't achieving 25/3 Mbps speeds. The Microsoft numbers are astounding once it's recognized that cable companies provide two-thirds of all broadband in the country – and predominantly sell speeds thar are claimed to be faster than 25/3 Mbps, usually at 100 Mbps or faster.

The Connect America Fund

Original CAF II

It's worth noting that CenturyLink participated in the original Connect America Fund II (CAF II) in your service area. The FCC set aside $1.7 billion per year for the 6 years ending in 2020 for the big telcos to build or upgrade rural broadband. These funds were made available to census blocks that had little or no broadband at the time.

The FCC awarded these funds to Frontier and CenturyLink in San Juan County as follows:

- In your part of the county, CenturyLink accepted $876,353 per year, or $5,258,118, to bring better broadband to 2,329 rural customers - $2,258 per home.
- In other parts of the county, Frontier accepted $2,057,585 per year, or $12,345,510 to bring better broadband to 3,160 rural customers - $3,907 per home.

These funds were distributed over 6 years, with the final year being 2020. There are buildout requirements, and the telephone companies should have upgraded at least 60% of the customers in the whole state at the end of 2018, 80% by the end of 2019, and everybody by the end of 2020.

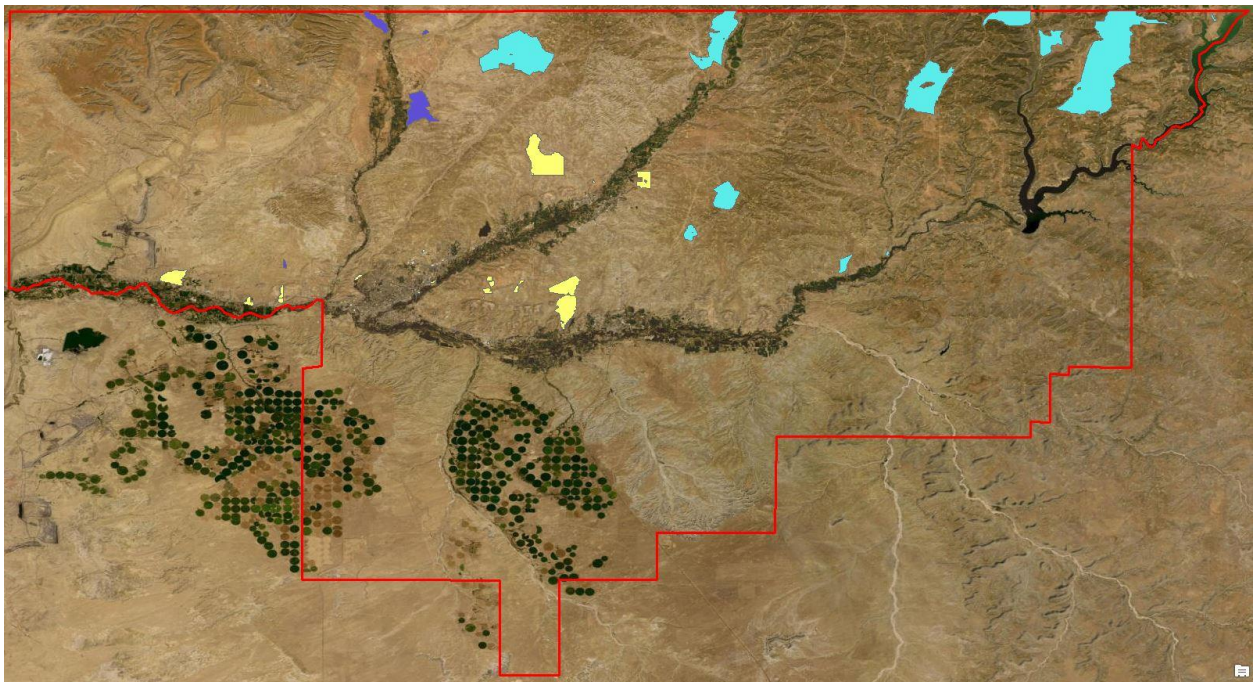
Both telephone companies are using the funds to upgrade rural DSL. The CAF II program required that customers must be upgraded to data speeds of at least 10 Mbps download and 1 Mbps upload. Note that those speeds are far slower than the FCC's definition of broadband, which is 25 Mbps download and 3 Mbps upload.

In a surprising move, the FCC has allowed the large telcos to collect a seventh year of CAF II payments. This means that CenturyLink will collect an additional $876,353 during 2021 for the county. This money comes with no strings and the carriers don't have any additional obligations to improve broadband.

CAF II Reverse Auction

In July 2018, the FCC awarded $1.98 billion of grants to be dispersed monthly over 10 years. These grants covered areas that were not claimed by the big telcos in the original CAF II grants described above. This money was awarded by reverse auction, meaning that the funding went to the carriers in each geographic area that was willing to take the lowest amount of money per customer.

Below is a map of the pats of your service area that were awarded funding in the CAF II reverse auction.



The three winners were:

Plains Internet won the funding for the Census blocks shown in yellow. They promised to deliver speeds of 100/20 Mbps or greater, and low latency (Less than 100 milliseconds).The ISP provides fixed wireless service.

Commnet Wireless won the funding for the Census blocks shown in purple. They promised to deliver speeds of 100/20 Mbps or greater, and low latency (Less than 100 milliseconds). The ISP provides fixed wireless service in the area today.

Viasat won the funding for the Census blocks shown in blue to provide speeds of at least 25/3 Mbps and high latency (Cannot be higher than 750 milliseconds). Viasat provides broadband from high-orbit satellites. These awards in the auction puzzle us because Viasat already has customers in the area today. For the speed tests we say they already can meet the speed test, but already today fail the latency test.

The Gap in Broadband Availability

The National Telecommunications and Information Administration (NTIA) released the results of a survey in 2019 that looked at households that don't use the Internet.[11] The survey says there are around 28 million households in the US that don't use broadband at home. Some of these homes fall into the following circumstances:

- The most drastic case are homes that have no landline broadband options. Such homes are limited to getting broadband from high-orbit satellites (assuming they can see the portion of the sky where the satellites sit), or from cellular data from their cellphone plans. Almost every rural area has homes that have no landline broadband options.
- The broadband availability gap also refers to homes that can't get broadband that meets the FCC definition of broadband.
- The availability gap also is sometimes used to describe the difference between urban and rural broadband, which was described in some detail above in the discussion of broadband technologies.

Comparing San Juan County with the Rest of the World

There are numerous ways to compare San Juan County to the rest of the state, country, and world.

FCC Adoption Rate

It's worth first looking at how New Mexico compares to other states. In the 2019 annual report to Congress the FCC reported on broadband adoption by various speeds by state. Adoption rate is the percentage of households that have purchased broadband that meets or exceeds various speed thresholds. For some reason that they don't explain well, in the 2019 broadband report to Congress the FCC reported broadband adoption rates for 2017. This means two things. The overall adoption rates are understated because we know that the overall number of homes buying broadband has been increasing every year. However, since the data used in the FCC report comes from the Form 477 data, the percentage that that buying a given speed is likely overexaggerated. That makes for some confusing results, but since the same issues affect every state, the overall rankings of broadband adoption by state is probably reasonable.

In the annual report to Congress the FCC reports on broadband adoption by various speeds by state. In the 2020 report to Congress, the FCC reported the following broadband adoption rates for New Mexico (meaning the percentage of customers who can buy the listed speeds at their home):

Homes buying at least 10/1 Mbps	50.4%
Homes buying at least 25/3 Mbps	45.8%
Homes buying at least 50/5 Mbps	40.7%
Homes buying at least 100/10 Mbps	16.8%
Homes buying at least 250/25 Mbps	1.4%

To put the FCC numbers into perspective, the percentage of homes that get at least 10/1 Mbps broadband (50.4%) ranks ahead of only Mississippi, which is last at 48.2%. It's worth noting again that these numbers

[11] The NTIA survey results are at: https://www.ntia.gov/blog/2019/unplugged-ntia-survey-finds-some-americans-still-avoid-home-internet-use

are based upon faulty FCC 477 data reported by the ISPs in the state and the actual speeds being purchased are not nearly as good as the numbers shown.

FCC Availability of Broadband

The FCC also looks at the availability of broadband by county, meaning the percentage of homes that could buy broadband at various speeds. This is where the FCC data and the faulty nature of the maps are quickly evident. Here's what the FCC reported to Congress in 2019 about San Juan County:

Urban population:	75,811
% that can buy at least 25/3 broadband	88.3%
% with 4G LTE coverage at 5/1 Mbps	100%
% with both	88.3%
Rural population:	49,232
% that can buy at least 25/3 broadband	28.8%
% with 4G LTE coverage at 5/1 Mbps	99.7%
% with both	28.8%

We know that everybody (or practically everybody) in Farmington can buy broadband from Comcast at speeds faster than 25/3 Mbps. When the FCC shows only 88.3% of urban homes can get broadband, that result might be due to way that the data is reported by Census blocks that doesn't match the city boundaries, or it could be that they are counting one or more other cities as being urban.

The rural percentages are startling because the FCC data shows that almost 30 percent of the homes in the rural parts of the county can buy 25/3 Mbps broadband. We find it likely that few, and possibly no homes outside the city area can buy broadband that delivers that speed. The FCC data is based up what is reported by ISPs, many which report marketing speeds (what they advertise) rather than the speeds delivered to customers.

How Does the US Rank with the Rest of the World?

Cable Company from the United Kingdom has been gathering data each year that compares broadband speeds and prices from around the world.

The most recent report on broadband speeds is from 2019.[12] The rankings are based upon many millions of speed tests, and 2019 average download speed for the US is based upon over 132 million speed tests. The US ranked 15th in the world in 2019 with a national average download speed of 32.89 Mbps which is behind countries like Taiwan, Singapore, Sweden, Denmark, Japan, Netherlands, Spain, Norway, Belgium, and others. The average speeds in the US have been increasing and was 25.86 Mbps in 2018 and 20.00 Mbps in 2017. During that time, the US climbed from 21st fastest to the current rank of 15th. The speed increases are largely due to upgrades in speeds in urban areas by cable companies, although there are also fiber-to-the-home builds in both urban and rural markets across the country.

[12] Broadband speeds around the world. https://www.cable.co.uk/broadband/speed/worldwide-speed-league/

Comparing San Juan County with the Rest of New Mexico

The broadband coverage in New Mexico varies more widely than any other state we've looked at. There are three counties in the state – Catron, Hidalgo, and Socorro – for which the FCC say there is less than 10% broadband coverage (with 3.1% coverage in Hidalgo County). At the other end of the scale, the FCC says four counties have in the state have over 95% coverage of 25/3 Mbps broadband – Bernalillo, Curry, Los Alamos, and Santa Fe, with Los Alamos showing 99.5% broadband coverage.

According to the FCC data, 64.8% of total homes in San Juan County can buy 25/3 Mbps broadband, that includes only 28.8% of rural households. Only 7 counties show a lower percentage of rural broadband coverage at 25/3 Mbps. The county with the closest similar rankings is San Miguel County. As mentioned throughout the report, the broadband coverage in the FCC report seems overstated for rural San Juan County, but it's likely overstated for much of the rest of the state as well.

The Gap in Broadband Affordability

The FCC reports that broadband adoption for the country is around 86%. Even after accounting for the rural areas that have no broadband option, there are many millions of customers that can get broadband at their homes, but that do not buy it. Numerous studies and surveys have asked people why they don't buy broadband when it's available. The number one reason that's always cited is price – people say they can't afford broadband.

Statistics on Affordability

In larger cities it's somewhat easy to equate broadband penetration rates to household incomes. This is because a Census block in a city might be as small as a block or two, and it's easy to match Census data to broadband data from the FCC.

An analysis of recent FCC 477 data shows that there is a direct correlation between household income and buying a home broadband connection. Only about half (53%) of households with annual incomes under $30,000 buy broadband. This contrasts sharply with 93% of homes with incomes over $75,000 buy broadband. There is no clearer evidence that there is an affordability gap for broadband.

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.[13] The second report is issued by the Quello Center and is authored by Bianca Reisdorf.[14] 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 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

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

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

for getting broadband into homes without it is going to have to involve finding a way to pay for the monthly broadband access.

Such studies have little direct correlation to rural locations since the areas with broadband are generally relatively small. The fact that Farmington has a cable provider is due more to the density of homes (meaning it's more affordable to build a network there) than it is to the incomes of people that live inside and outside of the city. With that said, there is still always a direct correlation in that homes with low incomes have a lower penetration of broadband when it's available to everybody – it's just not something that can be easily mapped in a rural community.

Comparing US Broadband Prices to the World

Cable Company of the United Kingdom also tracks broadband prices around the world. The most recent comparison of prices is from 2020.[15] The average price of broadband in the US in 2020 is $50. It's worth noting that these prices were gathered from advertised prices, and most big ISPs in the country advertise temporary special prices that expire after a one or two-year period. The price also doesn't include the cost of a modem or WiFi router. The average price of the US ranks as the 119th most affordable out of 206 countries. However, it's worth noting that most the countries that are more expensive than the US are either third world countries or island nations. The few exceptions of first world countries that are more expensive than the US are New Zealand, Norway, and Switzerland.

In that same report, the US looks better when looking at advertised prices compared to advertised bandwidth. In that comparison the average cost per megabit of speed in the US is $0.26, placing the US 27th in terms of affordability. However, we know that many ISPs advertise speeds that are faster than what they actually deliver – but this may be true in other countries as well. We also know that many ISPs in the US charge prices to many customers that are higher than advertised prices. The real price of broadband in the US is higher than is shown in this analysis.

Broadband Prices in the County

Earlier in the report we discussed the prices for CenturyLink, Comcast, and the various WISPs.

ISPs Bridging the Price Gap

Federal Lifeline Program

CenturyLink participate in the FCC's Lifeline program that is part of the Universal Service Fund. With the program a customer can receive a discount in New Mexico of $9.25 per month off a telephone bill a broadband bill for qualifying customers. The program works by the telephone companies providing a discount to customers and the FCC then reimburses the companies for the discount. This means it costs the telephone companies nothing to offer the discount – the discount is funded by the FCC.

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

[15] Broadband prices around the world. https://www.cable.co.uk/broadband/pricing/worldwide-comparison/

recently established a web portal where participating carriers can check the eligibility monthly of households to meet one of the above tests.

CenturyLink doesn't aggressively pursue giving this discount to eligible households – but they will enroll anybody that qualifies and who asks for the discount.

Comcast Internet Essentials

Comcast has a low-income program called Internet Essentials that provides broadband to qualifying households. Comcast delivers 10 Mbps download speeds for $9.95 per month. The program was created as a condition by the FCC for its 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 announced that it had connected over 8 million people to the Internet with the program (not sure how that translates into households).

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, on online safety and security, on 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 currently families participating in Medicaid; live in public housing; who participate in SNAP, TANF, SSI, National School Program, Headstart, LIHEASP, or WIC; are attending college under a Pell grant; receive a VA pension; or receive various kinds of tribal assistance.

FCC Modifies the Lifeline Program

In November 2019, the FCC announced major changes to the Lifeline program.[16] These rules make it harder for some companies to participate in the program, but it opens up the door to many new participants.

The FCC has obsessed for years about fraud in the program. There are numerous cases over the years of the program providing Lifeline subsidies to people who are no longer eligible or who had died. However, a lot of that blame must be placed on the FCC. Carriers have never had any ways to know if a Lifeline participant gets a job and or is no longer eligible. The FCC has finally taken the steps to fix such problems through the creation of the National Lifeline Eligibility Verifier – a database updated monthly by government agencies that provide the support that makes participants eligible.

The following new rules are lifted directly from the FCC, which says the new rules will improve the program by:

- Prohibiting participating carriers from paying commissions to employees or sales agents based on the number of consumers who apply for or are enrolled in the Lifeline program.
- Requiring participating carriers' employees or sales agents involved in enrollment to register with the program administrator, the Universal Service Administrative Co. (USAC).

[16] New FCC Lifeline Rules https://docs.fcc.gov/public/attachments/FCC-19-111A1.pdf

- Strengthening prohibitions barring Lifeline providers from claiming "subscribers" that are deceased.
- Taking additional steps to better identify duplicate subscribers, prevent reimbursement for fictitious subscribers, and better target carrier audits to identify potential FCC rule violations.
- Increasing transparency by posting aggregate subscribership data, including data broken out at the county level, on USAC's website.
- Increasing transparency with states by directing USAC to share information regarding suspicious activity with state officials.
- Restoring the states' traditional role of designating carriers to participate in the Lifeline program.

The last bullet point highlights an opportunity for ISPs that want to participate in the program. For the last several years it's been exceedingly difficult for an ISP to enter the Lifeline program. During that same period, we've seen big telcos like AT&T withdraw from the plan in most of the states where they operate.

An ISP that wants to offer a low-price broadband product for low-income households can collect the Lifeline subsidy to offset price discounts. For example, an ISP could offer a low-income broadband connection and collect $9.25 Lifeline subsidy from the Universal Service Fund and the rest of the bill from the customer. The Lifeline funds are paid directly to the ISP from the Universal Service Fund.

More importantly, ISPs now can apply to become eligible for Lifeline with state regulators rather than from the FCC – which has been blocking new applications for several years.

The Computer Gap

One of the things that digital inclusion advocates have learned is that it's not enough to get affordable broadband to a home if they can't afford a computer or other devices to use the broadband. It's also now clear that cellphones 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 Pew Research Center in 2019 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	56%	81%	94%
Smartphone	71%	85%	97%
Desktop	54%	83%	94%
Tablet	36%	55%	70%
All the Above	18%	39%	64%

Other studies have shown that the percentages of homes that have any these technology tools shrinks significantly for homes making under $25,000 per year.

A big problem 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 have to be replaced every 3 or 4 years.

The above numbers highlight the problem of getting broadband into low-income homes – a solution is needed for both broadband and for a computer. As will be discussed below, low-income homes also often need computer training.

The historical solution to lack of computers was to put computers in libraries and public places. However, in communities like the rural parts of the counties, this solution is inadequate for many reasons. First, it requires students to travel to where the computers are. In communities where a lot of students don't have computers it's difficult to have enough 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 compared to 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 part of daily life and convenient to use when needed.

We can't forget that computers aren't only for students. Adults need computers today just 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 employees to work from home. Computers are needed today to interface with many government programs.

There are a number of different approaches that communities have tried to solve the computer gap that will be discussed below in the section talking about solutions for the digital divide.

The Gap in Broadband Skills

The current US job market appears to be robust due to the low unemployment rate, which is low by historic standards. However, a closer look at the statistics tell a different story.

Workers with upper income jobs are faring extremely well. For example, starting jobs for new computer, engineering, and similar tech graduates are at an all-time high. It's a good time to be a high-tech worker. However, 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). These 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 rather than need people 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 other expected tasks in the average workplace.

In the early days of the computer age the federal government operated many training programs that taught the basic computer skills. Today it seems to be 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. Since the federal and most state governments don't offer any significant training programs in computer literacy, it's up to local communities to find their own solutions.

I talked to Deb Socia who heads the Enterprise Center in Chattanooga, Tennessee. This is a nonprofit that is looking for ways to solve the digital divide in the city. Chattanooga is a city that has invested in broadband and offers gigabit broadband on fiber to every resident of the city. However, like in all cities they found out that low income homes couldn't afford the broadband, didn't have computers, and didn't have the digital skills needed to use a computer. The Enterprise Center began offering basic computer training a year ago and was overwhelmed by the huge number of people who wanted basic training. The Enterprise Center is now looking for ways to greatly expand the training to meet the demand.

A Pew Research Center survey in 2016 showed that a lot of adults were interested in digital training. 60% of adults were interested in learning how to use online resources to find trustworthy information. In today's world of misinformation, I would think that percentage is even higher today. 54% of adults were interesting in training that make them more confident in using computers and the Internet.

Future Broadband Gaps

The Future of Broadband Speeds and Capacity

This gap analysis so far has discussed 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 broadband speeds are a moving target – that is, 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 nearly the same rate since the early 1980s. Home and business need for bandwidth has been doubling every three to four years since then.

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 nearly twenty times faster than dial-up, and many people thought that speed would be adequate for many years. However, over time, households needed more speed and the 1 Mbps connections started to feel too slow and 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 the cable companies have captured the lion's share of the market by offering internet speeds starting between 100 Mbps and 200 Mbps.

Bandwidth requirements are continuing to grow. Firms like Cisco and Opensignal track speeds achieved by large numbers of households by examining Internet traffic that passes through the major Internet POPs. Both companies estimate that home internet need for bandwidth downloading as well as the need for broadband speeds are growing currently at about 21% annually. Business use of bandwidth is currently growing at 23% annually.

This report earlier discussed how the FCC set the definition of bandwidth in 2015 at 25/3 Mbps. If you accept that speed as an adequate definition of bandwidth in 2015, then growing the requirements for speed every year by 21% would result in the following speed requirements by year.

2015	2016	2017	2018	2019	2020
25	30	37	44	54	65

This is somewhat arbitrary because it assumes that the broadband needs in 2015 were exactly 25 Mbps. For example, if the actual broadband need for the average household in 2015 was 22 Mbps, then the predicted speed for 2020 would be 57 Mbps. What is not arbitrary is that the need for bandwidth and speed increases over time.

If we accept the premise that 25 Mbps was the right definition of broadband in 2015, then it's reasonable to believe that the definition of broadband today ought to be at least 50-60 Mbps. That would infer that there is a broadband gap today for any customer who can't buy 50-60 Mbps broadband.

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 by households using software deployed by the biggest ISPs around the country and around the world. They recently announced that the average US household in in the fourth quarter of 2019 used 344 gigabytes of data per month (downloads and uploads combined). That number leaped from 275 gigabytes in 2018 and 215 gigabytes in 2017. Further, OpenVault says that the average cord-cutting household now uses over 520 gigabytes per month – a number that would have floored any network engineer a decade ago.

These various statistics infer that the FCC should be periodically increasing the definition of broadband. The agency looked at broadband speeds in a docket in 2018 and concluded that they were going to keep the definition at 25/3 Mbps. However, there was a lot of compelling filings in that docket that argued that the definition of broadband should be 50 Mbps to 100 Mbps.

The point of this section of the report is that we can't get hung-up on the FCC's definition of broadband when looking at the broadband gap. Practically every home that uses 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 into the future when considering broadband needs for San Juan County. 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. This applies the same 21% annual growth rate for bandwidth demand that we're currently seeing. Forward predictions are always criticized for being too aggressive, but when considering that the need for broadband has been growing at roughly the same rate since 1980, it's not a big stretch to predict broadband needs into the future.

2020	2021	2022	2023	2024	2025	2026	2027
65	79	95	115	139	169	204	247

It's not hard to put this prediction into perspective. Cable companies that serve over 60% of all broadband customers in the country already provide minimum speeds today of between 100 Mbps and 200 Mbps.

That speed varies a bit by market due to the condition of local coaxial networks. But in markets where the coaxial cable in in good condition, big ISPs like Comcast and Charter provide 200 Mbps broadband today as the target speed for their introductory broadband product.

The above chart suggests that by 2027 (or some year close to then) that the Comcast 200 Mbps product will start to feel sluggish to many households. Comcast has unilaterally increased speeds over the years and it would not be surprising to see them increase the basic speed again before 2027. The company seems to have a policy to stay in front of the demand curve. I'm sure this greatly cuts down on complaints and customer service issues. If the cable companies are staying ahead of this curve voluntarily, it raises the question of why the FCC isn't keeping up with the events in the marketplace.

It's not hard to imagine that seven years from now that the national definition of broadband ought to be around 250 Mbps. That doesn't mean that the FCC will continue to increase the regulatory definition. In 2018 the FCC rejected numerous filing asking them to increase the 25/3 Mbps definition. There is a political downside if the FCC increases the definition of broadband – it would reclassify numerous homes as not having broadband. Today the 25/3 Mbps definition of broadband is lower than the reality of what many homes need, but my guess is that there will have to a big difference before an FCC will react and change the definition.

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 of the next decade. The only technologies capable of that are fiber-to-the-premise, cable company hybrid-fiber networks, and some wireless technologies using millimeter wave spectrum that are just now being trialed in a few markets.

The FCC and state governments should not support grants, or in other ways promote technologies that can't meet the expected future broadband needs. Any gap analysis needs to consider future needs and not just the speeds used by households today.

Section II. D. of this report looks at the existing technologies in place in San Juan County today, at how those technologies might improve in the future, and at other expected technologies we are likely to see introduced in the not-too-distant future.

The point that should be taken from the lengthy discussion on technology is that any technology built in San Juan County today should be ready to handle today's broadband needs as well as the expected broadband needs of the future.

The Consequences of the Broadband Gaps

There was a time when academics theorized about the impacts of poor broadband. We don't need to theorize today because you can go to any rural community with poor broadband and residents and businesses will fill your ear with stories of the negative consequences of having poor broadband. The problems with lack of broadband just got magnified due to the COVID-19 crisis.

Impact of Poor Broadband for Citizens

Lack of good broadband causes major problems for rural homeowners:

- Lower Property Values: There are numerous studies showing 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. From everything we hear it is now difficult to attract people to move to rural places that don't have good broadband. That is a big negative for the small towns without good broadband. Without a broadband solution, the rural parts of San Juan County will become undesirable places to live, and this is only going to get worse over time as broadband speeds keep increasing in the places that have broadband.

- Education: The concern for the schools is that they are unable to send computer-based work home with students since they know that many of them don't have good home Internet. It's incredibly hard to raise kids today 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 inadequate for doing homework. The same is true with cellular data; we have heard horror stories of people with kids ending up with astronomical broadband bills for using broadband from cellphone hotspots for homework.

  Schools want students to be able to use broadband outside the school. 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 video in class. The whole education process is increasingly moving to the web and kids without access to the web are lacking the tools that their peers take for granted.

  There was a major study performed to look at what is being called the homework gap by the National Center for Education Statistics (NCES),[17] an agency within the US Department of Education. 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 testing for mathematics, students with a computer at home scored 285, while those without 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 score 152, compared to 128 for students without a home computer.

  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 now can be achieved mostly online. Online training courses require decent broadband speeds, but also low latency since the training is usually done in real time.

[17] https://nces.ed.gov/pubs2017/2017098/index.asp

The COVID-19 crisis has highlighted the need for good home broadband for students since in many places in the country both K-12 and college students were sent home to complete the school year online. This has instantly created a crisis in rural homes outside of Farmington that don't have enough broadband to allow students to successfully do schoolwork 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 connection of bandwidth that is carved out of the Internet path and that remain live 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 of the types of broadband available in San Juan County have much smaller upload speeds that download speeds and even homes with adequate download bandwidth might not be able to establish a VPN connection due to the inadequacies of the upload path.

Many school systems are trying to recreate the classroom feel using videoconferences where a teacher and all of the students can see each other. That requires a 2-way video connection that can use a 1 – 3 Mbps connection for both upload and download. Students without good home video are not going to be able to participate in this kind of remote classwork.

Both VPN connections and video conferencing require reasonable latency (delay) to maintain a connection. This makes it nearly impossible to make either kind of connection reliably over satellite broadband – one of the more common kinds of rural broadband connection.

Doing schoolwork from home is also going to use a significant amount of bandwidth during a month, and that raises the issue of data caps and data overage charges. Both satellite broadband and cellular broadband have small data caps – and all data usage about the data caps can be expensive. We talked to one home in San Juan County who had cellular bills as high as $500 to support two kids that are homeschooled. That size of bill is going to shock homes that suddenly have students doing schoolwork from home.

- Working at Home: More and more jobs today can be done at home, 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. Many of your residents could find work that would allow them to work at home and to make a larger income than they can make today locally – if they have great broadband. 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 early March. Across the country employees that live in rural areas were 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 work connecting to school WANs. Working at home is also coming to mean connecting by video conference with others 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.

Both VPN connections and video conferencing require reasonable latency (delay) to maintain a connection. This makes it nearly impossible to make either kind of connection reliably over satellite broadband.

What's become painfully obvious due to the coronavirus crisis is that homes need more than the ability for a student to do homework or a person to work from home – because many homes have multiple students and possibly also more than one adult all trying to function on the Internet at the same time.

- Medical: We are finally starting to see a big uptick in the use of telemedicine. This is the process of using broadband to connect patients to specialists without having to make the long drive in for an appointment. Patients can talk to doctors using a video connection if the home has adequate broadband. The biggest benefit of telemedicine is being able to talk to a specialist without having to make a long trip to some distant city.

  One of the best uses that has been found for telemedicine is for administering 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 readmission rates of patients after surgery by 44%. CoBank recently sponsored a trial in Georgia for rural diabetes patients and showed a significant improvement for patients who could be monitored daily and who could communicate easily with doctors.

  The coronavirus crisis has highlighted the need for telemedicine. Doctor's offices and clinics all across the county have shifted some of their office "visits" to video meetings on Zoom or other video platforms in order to reduce contact between doctors and patients when it can reasonably be avoided. There have been widespread reports that some doctors are requiring video connection for all non-emergency visits. Councilors and mental health workers also report to largely migrating most, or even all contacts with clients online. It's immediately become clear that patients without home broadband or without a strong cellular signal can't make the needed video connection. There is a lot of speculation that video meetings and telemedicine are going to become mainstream by the end of the coronavirus crisis, once doctors understand how effective it can be in many cases.

- Taking Part in the Modern World: People with good broadband have access to features of the web that require bandwidth. Households with good bandwidth routinely use broadband for things like watching videos on services like Netflix, talking to friends and family on services like Skype,

playing video games (many of which have largely moved online), taking online courses from numerous colleges, or even just browsing today's video-rich Internet. Many of the businesses people now interact with (utilities, insurance companies, shipping companies, etc.) assume that people have a broadband connection. Many people's social lives, for better or worse, have moved to the web; it is not uncommon to now have friends all over the country based upon some shared interest instead of based upon geographic proximity. Homes without broadband can't participate in any of these 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 have files automatically backed-up in cloud storage. Numerous appliances and devices in our home periodically connect with the cloud wither providing updates or just to make sure that the connection is still live. Many cars now communicate with the cloud when they get into range of a home broadband connection to provide status of all car sensors and to upload driving data that can later be used by the car owner. Cisco predicted early this year that this traffic would represent over 50% of all the traffic on the web by 2023.
- Online Everything. Many of the functions we do have migrated to being only online – we couldn't even begin to make a full list of things that are largely now online. This includes both major and minor functions including things 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.

- 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 home, and so large percentages of each graduating class migrate to larger cities and towns to pursue careers. One of the promises of fiber is the ability to create new jobs and to also 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.

Impact of Poor Broadband for Businesses

There are numerous consequences of poor broadband for businesses. While some businesses have unique and specific requirements, there are a number of problems caused by poor broadband that affect most businesses.

Impact on Day-to-day Operations. Just like with households, most businesses are seeing their broadband needs growing rapidly year-over-year. Each one of the following routine business functions requires

decent bandwidth. Businesses without adequate bandwidth must forgo or compromise on how they communicate with the world and function day-to-day.

- To Communicate with Customers. Businesses routinely have portals that make it easy for customers to place and track orders and to communicate the with business. Inadequate broadband means lower sales. The old days of calling purchasing agents are slowly passing behind us and most commerce between companies is becoming automated – which improves accuracy and speeds up the ordering process. Businesses that operate busy ecommerce ordering sites need big amounts of bandwidth to make sure that all customers have a successful purchasing experience. A concern in the rural parts of the county is that many businesses report that their broadband is not even sufficient enough to consistently process credit card transactions. That requires almost the bare minimum of bandwidth, which speaks volumes about the quality of rural broadband in San Juan County. Businesses in the County report that they are unable to maintain ecommerce web sites for selling goods or services, taking customer reservations, or other routine functions necessary to conduct routine business.
- To Communicate with Vendors. Businesses also routinely use the portals of their own vendors to buy whatever they need to operate.
- To Communicate with Other Branches of the Company. Many businesses are now part of larger corporations and maintain open data connections to communicate with other parts of the company and with headquarters.
- 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, or Microsoft or it can be a private cloud available only to employees of the business. This is the change in the ways that companies operate that has probably created the most recent growth in bandwidth. A business doesn't need to be highly sophisticated to work in the cloud. Today banking is routinely done in the cloud. A lot of basic software like Microsoft Office has migrated to the cloud. Even interfaces with local, state, and federal governments has migrated to the cloud.
- Security Systems. Businesses often have their network and computer security monitored by offsite firms. Security today also means the use of video surveillance cameras, which require upload video streams to be viewed outside of the business.
- Sending and Receiving Large Data Files. Most businesses report that the size of data files they routinely transmit and receive have grown significantly larger over the last few years. Some surprisingly small businesses like photographers, architects, engineers, and others routinely want to send and receive big data files.
- VoIP. Many businesses now provide the voice communications between their various branches using Voice over IP. A reliable VoIP system needs to have dedicated bandwidth that is guaranteed and 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 both inside and outside the business. We saw a huge surge in this during the COVID-19 crisis as students and employees increasingly used video conferencing services, but these services had already become routine for businesses before the crisis. Another specific concern in San Juan County is that rural broadband is so poor that tourists visiting the county are routinely unable to upload videos of their activities, which locks tourism destinations in the county from social media coverage.
- Email and Advanced Communications. 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. These services require good download and upload bandwidth.

- Supporting Remote Employees. Many businesses now save money by allowing employees to work from home full or part time. They need reliable broadband links to provide home-based employees the same access to systems that are on site. A complaint heard often by rural businesses is that they must physically carry files to their homes or other places with good broadband in order to conduct routine business.
- Data Back-Up. 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. Data backup requires a steady and reliable upstream broadband connection.
- Internet of Things Sensors. Companies of all sizes now routinely use devices that include sensors that communicate with the Internet. One common function of this sort are burglar alarm systems that monitor physical security and sensors inside equipment that monitors data security. Routinely used office equipment like printers, copiers, postage machines, and many others only function correctly when connected to the Internet.

Entrepreneurship. The fastest growing parts of many local economies is the growth of small business, many which start in the home. Small businesses often begin with a few employees and grow over time as they succeed. Start-up businesses generally are highly reliant upon good broadband. Lack of adequate bandwidth and reliable broadband connections means that small businesses have a difficult or impossible time starting in rural parts of the county.

Agriculture/Other Industries. Every industry has specific requirements for broadband. Perhaps the easiest way to demonstrate this is to talk about how broadband is transforming one specific industry - agriculture. A similar list can be made of the specific uses of broadband for numerous other industries.

- The most data-intensive farming application is the creation of real-time variable rate maps of fields. Farmers can use smart tractors or drones to measure and map important variables that can affect a current crop like the relative amounts of key nutrients, moisture content, and the amount of organic matter in the soil. This mapping creates massive data files that are sent off-farm. Expert agronomists review the data and prepare a detailed plan to get the best yields from each part of the field. The problem farms have today is getting the data to and from the experts in a timely manner. Without fast broadband, the time required to get these files to and from the experts renders the data unusable if the crop grows too large to allow machines to make the suggested changes.
- Using sensors for monitoring livestock is the most technologically advanced area and there are now dairy farms that measure almost everything imaginable about each milking cow. There are also advanced sensor systems monitoring pigs, chickens, egg farms and other food animals. Ranchers that have good cellular data coverage over range areas can track the location of every member of their herds.
- There has been a lot of progress in creating self-driving farm implements. These machines have been tested for a few years, but there are not a lot of farmers yet willing to set machines loose in the field without a driver in the cab. But the industry is heading towards the day when driverless farming will be an easily achievable reality. Smart devices have moved past tractors and now include things like automated planters, fertilizer spreaders, manure applicators, lime applicators, and tillage machines. Machinery now comes with sensors that will alert a farmer of a problem and can even automatically order a replacement part before a working machine fails.

- One of the more interesting trends in farming is to record and report on every aspect of the food chain. When the country stopped eating romaine in late 2018 because of contamination at one farm, the industry started to develop a process where each step of the production of crops is recorded, with the goal to report the history of food to the consumer. In the not-too-distant future, a consumer will be able to scan a package of lettuce or other crop and know where the crop was grown, how it was grown (organic or not) when it was picked, shipped, and brought to the store. This all requires creating a blockchain with an immutable history of each crop, from farm to store, and making this history immediately available to stores and to consumers.
- The industry has been developing soil sensors that can wirelessly transmit real-time data on pH, soil moisture, soil temperature, transpiration, etc. These sensors are still too expensive today to be practical – but the cost of sensors is expected to drop drastically with sales volumes. Research is even being done to create low-cost sensors that can measure the health of individual plants in orchards and similar environments.
- The smart farm today measures an immense amount of data on all aspects of running the business. This includes gathering data for non-crop parts of the business such as the performance of vehicles, buildings, and employees.

Economic Development and Jobs. Reliable and affordable broadband is still one of the key elements in traditional economic development to lure new companies to a community or to keep existing companies from leaving. As vital as broadband is to residents it's even more vital to businesses.

Businesses want more than just fast broadband. They often require multiple feeds of broadband from different ISPs, on diverse routes to guarantee that they don't lose connectivity.

Many businesses now want their employees to have broadband at home so that they can work from home as needed while gaining access to data in company servers. A new business will consider the whole broadband profile of an area before deciding to locate there. There are numerous municipal fiber ventures that claim significant economic benefits from fiber networks they've built. Many of them have been able to lure new businesses or have seen existing businesses expand.

II. ENGINEERING DESIGN AND COST

This section of the report looks at the engineering and technical issues involved with estimating the cost of providing a fiber broadband to all of the business and consumer locations in the Farmington Electric Utility System service area.

A. Existing Provider Analysis

Our analysis started with field reviews in the FEUS service area by Jason Kilmon and Dan Carter of Finley Engineering. Finley's field review had two goals. First, we wanted to understand the broadband that was available today from the incumbent providers. Finley made an extensive drive through the FEUS service area and identified existing infrastructure that supports broadband. This meant looking at the various electronic sites supporting broadband in the CenturyLink and Sacred Wind telephone networks and fiber and cable nodes in the Comcast cable broadband network. Finley also reviewed sites deployed by a competitive fiber provider and several wireless ISPs.

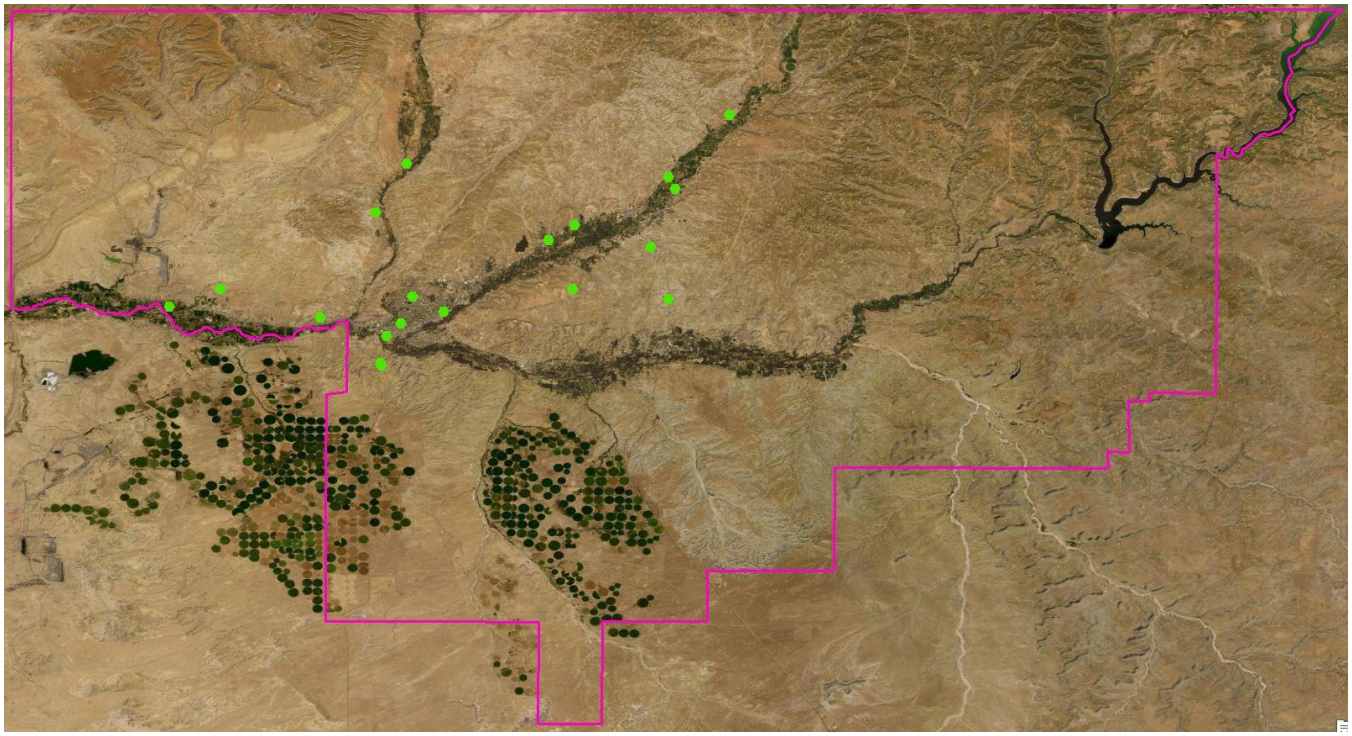
Finley's second was to estimate the cost of building a new fiber network, and that effort is described in Section II.B. below.

CenturyLink

CenturyLink is the incumbent telephone company in most of the FEUS service area where they predominantly have deployed copper-based DSL equipment capable of providing basic internet capability.

In our review we discovered the sites from which CenturyLink deploys DSL technology. The first thing we noticed was that in many areas that CenturyLink was still deploying older technology that is not capable of delivering the advanced broadband required by consumers in 2020. We believe the DSL platform in many rural areas is only capable of providing a maximum of 10/1Mb broadband in ideal conditions. Even then speeds that fast would only be available within 5,000 feet of street miles from a CenturyLink central office (C.O.) or field equipment cabinet. Customer residing at greater distances than 5,000 feet would get much slower speeds.

The green dots on the map below show the locations of CenturyLink remote DSL hubs we are able to identify in our review. We know this is not all the CenturyLink remote locations in place, but we do feel this sample is representative of the deployments CenturyLink has made in the FEUS service area.



Some of the hubs found by Finley use an old technology called HDSL. This technology was used in the early 2000's for some of the first-generation deployment of DSL. We are uncertain if this equipment is currently in service for end-user services or to provide backhaul bandwidth to serve the DSL site. If HDSL is used for backhaul purposes, then broadband speeds from the hubs would be very limited. We expect CenturyLink is still using DSL for backhaul because in some of these locations there were no markers to indicate the presence of fiber.

In some instances, there is fiber backhaul to DSL sites. We observed optical transport equipment that indicated that the speed of the backhaul route is likely not larger than an OC3 (155 Mbps). That would be the maximum total bandwidth available to the neighborhood, but even that assumes that electronics are fully populated with circuit cards to support voice, broadband or voice/broadband services. We've seen many other CenturyLink sites where only a portion of circuit cards are installed, meaning the neighborhood is fed by a small amount of bandwidth.

The amount of backhaul bandwidth is a major factor in the speeds of broadband that can be delivered to a customer. For example, if a DSL site is fed by a full 155 Mbps, then during non-busy times when there are only a few customers using that network in the neighborhood the speeds would be as fast as allowed by the last mile conditions. But when more customers use the network, the speeds get diluted – for example, this network would bog down if 100 or more customers in an evening were watching video and using the network. A 155 Mbps connection would get easily overwhelmed by a whole neighborhood of modern Internet users.

Another issue that negatively affects customer DSL speeds is the condition and age of the copper wires that extend from DSL equipment to the customer location. We observed old copper that was placed many decades ago by Qwest, US West, or even Mountain Bell which is still operating today. Older copper wiring, especially when not maintained can significantly impair the performance of DSL broadband due

to the ingress of noise from other services in the copper cable, the leaking of energy from copper pairs in a cable, ground issues which originate from cracks in the older plastic covering the copper pairs of wire, and grounding issues of the entire copper cable in telephone pedestals and cabinets.

We did not find any newly deployed broadband equipment at CenturyLink sites. Many of the areas we examined were in areas where CenturyLink had taken money to upgrade all customers to speeds of at least 10/1 Mbps. Those upgrades were to be done over six years and finished by the end of 2020. We just made our observations in October and there was zero evidence of upgrades made to meet CAF II requirements.

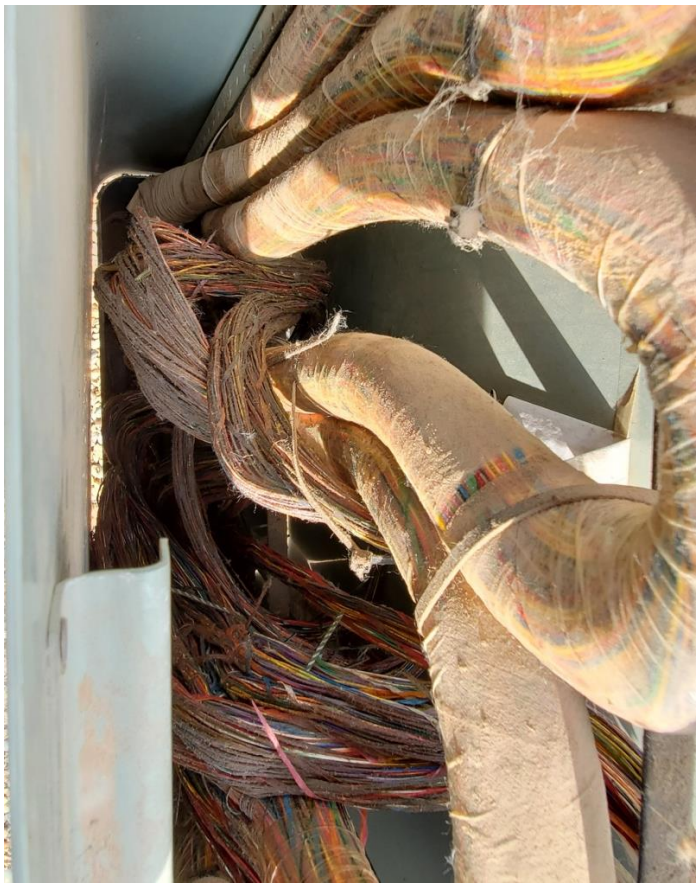
In fact, after looking at the age of the electronics, the type of backhaul being used, and the general degraded condition of the copper wires, it's the opinion of Finley that that there are neighborhoods where it's unlikely that the speed could be any faster than 1 Mbps. This was verified by the speed tests taken by the public for the project that showed numerous CenturyLink customers receiving speeds under 1 Mbps.

Earlier in the report we show maps of the speeds that CenturyLink reports to the FCC. The company reports a mix of speeds in various areas: less than 10Mb, 10Mb thru 25/3Mb and of greater than 25Mb in different segments of the FEUS service area. Our field observations are that we saw many examples where we don't think those speeds could be achieved with the electronics used and the conditions of the copper wiring we observed.

Below are several pictures of the CenturyLink installations with brief notes explaining what is in each image.

CenturyLink Remote Site with older HDSL Technology. At this location we did not note the presence of fiber optic cable markers; this leads us to believe that this remote may not have fiber backhaul facilities.

CenturyLink remote site with fiber backbone. Note the remote installation of this remote cabinet; if the cabinet is equipped with VDSL equipment it may be possible to provide 50/10Mb broadband for very short distances (< 1,000') with fallback speeds of 25/3Mb broadband to 3,500'. Speed after 3,500 feet get progressively slower with the distance between this site and a customer. CenturyLink can use the capability of this site to claim fast coverage for several Census blocks, but in reality, only customers in very close proximity to this site could get decent broadband. Note that this site is not close to homes.



The above picture is of a copper cable pedestal. This is a box that gives technicians access to the copper wire. Note the dust and material on the copper cables. The dust and material on the copper wires can degrade the plastic coating which allows moisture to interact with the copper wires. Over time this leads to corrosion and allow for leakage of the phone/internet electrical signals which results in poor phone conversations and degraded broadband service.

This DSL site includes electronic equipment and a copper cross-connect installation. This site has legacy HDSL/T1 transport equipment and also has fiber backbone connectivity. This site is located near to homes, meaning nearby homes should be able to get decent DSL speeds.

This shows a legacy Qwest (now CenturyLink) cross-connect cabinet.

Copper cross-connect and copper pedestal fed by HDSL and may be used to provide low bandwidth (1 Mbps or less) to a limited number of customers.

Comcast

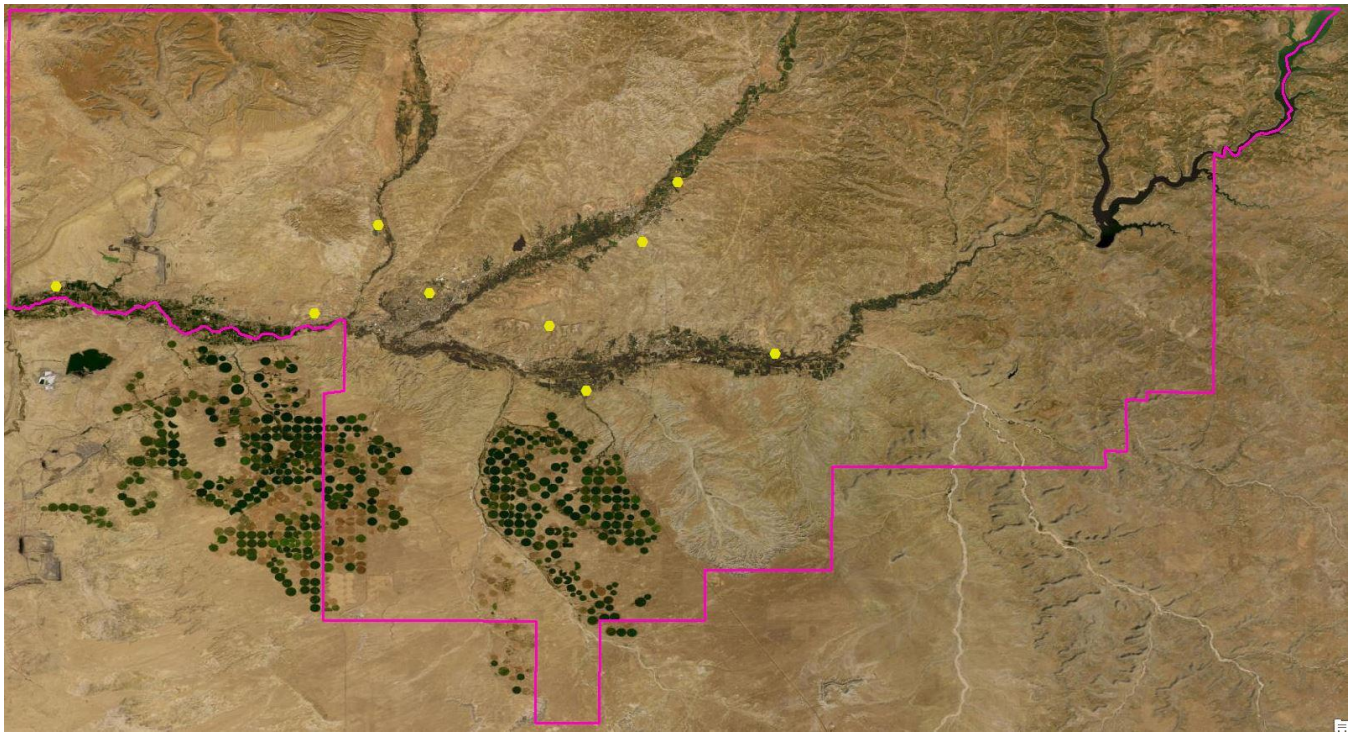
Comcast is the incumbent cable company serving the more populated areas of the FEUS service territory. Per our review, Comcast has made some upgrades to the coaxial cable system with a hybrid fiber/coax system. We observed some newer cable nodes in their system; a node serves a specific neighborhood and is the place that converts the signal from fiber to the coaxial cable used to carry signal to homes and businesses.

The speeds that Comcast reports to the FCC indicate that the entire system has been upgraded to the latest technology – DOCSIS 3.1. Comcast also makes this claim in nationwide press releases. However, our field review shows that the conversion and upgrade to full DOCSIS 3.1 has not been completed.

Our review found many fiber-fed cable node installations with older coaxial cable nodes and amps in place in very close proximity to the new cable nodes. This would indicate to us that Comcast still has multiple cable node that 'cascade' from one neighborhood to the next. The effect of serving multiple neighborhoods of customers in the cable cascades is that the available bandwidth is oversubscribed with too many customers, with the end result being lower broadband speeds and poor performance in peak times of usage.

Comcast also reports that they can deliver 987Mb/35Mb broadband in the area. However, the low upload speed claimed shows an imbalance between downstream and upstream bandwidth is a further indication that the local network has not been fully optimized for high performance broadband service.

The image below is the location of the Comcast cable node locations we were able to identify in our review. We think this sample is representative of the other deployments Comcast has likely made in the FEUS service area.



Below are several pictures of the Comcast installations with brief notes explaining each image.

This shows a Comcast fiber cable node (the box labeled as “alpha”) that is pole mounted and powered by FEUS electric meter located lower on the pole. Note the existing cable amplifier (on strand) located in in the top left of the picture. The older cable amplifier appears to be still connected to the coaxial network. An older amplifier means that the full capability of DOCSIS 3.1 isn’t being delivered to customers.

This is a Comcast buried coaxial cable amplifier and a tap for customer drops. A tap is the small device where customer drops are connected to the network. Note that the newer orange customer drops are connected directly to the tap and not routed through the base of the closure. That's an installation short-cut that can allow damage and degradation to the customer drop over time.

This shows a Comcast fiber cable node where the node does not appear to have any connection to the existing coaxial cable network and customers.

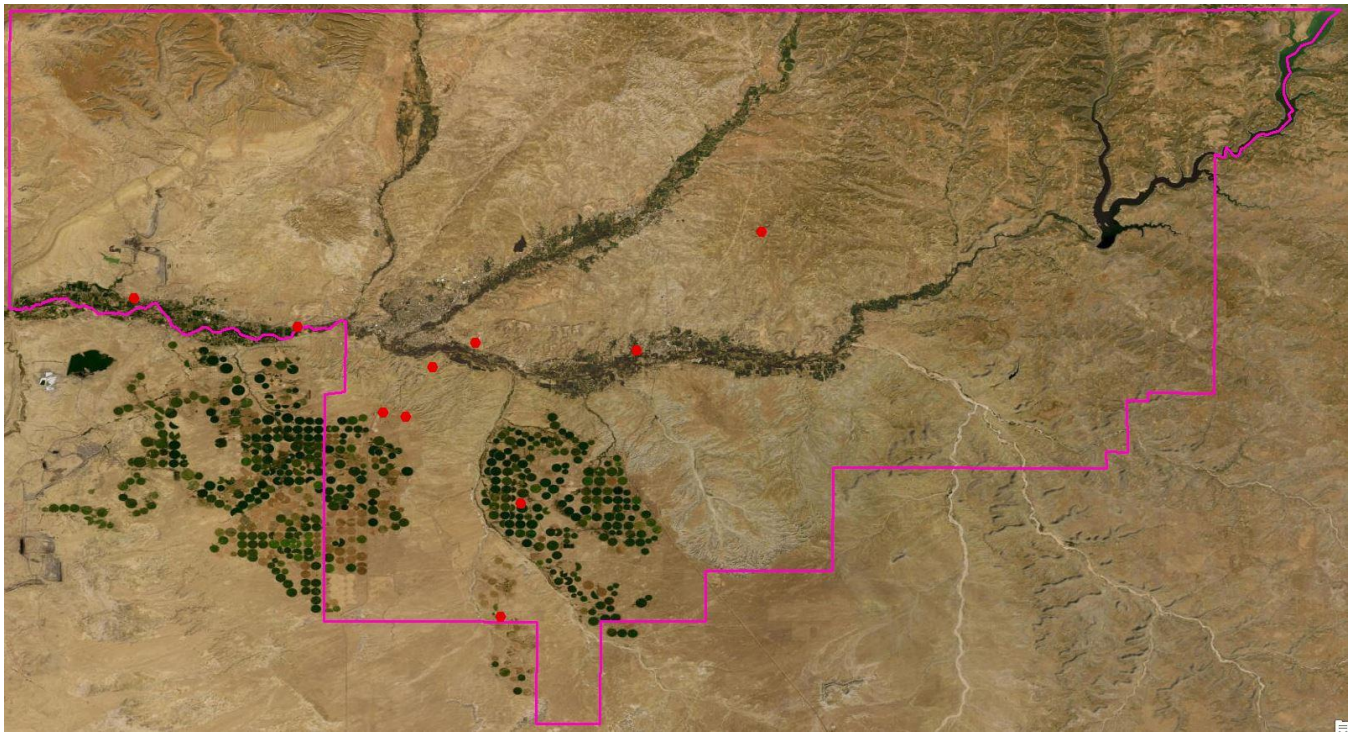
Sacred Wind

Sacred Wind advertises under the brand name Wi-Power and is a fixed wireless and wireline service provider in the southern part of the FEUS service area.

Inside the regulated telephone exchange service area, Sacred Wind has deployed a combination of fiber-fed equipment cabinets where they provide ADSL/ADSL2+ services with 25/3Mb broadband; there are a few locations where they have deployed fiber cable directly to Navajo Agricultural Products Industry (NAPI) locations and Navajo Nation critical locations.

In other locations Sacred Wind has deployed fixed wireless facilities capable of delivering broadband speeds up to 10/1Mbps.

The image below is the location of the Sacred Wind ADSL/ADSL2+ and fixed wireless locations we were able to identify in our area review for competitive analysis, we feel this sample is representative of the type of deployments Sacred Wind has made in the FEUS service area.



Below are several pictures of the Sacred Wind installations with brief notes explaining each image.

Sacred Wind ADSL/ADSL2+ remote location with fixed wireless backhaul radios included on the wooden H-frame.

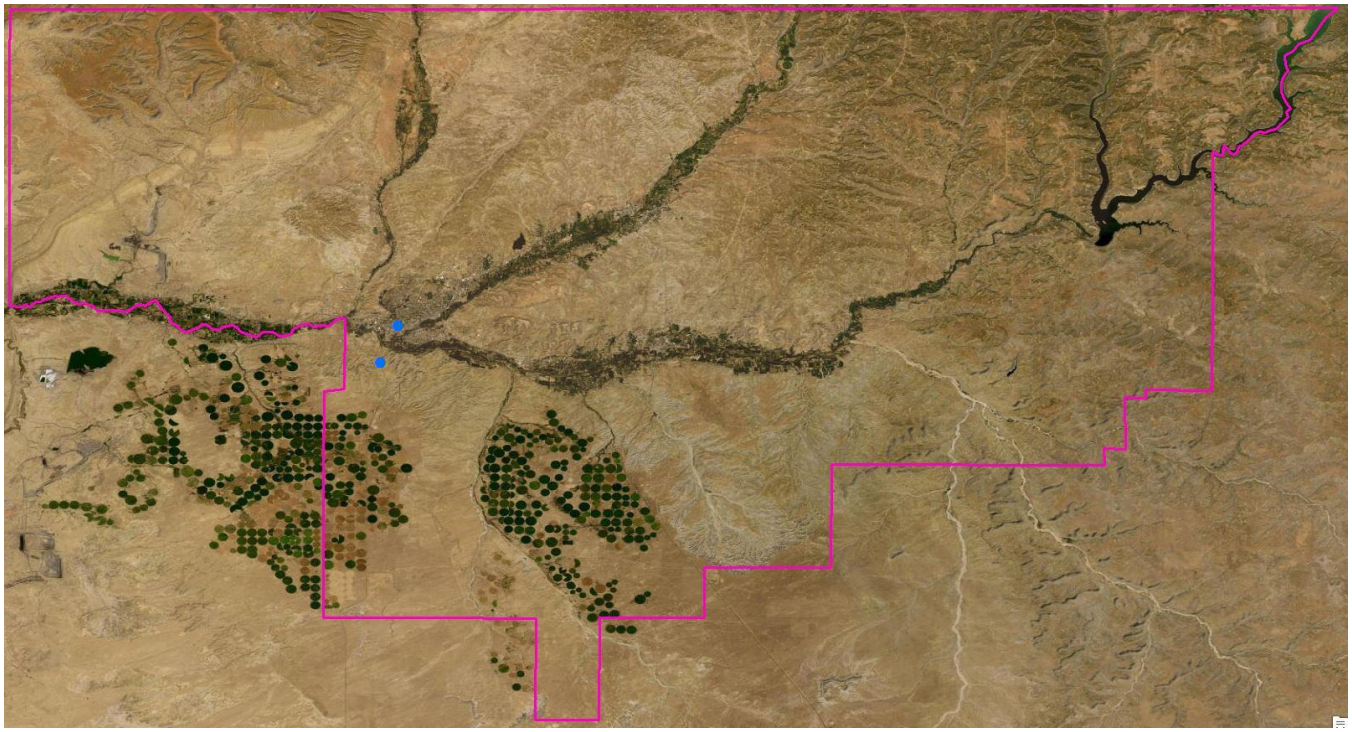
Sacred Wind fixed wireless compound, building, and tri-leg wireless tower to support backhaul and fixed wireless broadband service.

FastTrack

Fast Track is fiber transport and dedicated business service provider in parts of the FEUS service area. Fastrack has a fiber ring which traverses territory between Denver and Grand Junction, CO down through Durango to Farmington and Albuquerque and back to Denver.

While Fastrack does not offer residential services, they do offer broadband to some businesses in Farmington and can also provide another option for backbone internet connectivity to the area.

Below is an image of the Fast Track location we discovered and a picture of a Fast Track Point of Presence (POP) building.



Fast Track POP building installation. This building is where long range fiber transport and local fiber service equipment is located. Fiber terminations for transport and business services is also terminated in this structure.

Commnet and NTUA Wireless

Commnet and NTUA wireless are carriers with minor service coverage in the FEUS service area. While we were not able to locate standalone wireless assets for the providers, we did note locations on American Tower structures which contained fixed wireless equipment that probably belongs to these ISPs.

Based on the speeds reported in the FCC Form 477 and the description included on the ISP websites we conclude that both entities are providing fixed wireless broadband using older 900 MHz or 2.4 GHz line-of-sight equipment - with limited backhaul capabilities and internet backbone capacity. The level of internet service offered from these carriers would be considered basic broadband capable of supporting emails and some web browsing but would be challenged in providing the necessary bandwidth for any streaming content.

B. Network Design

Evaluating the Network Options

In our evaluation of the FEUS service area, we considered the application all potential terrestrial broadband network technologies. The two options that seemed worth considering were building fiber everywhere, building a fixed wireless network, or building a network that is a mix of the two technologies.

In evaluating the options, we considered the following criteria that are necessary elements of a broadband solution:

- Bandwidth capacity.
- Availability of funding source for the construction of a broadband network.
- Cost of the network.
- Expected lifecycle of each technology.

Our Thoughts on Wireless Technology

Finley considered the deployment of wireless technologies that could bring broadband to remote and rural customers. Today there are wireless technologies that can deliver a 25 Mbps broadband connection up to 6 airline miles from a tower. This technology places transmitters on tall towers and beams the signal to a small dish placed on customer homes and businesses. Customers living closer to a tower can get speeds as fast as 100 Mbps.

There are several different frequencies of radios that can be used for the wireless deployment by broadband providers:

- The primary frequency used for this technology today is WiFi. This is the same WiFi frequency used to deliver broadband inside homes. WiFi is really two frequencies – one at 2.4 GHz and another band at 5 GHz. Probably the biggest advantage of WiFi in this use is to use each frequency to serve different customers – matching each customer to the one that gives them the best signal.
- New radios also include the 3.65 GHz frequency that was recently approved for rural broadband by the FCC. There are several advantages of this frequency over WiFi. First, the channels in this frequency naturally allow for greater bandwidth delivery. The 3.65 GHz frequency handles trees much better than WiFi. But no frequency is perfect with foliage and some customers, particularly those farther away from the tower, might need to take some steps like cutting down trees to improve reception.
- There is another wireless technology that should become more widely available. The frequency is referred to as white space radio and uses the same frequencies that are deployed by UHF television channels (channels above channel 13). The FCC conducted an auction a few years ago that awarded some of this spectrum to cellular carriers, where TV stations offered their frequencies which were then sold in an auction to bidders. The frequencies were bought by the wireless carriers like T-Mobile and AT&T. Dish Networks also bought spectrum. The surprise buyer was Comcast, which is now entering the wireless business and has announced partnering with Charter to do so. For now, the FCC licenses white space spectrum for rural use by the market and by request, so the availability will depend upon an FCC decision.

Unfortunately, we do not feel that wireless technology is a good fit for your service area. The wireless path between a tower and a customer must be wide open without impediments, which in the industry is described as having line-of-sight. The wireless signals are disrupted by hills and the terrain and distance for very rural customers in the FEUS service area. There would likely be some customers that could be served from any given tower, but the technology could not deliver a broadband product to everybody (or even not to a significant percentage of households).

Additionally, each sector of a fixed wireless network has a limitation for the number of customers it can support in order to provide high bandwidth broadband. In the denser areas of the FEUS service area the

tower and installation requirements for the number of fixed wireless access points would be significant and while achievable we do not believe it meets the long term investment and service goals of FEUS.

Our physical inventory of FEUS shows that there are a few wireless providers using this technology in the area today, and the slow broadband speeds some offer show the futility of trying to deploy this technology over a wide footprint. All the research we did for this study show that most customers on the existing WISP networks are not seeing speeds any faster than a few Mbps.

After considering all the factors we elected to not quantify the use of wireless technology for the following reasons:

- The speeds on a wireless network would be an improvement over today, with speed varying between perhaps 25 Mbps and 75 Mbps depending on the distance a given customer resides from one of the towers.
- Because of the mountainous terrain, a fixed wireless network would have required the construction of a significant number of new towers. There would also be expensive construction to bring fiber to the new towers. The overall costs for a network to sufficiently cover everybody in the county looks to be excessively expensive.
- A wireless network would also require a significant fiber investment to connect the various towers and to also connect to a broadband backbone connection to the world.
- The expected lives of wireless assets are relatively short with the electronics lasting from 5 – 7 years before the need for replacement.
- It is also becoming increasingly difficult to find grant funding for wireless networks. Both state and federal grants are migrating to grant award systems that reward faster broadband speeds. We think it would be difficult to find grant funding to build the needed new towers and fiber backhaul.
- While the speeds on a wireless network would be sufficient for customers today, the gap analysis in this study shows that such a network would be perceived as obsolete within a decade.

After considering all these issues we elected to concentrate this study on building fiber everywhere. This is not to say that fixed wireless technology does not have a place in the broadband marketplace, but we don't think it would be worth the high one-time investment needed to build a robust wireless network.

Network Design

The engineering study looks at building fiber to pass every home and business. Fiber broadband networks have been around as an end user delivery platform since the late 1990s. The Fiber-to-the-Premise (FTTP) technology that is currently in the marketplace has been around for over 15 years and the technology is now mature and widely used around the world.

The design of fiber networks and the associated electronics are fairly straightforward, but every network 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 fiber provider. Below is a description of the major component of a FTTH network and a discussion of the factors which influenced our design decisions for the network.

There are two primary types of fiber electronics used in FTTH networks – passive and active. Finley chose a passive network for several reasons, and a detailed comparison of the two technologies is included below.

All the network architecture, the design elements, and the electronic equipment used in this design have been used successfully by Finley in past projects. We note that Finley and CCG are both vendor neutral are not recommending any specific vendors for network components. In the descriptions of our design below you may see us referring to various brands of routers, switches, or FTTH electronics – but note that there are numerous vendors that can supply the needed devices and in some cases we chose a typical vendor for purposes of developing a network cost estimate. The market for fiber electronics is competitive and similar prices are available from multiple vendors.

The FEUS network is designed as an all Internet Protocol (IP) network; meaning that all traffic and connections are IP based. The FTTH network is broken into two distinct types of connectivity:

- Fiber network (Physical network of connectivity from central office to customers)
- IP network (IP packets with internet information on optical signals)

The easiest way to understand the distinction is that the fiber strands (the physical network) carry IP packets that communicate to and from the Internet.

Overall Design Criteria

In the FEUS service area, the existing utilities and the telecom and cable operators use a mix of aerial and buried construction. It is advantageous to consider the existing electric utility poles for FTTP network deployment as terrain and topography dictate that buried construction is a comparatively expensive venture compared to aerial construction.

Since FEUS owns their own pole line the best approach for construction of fiber network is to utilize this existing asset for placement of aerial fiber. Some of the FEUS electric distribution system is buried and we have assumed a buried FTTP network in these areas.

The basis for any FTTH network design relies mostly on the network topology, fiber cable fill percentage, and the number of potential broadband customers – these factors largely determine the size of fiber required, the requirements to terminate the fiber in cabinets or frames, and the type of buildings or cabinets required for the FTTH optical equipment.

In the FEUS design, Finley worked with FEUS GIS data to understand the mix of residential, business, municipal and anchor institutions and designed the network accordingly.

In the telecom industry the number of potential customers is referred to as passings. Using the FEUS GIS records, we selected all meter locations for the FTTP fiber requirements. We also utilized census block data from the U.S. Census Bureau to remove any of the cable which was located in census blocks showing zero housing units to ensure we were only including cable which would serve potential broadband customers and not wellheads, agricultural installations or other non-customer locations.

In the telecom industry the number of potential customers is referred to as passings. Finley counted passings using GIS and meter data provided by the utility. This study includes the following passings:

	Rural	Other	Total
Residential	14,662	15,961	30,623
Business	400	3,172	3,572
Total	16,062	19,133	34,195

The passings include:

- Residential. This includes single family houses, apartment units, and mobile homes, etc.
- Businesses. The GIS data included a detailed listing of business locations – something we rarely get, and includes standalone businesses, churches, government buildings, schools, utility barns, and water tanks.

We also considered the amount of capacity on the network needed for future growth. While we understand that many rural areas are contracting in population, we know from years of building fiber networks that it is prudent to plan for increased fiber utilization over time. It's impossible to predict today where new homes and businesses will be located twenty-five years into the future. In the network design we applied a 1.5 fiber factor, meaning that for the number of meters being served on any given tap we multiplied that number 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. The network design also includes additional fiber on routes which might be attractive for dedicated connection for connections outside of the FEUS service area.

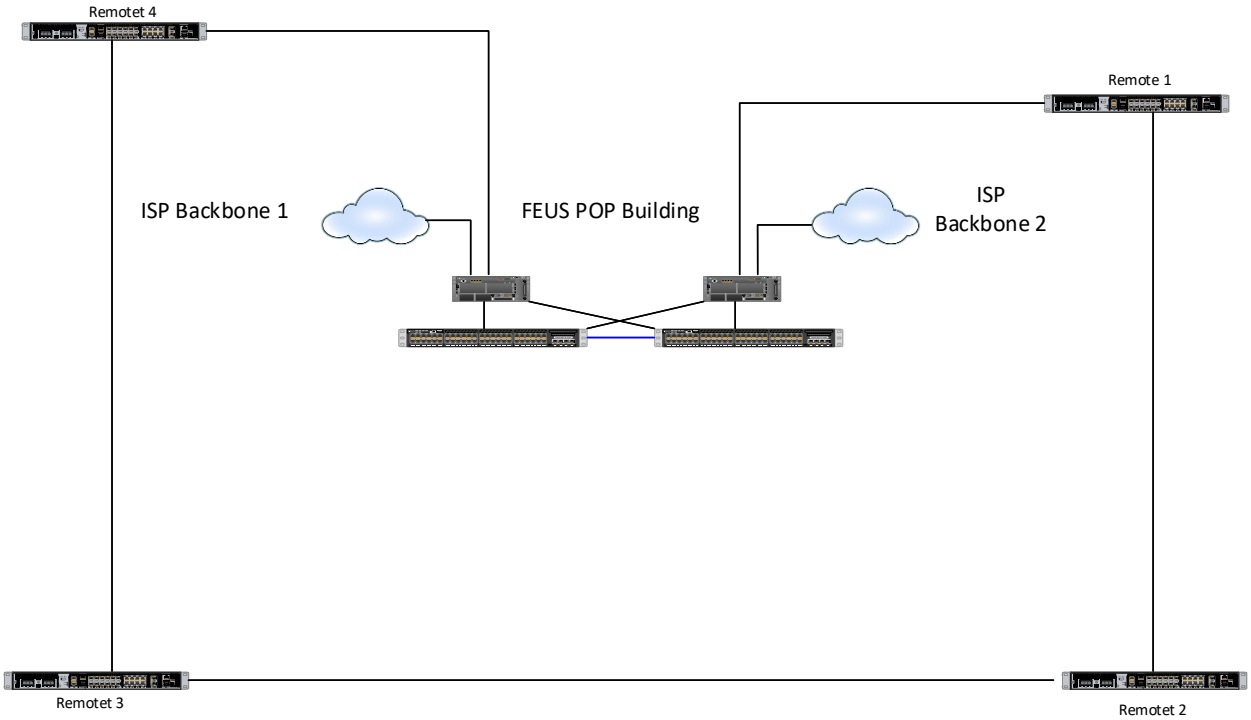
Fiber Network Design

There are two components of the fiber network design:

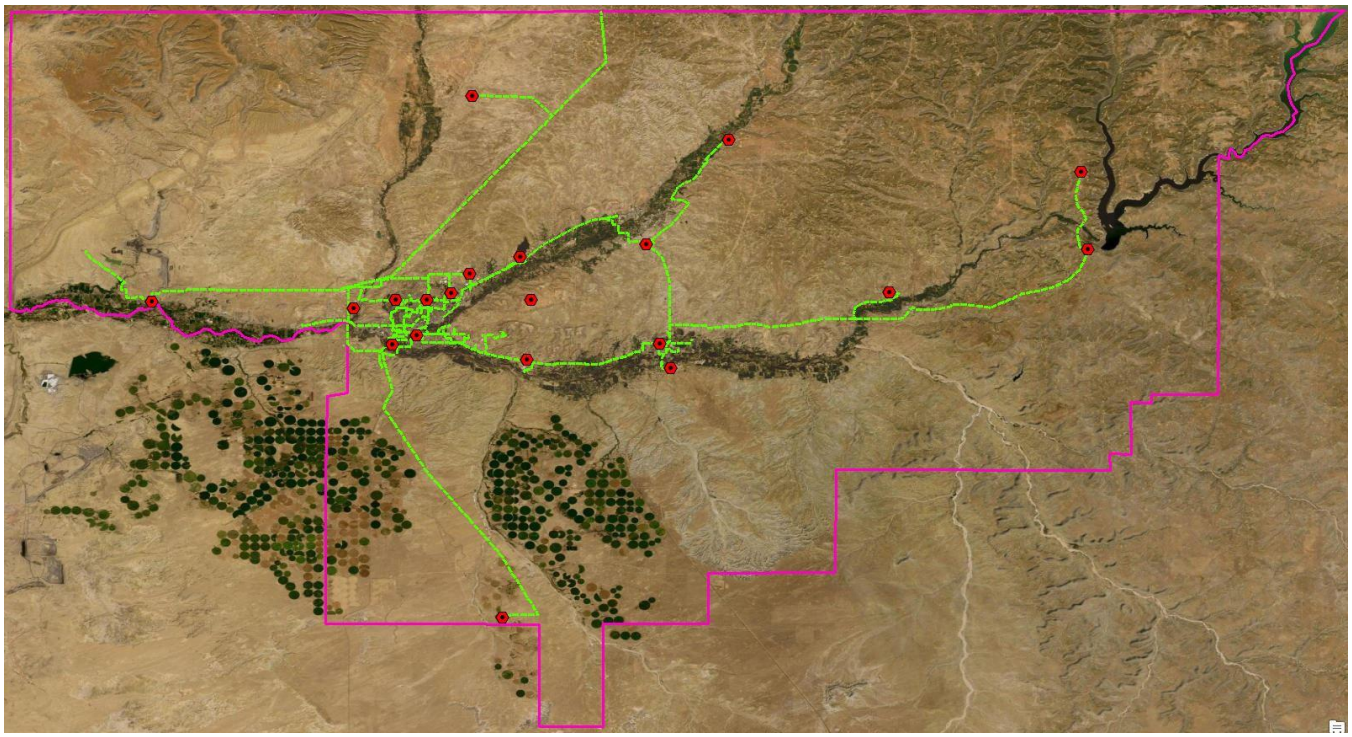
Backbone Fiber. Our preliminary network design includes twenty locations that will house electronics. These locations include two primary central office location and eighteen hut/remote locations at existing substations.

With the existing FEUS fiber infrastructure we are able to engineer a ring within the network and also create other transport/sub rings which consists of 12 fibers that are connected to these sites and are dedicated for this purpose and that are not used to serve customers. The ring configuration provides for redundant fiber paths between all locations. This means that each of the node locations has a fiber connection to two adjacent nodes in the ring so that if connectivity is lost in one connection all traffic routes over the other connection in the ring network ensuring that each node stays connected.

Following is a basic diagram of the network fiber ring.



Following is a map of the existing FEUS backbone fiber; this existing fiber is integrated into our overall network design; due to the size density of the FTTP network the imagery does not display well in a report format. The complete preliminary network design is included in the GIS FTTP network design which will be provided to FEUS.



Last Mile Fiber Network. The last mile fiber network extends from each of the nine hub locations to reach member premises. The total fiber network, including the backbone fiber, covers 686 miles of aerial line.

Finley utilized standard fiber cable sizes for the FEUS fiber network design; the fiber cable sizes used were 12, 24, 48, 72, 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 contractor and vendors for additional network construction and repair. Also, standard sized fiber is generally priced more competitively.

Our design tries to determine 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 to not include unneeded fiber pairs so as to limit the needed number of splices. Every splice in a network also adds a small amount of signal loss, so the ideal network is one that includes the least number of splices.

Aerial Fiber Basics. There are several factors that can determine the cost of aerial cable. We've estimated these various factors in making construction cost estimates, but actual pricing will require detailed field engineering that will determine the best construction method to use in various sections of the aerial network. The primary factors that affect aerial construction costs include:

- The location of the new fiber on existing poles. The current FEUS poles include fiber, cable television attachments and telephone cable attachments. From our observations, the existing cable and telephone attachments are in the communications space (40 inches below the neutral).
- If the new fiber is to be placed closer than 40 inches from the neutral wire the installation would have to be done using contractors who are qualified to work in the energized supply space. This adds to the installation cost since qualified installers with that skill generally are paid higher salaries than other installers. If the fiber is to be placed lower in the communications space the primary issue is whether there is enough room to add the fiber and still provide enough space between the existing cables on the poles. The NESC electrical code requires specific clearances between different kinds of cables on poles, and any new construction is expected to meet these codes.
- The chances are that there are places in the existing pole network where the spacing is not adequate, and that often differs from pole to pole, even in the same neighborhood. Some of the spacing issues might be due to short poles or to shoddy construction by the companies that previously put wires on the poles. If there is not enough spacing, then a provider would have to pay to move existing wires to create the needed space. Federal rules dictate that cost is strictly the new attaching provider responsibility. In the industry the cost to make space on poles is called "make-ready" and we have estimated rural make-ready costs as $3,750 per mile for cables between 12 and 96 fibers. We estimate the rural make-ready costs for the larger 144 and 288 fiber cables to be $5,500 per mile. We have estimated urban make-ready costs as $4,250 per mile for cables between 12 and 96 fibers. We estimate the urban make-ready costs for the larger 144 and 288 fiber cables to be $7,500 per mile. That's a soft estimate and before undertaking construction of the network we recommend that any provider fine-tune that estimate by looking in detail at the cable route to determine the condition and spacing of current wires and talking with each specific electric utility regarding a provider's specific project and their make-ready policy.
- It's also sometimes necessary to place a new pole if rearranging the current wires still won't meet NESC code. The cost of placing the new pole and of moving everybody else's wires to the new pole would also be the responsibility and cost for a new broadband service provider.

- The Finley network design assumes an ADSS cable installation, which means using all dielectric cable with no steel messenger being used for the FTTP network. This cable can be placed in close proximity to the electrical neutral or other energized parts of the electric distribution system. This cable placement is acceptable in industry practices and meets typical construction standards and the requirements of the NESC code.

Make-Ready. The most important aspect is something that the industry calls make-ready. There are national electric codes that define the spacing between the wires of different utilities. In rural areas most poles will already be carrying electric wires and telephone wires. There also could be existing fiber on some roads that is used for some purpose other than serving households and businesses.

The national electric codes include two important requirements that can affect the cost of getting onto poles. There must be sufficient space between the different providers on a pole. For example, a new fiber must be at least 18 inches above the cable below it (be that a telephone cable or wires from a cable TV company). There are also minimum clearance rules for the lowest that any cable can be above ground for the safety of those beneath the pole. These rules are in place to provide safety for technicians that work on cables during and after storm damage.

When there is not sufficient room for a new wire, then an industry practice called make-ready is invoked. Make-ready is the process of moving the existing wires on poles, as needed, to make room for a new wire. The make-ready can be somewhat simple, such as moving an existing wire by a few inches, or it can be major, such as having to move all of the wires on a pole or possibly even replacing the pole with a taller one.

Make-ready is expensive for two reasons. First, the new attacher must pay to make all the needed changes, even if the old wires were out of specification. Second, there can be big time delays while other providers using a pole come and make their changes to make room. Make-ready can be some expensive that in some cases it's cheaper to bury a fiber rather than to deal with the cost and delays doing the make-ready to be able to add a new fiber.

One Touch Make-Ready. The FCC passed new rules that went into effect in May of 2019 that should make it easier to get onto poles. The new rules apply only in the thirty states that follow FCC pole attachment rules, and New Mexico is one of those states.

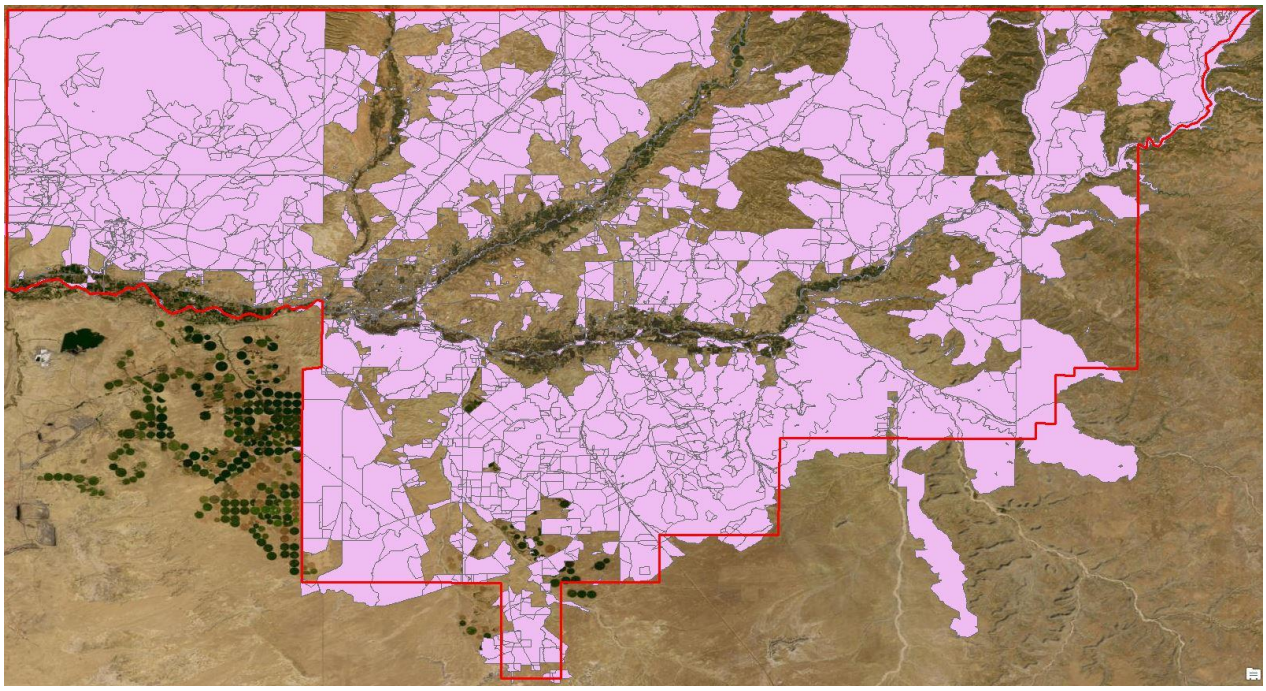
The most significant change in the rules is a new classification of poles as either simple or complex make-ready. The order defines how to make this classification. In real life practice, the new attacher will suggest this determination, although it could get overturned by the pole owner.

There are streamlined new rules and timelines for completing the make-ready on simple poles. If the pole owner is unwilling to commit to fixing simple poles in the needed time frame, then the new attacher can make the changes after properly notifying the pole owner. The new attacher is free to rearrange any existing wires as needed, again after having properly notified all the parties. These new rules eliminate situations where a pole owner refuses to cooperate with a new attacher, as happened in a few cities where AT&T fought Google Fiber. Something to consider is that the rules require using a make-ready contractor that has been pre-approved by the pole owner – but there are ways around this in some circumstances.

These new rules can mean a big improvement in construction schedule where the needed changes are for simple poles. That would be poles where wires need to be moved to make room for the new attacher. However, the new rules are not necessarily faster for complex poles. Those are poles where the make-ready could cause damage to existing wires or where the old pole must be replaced. The make-ready process for complex poles has always been slow. The new rules tighten up time frames a little, but the time required to get onto a complex pole can still take a long time.

For complex poles the process will still allow the existing wire owners to work sequentially – meaning that they can invite each existing company on the poles to do their own work, one company at a time. This coordination must be scheduled by the pole owner. The process could still take six months even if done perfectly. The new rules don't seem to provide a solution for when the pole owner or the existing attachers drag their feet on complex poles. Other than some slightly improved timelines, the work on complex poles looks to still be as dreadful and slow as the old make-ready rules.

Farmington Electric Utility System Census Blocks with Zero Housing Units



Finley, during the field review, also discovered that the electric serving area includes a large number of census blocks that contain no houses or businesses. These are shown in the map above. While these areas have roads (many of the areas contain oil wells or agricultural areas), there was no reason to build fiber to areas where there are no potential subscribers, and so the fiber design avoided many of the areas shown in pink above, other than to build fibers that pass through the area.

Miles of Fiber Construction

The total miles of mainline fiber in the network design is as follows. The cost included fiber construction, make-ready, engineering, construction management, and contingency costs.

	Miles	Cost	Cost / Mile
Rural Area	1,221 miles	$ 52,917,044	$ 43,339
City Area	574 miles	$ 47,265,178	$ 82,344
Total	1,795 miles	$100,182,222	$ 55,812

This shows a typical difference in the cost per mile in building in city versus rural areas. In cities there are more impediments that add to the cost of construction such as more access points needed per mile of fiber, more expensive impediments such as intersections and driveways, busier rights-of-ways and poles with greater numbers of other utilities, etc.

Electronics Design

The predominant technology solution for FTTH networks deployed today is a gigabit passive optical network (GPON). These networks are capable of delivering 2.5 Gigabits of downstream bandwidth to a cluster of customers. There are future-looking PON technologies such as XGS-PON and NGPON2 that can deliver 10 gigabits of downstream bandwidth to customers. We will discuss later in the report why we did not choose these technologies. We have designed the network to allow for expansion to faster technologies if needed at some time in the future.

One consideration when designing PON networks is the optical distance from an OLT port to the customer ONT, the design of the 2.5 GPON network for the FEUS service area includes a 35km design limit and was selected based on vendor optic availability. We designed the hut locations to account for this optical budget limitation.

The basic design characteristic of a PON network is that multiple customers in a neighborhood can share the same fiber. This is accomplished by use of splitters located throughout the network that are used to split one fiber from the central office or one of the huts to serve up to 32 customer locations. The primary advantage of this fiber sharing is that far fewer pairs of fiber must be deployed in the customer network.

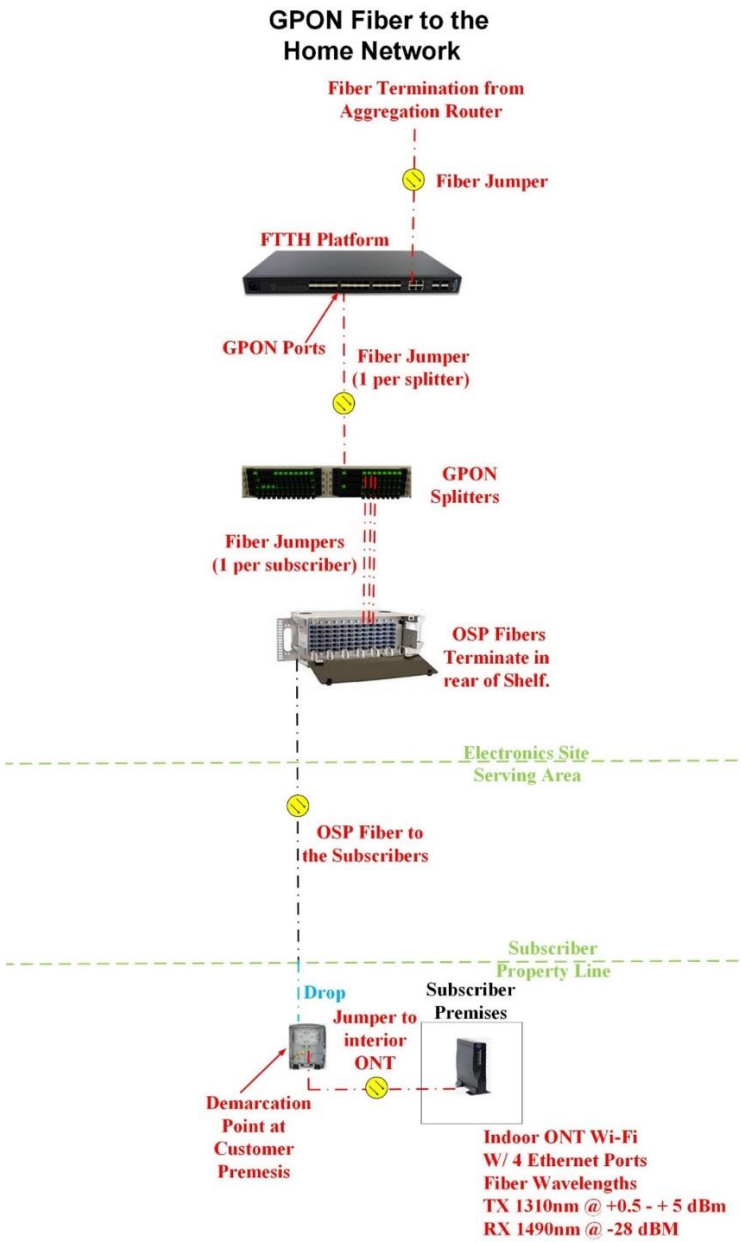
Our design provides the ability to serve 100% of FEUS customer locations. The design is also scalable so that future customer or future electric meters could easily be incorporated into the network.

Future expansion of the network could utilize several technologies such as course wave division multiplexing (CWDM) or dense wave division multiplexing (DWDM) to increase bandwidth without having to remove and replace equipment in the network.

Each network node is also capable of offering metro ethernet services. Think of metro ethernet service as the IP equivalent of traditional T1 type services offered by legacy telecom carriers. There are likely to be businesses or large data users around the network that will want metro Ethernet connectivity.

Local Network Configuration

The following diagram shows the configuration of the network starting with one of the hub sites and ending at each member premises.



Connection to the Internet

The Farmington area is currently constrained in terms of the number of backbone connections available to reach the open Internet. Ideally an ISP would have connections to the Internet in different distant cities and use diversely routed fiber (not along the same roads) to connect to those locations. Diverse Internet connections reduce the chance of the local network from going dark if there is a major fiber cut or other kind of outage affecting any given route to the Internet.

For design purposes we have assumed connection to existing backbone connections at the existing CenturyLink co-location building and also the potential connection to FastTrack. We know that the Southwest Colorado Council of Governments is considering how to expand broadband backbone connections in SW Colorado and that connections in that part of the state would extend south along the western edge of the FEUS service area and may provide a potential different redundant connection path.

We are also aware of another privately funded transport fiber network build that could extend from Albuquerque into southern Colorado and may provide another path of connectivity.

There is no guarantee that either of these transport networks are built thru the FEUS area; it is possible that an FEUS fiber project could be a catalyst for the construction of these transport networks.

Central Office & IP Core Network

Our design assumes those connections could be made using two 80-gigabit Ethernet routers. Using two routers will allow providers to balance the Internet traffic load across two connections (send some Internet traffic on each route) and also will assure that FEUS customers will remain connected to the Internet should a fiber get cut or one of the routers fail.

Also not shown on the diagram is a pair of redundant 10-gigabit Ethernet switches that are located in each hub. The primary purpose of these routers is to light the fibers on the backbone fiber and communicate with the two neighboring hub locations. These Ethernet switches can also be connected to other electronics at a hub site that is used to provide customer products. For example, the Ethernet switches can be connected to DHCP/DNS servers that route and receive traffic from the Internet. They can be connected to network management servers that give technicians access to look at the network. They could be used to connect to electronics that provide telephone service, smart-home services, or other future services for members.

Optical Line Terminal (OLT)

The electronics used to light the fiber to customers is called an optical line terminal (OLT). This is the top piece of electronics shown on the diagram. Our design places one OLT in the central office and one in each remote hut. OLTs must be powered, and so each hut location will contain equipment needed to provide power, including batteries and other back-up power to keep the network functioning in case of a power outage.

An OLT functions using circuit cards which can each service between 128 to 256 subscribers. Multiple cards can be installed in each OLT chassis and multiple chassis can be installed in each remote hub site if ever needed, meaning that it's easy to scale the network to accommodate significant future growth.

There are multiple vendors that provide an all-inclusive PON solution combining the cabinet and FTTH equipment solution. All vendors meet industry standards and all of them are priced similarly.

PON Splitters

The next component on the network diagram is a PON splitter. This is a device that can "split" one fiber in order 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 of the splitters are located in the central office core

or at the various network nodes, but many are located in small neighborhood cabinets located closer to customers.

PON Cabinet

Associated with a splitter cabinet is a PON cabinet. The purpose of these device is to neatly 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 that no fiber in the network needs to be larger than 288 fibers. The PON cabinets designed for the FEUS network are of varying sizes that depend on the customers served from a given hut location. These cabinets are all sited in areas adjacent close to road access and we would recommend that FEUS acquire a private easement for these sites. The exact location of PON cabinets would be determined as part of the detailed fiber plant design.

Below is a picture showing the insides of a typical PON cabinet site. This site includes both a PON cabinet and a splitter cabinet.

Fiber Drops

The local distribution fibers are built to emanate from PON cabinet sites to reach to every customer location. The fiber design assumes a fiber built to reach each location in the FEUS service area, even if they don't initially buy service.

To connect a customer to the fiber network a fiber drop is built from the street to connect to the outside of a customer premise building. The customer drop is a two-fiber cable which is fusion spliced to a single fiber of the main line cable. These splices are housed in a splice case that is sized for each location

depending upon the number of homes or businesses that can be served. Splice cases are installed everywhere in the network to provide future access for connecting customers – even in locations where there are homes or businesses that might not initially take service.

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 is an electronic device that contains a laser, and which 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.

Originally the ONTs were only placed on the outside of 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 that 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 are nearly identical and so the study doesn't choose between the two types of units.

Some companies still put the ONT on the 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 it appears that internal units are becoming the most predominant choice for new construction. One of the major contributing factors that favors 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 that can be categorized into units designed to serve homes and small business 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 FTTH networks have been designed with battery back-up for the ONT. However, many small fiber providers have stopped providing batteries. The batteries were historically installed to power telephones in the case of a power outage at the home. Old copper phones received power from the line and could be used when the power was out. However, there is no power in a fiber and thus a battery backup is required to maintain phone service. In 2015 an FCC ruling declared that every voice provider must offer a battery back-up solution for customers that buy telephone service that is not delivered on copper. That ruling said that fiber ISPs only have to make these units available and that customers could be charged the full cost of the unit.

Regardless of the type of ONT (indoor or outdoor), it will be necessary to drill through the side of the home to bring wiring. ISPs have widely differing ideas on the best way to do this – but most ISPs look for the installation method that requires the least amount of work inside of the customer premise. Much of the wiring needed inside a premise is driven by trying to get wires to a cable TV settop box, but since we've assumed the FEUS provider won't be offering cable TV your options are easier and costs lower.

Multi-Dwelling Units (MDUs)

There are some apartment buildings in the FEUS serving area, and there are several issues that affect your ability to bring fiber to MDUs, which are apartment and condominium complexes. Generally, the drop and electronics costs are lower for an MDU since these components can be shared among multiple tenants. But the wiring costs to reach these tenants can easily offset these savings.

The study assumes that the cost of serving an MDU customer is roughly the same as serving an equal number of single-family homes (a triplex would cost the same as 3 homes, for example). The most cost-efficient way to serve these units is to bring fiber directly from the street to the individual units.

Apartment property owners are not required to allow anyone to build fiber on their property or bring fiber to their tenants. You may find a few apartment owners that will not give access. This is generally due to compensation and an apartment might already have a long-term contract with the telco or cable company to provide service. The ISPs often enter into financial arrangements where they might pay commissions to the property owner for giving them access.

C. The Technology

Fiber Technology

As discussed above, and per the utility's preference, we only studied fiber technologies. Following is a more in-depth look at fiber technology.

The fiber design considered two technologies. Active Ethernet technology has been in widespread use for more than 30 years; GPON has been used for over 15 years. These are both mature technologies that are widely used and well understood industry wide.

Gigabit Passive Optical Network (GPON**)**

This technology was chosen as the primary way to deliver broadband. GPON makes use of optical splitters so that as many as 32 customers can share the same fiber (i.e., light source). With a GPON network, 32 customers may share the same fiber and all customers can still to subscribe to a 1 gigabit broadband package. As demand in the system grows; since a single fiber can accept more than one light wavelength the same fibers will allow newer technology such as 10 gigabit PON to be implemented where required without any disruption to the existing GPON customers service.

It's possible to provide a gigabit to everybody on a neighborhood PON due to something we call oversubscription in the industry. Oversubscription comes into play in any network when the aggregate subscribed customer demand is greater than the available bandwidth.

The easiest way to understand the concept is with an example. Consider a passive optical fiber network where up to 32 homes share the same neighborhood fiber PON. In GPON technology the customers on one of these neighborhood nodes share a total of 2.4 gigabits of download data.

If an ISP sells a 100 Mbps download connection to 20 customers on a PON, then in aggregate, those customers could use as much as 2 gigabits of data, meaning there is still unsold capacity – meaning that each customer is guaranteed the full 100 Mbps connection inside the PON. However, if an ISP 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 8 times more capacity to customers than is physically available, and this particular PON has an oversubscription ratio of 8.

When people first hear about oversubscription, they are often aghast – they think an ISP has done something shady and is selling people more bandwidth than can be delivered. But in reality, an oversubscription ratio recognizes how people use bandwidth. It's highly likely in the example of selling gigabit connections that customers will always have access to their bandwidth.

ISPs understand how customers use bandwidth and they can take advantage of the real behavior of customers in deciding oversubscription ratios. In this example, it's highly unlikely that any residential customer will ever uses a full gigabit of bandwidth – because there is almost no place on the web that where a residential customer can connect at that speed.

But more importantly, a home subscribing to a gigabit connection mostly doesn't use most of the bandwidth they've purchased. A home isn't using much bandwidth when people are asleep or away from home. The residents of a gigabit home might spend the evening watching a few simultaneous video streams and barely use any bandwidth. The ISP is banking on the normal behavior of its customers in determining a safe oversubscription ratio. ISPs have come to learn that households buying gigabit connections often don't use any more bandwidth than homes buying 100 Mbps connections.

Even should bandwidth in this example PON ever get too busy, the issue is likely temporary. For example, if a few doctors lived in this neighborhood and were downloading big MRI files at the same time, the neighborhood might temporarily cross the 2.4-gigabit available bandwidth limit. Since transactions happen quickly for a gigabit customer, such an event would not likely last more than a few seconds, and even when it was occurring most residents in the PON wouldn't have seen a perceptible difference.

It is possible to badly oversubscribe a neighborhood. Anybody who has used a cable company for broadband can remember back a decade when broadband slowed to a crawl when homes started watching Netflix in the evening. The cable company networks were not designed for steady video streaming and were oversubscribing bandwidth by factors of 200 to one or higher. It became routine for the bandwidth demand for a neighborhood to significantly surpass network capacity, and the whole neighborhood experienced a slowdown. Since then, the cable companies have largely eliminated the problem by decreasing the number of households in a node.

As an aside, ISPs know they have to treat business neighborhoods differently. Businesses might engage in steady large bandwidth uses like 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 is likely to be far too high in some business neighborhoods.

A GPON 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 generally inserts the signals for the various products being delivered to customers.

From the core there are direct fibers to Optical Line Terminal (OLT), which are the devices that provide the light source for customers. These OLTs can be located in the same location as the fiber core or else can be spread around the city in neighborhood nodes, generally in huts or large cabinets.

There is one fiber leaving the 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 the 32 separate fibers that go to customers. The splitter cabinets can be located at the same location as the OLT electronics, or they can be moved 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 splitting is just what it sounds like – one fiber is spliced and split into 32 individual paths. The paths from the splitter are "home runs" meaning that there is a dedicated fiber between a splitter site and each customer.

One of the biggest benefits of the GPON network is a savings in fibers in the network. Only one fiber is needed to serve an OLT and one fiber goes from the OLT to each splitter. The fiber is only divided into individual customer fibers at the splitters, which can be deep into the network. The GPON technology chosen provides 2.4 Gbps down and 1.2 Gbps upstream from each group of 32 customers.

Another advantage of PON is the number of electronic interfaces is reduced by the split, since one laser at the OLT can communicate with up to 32 customers. Increased bandwidth can be gained by reducing the number of customers on a PON – reducing a PON to 16 customers would double the bandwidth available per customer. Most fiber builders today choose GPON for residential service because it provides acceptable bandwidth and is less expensive than competing technologies.

One consideration when designing PON networks is the optical distance from an OLT port to the customer ONT; the design of the 2.5 GPON network includes allowance for 1.32 split and a distance limitation of 20 km (12.4 miles) design limit. This design was selected based on current vendor optical transmission availability. Due to the limited size and distances within the electric service territory, the number of remote cabinets resulting from detailed engineering will be mostly constrained by cabinet capacity rather than distance.

Future expansion of the network could utilize several technologies such as course wave division multiplexing (CWDM) or dense wave division multiplexing (DWDM) to increase bandwidth without having to remove, rearrange, and/or replace equipment in the network.

The current vendors for PON equipment include Alcatel-Lucent, Adtran, Zhone, Nokia, and Calix. Today passive optical networks use the gigabit passive optical network (GPON) technology primarily, even though more advanced versions do exist and are discussed below.

Advantages.

- Lower Cost (typically 10-20% less than Active E for the core fiber electronics).
- Can support both RF Broadcast TV and digital IPTV.
- More efficient use of bandwidth at the customer premise. A GPON network delivers 2.4 Gbps of data to a small cluster of houses and an individual customer will normally have access to much of this bandwidth for data transmission, thus giving the customer a faster bandwidth experience at the home.

- For the most part the technology can utilize existing home wiring. The PON network is designed to tie into existing telephone and cable wiring if they are conveniently located and in good working order.
- Requires no field electronic devices. The key word about a PON network is that it is passive. This means that no power is needed except in those locations, generally at central offices and major hubs or huts, where the provider places electronics.
- Can easily provide traditional T1s for larger business customers using business ONTs.

Disadvantages.

- Customer must be within 12 miles of hub when using 1x32 splitter. This means with large installations that multiple hubs are required.
- More customers potentially are affected by a fiber failure in the field.

Active Ethernet (Active E**)**

Each network node in the design is capable of offering metro Ethernet services using active Ethernet technology. This technology provides a direct data connection to a single customer.

An Active E network is essentially a fiber "home run" from the Central Office or other node, meaning that one fiber goes from the electronics core directly to the customer. This technology has several advantages and is well-suited for serving large businesses where the customer requires more stringent network uptime and higher bandwidth. An Active E network also can provide symmetrical data capabilities (upstream and downstream data rates are the same) at high data speeds. The downside to Active E is that more fibers are required in the network since fibers are not shared between customers. Electronic costs are generally also higher since there is a dedicated laser at both ends of the connection to every customer. Active E also has higher data capabilities and can inexpensively provide for data rates up to 10 gigabits per second. Faster speeds are possible, but with significantly higher electronics costs. One of the biggest advantages of Active E is that it's easy to change the connection to a single customer as customer requirements change – the laser serving that customer can be changed without affecting any other part of the network.

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 been in a bit of a decline for a few years. Active E is easier to engineer and expand and is useful for customizing solutions for small volume specialized applications.

Advantages.

- Can serve customers up to 36 miles from last active field device.
- Requires less pre-planning and engineering.
- A single point of failure will often affect fewer customers.
- Offers true non-blocking 1 Gbps and faster speeds.
- Easily upgradeable to 10 Gbps by switching optics.

Disadvantages.

- Shares data and CATV bandwidth in the same data stream. Today an Active E system can cost-effectively deliver up to 10 gigabits of data to each home, but more typically these

networks are designed to deliver 1 gigabit. This is not a shared pipe with neighbors and each customer can get a dedicated gigabit pipe. However, this one data stream must support CATV, data, and voice together. Thus, if a customer is watching multiple HDTV sets, the amount of bandwidth left for data will be something less than a gigabit.

- Usually requires additional home wiring. Since Active E provides only one bandwidth (the data stream), the video service (IPTV) always requires a high bandwidth data wire, such as category 5 or 6 wire to each TV location. The increased use of WiFi and advances in WiFi speeds have mitigated some of this.
- More physical space is required for electronics because there are more fiber terminations onto the electronics. If the electronics are in the field, the cabinets housing the electronics and fiber terminations can become relatively large. This means most cabinets need to be on private land and not on public rights-of-way.
- Fewer customers served per electronic chassis. Since only one customer can be served per laser then there are fewer customers that can be served from a single card.
- Larger fiber cables are typically used due to the requirement of a single fiber per customer from the ONT to the electronic chassis. The use of larger fiber cable in an aerial application may significantly increases make-ready costs.

D. Competing Technologies

Existing Technologies

There are at least eight broadband technologies used in the county today to deliver broadband. Each of these technologies will be explained below.

- CenturyLink and Sacred Wind serve parts of the area with copper telephone wires using DSL technology. There are many rural residents who live outside the range of DSL.
- Comcast uses hybrid fiber/coaxial (HFC) technology to provide the triple-play services in Farmington and other concentrated pockets of households.
- There are some customers in the area served by active Ethernet technology. The schools use the technology on a school-owned network to bring large broadband to the classroom. Fast Track serves some large business customers in the areas. Both CenturyLink and Comcast bring fiber to some business customers.
- We saw point-to-point microwave technology being used by wireless ISPs to bring backhaul to small local towers.
- There are several wireless ISPs (WISPs) delivering broadband using point-to-multipoint wireless technology.
- Some rural homes buy broadband from satellites.
- Some rural homes get broadband using the data on their cellphone plans or using cellular hotspots.
- There are likely at least a few households that still us dial-up to reach the Internet.

DSL over Copper Wires

CenturyLink provide broadband using DSL (Digital Subscriber Line). DSL is used to provide a broadband path over the copper. These networks were mostly built between the 1950s and early 1970s. The copper networks were originally expected to have an economic life of perhaps 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. Maybe even more importantly, the copper networks have deteriorated due to neglect. The big telcos started to cut back on maintenance of rural copper in the 1980s as the companies were deregulated from some of their historic obligations. Maintenance has been reduced even further as the telephone properties changed ownership and are now owned by CenturyLink. At some point the copper networks will become non-functional and die.

DSL works by using frequency on the copper that sits just above the frequencies used for telephone service. There are different kinds of DSL standards, each of which has a different characteristic in terms of how much bandwidth they deliver and how far the signal will travel. The most efficient forms of DSL can deliver up to 24 Mbps service over a pair of telephone wires. In Farmington, CenturyLink also offers DSL using four copper wires that can provide speeds up to 48 Mbps. Most of the DSL that Finley observed in the field 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. This means that rural customers often get slow DSL, which in the worst cases is not much faster than dial-up. The general rule of thumb is that most of the types of DSL can deliver a decent amount of bandwidth for 2-3 miles over copper. The telephone companies transmit DSL from each of their historic central offices. They also might transmit DSL from deeper in the copper network from field cabinets, such as one that might be placed at the opening into a subdivision. The vast majority of rural households in San Juan County are more than two miles from a town or a field transmitter, meaning that most rural customers in the study area can get only very weak and slow DSL, if they're able to get any DSL at all.

DSL signal strength is also affected by the quality of the copper. The newer the copper and the larger the gauge of the copper wires, the better the signal and the greater the bandwidth. Many of the copper wires in San Juan County are likely to be 50 or more years old and have outlived their original expected service life.

CenturyLink accepted a federal grant in 2014 that was supposed to be used to strengthen rural DSL to speeds of at least 10/1 Mbps. This was done with the CAF II program and was described earlier in the report. The CAF II upgrades are scheduled to be completed by the end of 2020. Finley observed that they saw no recent upgrades of DSL equipment.

Hybrid Fiber Coaxial Network

Comcast purchased the existing small cable company that serves Farmington and other denser pockets of households. The coaxial copper wires in that network are also aging, like the telephone copper wires. The coaxial network there was likely built in the 1970s. Coaxial cable networks exhibit signs of aging sooner than telephone copper networks because the wires act like a huge antenna, and older networks attract so much noise that it become harder to transmit the signals through the wires.

The technology used in the network is referred to as Hybrid Fiber Coaxial (HFC). Hybrid refers to the fact that an HFC network uses both a fiber backbone network and a copper network of coaxial cable 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.

An HFC system handles delivery of customer services differently than an all-fiber network. For example, in an HFC network, all 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.

In an HFC network, all 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 - the fewer the customers, the stronger and more reliable the 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 the data pipe for a given neighborhood. It is the architecture of using neighborhood nodes that has always given a cable network the reputation that data speeds will slow down during peak usage times, like evenings. If nodes are made small enough then this slowdown does not necessarily have to occur.

The amount of bandwidth available to deliver Internet access that is available at a given node is a function of how many "channels" the cable company has dedicated to data services. Historically a cable network was used only for television service, but in order to provide broadband the cable company had to find 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 data to be delivered over an HFC system follows a standard called DOCSIS (Data Over Cable Interface Specification) that was created by CableLabs. All except a few tiny and rural cable networks have upgraded in the past to the DOCSIS 3.0 standard that allows them to bond together enough channels to create broadband speeds as fast as about 250 Mbps download. A few years ago cable companies started upgrading to a new standard, DOCSIS 3.1, that theoretically allows all of the channels on the network to be used for data and which could produce 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 a cable network, most cable companies have increased the maximum broadband speeds to between 500 Mbps and 1 Gbps using DOCSIS 3.1.

Comcast says they have upgraded nationwide to the new DOCSIS 3.1 standard and since we see gigabit customers the upgrade was done in Farmington. However, we saw evidence in the field and also evidence with the speed tests that this upgrade was never fully implemented. For example, Comcast is still using the technique called cascading in the network. That's where fiber is build to one neighborhood and the bandwidth provided is then extended into additional neighborhoods. The problem with using this configuration is that this layers too many customers into a node and the broadband speeds decrease. The speed test showed a significant number of customers with broadband speeds below 50 Mbps, and even many below 25 Mbps. This would not occur in a network where there was a fiber and a node installed in each neighborhood. CCG has studied other Comcast markets where most of the customers in the markets are getting speeds at or even above the advertised speed. In Farmington customers are getting speed that are lower, sometimes significantly lower, then the advertised speed.

The one big data limitation of a DOCSIS network is that the standard does not allow for symmetrical data speeds, meaning that download speeds are generally much faster than the upload speeds. This is an inherent design in DOCSIS 3.0 and 3.1 where no more than 1/8 of the bandwidth can be used for upload. Most Comcast customers in the market are getting less upload bandwidth than expected, and this is another indication of flaws in problems in the network configuration.

CableLabs has developed an upgrade called DOCSIS 4.0 that will allow for symmetrical gigabit data speeds. This will require even more empty channel slots on a cable network and the new standard assumes that cable company would increase total system bandwidth of the network to at least 1.2 GHz of bandwidth. So far, the big cable companies have been silent on the topic and there is speculation that few of them will be interested in this expensive upgrade.

There is a distance limitation on coaxial cable, but since these networks are rarely built in rural areas this seldom comes into play. Unamplified signals are not generally transmitted more than about 2.5 miles over a coaxial network. This limitation is based mainly on the number of amplifiers needed on a single coax distribution route. Amplifiers are always needed for coax distribution over a couple of thousand feet. Modern cable companies try to limit the number of amplifiers on a coaxial route to five or less since adding amplifiers generally reduces broadband speeds.

Metro Ethernet

Metro Ethernet is the primary technology used to deliver large bandwidth to a single customer over fiber. This technology is used the area to deliver fiber to cell towers and some business customers. The school district owns and operates a fiber network and uses the technology to supply bandwidth to the schools. Fast Track owns some fiber and serves some businesses in the market. The utility uses this technology today to deliver bandwidth to electric substations.

Metro Ethernet technology generally uses lasers that can deliver 1 gigabit or 10 gigabit speeds, although lasers as fast as 100 Gbps are available. ISPs can choke these speeds to slower levels based upon what a customer is willing to pay for.

Many ISPs dedicate a fiber for each metro Ethernet customer, but that's not mandatory. For example, an ISP could light a fiber to deliver 10 Mbps and string that fiber to multiple customers each buying 1 Mbps service.

Point-to-Point Microwave.

This is a wireless technology that also delivers Ethernet using a wireless technology instead of fiber. We saw a few microwave links being used to bring bandwidth to short towers used by wireless providers. Wireless point-to-point technology today can deliver speeds as fast as 2 Gbps for one mile, or smaller amounts of bandwidth for greater distances, with the longest being around six miles. ISPs elect to use wireless point-to-point technology because it can be significantly less expensive than building fiber, particularly in areas with challenging terrain.

Satellite Broadband.

There are currently two satellite providers available in the US – Viasat (which was formerly marketed as Exede or Wildblue) and HughesNet. For both, the availability depends upon having a clear line of sight from a satellite dish at a customer location to a satellite.

The most limiting aspect of satellite broadband is latency, which means delay in the signal. These satellites are parked at over 22,000 miles above the earth, and when an Internet connection must travel to and from a satellite, there is a noticeable delay; that delay makes it hard or impossible to do real-time transactions on the web. Current satellite latency can be as high as 900 milliseconds. Any latency above 100 milliseconds creates problems with real-time applications such as streaming video, voice over IP, gaming, web sites that require real-time such as online education, and making connections to corporate WANs (for working at home). When the latency gets too high such services won't work at all. Any website or service that requires a constant connection will perform poorly, if at all, with a satellite connection.

Broadband from the two providers comes with tiny data caps, meaning a customer is highly limited by the amount of data they can send or receive during a month.

Cellular Broadband.

There are rural homes using their cellphone data plans for home Internet access. There are a number of issues with this. The amount of broadband available is small. Most cellular data plans are for less than 10 gigabytes of total broadband usage in a month.

The cellular companies also offer "unlimited" data plans, but these plans only provide only 20-30 gigabytes in a month, after which they get restricted to extremely slow speeds. There have been reports across the country of cellular carriers that refuse to honor unlimited plans for rural customers who use this for home Internet access. The unlimited plans typically restrict the amount of broadband that can be "tethered," meaning connected to a computer or other device other than the cellphone. CCG has talked to rural customers across the US who have monthly cellular data bills in excess of $500 per month if they use cellular data to support students doing homework.

Another variation of this product is called a cellular hotspot. This requires a cellular receiver instead of a cellphone. The plans have higher data caps than regular cellphone plans but can easily cost hundreds of dollars per month for any home that used even a moderate amount of bandwidth.

Each major cell carrier also offers fixed cellular data plans. With these plans the carriers place a small dish on a customer home and use cellular frequencies to deliver fixed wireless broadband. These plans also have data caps, but they are much larger than the caps on regular cell phones. For example, the AT&T fixed cellular plan has a monthly data cap of 215 gigabytes. These plans are relatively new and likely are not yet available in the area. Currently, AT&T only offers this plan in places where they are the incumbent telephone company. T-Mobile has said they are going to offer this nationwide as a result of its merger with Sprint – but so far we've not seen a lot of evidence of this being offered.

Point-to-Multipoint Wireless.

There are wireless ISPs (WISPs) using this technology to deliver rural broadband. The network generally consists of radios placed at a tower or other tall location and connections to homes and businesses are beamed wireless. There are several current frequencies of spectrum that can be used for this purpose and more that will be coming on the market in the next few years:

- WiFi: WiFi is short for **wi**reless **fi**delity and is meant to be used generically when referring to any type of 802.11 network. The FCC has currently set aside two swaths of frequency for WiFi: 2.4 GHz and 5.7 GHz. In a point-to-multipoint network, these two frequencies are often used together. The most common way is to use the higher 5.7 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 speeds can be slow at the far end of six miles. Nationwide many wireless carriers advertising speeds in the range of 25 Mbps. We know of networks doing speeds up to 75 Mbps for short distances. Such a network must have fiber built to the radio transmitters and also can't carry too many customers on a given radio system.

  The FCC has approved the use of 6 GHz WiFi for indoor use but is still investigating the use in outdoor point-to-multipoint networks. There are around 100,000 existing outdoor microwave links using the frequency and the fear is that unlicensed spectrum could interfere with existing links.

- 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 will auction the remaining spectrum of 70 MHz in June 2020. In all cases this spectrum is shared with military uses and the military will always get priority to use the spectrum.

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

  The FCC is also making it a little easier for smaller companies to win some of this spectrum in the coming auction. The spectrum will be auctioned by county, one of the smallest coverage areas ever used by the FCC. There is hope that the bigger carriers won't pursue the licensed spectrum in rural areas since they can use the free spectrum. The FCC has provided bidding credits to smaller entities to help them bid against the larger carriers.

  There are already a few rural carriers using the public portions of the spectrum for fixed wireless service. This spectrum sits in the middle between the two WiFi bands used for fixed wireless today and has great operating characteristics.

- White Space Spectrum: The FCC has been doing trials in what is called white space spectrum. This is spectrum that is the same range as TV channels 13 through 51, in four bands of frequencies in the VHF and UHF regions of 54–72 MHz, 76–88 MHz, 174–216 MHz, and 470–698 MHz. The FCC order refers to whitespace radio devices that will work in the spectrum as TVBD devices. The FCC approved greater use of these frequencies for point-to-multipoint radios.

  The FCC auctioned a lot of this frequency in 2018, with the buyers ranging from the big cellular companies and Comcast. This was called an incentive auction, because TV stations that gave up their spectrum got a share of the sale proceeds. The FCC is now expected to make some of this spectrum available for rural broadband. The rules have not yet been worked out, but they will probably be something similar to what governs WiFi and be available to anybody.

  There are two possible uses for the spectrum. On a broadcast basis, this can be used to make better hotspots. A 2.4 GHz WiFi signal can deliver just under 100 Mbps out to about 100 meters (300 feet). But it dies quickly after that and there may be only 30 Mbps left at 200 meters and nothing much after that. Whitespace spectrum can deliver just under 50 Mbps out to 600 feet and 25 Mbps out to 1,200 feet.

  There is potential for the spectrum to extend point-to-multipoint radio systems in rural areas. White space radios should be able to deliver about 45 Mbps up to about 6 miles from the transmitter.

  One issue to be worked out is that the FCC rules require the radios using this frequency to use what they are calling cognitive sensing. What this means is that an unlicensed user of the spectrum will be required to vacate any requests for usage from a licensed user. While this would not be a problem where there is only one user of the white space spectrum, where there is a mix of licensed and unlicensed users the unlicensed provider needs to pair radios with other spectrums to be able to serve customers when they have to cede usage to a licensed user.

  C-Band Spectrum. On February 7, 2020, the FCC announced an upcoming auction in December 2020 of C-Band spectrum. This spectrum sits between 3.7 GHz and 4.2 GHz. The spectrum has historically been used by satellite companies for communication between satellites and earth stations. This is prime spectrum for 5G cellular broadband, but also could provide a huge benefit to fixed wireless providers in rural America.

  FCC Chairman Pai is asking Congress to approve using 10% of the proceeds of the auction to provide the spectrum for rural broadband. At this early stage there's no way to know if Congress will do this or how it might work. There are a number of members of Congress pushing for better rural broadband.

  The C-Band spectrum sits next to the recently released CBRS spectrum at 3.5 GHz. Just as additional spectrum benefits 5G, fixed wireless technology improves significantly by combining multiple bands of frequency. Rural carriers have been arguing for years that the FCC should allow for the sharing of spectrum. Proponents of rural broadband argue that two uses of spectrum can coexist since most 5G spectrum is only going to be needed in urban areas. They believe that such spectrum can be used in a point-to-multipoint configuration without interfering with urban 5G.

> The big cellular carriers have always been reluctant to share spectrum mostly because it causes them extra effort, so only the FCC, and in this case Congress, can make it happen.

There are several factors that are critical to a 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, and 5.0 GHz. Radios will get even better if they include white space spectrum, CBRS spectrum or C-Band spectrum. Having more spectrum matters because each frequency band has different operating characteristics in terms of distance and ability to penetrate obstacles. Having multiple frequencies available means an increased opportunity to find a good solution for each customer in the service area.

- Adequate Backhaul. The best fixed wireless coverage comes when there is fiber at the transmitter. Customer broadband speeds are diminished if a tower doesn't receive enough bandwidth – this is the primary reason why many WISPs deliver speeds under 10 Mbps.

- Terrain/Topology. There are often physical barriers like hills or heavy woods that can limit or block customer bandwidth. Most of these technologies require a line of sight, meaning that there must be a clear unimpeded visual path between the tower and the customer. Customers that live in valleys or behind hills might not be able to get service. If the signal has to pass through trees or other obstacles the strength of the signal is diminished. The signal can also degrade with rain or snowstorms blocking some of the signal.

Future Technologies

This section looks at new technologies that are likely coming within the next years to the US.

Next Generation Fiber Technologies. There are two next-generation and competing fiber-to-the-home technologies that will allow connections to customers to be upgraded to 10 Gbps broadband and even faster - NG-PON2 or XGS-PON. The current widely deployed GPON technology will eventually hit a technology wall. The technology delivers 2.4 Gbps downstream and 1 Gbps upstream for up to 32 customers, although many networks are configured to serve 16 customers at most. This is still an adequate amount of bandwidth today for residential customers and can easily provide a gigabit product to every customer if desired.

GPON technology is over a decade old, which generally is a signal to the industry to look for the next generation replacement. This pressure usually starts with vendors who want to make money pushing the latest and greatest new technology - and this time it's no different. After taking all the vendor hype out of the equation it's always been the case that any new technology is only going to be accepted once that new technology achieves an industry-wide economy of scale. That almost always means being accepted by at least one large ISP.

The most talked about technology is NG-PON2 (next generation passive optical network). This technology works by having tunable lasers that can function at several different light frequencies. This would allow more than one PON to be transmitted simultaneously over the same fiber, but at different

wavelengths. That makes this a complex technology with multiple lasers and the key question is if this can ever be manufactured at price points that can match other alternatives.

The only major proponent of NG-PON2 today is Verizon, which recently did a field trial to test the interoperability of several different vendors including Adtran, Calix, Broadcom, Cortina Access, and Ericsson. Verizon seems to be touting the technology, but there is some doubt if they alone can drag the rest of the industry along. Verizon seems enamored with the idea of using the technology to provide bandwidth for the small cell sites needed for a 5G network. However, the company is not building much new residential fiber. They announced they would be building a broadband network in Boston, which would be their first new construction in years, but there is speculation that a lot of that deployment will use wireless 60 GHz radios instead of fiber for the last mile.

The market question is if Verizon can create enough economy of scale to get prices down for NG-PON2. The whole industry agrees that NG-PON2 is the best technical solution because it can deliver up to 40 Gbps to a PON while also allowing for great flexibility in assigning different customers to different wavelengths. Still, the best technological solution is not always the winning solution and cost is the greatest concern for most of the industry. Today the early NG-PON2 electronics are being priced at two or more times the cost of GPON, due in part to the complexity of the technology, but also due to the lack of economy of scale without any major purchaser of the technology.

Some of the other big fiber ISPs like AT&T and Vodafone have been evaluating XGS-PON. This technology can deliver 10 Gbps downstream and 2.5 Gbps upstream—a big step up in bandwidth over GPON. The major advantage of the technology over NG-PON2 is that is uses a fixed laser which is far less complex and costly. In addition, these two companies are building a lot more FTTH networks than Verizon.

While all of this technology is being discussed, ISPs today are already delivering 10 Gbps data pipes to customers using Active Ethernet technology. For example, US Internet in Minneapolis has been offering 10 Gbps residential service for several years. The Active Ethernet technology uses lower cost electronics than most PON technologies, but still can have higher costs than GPON due to the fact that there is a dedicated pair of lasers—one at the core and one at the customer site—for each customer. A PON network instead uses one core laser to serve multiple customers.

It may be a number of years until this is resolved because most ISPs building FTTH networks are still happily buying and installing GPON. One ISP client told us recently that they are not worried about GPON becoming obsolete because they could double the capacity of their network at any time by simply cutting the number of customers on a neighborhood PON in half. That would mean installing more cards in the core without having to upgrade customer electronics.

The bottom line of this discussion is that Finley Engineering chose not to consider NG-PON2 for the primary technology to deliver FTTH services. The technology is still at least 40% more expensive than GPON technology and it has not yet been accepted widely in the industry. However, if the price difference continues to close this could become the preferred technology within a few years.

The Finley design allows for an eventual migration to XGS-PON or NG-PON2 through what is called an overlay. That means introducing the new technology while maintaining the current network. This would

allow for an orderly transition over time while bringing faster 10-gigabit connection to customers that need it immediately. The fiber network design can accommodate these future technologies and faster speeds.

5G Cellular Technology. Today's cellular network uses a technology called 4G LTE, although there are still many rural cell sites using 3G technology. Nationwide, the cellular carriers in the US average data speeds for 4G LTE is around 25 Mbps download, but the connection speed at rural cell sites are usually slower than that average. Additionally, speeds drop in relation to the distance a customer is from a cell site and good cellular data speeds only are available for 2-3 miles from a cellular tower. A customer that is more than 3 miles from a tower will get slower cellular data speeds. This matters more in rural areas since the cellular towers are a lot further apart than in larger towns.

The cellular carriers are in full 5G marketing mode. If you believe the TV commercials, you'd now think that the country is blanketed by 5G, as each cellular carrier claims a bigger coverage area than their competitors. The cellphone companies like Apple and Samsung now sell 5G phones. Unfortunately, almost all of their claims are marketing hype.

In 2020 there will be no cellular deployments that can be legitimately called 5G. Full 5G will not arrive until the carriers have implemented the bulk of the new features described in the 5G specifications. For now, none of the important features of 5G have been developed and introduced into the market. 5G deployment will come in stages as each of the 5G features reaches markets – the same thing that happened to 4G. For now, all the major 5G improvements are still under development in the labs.

From what is discussed in the IEEE forums, most of the 5G features are 2 - 6 years away. The same thing happened with 4G and it took most of a decade to see 4G fully implemented – in fact, the first US cell site fully meeting the 4G standards was not activated until the end of 2018. Over time we'll see a new 5G features implemented as they are released from labs to field. New features will only be available to those that have phones that can use them, so there will be a 2- to 3-year lag until there are enough phones in the market capable of using a given new feature. This means every 5G phone will be out of date as soon as a new 5G feature is released.

Most of what is being called 5G today refers to the introduction of new bands of spectrum. New spectrum does not equal 5G – the 5G experience only comes with 5G features. Existing cellphones cannot receive the new spectrum bands, and so the carriers are selling new phones that can receive the new spectrum and labeling that as 5G.

Even when 5G is fully implemented, the cellular data speeds are not going to be blazingly fast – and maybe not faster at all. The 5G specification calls for eventual 5G cellular speeds of about 100 Mbps – which was also the specification for 4G, but never realized. There will be reports of fast speeds using new spectrum, but that will die down quickly. At first, anybody lucky enough to grab new spectrum will likely have a great experience. This will mostly be because almost nobody else is using the spectrum at a given cell site. As more phones can use the new spectrum, the performance will drop back to normal 4G speeds – and maybe even a little slower. Much of the first wave of spectrum being released is in lower frequency bands such as 600 MHz for T-Mobile and 850 MHz for AT&T. These lower frequency bands don't carry as much data as higher frequencies, and it's being reported that speeds are slower than 4G.

5G is likely not coming to rural America for a long time. It's still more likely today for a rural caller to snag a 3G connection than a 5G one using the new frequencies. Rural cell sites aren't under the same stress as urban ones due to fewer customers trying to use a given cell site, so there is no urgency upgrading to 5G. Even when true 5G features comes to rural cell sites it's not going to make much difference since rural cell sites are far apart, and the cool bells and whistles with 5G involve having smaller cell sites close together.

5G Hot Spots. There are commercials on TV showing cellphone speeds of over a gigabit. This is not 5G. This is a phone equipped to use a new frequency band called millimeter wave spectrum to deliver hot spot Ethernet to phones. This is an ultra-high frequency and is 10-30 times faster than traditional cellular frequency.

It's easiest to think of this technology as a 5G hot spot, similar to a hot spot that might be found in a coffee shop, only mounted outdoors on a pole. The signal only travels a short distance, mostly under 1,000 feet from a transmitter. It needs line-of-sight and can be easily blocked by any impediment in the environment. The signal won't pass from outdoor transmitters into buildings – it won't connect to a phone if a user's body blocks the signal from the hot spot. This technology only makes sense where there are a lot of people, such as downtown urban corridors, stadiums, and business hotels.

There is a lot of speculation in the industry that this is a novelty product being deployed to convince the world that 5G will be blazingly fast everywhere. The cellular carriers seem desperate to deploy something they can call 5G, and super-fast cellphones are a good way to get headlines. However, it's extremely unlikely that any carrier is going to invest in cell sites that close together outside of major downtown business districts. This technology is likely to never reach to residential neighborhoods in cities, suburbs, small towns, or rural America. A lot of industry experts are asking why anybody needs gigabit broadband for cellphone, and only outdoors, since there are no high bandwidth applications for cellphones.

Millimeter Wave Fiber-to-the-Curb

Another new technology getting a lot of press is 5G fiber-to-the-curb using millimeter wave spectrum. Verizon built this technology in a few neighborhoods in Sacramento and a few other cities in 2018. It's now being deployed in a few more markets like Detroit. The technology consists of deploying small cell sites on telephone or power poles and then beaming broadband to a small receiver sitting inside a customer window. To get fast speeds, this network requires building fiber to feed the small cell sites. Verizon achieved speeds in the first trials of 300 Mbps and is supposedly doing a little better in the newest variation.

This technology has historically been referred to as fiber-to-the-curb (FTTC). The technology required building fiber close to every potential customer and then using wireless, or some other technology other than fiber to bring the broadband into each customer's premise.

Millimeter wave spectrum is at extremely high frequencies of 24 GHz and higher. The primary operating characteristic of millimeter wave spectrum is that the signal doesn't travel very far. Most engineers set the realistic top distance of this technology at about 1,000 feet from a wireless transmitter – and probably less is field deployment.

The biggest impediment to the business plan is that it requires building fiber along each street served, making this at least as costly as building fiber-to-the-home. The cost of putting fiber on poles can be expensive if there are already a lot of other wires on the poles (from the electric, cable, and telephone companies). In neighborhoods where other utilities are underground the cost of constructing fiber can be even higher. Another challenge for the technology is that the millimeter wave spectrum requires a clear path between the transmitter and a dish placed on the home – and that means that 5G is best deployed on straight streets without curves, hills, or dense tree cover.

The technology will only make financial sense in some circumstances. This means neighborhoods without a lot of impediments like hills, curvy roads, heavy foliage, or other impediments that would restrict the performance of the wireless network. It also means avoiding neighborhoods where the poles are short or don't have enough room to add a new fiber. It means avoiding neighborhoods where the utilities are already buried. An ideal 5G neighborhood is also going to have significant housing density, with houses relatively close together without a lot of empty lots.

This technology is not suited to downtown areas with high-rises; there are better wireless technologies for delivering a large data connection to a single building, such as the point-to-point microwave radios used by Webpass. This also makes no sense where the housing density is too low, such as suburbs with large lots. This technology is definitely not a solution for rural areas where homes and farms are too far apart.

Verizon has not built any more of this technology since the trial in 2018. AT&T has said repeatedly that they can't see a business case for the technology unless the cost of radios come down significantly. It's hard to predict if this will ever be a viable business plan. However, for now, nobody other than Verizon is deploying this, and it doesn't seem like a good fit for much of your area.

One thing that is seldom mentioned in the press when talking about any of the 5G technologies is how wonky all wireless technologies are in the real world. Distance from the transmitter is a huge issue, particularly for some of the higher frequencies. More important is local interference and propagation issues. As an example, I live in Asheville, NC. It's a hilly and wooded town and at my house I have decent AT&T coverage, but Verizon sometimes has zero bars. I only must walk a block away to find the opposite situation where Verizon is strong and AT&T doesn't work. 5G will not overcome the inherent topographical and interference issues that affect cellular coverage today.

The Need for Small Cell Sites. Communities of all sizes are seeing requests for adding small cell sites. These are small cellular sites that are placed on poles rather than on the big cellular towers. It's likely that when a cellular company, or one of their subcontractors makes such a request they will tell you this is for 5G.

The fact, is, for now these cell sites are being added to bolster the 4G networks. It's not hard to understand why the 4G cellular networks are stressed. The cellular companies have embraced the "unlimited" data plans, which while not truly unlimited, have encouraged folks to use their cellular data plans. According to Cisco the amount of data on cellular networks is now doubling every two years – a scorching growth rate that would mean a 60-fold increase in data on the cellular networks in a decade. No networks can sustain that kind of traffic growth for very long with becoming congested and eventually collapsing under the load. There was no way for us to assess if the cellular networks in and around Farmington or throughout San Juan County have adequate cellular broadband capabilities.

The cellular companies have a 3-prong approach to fix the performance problems for 4G. First, they are deploying small cell sites to relieve the pressure from the big cellular towers. One small cell site in a busy neighborhood eliminates a lot of stress from the big cellular tower in the neighborhood.

The cellular companies also have been screaming for new mid-range spectrum, because adding spectrum to cell sites and cellphones expands the data capability at each cell site. Unfortunately, it's a slow path between the FCC approving new spectrum until the time when new spectrum is installed in cell sites and enabled in smartphones. The FCC has awarded several bands of mid-range spectrum in the year and are looking at more.

Finally, the cellular carriers are counting on 5G. There are a few aspects of 5G that will improve cellular service. The most important benefit comes from frequency slicing that will right-size the data path to each customer and will get rid of today's network that provides a full channel to a customer who is doing some minor broadband task. 5G will also allow for a customer to be connected to a different cell site if their closest site is full. Finally, the 5G specifications call for a major expansion of the number of customers that can be served simultaneously from a cell site. Unfortunately for the cellular carriers, most of the major 5G improvements are still five years or more into the future.

There is a fourth issue that is a likely component of the degrading cellular networks. It's likely with expanding broadband needs that the backhaul links to cell sites are overloaded at times and under stress. It doesn't matter if all of the above changes have been made if the backhaul is inadequate – because poor backhaul degrades all broadband services. The big cellular carriers have been working furiously to build fiber to cell sites to eliminate leased backhaul. But much of the backhaul to cell sites is still leased and the lease costs are one of the major expenses for cellular companies. The cellular companies are reluctant to pay a lot more for bandwidth, and so it's likely that at the busiest times of the day that many backhaul routes are now overloaded.

Low Orbit Satellite Technology

There are several major companies planning on providing fleets of low-orbit satellites to provide broadband service. This includes efforts by StarLink (Elon Musk), Project Kuiper (Amazon), and OneWeb that have announced plans to launch swarms of satellites to provide broadband. Following is a list of the satellite plans that have been announced:

	Current	Future	Total
StarLink	11,927	30,000	41,927
OneWeb	650	1,260	1,910
Telesat	117	512	629
Samsung		4,600	4,600
Kuiper		3,326	3,326
Boeing	147		147
Kepler	140		140
LeoSat	78	30	108
Iridium Next	66		66

SES 03B	27		27
Facebook	1		1
Total	13,153	39,728	52,881

Low-orbit satellites have one major benefit over the current broadband satellites which sit more than 22,000 miles above the earth. The new satellites are proposed to orbit between 200 and 800 miles high. By being significantly closer to the earth the data transmitted from low-orbit satellites will have a latency of between 25 and 35 milliseconds—about the same experienced in a cable TV broadband network. This is much better than the current latency for high-orbit satellites which has been reported as high as 900 milliseconds. The low-orbit satellites will be able to easily support real-time applications like VoIP, video streaming, live Internet connections like Skype, or distance learning.

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

Elon Musk and his company StarLink have the early lead. The company launched two test satellites in 2018 and launched 60 satellites in May of 2019. At the end of September 2020, the company had 715 satellites in orbit. In 2019 the FCC established a rule where an operator must deploy satellites on a timely basis in order to keep exclusive right of the spectrum needed to communicate with the satellites. Under the current FCC rules, a given deployment must be 50% deployed within 6 years and completely deployed within 9 years. The company recently revised its launch scheduled with the FCC for the first phases of launches with the following schedule.

	Satellites	Altitude (Km)	50% Completion	100% Completion
Phase 1	1,584	550	March 2024	March 2027
	1,600	1,110		
	400	1,130		
	375	1,275		
	450	1,325		
Phase 2	2,493	336	Nov 2024	Nov 2027
	2,478	341		
	2,547	346		
	11,927			

This is an incredibly aggressive schedule and would require launching 120 satellites per month just to meet the 50% completion goal – something Starlink is not yet meeting. Starlink also recently filed plans with the International Telecommunications Union (ITU) to launch 30,000 additional broadband satellites over the 11,927 now in the planning stages. The 20 new filings request to deploy 1,500 satellites each in 20 different orbital bands around the earth. These filings are clearly laying down the gauntlet for other planned satellite providers. Nobody knows if Starlink is serious about the huge number of planned satellites or if this is a play to gain more favorable regulatory rules around the world for spectrum.

The other company with six test satellites already launched is OneWeb, founded by Greg Wyler of Virginia in 2012. The company went bankrupt due to lack of cash and was recently purchased by the British government and an Indian ISP. The original plans were to launch a constellation of 650 satellites that will blanket the earth, with ultimate deployment of 1,910 satellites. The original plan concentrated on serving places like Alaska, but there is no news of the revised plans.

Another interesting entrant into the market is Jeff Bezos and Amazon. They recently got approval from the FCC to enter the business and filed with the FCC under the name of Kuiper Systems LLC. Amazon has big plans, and the FCC filing said the company wants to launch a constellation of 3,236 satellites in low earth orbit. That's 784 satellites in orbit at 367 miles above earth, 1,296 in orbit at 379 miles, and 1,156 in orbit at 391 miles. Like Elon Musk, Jeff Bezos also owns Blue Origins, which has developed an orbital-class rocket called the New Glenn.

We still know little about proposed broadband speeds or prices. Starlink has been conducting a few beta trials and customers have been talking about getting speeds in the 50 Mbps range. Starlink also provided a clue about the capacity of the satellites when it asked the FCC for permission to eventually create one million links to earth-based receivers, meaning customers. That's a good indication that the satellite providers in total are going to be able to serve perhaps a few million customers in the US. There are considerably more rural homes than this without broadband – so satellites may never satisfy the existing demand for rural broadband. The satellite companies are likely to limit their business to rural areas where they can command a premium price, not trying to bring broadband to every rural household.

Skeptics are doubtful that Starlink can launch all of the planned satellites. To put their plans into perspective, consider the number of satellites ever shot into space. The United Nations Office for Outer Space Affairs (NOOSA) has been tracking space launches for decades. They report at the end of 2019 that there have been 8,378 objects put into space since the first Sputnik in 1957. As of the beginning of 2019 there were 4,987 satellites still in orbit, although only 1,957 were still operational. There was an average of 131 satellites launched per year between 1964 and 2012. Since 2012 we've seen 1,731 new satellites, with 2017 (453) and 2018 (382) seeing the most satellites put into space. The idea of putting many thousands of satellites into space in a short period of time still seems like a daunting challenge.

While space is a big place, there are some interesting challenges from having this many new objects in orbit. One of the biggest concerns is space debris. Low earth satellites travel at a speed of about 17,500 miles per hour to maintain orbit. When satellites collide at that speed, they create many new pieces of space junk, also traveling at high speed. NASA estimates there are currently over 128 million pieces of orbiting debris smaller than 1 square centimeter and 900,000 objects between 1 and 10 square centimeters.

NASA scientist Donald Kessler described the dangers of space debris in 1978 in what's now described as the Kessler syndrome. Every space collision creates more debris and eventually there will be a cloud of circling debris that will make it nearly impossible to maintain satellites in space. While scientists think that such a cloud is almost inevitable, some worry that a major collision between two large satellites, or malicious destruction by a bad actor government could accelerate the process and could quickly knock out all of the satellites in a given orbit. It would be ironic if the world solves the rural broadband problem using satellites, only to see those satellites disappear in a cloud of debris.

III. FINANCIAL PROJECTIONS

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 for such a business. We believe that the financial results shown in these models are characteristic of similar operations elsewhere and we believe our assumptions are realistic.

The primary goal of the business models is to look at the potential profitability if a fiber broadband utility if operated by the Farmington power utility. With some modest changes this same model could be used to represent the costs of a commercial broadband ISPs. This would require changing from bond to bank financing and changing labor rates and benefits from a civil service structure to a commercial structure.

A. Services Considered

The following is a discussion of the products and services considered in the study.

Telephone Services (VoIP)

Voice over IP (VoIP) is a digital telephone service that transmits a telephone call to customers using their broadband connection rather than establishing a more traditional analog telephone connection. VoIP has been around the industry for a few decades. The first major seller of VoIP was Vonage, which still delivers VoIP over the open Internet. Most VoIP arrangements now use secure private broadband connections rather than the open Internet.

The study assumes that the retail provider of telephone service will purchase wholesale VoIP. This product is available from numerous vendors. These vendors own a digital telephone switch, and they deliver calls to and from customers from that switch to the ISP. Our clients tell us that offering voice is still mandatory when selling to businesses since many businesses insist on having a vendor that delivers all their communications needs.

The alternative to using VoIP is to buy a telephone voice switch and then establish connection between that switch and the public switched telephone network. These connections are referred to in the industry as “interconnection.” We’ve found through a number of studies that it’s hard to justify buying a switch and paying for interconnection costs unless a service provider expects to serve at least 5,000 telephone lines.

High-Speed Bandwidth (of at least symmetrical 100 megabits)

The network design for the studies deliver a symmetrical gigabit bandwidth product to every customer in the service areas. Additionally, the network can provide speeds up to 100 gigabits for the largest businesses, although there are probably none that want more than 10 gigabits. It’s anticipated that there would be residential and small business broadband products at speeds less than a gigabit. The study assumes the basic product is 100 Mbps, but that could easily be changed to some other speed.

Internet Services (ISP, email, web hosting, etc.) / Security

It was traditional in the industry for an ISP to provide all services related to the Internet as part of their ISP service. This included such things as email, DNS routing, virus checking, spam filtering, etc. Most ISPs also offered services like helping customers create web sites and then hosting them at the ISP headend. A decade ago, there was also a booming ISP business line of providing off-site storage for customer data.

The majority of small ISPs now outsource these functions and product lines. None of these functions are profitable when considering the cost of labor to perform them. In addition, all the basic ISP functions are now available as a cloud service or from a large centralized help desk company. Most small ISPs have decided that their primary function ought to be maintain a network designed to provide minimal downtime and leave these various ancillary services to somebody else.

A good example of this is virus checking and security. Virus checking today means not only trying to keep viruses away from customers, but today it means protecting against larger threats to the ISP such as denial of service attacks or the many other kinds of hacking. Most ISPs have found that they can buy better protection from a company that does this function for a hundred small ISPs rather than trying to do this themselves. They've found that there is no particular glory from doing these functions well, but there is a huge liability if they perform these functions poorly.

The feasibility studies assume these functions are outsourced. There is nothing to stop an ISP from tackling some or all of these tasks, but that would be contrary to where the rest of the industry is headed.

Managed WiFi

Many small ISPs now offer managed WiFi, which means that the ISP installs and controls the WiFi network at the customer premise. It's become obvious over the past several years that a large percentage of the problems experienced by customers have been due to poor WiFi networks rather than to the broadband connection. ISPs began selling a product where they would install a high-quality WiFi modem. If a house is large, the ISP installs a meshed network with several networked WiFi routers. Since these routers are part of the ISP network, they can monitor the performance to make sure they are operating properly. Many ISPs also offer related services like helping customers connect new devices to the WiFi system – something that can be done easily from the ISP end.

This is a profitable product. A quality WiFi router costs around $100 and ISPs are charging between $5 and $10 per month for the service. CCG know of ISPs that have already sold this product to more than 60% of their customers.

Cable TV

The analysis does not include a retail cable TV product. Most new small ISPs are not offering the product because it's complicated and there is little or no margins or profits from the product. Further, any rural households are already buying this service today from one of the satellite TV providers.

Other Future Products

Today many ISPs are expanding their product lines to add additional product lines that rely upon broadband. Perhaps the best example of this is Comcast. They now offer a wide range of new products. For example, they have sold home security monitoring to many millions of customers. They are now probably the largest single nationwide provider of smart home products and they have a line of products such as smart lighting, smart watering systems, smart door locks, smart thermostats, etc. Comcast has also been selling a cellular product to compete with the big wireless carriers. Comcast even recently tested bundling solar panels with their other products in a few markets.

CCG finds it likely that any ISP operating a fiber network will eventually offer some of these same kinds of products along with products that have yet to be developed. This could include things like medical monitoring to help the elderly live in their homes longer. It might involve intensive gaming connections, including virtual reality and holograms.

It's impossible to build a business case for products that have yet to be developed, but it's reasonable to believe that any sizable ISP will offer new products over the time frame of this study. Our business plans incorporate a generic small future revenue for "new products" which is undefined. The assumptions used will be described under the revenue assumptions below.

Wholesale Bandwidth Products

Wholesale bandwidth products are those sold to other carriers or to large business customers. Such products can be a major source of revenue for ISPs in larger cities. For example, CenturyLink is one of the biggest sellers of wholesale bandwidth products in the country after their merger with Level 3.

Following are the kinds of customers that buy wholesale connections:

- Cellular towers in most markets buy fiber connectivity and bandwidth to connect to the traditional tall cell towers. In the last few years, we've seen the cellular companies building small cell sites placed on power or light poles. Both kinds of cell sites require a fiber connection.
- Nationwide businesses like hotel chains, banks, manufacturers, etc. usually have an arrangement with a single ISP to serve all of their locations nationwide. These ISPs will consider buying from a new fiber network, but they probably already have reasonably priced connections from CenturyLink or Comcast.
- Complex businesses like hospitals and universities usually have complex needs and look for ISPs that can provide a lot more than just bandwidth.
- Businesses with multiple locations in San Juan County need connections between branches. This might include grocery stores, local banks or other businesses that might operate multiple locations inside the County.
- Giant bandwidth users. This could be things like data centers or large stock trading houses that want large bandwidth with low latency.

<u>Products</u>

Following are the typical wholesale products that are sold to the above kinds of businesses:

- Dark Fiber. This involves selling a fiber that is not connected to electronics. The ISP buying the dark fiber is responsible for providing and operating the electronics necessary use the fiber. Dark fiber might be sold by the mile of fiber, or else by a set fee per dark fiber connection.
- Transport. Some wholesale providers only sell connections between points A and B. This might mean the retail ISP might need to buy several transport paths to serve a customer – for example, there might be one transport connection between and end-user connection and the wholesale hub and a second transport connection between the wholesale hub and the ISP hub.
- Dedicated Bandwidth. Dedicated bandwidth means that the customer doesn't share it with anybody else. The typical products on an FTTP network share bandwidth at some point in the network, but some businesses are willing to pay to buy raw, unshared bandwidth. The network can deliver speeds up to 100 Gbps.

We have not included any large bandwidth or wholesale revenues in the studies. While there is always a chance that you might sell a lot of these products, it's also possible that you'll sell little. Our goal in such a circumstance is to be conservative in our projection.

B. Financial Assumptions

Incremental Analysis

All of the projections were done 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 the incremental analysis answers the question of whether a new business line will be able to generate enough revenue to cover the 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 not the same as 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 was to undertake one of these business plans, they would allocate some of their existing overhead costs to the new venture. The classic textbook example of this is that some of the existing cost of the general manager of the ISP would be allocated to the venture in the accounting books. However, the cost of the salary of the existing general manager is not considered in an incremental analysis since that salary is already being paid by the existing business. If these studies were to show an allocation of the general manager, then they would not be properly showing the net impact of entering the new market.

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 predictions of the speed of the roll-out of the business venture. That means that if an ISP could get customers faster than predicted by the projections that they can have better results than we've shown.

Following are the major milestones as predicted by these forecasts:

- All scenarios anticipate that the first customers will be added to any new networks in the tenth month of the first year after starting the project.

- Financing. All the forecasts assume that the financing is available on January 1 of the first year of operations. This is illustrative only and could be changed to any other month during the year.
- Construction. Fiber construction is assumed to stretch over five years.
- Reaching Customer Penetration. The forecasts assume that the business reaches the target customer penetration rate by the end of the sixth year.

Pricing Strategy

We assumed that the pricing would be simple. There are a number of different pricing strategies used around the country by various ISPs for broadband. Following is a discussion of some of the more common models and a discussion of the pros and cons of the various approaches to pricing.

- Competition. When building broadband into a market that already has existing competition it's important to consider the prices of the competition as well as predicting how they might react to competition. In rural areas with little or no existing broadband this is usually not a factor.
- Market Rates. A market rate is a rate that most people are willing to pay for broadband. The market rate can most easily be understood by looking at the rates charged by existing ISPs – these are the rates that people are already paying, I regularly see ISPs that set prices too low based upon the assumption that nobody will change providers with prices near to existing market rates. However, I have numerous clients that charge market rates for broadband and get similar penetration rates to ISPs with lower rates.
- General Pricing Philosophy. ISPs often come to the market with predetermined notions of how prices ought to work. A pricing philosophy is often based upon the overall goals for the business and the way that an ISP thinks about business. For example, some ISPs have a goal of maximizing cash flow or maximizing profits (not the same thing). Other ISPs are more community based and want to bring fast broadband to as many households as possible. These basic philosophies are often the driving force behind a pricing strategy.

  For examples, some ISPs believe in simplicity and only offer a few products. Other ISPs stress bundles and price accordingly. Some ISPs think that the way to sell a lot of services is by having low prices. Other ISPs think it's better to have higher prices and fewer customers. Some ISPs think it's important to the community to have a low-priced product for low-income households. Some ISPs charge the same prices to residents and businesses – others charge businesses a lot more.

Those various philosophies result in a couple of different pricing schemes that we see in the marketplace. A few key examples include:

- One Broadband Product. A few ISPs like Google Fiber, Ting, and a handful of smaller ISPs have one broadband product. They sell a gigabit of speed for a set price. Google Fiber had gone to a 2-product offering, but recently announced they are returning to the flat-rate $70 gigabit. Any ISP with this philosophy is likely not trying to capture a huge share of the market but is content to sell a high-margin product to a smaller number of homes.

- Low Basic Price. Some ISPs set a low price for the basic broadband product. This is done more often by municipal ISPs, but there are small commercial ISPs with the same philosophy. As an

example, in these markets somebody might set the price of the basic product on the fiber network as something like 50 Mbps for $40. If the lowest price product offers acceptable speeds, a big percentage of households will opt for the low price.

- Low-Income Pricing. This is covered in more detail Section I.C. of this report. Some ISPs, both giant ones and small ones, offer products to low-income households. Most try to set rates to make it affordable, and most have some criteria for how customers qualify for the low rates, such as having students using the free lunch program. Most ISPs try to set the rates at a level that at least covers costs and perhaps returns a tiny margin.

- Introductory Marketing Rate. Some ISPs set a low introductory rate for new first-time customers. These rates are generally good for one or two years and customer routinely sign contracts to get the low rates. The long-term downside of this pricing philosophy is that customers come to expect low rates. Customers that take the introductory rate will routinely try to renegotiate for continued low rates at the end of the contract period.

  Customers dislike the introductory rate process because they invariably get socked with a big unexpected rate increase when rates jump back to list prices. The time of big introductory discounts might be starting to come to an end. AT&T decided last year to stop renegotiating customers to the low rates and when introductory offers end the company is sticking with the list rates. This has cost AT&T nearly four million customers on DirecTV, but the company says they'd rather have fewer customers that are profitable than maintain customers that don't contribute to the bottom line of the company. Verizon has abandoned the special pricing strategy because it attracts low-margin customers that often leave at the end if the contract period. We don't see many small ISPs that offer introductory rates since it gives out the message that rates are negotiable.

- Bundling. This is a pricing strategy to give a discount for buying multiple services. Most small ISPs don't bundle and take the attitude that their list prices are a good deal – much the same as car dealers who no longer haggle over prices. In order to bundle an ISP has to first set rates high (in order to lower them with the bundle discount). Comcast is probably the biggest bundler in the country, so in your market it's an issue that will arise since many customers will have bundled rates today.

  CCG Consulting has access to the prices and the resulting customer counts for hundreds of small ISPs and we have learned that most customers will buy the basic broadband product if the speed is okay. A basic product set at a low speed like 5 Mbps download likely wouldn't sell, but in today's market a product with a decent download speed like 50 Mbps or greater will be perceived as acceptable to most households. Since a majority of customers are likely to buy the lowest-price product, it's important to set that price at a level that makes sense for the bottom line.

  As mentioned above, it's debatable if an ISP with low rates captures any more of a market than an ISP with okay rates – but it's obvious that low rates leave a lot of margin on the table. In setting rates, we began by considering existing market rates in your area. These are "permanent" rates and don't recognize advertising special rates that last for a year before reverting to full price. ISPs often

make the mistake of setting their own permanent rates to compete with existing provider special rates.

Following are the core rates in the market today:

- The basic price for a new Comcast customer is $73 per month for the lowest tier of broadband speed. Customers additionally pay $14 per month for a WiFi modem, which is optional. Comcast offers lower speeds for first time customers and will also sign contracts for lower rates for existing customers that agree to a term contract of one or two years. These negotiated rates could be set at any level less than the list price.
- CenturyLink DSL starts with a list price of $47 for 7 Mbps DSL. The price for 12 Mbps DSL is $52 and 20 Mbps is $62. The fastest speed tier on DSL is $72 per month, and we see some DSL customers in the city with speeds faster than 40 Mbps. CenturyLink also has a mandatory fee for the DSL modem, but negotiates different prices with customers between $1.95 and $6.95 per month.
- Advantas Internet has a product starting of 3 Mbps for $44.99. Prices go as high as $79.99 for 15 Mbps.
- Sacred Wind wireless internet starts at $75 per month for 15 Mbps and we don't think anybody in the area is seeing speeds faster than that on the wireless network.
- Sivadnet prices for wireless internet start at $49.99 for 3 Mbps with prices up to $89.99 for 10 Mbps.
- Brainstorm Internet has a price of $57 for 3 Mbps and $70 for 5 Mbps. Customers can get a discount for pre-paying for a year.
- NTUA Wireless has two prices for wireless internet at $44.99 and $64.99 – speeds not specified on the web.

In all cases, a new ISP with a fiber network will be able to offer significantly faster speeds than most of these products. In our experience, ISP don't have a big problem selling a superior product. A customer paying $50 for a 5 Mbps service is usually willing to pay a little more for service that is twenty times faster.

In the forecasts for this study, we used $60 as the starting price for broadband. That's slightly higher than CenturyLink DSL but offers much faster speeds. It's significantly below the list price for Comcast, although there will be customers with introductory or bundled rates lower than $60. The rate is a big bargain compared to all of the wireless providers since the base product is like to offer ten to twenty times the speed, often at a lower cost.

- Price Steps or Tiers. Most ISPs price with tiers (like the above examples for incumbents). Probably the key attribute to tier pricing is the price differential between tiers. Consider three different pricing structures that begin with the $60 broadband product:

	Rate 1	Penetration	Rate 2	Penetration	Rate 3	Penetration
100 Mbps	$ 60.00	95%	$60.00	80%	$60.00	70%
250 Mbps	$ 90.00	4%	$75.00	18%	$70.00	25%
Gigabit	$120.00	1%	$90.00	2%	$80.00	5%

For 1,000 Customers:			
Revenue	$61,800	$63,300	$63,500
Increase		2.4%	2.8%

The difference in the steps or tiers is that "Rate 1" prices are set $30 between products, Rate 2 is at $15, and "Rate 3" is at $10. The impact of smaller tiers is that it's easier to upsell customer to faster products. I derived the relative rate structure for the various tiers based upon what I've seen at various ISPs. Customers might voluntarily choose a fast product when the step between tiers is small, and they are more likely in the future to upgrade anytime they feel their speed is bogging down or inadequate. Conversely, when the steps are too large, customer buy and then stick with the lowest-priced tier rather than jump their bill too much.

It's an interesting phenomenon and to some degree the customer reaction to the pricing is psychological. Consider in the examples above that more customers are likely to buy the gigabit product in Rate 3 for $80 than will buy the 250 Mbps product in Rate 1 for $90. We think this is due to the way that customers compare a product to the other products that are available - but we've learned that customers react to different product sets much like the above tables.

We have seen that having too many price tiers confuse customers. The above examples have three price tiers. We know of ISPs with seven to ten price tiers and in looking at their penetration rates we see that this confuses customers. We have seen the most effective rate structures having no more than four tiers, which can be explained to customers on a fiber network as fast, faster, and fastest and gigabit – our favorite rate structure has three tiers.

- Setting Business Rates. Philosophies vary widely on business rates. The incumbent telephone companies and cable companies generally charge a lot more to business than to residential customers. At one time the philosophy behind this is that businesses consume more resources and cost more to serve than residential customers. While that might still be true for medium and large businesses, ISPs will tell you that the average home today uses considerably more bandwidth than the average small retail store. The exception might be a coffee shop supporting a public hotspot, or a business that deals in large files like photographers or engineers.

  We know a few ISPs that charge the same rates to businesses and residences, although that is rare. Most ISPs follow the incumbent pricing practices and charge more for businesses.

  One thing that a first-time ISP learns quickly is that incumbent ISPs don't have standard rates for businesses, but rather they negotiate with them. It's not unusual to find two similar small businesses in the same neighborhood paying rates for the same products that are 50% apart. This creates a challenge for a competing ISP. Some ISPs set standard business rates that apply to all businesses and others set rates on a custom basis compared to what a business is currently paying.

  The other thing that a new ISP learns quickly is that most businesses care more about reliability than price. They want their broadband and telephones to always work during business hours. They don't want to pay more than they can afford, but they are not afraid to pay for a quality connection. While a new fiber provider might see good appreciation for a fiber-based ISP saving them money, the chances are that they decided to change ISPs due to outages they have had in the past with their

current provider – if they perceive fiber to be a more stable technology. One of CCG's clients recently did a survey of businesses in a new market and over half of them had experienced a half-day or longer broadband outage during the last year. For most businesses, such outages are the deciding factor they cited when they talked about the willingness to talk to a new network provider.

Rates Used in This Study

Telephone Rates

The studies used the following very simplified pricing for residential phone service:

Basic Local Line	$15.00
Line with Unlimited Long Distance	$25.00

We've assumed that both kinds of lines include a full package of features like voice mail, caller ID, etc. The above prices also include any extra fees that the incumbent telcos show separately on the bill, but which are part of the rate. These rates would not include true taxes on the service, such as the tax that supports 911.

Customers who buy the unlimited long-distance plans considered by these studies would be able to call anywhere in the country as part of their plan. Similar plans today often include Canada, Mexico, and even some other international locations.

The studies have assumed the following rates for business telephone. In practice you might offer more rates than this to match any unique phone products in place today. Larger businesses might pay more than these rates. It's worth noting that home businesses usually buy residential products for both broadband and telephone service.

Basic Local Line	$25.00
Line with Unlimited Long Distance	$40.00
Business trunk Line	$30.00

Broadband Products

The studies do not specify data speeds, but we assume that broadband over fiber will be far faster than any broadband available today in the rural areas. We have shown data speeds by 3 tiers. A typical mix of products in three tiers on fiber might be something like 100 Mbps, 250 Mbps, and 1 Gbps.

	Price	Percentage
Residential Fiber Broadband		
Tier 1	$ 60.00	70%
Tier 2	$ 70.00	25%
Tier 3	$ 80.00	5%

Business Fiber Broadband		
Tier 1	$ 75.00	55%
Tier 2	$ 85.00	35%
Tier 3	$ 95.00	10%

Most ISPs charge more to businesses for broadband, and the studies assume a $15 additive to business rates for each of the three tiers.

These are all shared data products, meaning that the overall bandwidth to provide them is shared among multiple customers. That implies these are "up to" speeds and that sometimes customers might get slower speeds when the network is busy. On fiber networks we have many clients that are always able to deliver the subscribed shared speeds – but these are still not the same as a dedicated product where a customer it totally guaranteed the speeds at all times. The network Finley has designed will be able to provide a dedicated data product using an active ethernet connection. Prices for these services would cost a lot more than shared data services.

The financial models assume that the data products don't have data caps and provide unlimited broadband usage to customers. If there were data caps, then customers that exceeded those caps would be charged more than the basic prices. Both Comcast and CenturyLink DSL have data caps, although it's been widely reported that the CenturyLink often doesn't bill for data overages. A fiber provider has a marketing advantage over Comcast due to the data caps which can raise broadband rates as much as $50 per month for a residential customer. However, Comcast often waives data caps in markets where it competes with a fiber overbuilder.

Managed WiFi

This is a relatively new product that's been around for a few years. ISPs have found that one of the biggest problems with home broadband is 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 a carrier-class WiFi router in the home that is placed and operated by the ISP. High quality routers, and the placement of multiple routers for larger homes usually means better broadband coverage throughout a home. ISPs often also assist customers when adding a new device to the wireless network. The managed WiFi routers provide a secondary benefit to an ISP because it provides a network monitoring point 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 65% of residents would buy this product and 40% of businesses.

Large Broadband Products

There are business customers in the city that buy larger bandwidth products. The studies are conservative and predict minor revenues for such sales. Such sales are typically made to bring service to cellular towers, schools, or large businesses.

Cell towers are an interesting challenge. In some parts of the country we have clients with networks like what you are contemplating that get almost every cellular tower as a customer. But we have other similarly situated clients that get none of this business. The cellular carriers like to buy large volumes of connections from a single regional provider and they often already have a long-term contract for an area much larger than the county.

There will be a newer opportunity for selling connectivity to 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. We are already seeing small cell sites popping up in towns the size of Farmington, and over time this should be a growing market opportunity.

There is a unique new opportunity for somebody building fiber in that you would be able to offer putting small cell sites anywhere in the market. That would allow the cellular companies to engineer the cellular network for the best performance. The FCC is also planning to provide $9 billion in grants to cellular companies to expand cellular coverage to rural parts of the country, and that might mean an opportunity for the rural parts of your contemplated network. The new grant program has been named the 5G Fund, although it's likely that if somebody brought cellular coverage to the most remote parts of these counties that they'd likely use 4G LTE technology. Somebody building rural fiber to remote places for the next few five years might have an opportunity to partner with cellular providers as part of this new grant program – meaning at least some fiber might get subsidized with grants. Finally, there is a new nationwide cellular company, Dish Networks, which is in the process of deploying cellular sites nationwide. They might be amendable to working directly with regional fiber owners.

Network Capital Costs

The telecom industry uses the term capital costs to describe is the industry term for 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. The amount of capital investment required varies by the technology used as well as by the number of customers covered by a given scenario.

Capital for broadband networks include several broad categories of equipment including fiber cable, electronics for FTTP, huts and wireless towers, wireless electronics, and customer devices like cable settop boxes and WiFi modems. In addition to capital needed for the network, there are operational capital costs predicted in the projections for assets like furniture, buildings, computers, vehicles, tools, inventory, and capitalized software.

We have tried to be realistic, but a little conservative in our estimates, so that hopefully the actual cost of construction will be something lower than our projections. However, it is important to remember that the engineering used to make these estimates is high level. The detailed engineering needed to be more precise is expensive and would involve having an engineer examine all places in the potential network to look at local construction conditions. That kind of engineering is generally not done until a project is ready for

construction. Instead, the engineering was done using some field examination of the county, along with maps and other tools. Finley has made many such estimates over the years and we know that this level of engineering is generally good enough to assess if a project is worth further consideration.

The studies all assume that the provider of service will not build a new cable TV headend or buy a new voice switch for the provision of cable TV or telephone service. If the new provider is an ISP that already offers those products elsewhere, the assumption is that they would transport in the products over the fiber backbone. These services are widely available today on a wholesale basis.

Following is the capital required for the base case for each scenario. This represents the capital expended during the first 6 years of the project, by which time most of the customers have been connected. The scenarios assumed different customer penetration rates. The rural scenario uses a 60% customer penetration rate. We assumed a 50% penetration rate for Farmington and other town areas. The total study area is a combination of those two different penetration rates.

	Rural	Total Area
Fiber & Drops	$52,917,044	$100,182,222
Drops	$ 2,861,919	$ 5,398,710
Electronics	$ 7,389,304	$ 15,115,428
Operational Assets	$ 1,329,916	$ 2,002,692
Total	$64,498,183	$122,699,052
Cost per Passing	$4,282	$3,588

To put the cost per passing and per customer into perspective, the cost per rural passing is a lot lower than costs we've seen in other rural counties. This is due to several reasons. First is that most of the network would be put onto existing utility poles and burying fiber would be a lot more expensive. The lower cost is mostly due to the fact that people in rural areas are concentrated along rural roads, creating a relatively high housing density per mile of road. To contrast this with other parts of the country. For example, in a Midwest agricultural county, the density of customers per square mile of land might be similar to your area, but the density for road mile would be a lot lower. In this study area we were able to eliminate rural roads where there are no homes and businesses such as in the oil fields, whereas in a Midwest farm county farms would be scattered along almost all of the roads.

Customer Costs

Installation Labor. The study assumes that the utility would assemble a team of contractors to build fiber drops and install customer electronics. The number of contractors grows to 11 by the third year of the project. The utility would likely use its own employees to install complex business customers, but the contracted installers would install everybody else.

The alternative way to pay for fiber drops and installations would be to outsource the function to a commercial drop vendor. Such an entity would likely add several hundred dollars of profit to the cost of each installation. In the base conservative business plan, the business adds 18,400 customers by the end of year 6. If a commercial contractor tacked on $200 profit to each installation the overall costs of installations would be almost $3.7 million higher than is used in the forecasts. Since you need a significant

number of contractors for multiple years, it's a lot more cost effective to hire contractors individually rather than pay a profit to a commercial firm for the same labor force.

There are several advantages other than the cost savings for hiring contractors directly:

- The contractors would work directly for the utility, making it easier to make sure that they do things your way. This is particularly important since these technicians will be installing the customer electronics at the customer home, and this means you can train and control the technician interface with your customers.
- Hiring contractors is also an advantage compared to hiring full-time employees. The installation jobs are temporary – installation would likely be spread over about five years, but at the end of that time you would no longer need these positions. That would make it awkward to have a large layoff.
- The utility will have normal attrition of technicians during the six years and you would be able to select the best installers for permanent positions during that time.

Residential Fiber Electronics Costs: The model assumes that the hardware electronics for an ONT cost $210. The forecasts assign 25% of the installation costs, described above, to the cost of customer electronics.

We've assumed that the cost of a carrier-class WiFi router to be $115. The model makes it optional for customers to use your routers, so there is not a router cost for every customer.

Fiber Drop Costs: Fiber drops are the fiber that connects from the street to the customer premises. Drop costs vary according to the length of the drop. The fiber drops in the city would be shorter, on average, than the length of rural drops. Finley calculated the average length of drops by sampling drop distances from street to customers in the mapping process. The cost for drop materials in the city is assumed to be $105, and the cost of drop materials in the rural areas at $141, meaning the rural drops on average are 34% longer.

Customer Penetration Rates

Probably the most important variable in the study is the customer penetration rate, or the percentage of the homes and businesses that will buy broadband service. There is no way of knowing how many customers a broadband business might attract, so we looked at customer penetration rates in several different ways.

- We started by establishing a base penetration rate that we think is likely a conservative place to start our analysis. CCG has witnessed the roll-out of broadband in dozens of markets over the last ten years and we based the expected penetration rates to be conservative compared to what we have seen in other markets.
    - We used a starting penetration rate for the rural areas of 60%.We think that is conservatively low. We have seen penetration rates in other rural markets vary between 65% and 85%, with a few even higher. We arbitrarily chose 60% as a conservative starting point for the analysis.

      It's not too difficult to put the rural rates into context. Today the broadband options out the cities are poor or nonexistent, as was described earlier in the market analysis. There are no

realistic broadband alternatives to fiber broadband in these areas. The nationwide penetration rate for broadband is over 86%. That number can vary by community based mostly upon area household incomes. Unless there is extreme poverty in the areas outside of Farmington, we would expect the market penetration to be 65% or higher.

  - It's harder to predict penetration rates in cities like Farmington. The online residential survey showed a lot of interest in faster broadband, but since that survey wasn't random, we can't use it to predict a market penetration rate. The speed show that the Comcast network has problems and that broadband speeds tend to be slower than what is advertised, in some cases drastically slower. CenturyLink shows some speeds faster than 25 Mbps in town, but speeds are still only a fraction of what can be delivered over fiber. We used a starting penetration rate of 50%. This is not as conservative as the rural starting rate, but we think it's a realistic target market penetration.

- Next, we looked at different levels of penetration rates. For example, we looked at the impact on future cash flows from raising the penetration rates by 5% (65% rural and 55% city) and lowering the penetration rates by 5% (55% rural and 45% city). We also looked at two scenarios that we think are achievable and a little less conservative that our starting assumptions. The first scenario considered a 70% penetration rate in the rural areas and 50% in the city. We also looked at 45% in the city and 75% in the rural areas.
- Finally, we calculated what we call the breakeven penetration rate. This represents the lowest number of customers that are needed in order for the business to always maintain a positive cash balance. Our analysis shows that the breakeven penetration rate is a combination of 35% in the cities and 56% in the rural areas. This might be the most important finding of our analysis because we think this demonstrates a low level of risk in the business plan. The customer interest shown in the surveys and interviews tell us that it's highly likely that the penetration rates in the cities and the rural areas would be far higher than these breakeven levels. But the good news is that even if you achieved the 35%/56% breakeven penetration rates, the business would be self-sufficient and revenues would cover all costs.

There is one reliable way that we know of to understand the potential market penetration rates – using a statistically valid residential survey or a canvass. We discuss this in more detail in the recommendation section of the report – but we have repeatedly seen that surveys can be a good predictor of eventual penetration rates.

C. Expense Assumptions

As a reminder, unless otherwise noted, all scenarios are created from the perspective of the utility being the ISP and offering the services. The results would be similar if the city instead attracted an independent ISP to overbuild the community with fiber.

Expense Assumptions

Expenses are the recurring costs of operating the business once it's built. We strive when building financial projections to be conservatively high with expense estimates. As mentioned earlier, expenses are estimated on an incremental basis, meaning that the models only consider new expenses that would be needed to add the broadband product line to the utility. In an incremental analysis it's assumed, for example, that the utility is already paying for positions like a general manager, accountants, etc. – the utility would only

have to hire employees or incur the expenses needed to add broadband customers.

The primary expense assumptions are as follows:

Employees: Labor is generally one of the largest expenses of operating a broadband network. The models assume that the utility will need to hire additional staff to enter the broadband business. We have assumed salaries at market rates with an annual 2.5% inflation increase for all positions. We've assumed that the payroll tax and basic benefit loading is 20% of the basic annual salary for each employee. That covers payroll taxes and other taxes like workers' compensation, as well as basic employee benefits. We've also added an annual cost of health insurance per employee of $11,000, also increased each year by inflation. Finally, we've added an annual loading of $11,000 per year to each employee for allocations that would come from the city for each utility employee. This loading is a real cost to the utility and covers a wide range of costs covered by the city such as payroll services, human resources, building rent and maintenance for office space, etc.

As stated earlier, these models are incremental and only consider the additional labor needed because of the customers added. At a minimum, the new business would require the following additional employees. These positions are added over time and the counts below represent the number of employees added by the end of the sixth year.

Business Unit Manager. We've assumed that the utility will hire a new business unit manager to be in charge of the ISP business and the new staff.

Marketing/Sales Coordinator. This position coordinates the residential sales process and also knocks on doors and sells broadband to businesses. We've assumed the business will require the following new positions. If the utility only launched the rural market, then the primary function would be residential sales. In the total market scenario, the second salesperson would likely sell full-time to businesses. It might make sense to add even one more additional salespeople if the goal is to get broadband to businesses as quickly as possible.

Rural	1 new Salesperson
Total Service Area	2 new Salesperson

Customer Service Representative: Takes new orders, answers customer questions about billing, services, etc. We've assumed the business will require the following new positions:

Rural	4 new CSRs
Total Service Area	6 new CSR

Install/Repair Technician: These technicians provide maintenance and repair calls and generally work outside in the field. The technicians would maintain both network electronics and facilities as well as customers. We've assumed the business will require the following new positions:

Rural	4 new technicians
Total Service Area	7 new technicians

Electronics Technician: These technicians generally work inside and maintain the electronics that operates the network and that provide the services. We've assumed the business will require the following new positions:

Rural	1 new technician
Total Service Area	1 new technician

Provisioning Coordinator: This position is responsible for making sure that each customers gets the right set of products and that everything that is provided to customers is billed for. We've assumed the business will require the following new positions:

Rural	1 new provisioner
Total Service Area	1 new provisioner

Total Employees Added. The total new employees assumed are as follows:

Rural	12 new employees
Total Service Area	18 new employees

It's possible over time that the new ISP department might hire some additional positions. This might include somebody who is in charge of budgets, or additional marketing help.

The projections also assume that this new business will hire contractors for the first six years of the project to install customers. It's assumed that construction contractors will build the fiber network.

Start-Up Costs: To be conservative, there are start-up costs included in each scenario. There are expenses associated with launching a new business or new market and rather than list them all specifically in the model we have included them as start-up costs. We've assumed the start-up costs are $405,000 for the rural scenario and $510,000 for serving the whole area.

Sales and Marketing Expenses: Every scenario is going to require a significantly high customer penetration rate to be successful. We used the assumption that there would be a marketing effort to sign customers (instead of the word-of-mouth that often happens in rural markets). It would be too risky to spend the money to build a network without knowing for sure that there are enough interested customers to allow the business to pay for itself. Marketing expenses shown in the models are likely going to be for that effort. It's possible that such money would be spent earlier than shown in the model.

The marketing budget for the first 5 years of operations for the three scenarios are as follows:

Rural	$550,000
Whole County	$880,500

Delivery of Products: The projections assume that the new business will not construct a headend to provide the services. Today is easy to outsource the basic functions needed to provide telephone and broadband services, and the forecasts assumed these products are purchased wholesale. 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. This will likely include buying maintenance agreements with the primary vendors of electronics.
- Internet Backbone. This is the cost of buying a connection to deliver broadband traffic to and from the internet. This involves buying fiber transport to reach a larger nearby market and also paying for the amount of bandwidth used.
- Internet Help Desk. The monthly fee for this service covers several different functions. This fee would cover those functions used to deliver broadband such as spam monitoring and security. This also includes network monitoring. The fee includes the help desk function, which is the function of assisting customers with broadband and network issues.

Software Maintenance: ISPs typically maintain a complex software system called BSS/OSS (billing and operational support systems). This software provides a wide range of functions: order taking, provisioning new customers, tracking of customer equipment, tracking of inventory, creation of customer bills, tracking of 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. This could be new software, or a telecom module added to the existing utility software system.

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, of charging bills to credit cards, and of charging bills directly as debits to bank accounts.

Taxes: The model assumes there are no state or federal income taxes. We have assumed no property taxes on assets, but it's possible that some amount of this might apply. There are a few places in the country that charge property taxes on fiber networks, but most of the country doesn't. The issue of charging or not charging is usually county specific.

The forecasts do not include any taxes that are assessed to customers. For example, this business would be expected to charge and collect various telephone taxes. These kinds of fees are normally added to the customer bill, and thus customers pay these 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. They are not shown as revenue or expense to the forecasts, but rather are just a pass-through.

Administrative and Overhead Expenses: The forecasts include incremental overhead expenses. This would include things like legal expenses, accounting audit expenses, consulting expenses, business insurance, and other similar expenses that are directly 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 (is written off over 5 years). The cost of a new vehicle is then depreciated monthly to write off the asset over the 5 years, or 60 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 instead amortized, using the same process as depreciation.

Financing Assumptions. The cost of debt is one of the major costs or building a new fiber network. The financing assumptions for this project made the following assumptions for the base study:

- 100% of the cost of the project will be financed with general obligation bonds backed by the electric utility.
- Interest rate on bonds is assumed at 3.0 %.
- The term of the bond is assumed at 25 years.
- Capitalized interest is borrowed to cover the cost of interest for the first three years.
- There are no principal payments for the first two years.

In some scenarios we also considered the availability of a federal grant from the RDOF grant program that is explained in more detail elsewhere in the report. A map of the RDOF awards is shown on page 5 of the report and shows that grants were awarded to EUS, Windstream and CenturyLink.

D. Financial Results

It is never easy to summarize the results of complicated business plans to make them understandable to the nonfinancial layperson. In the following summary are some key results of each study scenario that we think best allows a comparison of the numbers between scenarios. These summaries use the primary metric of the amount of cash generated over time as the easiest way to compare different scenarios.

The way to measure profitability in a new business will differ according to the nature of the business structure. A municipal business, for example, generally measures success by the ability of the business to generate enough cash to operate without any external subsidy. A for-profit business would more typically measure success using a metric like net income or net margin.

Following are the results of the various scenarios. Note that a table of all the financial results is included in Exhibit II. That Exhibit makes it easier to compare different scenarios.

Why the Projections Are Conservative

We always try to make our business plans conservative. By conservative, we mean that an actual business plan ought to perform a little better than we are projecting. Following are some of the conservative assumptions used in the business plan:

- The Finley Engineering estimates of network cost are generally a little conservative. Additionally, we've added a 5% contingency to the cost of the fiber network.
- Our model assumes a regular replacement of electronics. However, it is possible that upgrades will be needed less often than we have shown. Further, our assumption is that the cost of electronics at the time of each upgrade would cost as much as the equipment that is being retired. The experience of the electronics industry is that electronics get cheaper and more efficient over time, so the cost of upgrades is probably going to be less than is shown in the model. The vendors in the industry have also gotten better at having phased upgrades that allow for keeping older equipment in place and not having to replace everything at once, making upgrades less expensive than we have projected.
- The projections include no sales of large or wholesale bandwidth products. It's likely that the business will have some such revenues, but it's impossible to anticipate if this will be a minor or major revenue stream.
- As described above, we think that the customer penetration rates used in the analysis are conservatively low.
- There are ways that an ISP could beat our projections:
    - Preselling. We've seen service providers that are able to get earlier revenues when they presell to customers. This gives them the opportunity to begin connecting the network to the homes of presold customers while the network is being built. This would allow customers to be turned on in "nodes" or neighborhood-by-neighborhood as construction to specific neighborhoods are completed.
    - Adding Customers Sooner. These models assume that most customers will be gained by the end of the fifth year. There is a significant cash boost from selling faster and adding customers sooner.
    - Building in Stages. The forecasts assume that the projects are financed with bonds and that a bond for the entire project is floated at the start of the project. There could be a significant savings from borrowing and building the project on phases. For example, the forecasts in all assume that the money needed for installing customers in year four are borrowed at the start of the project. There would be a savings of interest expense if that money is funded sometime later than the start of the project.
    - Provide some Equity. There could be a significant savings on interest expense for any part of the project funding by equity instead of debt.

The Entire Study Area

Note that these results include building to the entire rural area – something that seems unlikely as a result of RDOF funding being awarded to CenturyLink and Windstream is parts of the rural areas.

Base Study

This analysis looks at bringing fiber everywhere in the electric service area. Following are the key assumptions in the base study:

- The starting penetration rate used in the city was 50%, in the rural areas 60%.
- New employees grow to 18 over 6 years.
- Asset costs were provided by Finley Engineering. The base study includes a 5% contingency on the cost of fiber.
- Financing was assumed to be with 100% municipal bonds financed over 25 years with a 3.0% interest rate.
- We looked at versions with and without the actual RDOF grant award of $3.18 million.
- Broadband rates were assumed in three tiers priced at $60 / $70 / $80. A conservative rate increase was assumed over time, with rates being increased by 3% every fifth year.

The base study results were as follows :

	No Grant	With RDOF
Asset Costs	$122.70 M	$122.70 M
Grant	$ 0.00 M	$ 3.18 M
Bond	$136.20 M	$134.40 M
Penetration Rate	50% / 60%	50% / 60%
Cash After 10 Years	$ 17.85 M	$ 20.11 M
Cash after 25 Years	$ 66.58 M	$ 70.88 M

There are a few key points that are obvious from this summary:

- Accepting the RDOF grant adds $4.3 million in cash flow over 25 years.
- With the assumptions we've made, a fiber business would generate significant cash flow over time, with or without accepting the RDOF grant.
- The biggest issue faced by the city is likely the size of the bond issue required to construct the networks, at over $130 million.

The Impact of the Key Variables

Customer Penetration Rate

Raising penetration rates by 5% – going to 55% in the city and 65% in the rural area – increased cash flow over 25 years by over $25.8 million. This infers that changing the penetration rate by 1% overall would increase or decrease cash flow over 20 years by about $5.2 million, Lowering the penetration rates to 45% and 55% had a similar impact and changed cash flow over 25 years by $26.6 million.

Keeping the city penetration rates at 50% and raising rural penetration to 70% increased cash flow over 25 years by over $25.4 million.

Lowering the city penetration to 40% and increasing rural penetration to 75% increased cash by 19.4 million over 25 years.

We calculated a breakeven penetration rate. This quantifies the number of customers that is needed so that the project always has a positive cash flow. The breakeven came in low at 35% in the cities and 56% in the rural areas.

The penetration rate seems to be the most sensitive variable in the business, so it's vital for the utility to get comfortable with the likely range of performance. We think the starting assumption of achieving a 50% city and 60% rural penetration rate is conservative and the business has the opportunity to perform a lot better than that. The easiest way to get comfortable with the likely customer penetration rates would be to conduct a statistically valid survey which could be used to pin down the likely range of customer interest in buying from the network.

Broadband Prices

Broadband prices also have a big impact on long-term cash flow. The analysis shows that changing broadband prices upward or downward by $1 per month will change longer-term cash flow over 25 years by almost $5.5 million.

Interest Rates

The business plan is also sensitive to interest rates since the project is financed with bonds. The analysis shows that changing interest rates by 0.1%, or 10 basis points (changing rates from 3.0% to 3.1%) changes cash over 25 years by $2.7 million.

Loan Term

A loan term is the number of years over which you borrow. The basic study assumes a 25-year loan term, which is pretty typical for a fiber project. If you were able to stretch a bond to 30 years, the cash flow over 25 years would improve by $26.5 million. The project would also benefit with a shorter 20-year loan and cash would increase over 20 years by $9.9 million.

Asset Costs

We looked at the impact of changing capital costs, meaning coming in higher or lower than the estimate made by Finley Engineering. The analysis shows that changing the capital costs by $1 million will change the cash flow over 25 years by $1.7 million.

Retire Debt Early

We looked at the impact of retiring debt early. In the following two scenarios, starting in years 6, any cash greater than $1 million is used to retire bond debt early.

- In the base scenario with a 50% city penetration rate and a 60% rural penetration the debt is not fully retired until 2039 (year 19), which is 6 years early. In doing so, the cash accumulated by year 25 increases an additional $15.1 million since year 20 and later don't have to cover debt payments.

- In the scenario with a 50% city penetration rate and a 70% rural penetration the debt can be fully retired by 2037 (year 17), which is 8 years early. In doing so, the cash accumulated by year 25 increases an additional $18.5 million since year 18 and later have no required debt payments.

The Rural Area

Note that these results include building to the entire rural area – something that seems unlikely as a result of RDOF funding being awarded to CenturyLink and Windstream is parts of the rural areas.

Base Study

This analysis looks at bringing fiber to just the rural areas outside of the city. These are the areas that have the worst current broadband options for residents and businesses.

- The starting penetration rate used for analysis is 60%.
- New employees grow to 12 over 6 years.
- Asset costs were provided by Finley Engineering. The base study includes a 5% contingency on the cost of fiber.
- Financing was assumed to be with 100% municipal bonds financed over 25 years with a 3.0% interest rate.
- We looked at versions with and without the actual RDOF grant of $3.18 million.
- Broadband rates were assumed in three tiers priced at $60 / $70 / $80. A conservative rate increase was assumed over time, with rates being increased by 3% every fifth year.

The base study results were as follows:

	No Grant	With RDOF
Asset Costs	$ 64.50 M	$ 64.50 M
Grant	$ 0.00 M	$ 3.18 M
Bond	$ 72.40 M	$ 70.20 M
Penetration Rate	60%	60%
Cash After 10 Years	$ 1.25 M	$ 3.37 M
Cash after 25 Years	$ 2.43 M	$ 6.97 M

There are a few key points that are obvious from this summary:

- Accepting the RDOF grant adds $4.5 million in cash flow over 25 years.
- With the assumptions we've made, serving only the rural area can be profitable without needing to be subsidized with revenues from the town.
- Since the rural area can be profitable on a standalone basis, this open up the possibility of not funding the whole project at once. It would be possible to finance the rural area first (which would probably make sense if you accepted the RDOF grant), and the city area could be funding later. This would save on financing costs since you wouldn't be paying interest on the full cost of capital borrowed in a lump sum at the start of the project.

The Impact of the Key Variables

Customer Penetration Rate.

Raising penetration rates by 5% – going to 65% in the rural area – increased cash flow over 25 years by over $11.6 million. This infers that changing the penetration rate by 1% overall would increase or decrease cash flow over 20 years by about $2.3 million, Lowering the penetration rates to 55% had a similar impact and changed cash flow over 25 years by $13.0 million. Raising the penetration rate to 75% increased cash by $38.0 million over 25 years.

We calculated a breakeven penetration rate. This quantifies the number of customers that is needed so that the project always has a positive cash flow. The breakeven rate if you don't take the RDOF grant is just slightly less than 60% penetration. With the RDOF grant the rural breakeven is around 58% penetration.

The penetration rate seems to be the most sensitive variable in the business, so it's vital for FEUS to get comfortable with the likely range of performance. We think the starting assumption of achieving a 60% rural penetration rate is conservative and the business has the opportunity to perform a lot better than that. The easiest way to get comfortable with the likely customer penetration rates would be to conduct a statistically valid survey which could be used to pin down the likely range of customer interest in buying from the network.

Broadband Prices

Broadband prices also have a big impact on long-term cash flow. The analysis shows that changing broadband prices upward or downward by $1 per month will change longer-term cash flow over 25 years by almost $2.7 million.

Interest Rates

The business plan is also sensitive to interest rates since the project is financed with bonds. The analysis shows that changing interest rates by 0.1%, or 10 basis points (changing rates from 3.0% to 3.1%) changes cash over 25 years by almost $1.4 million.

Loan Term

A loan term is the number of years over which you borrow. The basic study assumes a 25-year loan term, which is pretty typical for a fiber project. If you were able to stretch a bond to 30 years, the cash flow over 25 years would improve by $13.7 million. The rural area does not produce enough cash flow to work with a 20-year loan term.

Asset Costs

Finally, we looked at the impact of changing capital costs, meaning coming in higher or lower than the estimate made by Finley Engineering. The analysis shows that changing the capital costs by $1 million will change the cash flow over 25 years by $1.9 million.

The Urban Area Only

These results were not included in the original report.

Base Study

This analysis looks at bringing fiber to just the urban portions of the FEUS service area.

- The starting penetration rate used for analysis is 50%.
- New employees grow to 12 over 6 years.
- Asset costs were provided by Finley Engineering. The base study includes a 5% contingency on the cost of fiber.
- Financing was assumed to be with 100% municipal bonds financed over 25 years with a 3.0% interest rate.
- There is no grant funding available in the urban areas.
- Broadband rates were assumed in three tiers priced at $60 / $70 / $80. A conservative rate increase was assumed over time, with rates being increased by 3% every fifth year.

The base study results were as follows:

	No Grant
Asset Costs	$ 58.99 M
Grant	$ 0.00 M
Bond	$ 66.50 M
Penetration Rate	50%
Cash After 10 Years	$ 10.84 M
Cash after 25 Years	$ 37.87 M

There are a few key points that are obvious from this summary:

- With the assumptions we've made, serving only the rural area can be profitable without needing to be subsidized with revenues from the town.
- Since the rural area can be profitable on a standalone basis, this open up the possibility of not funding the whole project at once. It would be possible to finance the rural area first (which would probably make sense if you accepted the RDOF grant), and the city area could be funding later. This would save on financing costs since you wouldn't be paying interest on the full cost of capital borrowed in a lump sum at the start of the project.

The Impact of the Key Variables

Customer Penetration Rate.

Raising penetration rates by 5% – going to 55% – increased cash flow over 25 years by over $20 million. This infers that changing the penetration rate by 1% overall would increase or decrease cash flow over 20 years by about $4 million, Lowering the penetration rates to 55% had a similar impact and changed cash flow over 25 years by $18.4 million.

We calculated a breakeven penetration rate. This quantifies the number of customers that is needed so that the project always has a positive cash flow. The breakeven penetration rate is 40%.

What Conclusions Can We Draw from the Financial Results?

It's worth noting again that all of this analysis was performed in an incremental basis, meaning it considered only new revenues, new operating expenses, new debt, and new capital costs. If you operate a broadband utility as part of the electric utility, there are going to be additional revenues and expenses that would be added the fiber broadband financial books. From a cost side there will be an allocation of overheads from other parts of the government that we have not included in this study. This study does include the most direct utility overheads that we know must be paid, but not the full range of overheads and allocated costs.

But the study also doesn't include revenues that would come from the utility and the city into the broadband business. Having broadband everywhere would provide a platform for the utility to fully implement smart grid and other technologies to improve the performance of the electric grid. It's only natural that the fiber group would charge the utility group for such uses of the network.

Finally, there are some savings within the city as a whole that will come from implementing a fiber network for the whole area. Both the utility and the city are paying externally for telecommunications costs today that can instead be provided by the new fiber utility. The new business wouldn't replace all telecom spending and there would still be billing for cellular telephones and for specialized services purchased to support the 911 center in the city. But most or all other telecom services could be provided by the new broadband utility.

There are a number of conclusions we can draw from the results of the business plan analysis.

Operating a Fiber Broadband Business is Feasible

The revised results show that it's feasible to profitably operate a fiber broadband business in the urban parts of the FEUS service area. There may still be a feasible plan to serve the rural areas, but that's going to depend upon how CenturyLink and Windstream perform in fulfilling the RDOF grants they won in the recent FCC auction.

Any final determination of the feasibility is going to depend upon how much you can rely on the key assumptions used in the study. We think the primary assumptions that matter the most – the customer penetration rate, the interest rate on debt, and the customer prices are all conservative – but you need to kick the tires hard on each of these assumptions. The variability of these assumptions is discussed in more detail below.

The RDOF Grant Award Process got Complicated

FEUS won $3.18 million in grant awards from the RDOF grant. This is smaller than the hoped-for $9.5 million that was available. The decision to accept the RDOF grant got more difficult due to significant

awards being made to CenturyLink and Windstream to bring gigabit broadband to parts of the rural FEUS service territory.

The fact that this money went to big telcos complicates any decision. These big telcos have taken federal funding in the past to build better rural broadband and then didn't follow through and build what those grants required. A case in point is CenturyLink that accepted money in 2015 to improve rural broadband in the areas around Farmington to speeds of at least 10/1 Mbps. The Finley Engineering investigation for this project show that rural broadband speeds do not meet that speed threshold. We don't know if CenturyLink just made a half-hearted attempt at improving rural DSL speeds of if they did nothing – but they didn't comply with the requirements of the previous federal grant. We see the same situation all across the country in areas where CenturyLink, AT&T, Frontier, and Windstream accepted funding in that same 2015 grant program.

FEUS can see from the work we did for this project that the RDOF grant, estimated to be around $9.5 million, is not nearly enough money to build fiber in the rural areas. If somebody like FEUS was already going to build fiber, then the RDOF grant would have made it a little easier to make a fiber project work. That makes the big telco grant awards so puzzling. Are CenturyLink and Windstream really going to make the additional large investment needed to bring gigabit broadband?

This report is being updated soon after the RDOF grant awards, so there are still a lot more questions than answers. One of the biggest speculations is that grant winners might try to substitute some less costly technology, such as fixed wireless to fulfill the grant requirements. This would hopefully not be allowed by the FCC. There is other speculation that the big telcos will just take the grant money and largely pocket it, as they've done in the past. But these (and many other rumors) are just speculation. We'll know more when grant winners file grant long forms in several months, but we may not really know what CenturyLink and Windstream plan to do until years from now as the build-out requirements for the rural areas kick into effect. Only then will you know if they are really going to build gigabit broadband in the areas surrounding FEUS.

For now, our recommendation is that FEUS should not consider building to the rural area where the two telcos won funding. It's never going to make sense for two providers to compete with fast networks in rural places. The results of the grant have reduced the FEUS decision to a different set of options than were covered by this report.

The Breakeven Penetration Rate Seems Achievable

In the revised report we've calculated the breakeven for operating a fiber broadband business in only the urban areas. We calculate that to be 40%. By looking at the success of other fiber overbuilders, we judge those penetration rates to likely be reasonably achievable. One of our primary recommendations is to conduct a statistically valid survey to quantify the likely range of customer penetration rates.

It's Safest to Finance over a Long Term, But Bonds Could Be Retired Early

It's possible to get bond terms for fiber builds as long as 30-years. The longer the loan term the lower the annual debt burden, so longer loan terms make it easier to make it through the first ten years of the project.

Once the business is mature, if penetration rates are higher than the breakeven then excess cash will be generated – which could be used to retire debt early.

The Business is Sensitive to a Few Key Variables. All the scenarios are sensitive to changes in a few key variables. The analysis shown above describes the dollar impact from changing key variables like the customer penetration rate, the interest rate on bond debt, the length of bond term, prices, and the amount of money spent to build the network.

It is essential before deciding to get into the business to pin down these key variables. This means that FEUS can't take the financial results listed above or in Exhibit II as the straight answer, because changing any one of these variables will impact the predicted results of each shown financial scenario. To some extent the effects of the variables are additive. For example, the improvements that might be achieved through raising the rates or lowering the interest rate on debt can be added together if both variables change.

IV. OTHER ISSUES

A. Funding for Broadband Networks

For many fiber projects the biggest challenge is finding the funding. That does not seem to be as big of an issue in Farmington since you have access to the municipal bond market. However, having the ability to borrow the money does not mean that there is the political will to do so. This section of the report looks at a few issues associated with financing fiber networks that should be of interest to you.

Public Financing Options

The two primary mechanisms used for public financing 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 out for 25 or 30 years. It's also possible to finance a project completely with bonds, meaning that no cash or equity is needed. The primary historic source of public money used to finance telecom projects is through the issuance of municipal tax-exempt bonds, meaning the buyers of the bonds don't have to pay federal and/or state income taxes on the revenue from the bonds.

Revenue Bonds: Most of the municipal fiber networks that have been built have been financed through revenue bonds. Revenue bonds are backed by the revenues and the assets of the fiber network and the associated business. With a pure revenue bond, a local government will not have to repay the bonds if the project fails. With that said, having a bond default is a financial black eye that might make it hard for a community to finance future projects. So, to some degree, most governments feel obligated to pay back revenue bonds, since there is a big cost for not doing so.

It has gotten harder to finance broadband projects with pure revenue bonds due to some failures on the part of other municipal networks. Among these are Monticello, MN; Crawfordsville, IN; and Alameda, CA. These kinds of failures have made investors leery about buying bonds that are only backed by the business. This reluctance has made financing with revenue bonds more expensive.

The cost of a bond issue cannot be judged only by the interest paid. In fact, the other financing costs of bonds can outweigh the interest rate in the effect on the bottom-line cost of repaying a bond issue. Because of market reluctance to buy revenue bonds, they often have higher interest rates than general obligation bonds, but they also can incur the following costs:

Debt Service Reserve Fund (DSRF): Many revenue bonds require borrowing additional funds to be kept in escrow as a hedge against missing future payments. The DSRF is often set to equal a year's worth of principle and interest payments. This money is put into escrow and is not available to operate the business.

Capitalized Interest: Bonds begin accruing interest from the day the money is borrowed. Since fiber businesses take a number of years to generate enough cash to make bond payments, the bondholders require capitalized interest that is used to make the interest payments for up to the first five years of the project. Basically, the project must borrow the

amounts needed to make debt payments which can add a significant amount to the size of the bond issue.

Bond Insurance: Bond insurance is an up-front fee paid to an insurance company that will then pay one year of bond payments to bond holders in case of a default. We've seen bonds issued that have required both a debt service reserve fund and bond insurance.

For several years now the interest rates charged to bonds have been lower than the interest rate on commercial loans. But that has not always historically been the case. The difference between bond interest rates and commercial interest rates both change over time; that difference is referred to in the industry as the "spread." Sometimes the spread favors bonds and at other times it favors commercial borrowing. In our financial analysis we assumed that the interest rates are lower on bonds. Interest rates are also not the same for all kinds of bonds. For instance, the interest rate for revenue bonds can be considerably higher than general obligation bonds due to the perceived higher risk.

General Obligation Bonds (GO Bonds): If revenue bonds aren't an option, then the next typical alternative is general obligation bonds. General obligation bonds are backed by the tax revenues of the entity issuing the bonds. This backing can be in the form of various government revenues such as sales taxes, property taxes, or the general coffers of a government doing the borrowing.

What these pledges mean is that if the broadband project fails and can't make the bond payments, then the backing, then the pledge revenue source, such as property or sales tax, would have to be used to make the bond payments.

Many states require a referendum to approve general obligation bonds. Most states have a few exceptions for things like economic development bonds that don't require a referendum, but local government sometimes hold a referendum anyway just to make sure the public supports the initiative being financed.

There are other financing mechanisms that have been used by other municipalities to fund revenue-generating projects. These include:

Variable Rate Demand Obligations (VRDOs): VRDOs are a bond where the principal is paid in a lump sum at maturity. However, the borrower has the right to repay the bonds in whole or in part at any time (upon an agreed-upon notice). VRDOs are effective in circumstances when the borrower wants to match the repayment of the bonds to a revenue stream that varies year to year or a revenue stream that can vary from initial estimates and changes over time. In the case of the new telecommunications system, this type of financing provides the flexibility to make bond payments that match the actual revenues received. If revenues are slower than anticipated, principal payments do not need to be made. If revenues come in faster than anticipated, repayment of the bonds can be accelerated without penalty. We can recall having only ever seen this used once for a municipal telecom system by the city of Alameda, California. This kind of financing is used fairly routinely for other kinds of municipal needs.

VRDOs are most commonly structured as 7-day floating rate bonds. Interest rates are reset each week, and this adds a lot of risk to this type of financing. Unlike fixed-rate bonds, the borrower doesn't know what the interest rate will be on the VRDOs over the life of the issue. Interest rates on VRDOs are on the short end of the yield curve and have therefore historically been lower than interest rates on fixed-rate bonds even with the additional ongoing costs for a liquidity provider and a remarketing agent. There is typically a maximum rate stated which the VRDOs cannot exceed. But in a market where there is a significant increase in overall interest rates this kind of financing could end up being significantly more expensive.

Capital Appreciation (Zero Coupon) Bonds (CABs): CABs are bonds that are issued at a deep discount and which do not bear any stated interest rate. Like a Series E savings bond, CABs are bought at a price that implies a stated return calculated on a basis of the bond being payable at par at maturity. With no stated interest rate there is no interest paid until maturity, at which time all the compounded accreted interest is paid. With no interest payments required in the beginning years of the bonds, this would enhance the cash flow in the beginning years of the business.

CABs do, however, have several drawbacks over other types of available financing. First, the interest rates on CABs are typically higher than both the fixed-rate and VRDOs. Second, investors prefer not to have a prepayment option on CABs, which limits the flexibility of the government to call the bonds early if revenue collections are better than anticipated or if a restructuring of the debt is needed. This structure is used frequently for various government borrowings, but we've not ever heard of this being used for telecom—although there is no reason why it could not be used.

A Few Issues to Consider with Bond Financing

Payments Can Vary over Time. Most municipal bonds have relatively steady payments over time, much like a home mortgage. When financing a fiber project, it's pretty normal to not make principal payments during the first two to five years to give the business a chance to generate the needed cash. But generally, the payments are usually stead once full payments begin. This is not a requirement for bonds and the payments can be made larger or smaller over time to match the expectation of the ability of the business to make the payments.

Bonds Usually Can be Repaid Early. Most bonds allow the borrow to repay the principal after some stated initial time, like five to ten years. Bonds can also be refinanced if interest rates are lower in the future. These allow borrowers to control their perceived risks. Some borrows pay off bonds early to free up borrowing capacity and to lower risk.

Free Cash Can be Used to Lower the Amount of Borrowing. We only looked at scenarios that borrow 100% of the cost of building fiber. Many cities have contributed at least some free cash towards building a fiber network. Sometimes this is done to lower the amount of risk in the project by lowering the annual bond debt payments. But other cities have looked at this as an investment. In recent years most cities are earning very low returns on cash reserves and a city can invest in a fiber project and expect the same interest return as earned by a bond issue. For a city making a tiny fraction of a percent on interest income, the ability to invest some funds at 3% or more can be an attractive financing option. It's worth noting that internal loans always get the last priority

compared to the external bond issue – the city would have to repay the external bond each year before being allowed to repay itself.

Fiber Can be Financed in Steps. One of the good features of bonds is that they can be used to borrow 100% of the cost of a project, but that can also be a downside. It's likely that it could take 3 – 5 years to build fiber everywhere in the serving area we studied, and that means paying a lot of extra interest expense in the early years on money that might not be spent until years into the future.

In your case there might be one easy way to break the financing into two pieces. You could borrow to build either the rural or the town part first, and then fund the second part of the network several years later. The only downside of this approach is that nobody can predict the interest rates two to three years into the future, so the second borrowing could be at a significantly higher interest rate – or could even occur at one of those rare times when it's hard to sell municipal bonds – it's happened before.

Grants

It's hard imagining the construction of fiber networks in rural areas without some grant support. This is particularly true in San Juan County, which has rugged terrain and other issues that add to the cost of building fiber compared to many other parts of the country.

Federal Broadband Grants: There are several federal broadband grant programs that might benefit this project.

Rural Digital Opportunity Fund Grant (RDOF). The FCC has created a massive $20 billion grant program that will be awarded in 2020 and 2021. This grant program is being funded from the FCC's Universal Service Fund.

The utility has registered to bid in the RDOF auction at the end of October 2020. Up for grabs is around $13.5 million dollars in grant funding that would be earmarked for specific rural Census blocks in the area. The grant is awarding funds in a reverse auction and it's expected that the actual grant award will be closer to $9.5 million.

Following are a few key elements of this new grant program:

- The FCC proposes awarding the money in two phases. The Phase I award will be awarded in late 2020 and will award around $16.4 billion. The Phase II will award will follow and award the remaining $4.4 billion plus any money left from the Phase I grants.
- The grants will be paid out to grant recipients over 10 years. Grant recipients need to understand the time value of money because they will likely have to borrow money and then use the grant funding to make the grant payments.
- The money will be awarded using a reverse auction. This means that ISPs will bid on the amount of grant money they are willing to accept for a given geographic area, with the ISP willing to take the least amount getting the grant.
- The Phase I auction will only be awarded in areas that are wholly unserved using the definition of not having any broadband capable of delivering speeds of 25/3 Mbps or faster.

This unfortunately is going to use the lousy FCC maps to determine the eligible areas. This means that many parts of the country that ought to be eligible for these grants will not be part of the program.

- The grant program will give priority to faster broadband technologies. The FCC will weight technologies that can deliver at least 100 Mbps, and weight even more for technologies that can deliver gigabit speeds. There is a grant disincentive for technologies with a latency greater than 100 milliseconds.
- Recipients must complete construction to 40% of the grant eligible households by the end of the third year, with 20% more expected annually and the whole buildout to be finished by the end of the sixth year.
- Grant winners will be expected to agree to become the carrier of last resort for the grant areas. Applicants must be able to obtain Eligible Telecommunications Carrier (ETC) status to apply, meaning they must be a facilities-based retail ISP. This will exclude entities such as open access networks where the network owner is a different entity than the ISP. Applicants will also need to have a financial track record, meaning start-up companies need not apply. Applicants must also provide proof of financing.
- Grant winners will be subject to controlled speed tests to see if they are delivering what was promised. The current FCC speed test requires that only 70% of customers must meet 70% of the promised speeds requirements for an applicant to get and keep full funding.

e-Connectivity Grant Program. In March of 2017 Congress passed a one-time $600 million grant/loan program to build rural broadband. The project was labeled as the e-Connectivity Pilot. There is a lot of hope that Congress will continue this program.

ReConnect Grants.[18] 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. Those grant applications were already due before the date of this paper. There is a lot of hope in the industry that Congress continues to renew these grants. These grants are administered and awarded by the US Department of Agriculture.

Community Connect Grants.[19] This program specifically targets the poorest parts of the country and ones with little or inexistent broadband. This program awarded $34 million in 2018 and $30 million in 2019. Grant awards for the program are generally between $100,000 and $3 million and require at least a 15% matching from the grant recipient.

BroadbandUSA Program.[20] This program is part of the Department of Commerce's National Telecommunications and Information Administration (NTIA). The agency provides an annual database of grants that can sometimes be used for broadband (and are often used for other purposes). Examples include the Appalachian Regional Commission and the Community Development Block Grant (CDBG) Program.

[18] https://www.usda.gov/reconnect
[19] https://www.rd.usda.gov/programs-services/community-connect-grants
[20] https://www.broadbandusa.ntia.doc.gov/new-fund-search

Future Grants. Our analysis of the county shows that there is a possibility of more grant funding past the RDOF grant. For example, there are areas of the service area where CenturyLink claims 25/3 Mbps broadband, when our analysis shows speeds are likely extremely slow. To the extent that the utility can convince a grant program that these areas are unserved, there could be more grant funding available in the rural areas.

State Grant Programs

New Mexico Broadband Program.[21] The New Mexico Department of Information Technology (DoIT) was awarded a 5-year grant totaling at least $5 million with the goal to create more accurate state broadband maps. As detailed throughout this study, the current federal databases (referred to as FCC maps) massively overstate the availability of broadband in San Juan County and most other rural places in the US. This program also is supposed to engage in training programs to inform communities and anchor institutions about broadband. Another goal is what they call capacity building, which they mean to bring together the various major sectors of the state economy and public sectors to work collaboratively towards broadband solutions. Finally, the Broadband Program is tasked with developing a digital literacy resource.

New Mexico Broadband Grants. The Rural Telecommunications Act of New Mexico allocated $5 million per year for broadband grants given to broadband service providers to bring broadband to the neediest parts of the state. These grants are being funded from the state's Universal Service Fund (SRUSF). Grant are administered and awarded by the New Mexico Public Regulation Commission. Announcements of grant cycles and grant award can be found on the Telecommunications web page of the Commission.[22]

Opportunity Zones. Congress created a new tax 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 then designated specific opportunity zones. The good news is that much of San Juan County and the utility district is classified as an Opportunity Zone.

Qualified investments made inside an Opportunity Zone can get special tax treatment. The first benefit is that taxes can be deferred from past investments if the gains are invested 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 and not pay taxes on the gains now, but have those gains deferred until as long as 2047. Investors have until 2026 to make such investments.

An investor also gets tax forgiveness on new investments made inside the opportunity zones if that investment is held for at least 10 years. Most of the opportunity zones include sizable areas of low-income residents and a qualified investment must meet a test of benefitting that community in some significant way. A fiber optic network that will bring broadband to all the homes in an opportunity zone should meet that test – there are lot of demonstrable benefits of fiber.

[21] https://www.doit.state.nm.us/broadband/index.shtml
[22] http://www.nmprc.state.nm.us/utilities/telecommunications.html

Any ISP building a network in San Juan County and in Farmington should consider getting at least part of their 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 likely have a smaller interest rate and might not have to pay back the full cost of the investment.

There are big opportunity zones in and around Farmington. The western third of the city limits is inside an opportunity zone. For rural construction everything south of the city except for the westernmost border area of the county is also covered by an opportunity zone.

It would take some creative financing to somehow bring opportunity zone financing into play along with bond financing – but it probably can be done.

New Market Tax Credit. 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 is 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 that 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 3 years, then 6% in the final 4 years, for a total of 39%.

The Community Development Financial Institutions (CDFI) Fund and the Department of the Treasury administer the program. The process of how the Treasury allots credits is a complicated one and we won't cover it, but in essence, there are entities around the country each year that are awarded tax credits and these entities work as brokers to allot the credits to specific project. The credits are often purchased by the large national banks or other firms that invest in infrastructure.

Generally, 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 7 years of the tax credit, and at the end would have a balloon payment for the principal. However, often some or even all of the principal will be excused, making this look almost like a grant.

Because the entities that get the credits change each year, and because you apply with the entities that hold the credits, and not with the federal government, the process for applying for this money is somewhat fluid. However, there are entities and consultants who help find New Market Tax Credits and who can help you through the maze of requirements.

Customer Financing

There are a few communities that have used customer-backed revenues to help pay for a fiber network. CCG is now working with several communities that are considering the idea. There are several examples of places where this has been done in the country:

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 part or all of a bond issue.

It's easiest to consider a hypothetical example. We've shown that a bond in the range of $30 million will be needed to build fiber everywhere in the utility serving area. Consider instead a scenario where $30 million is financed using some other revenue stream while the remaining $100 million is used to finance the fiber project. That means the debt payment due from the fiber project will be smaller since the fiber revenues only have to cover $100 million in debt. The $30 million could be covered by an increase in sales taxes, property taxes or any other municipal revenue stream.

Carried to the extreme, this could result in a far more profitable fiber business. For example, the city could reflect the savings on debt in the firm of lower rates, meaning the savings would be passed on to the public. The public might pay higher property taxes but get cheaper broadband in return.

There are some real examples of this kind of financing:

- Lyndon Township, Michigan: This is a township of about 1,000 homes voted to raise property taxes to fund to build 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 about $25 per month per household. This form of financing allows the citizens to get affordable gigabit broadband – something that would not have worked if the project were funded in the traditional way. Projections showed that customer revenues would never cover the cost of the debt and running the business. This is an area that 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. Each town has pledged property tax revenues to fund part of the cost of the network.
- Cook County, Minnesota: Cook County funded about half of their 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 pay for the matching funds needed to build the project.

Public Private Partnerships

We were not asked to look specifically at public private partnerships (PPP) where the utility would partner with a commercial ISPs to fund the business. However, this is a common model in use around the country, particularly for cities that don't already have a municipal electric utility.

There is no one model for a PPP and such an arrangement can be structured in many ways. The main benefit of a PPP is that the commercial operator of a project benefits by getting some bond financing from the municipal partner. This allows the business to blend the benefits of bond and commercial financing and is one of the ways that makes it easier to get through the first few years of the project.

The general benefits of bond financing are what makes public money attractive to a commercial partner—low interest rates, long repayment term, and small or no payments for the first few years. But the downside is that there are more overall financing costs and in the long run a bond makes a project cost more in terms of cash. The safety of a bond in the first few years, though, can be very attractive.

Combining Public and Private Financing. There are benefits to combining the two kinds of financing:

- Banks will often consider the financing that comes with bonds as the equivalent of equity, meaning that the commercial partner will not require as much, or even no, cash equity.
- In terms of the amount borrowed, the two methods work well together if construction loans are used to cover the construction and bond financing is used for the longer-term financing costs.
- Combining the two methods works to produce a payment term that is longer than a traditional commercial loan.
- Combining the two methods also usually means lower debt payments during the first few critical years while the network is being built.
- Both municipalities and commercial telcos have a natural borrowing limit—meaning that there is always some upward limit on the amount of money they can borrow. Combining both kinds of financing can mean that neither partner has to hit their debt ceiling. Just as an aside, the debt ceiling is often the main impediment to funding project 100% with bonds. Fiber projects are generally expensive projects, and the required funds can easily exceed the ability of a government to fund it 100%.

We would be glad to provide the utility with more information about partnerships if you are unable to operate this through the utility.

B. Getting Local Buy-In

This section of the report will discuss a community engagement strategy – how to bring the public into the decision-making and implementation of broadband. Government entities have always known how difficult it is to activate the public to get engaged on any issue. It takes an enormous amount of effort to do this right. This section will describe techniques used successfully by other communities.

A community engagement strategy generally has two phases:

- The first phase is exploratory and has the goal of understanding the level of community interest in broadband.
- A second phase would be activated at the point that the community decides to move forward with a broadband solution. The goal of a second phase is to identify residents and businesses who will support a broadband network when built.

Staffing for Community Engagement

Both phases of community engagement require some level of staffing to be successful. Both phases require a focused and persistent effort, so it's important to identify staffing needed to be successful. We've seen many efforts to get community buy-in fizzle when nobody was dedicated to the community engagement tasks. We've seen the following ways that communities have staffed the effort.

- Dedicated Government Staff. The most expensive option, but one of the most effective is to

dedicate government staff to concentrate on community engagement. That requires a commitment by elected officials to fund the effort. This would typically not be a permanent position, but rather somebody dedicated to the effort for some fixed period of time. This is also not a 9 to 5 job since interfacing with residents often means evening meetings.

A county in Minnesota found a broadband solution because the mayor of one of the smallest towns in the county told his economic development director that getting broadband was his top priority. This economic development leader spearheaded the first phase of the process – educating the public on the issue of broadband. This particular area had towns with okay broadband from a cable company and rural areas with little or no broadband. The economic development director met with everybody imaginable in the area including other city governments, county governments, state representatives, and every civic and social group imaginable. After two years of tireless work by this one staff person the communities in parts of two counties agreed on a broadband solution. This would never have happened without this one dedicated staff position.

- Volunteers. Volunteers are also an important part of this effort. Every community seems to have some people who really hate the state of the existing broadband and who are willing to volunteer time to hunting for a solution. In the example given above, the economic development director assembled a group of active volunteers to help with the effort to engage with and educate the public. These folks created email lists, went canvassing door-to-door talking about the need for broadband, and showed up at every government meeting to stress that they wanted a broadband solution. It's important that any volunteer effort have some structure and working with a staff person can make sure such a group stays focused. If a community decides to engage volunteers, there should still be a commitment to providing some funding. In the case of the Minnesota effort, local governments funded the effort required to engage in a canvass of the communities to understand the interest in broadband. This included several rounds of mailing postcards asking homeowners to pledge support for broadband.

- Broadband Task Force. Another approach is to create a formal committee of citizens who are willing to work together to explore the issues around community broadband. Such a Broadband Task Force generally is composed of citizen volunteers and perhaps a few elected officials. The group would meet regularly and work towards exploring the need for a broadband solution. It's normal that such a group would report back regularly to the government about their progress. Such a group can collectively take on some of the needed community engagement tasks, and we've seen effective committees do this well. It's not unusual for a Broadband Task Force to solicit help from additional volunteers.

  Such groups are usually given a budget, but also restrained by needing to have expenditure pre-approved. We could write pages on the dos and don'ts of operating a successful citizen's advisory group. It's likely the town has done this before for other issues. The main key for success is to make sure that the group has a specific agenda, a specified budget, and the specified authority to meet their goals. Citizen groups can accomplish great things if they are properly directed to do so – but can stray if not given good direction.

Consumer Education

One important aspect during both phases of community engagement is to provide useful information to help the public better understand broadband issues. 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's been written for the layperson.
- Hold Public Meetings. Public meetings can be held to explain the results of this study, or meetings could be more generic and be aimed at explaining the broadband issues. It's worthwhile to have elected officials at public meeting so they can directly hear the kinds of issues that households and businesses have with existing broadband. It's vital to advertise heavily to drive attendance at meetings. CCG and Finley Engineering have been to a community meeting where only one resident showed up, and to others that were standing room only in a large room.
- Broadband Web Site/Social Media. Many communities create a broadband web page or accomplish the same thing using social media. Such a page can be used to educate as well as inform. For example, a common educational feature is to have a lengthy section with responses to "Frequently Asked Questions." Such a website can also inform the public about upcoming events or other things the government wants to advertise.
- Gather List of Broadband Proponents. One important resource is to create a database of local broadband proponents – citizens who say they support broadband. Having list of emails, home addresses, and phone numbers will be useful when it's time to gather support for public actions.
- Broadband Newsletter. Communities often create a newsletter dedicated to broadband. These newsletters are aimed at educating the public on topics related to broadband and also to keep the public informed on the progress of the effort to get better broadband.
- 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 the local organizations to talk about broadband issues and to answer questions. This can be any sorts of groups – 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 or who have specific knowledge about broadband.

Pre-marketing Efforts

If the broadband effort reaches the second phase, one of the most important steps is to identify potential customers for a broadband network. The biggest concern that every ISP has about a new market is knowing if they can get enough customers to be successful. We already have an inkling of the support in the cities from the residential survey. The pre-marketing efforts go a layer deeper and ask residents and business to pledge support for a new network. There are several techniques that communities have used to understand market demand.

Statistically Valid Surveys. You've already undertaken a residential survey. Before launching a municipal business, you would likely consider an additional survey that asked the public about the proposed products and prices.

Canvass. A canvass is similar to a survey but has the goal of reaching out to everybody in the community. Communities often undertake a canvass at the point where there is a decision to move

forward to implement a broadband solution. A canvass can have several goals. The simplest goal would be to create a list of broadband supporters. A canvass could also be used to get homes and businesses to pledge to buy broadband if a network is built. Such pledges are typically non-binding but can provide good support when the community is looking for funding

Canvasses can be done in several ways. A canvass often starts with an online invitation to support a broadband initiative. Canvassing can also be done by mail. We've seen communities engage groups like the PTA or service organization to get people to participate in the canvass. We've seen communities that send volunteers door-to-door to ask citizens to participate in a canvass.

C. Benefit/Risk Analysis

It's always important for a community thinking about building a fiber network to assess both the benefits and the risks of doing so. The first question that cities typically ask is if there are benefits that a citywide fiber network brings that cannot be satisfied by the existing broadband providers. If there are, then a secondary question to consider is if the city needs to be an ISP to achieve the benefits of fiber. Many of the benefits of fiber come whether a fiber network is built by the city or a private ISP. However, there are a few benefits that are more easily achievable by a city-controlled fiber network – such as lower prices and a way to tackle the digital divide.

Community Benefits from a Fiber Network

Following are the most common benefits that have been reported for communities that are upgraded to fiber:

Choice. Customer choice is already dwindling, and it's going to become even a more significant issue in the coming decade. Cable companies are in the process of becoming de facto monopolies in most communities and offer the only broadband that is fast enough for homes and businesses that use the Internet.

AT&T recently announced that as of October 1, 2020 it will no longer sell DSL service over copper. This is the first step for a company that plans to walk away from copper. It's likely that Verizon will follow soon, but it's something that is coming from every copper-based telco because the copper wires are ancient, in technology terms, and at some point the telephone copper built in the 19060s and 19070s isn't going to work. We already see the cable companies acting like monopolies. Cable companies raise rates every year, provide poor customer service, and are slow to respond to outages and problems. No community wants to find itself without only one choice for broadband.

In the rural areas the fiber network will finally create the first option that can be defined as broadband. Rural customers in the area have low-speed or no options for broadband today.

Price Competition. We know that overall prices are lower in markets that have multiple fast broadband networks. A fiber network in the community would provide a major new competitor for Comcast. One only has to compare broadband products in prices in places where Google Fiber or a municipality has built a fiber network to see that it makes a difference in prices. Cable companies typically react to competition by lowering prices to meet (but not beat the competitor) and by stepping up customer service.

A city with a municipal fiber network will see that broadband prices in the community will rise at a slower rate than in surrounding communities. Over time, the saving for everybody in a community with fiber can be gigantic.

Lower prices benefit everybody in the community, even those who don't subscribe to the fiber network.

Download Broadband Speeds. The Comcast network in Farmington has not been upgraded to the degree seen in larger cities or in competitive markets. We were surprised by the number of homes getting speeds less than 50 Mbps and even 25 Mbps on a cable network. During the study process we heard that Comcast and CenturyLink both promised big improvements to the city a few years ago but have apparently not made the promised changes. CenturyLink merged with Level 3 and no longer has plans to build residential fiber. Comcast seems to be ignoring Farmington as a smaller and remote market.

In the rural areas, download speeds can best be described as either slow or non-existent.

Upload Broadband Speeds. This issue was described in detail in the broadband GAP analysis. The COVID-19 pandemic has highlighted a problem with the broadband everywhere. The current technologies deployed in Farmington offer meager upload data paths. This has historically not been important aspect of the network to most residents. However, as employees and students were sent home to work, it became obvious that many homes don't have a good enough upload data path to support multiple people simultaneously working from home.

High quality upload data paths are required to connect to office or school networks. Good upload speeds are needed to connect to Zoom and similar video chat applications. Good upload speeds are also needed for telemedicine in visiting with doctors from home. Good upload speeds are also now needed for many gaming applications when the biggest game companies moved games to the cloud over the past few years.

Fiber networks can provide symmetrical uploads data speeds that can easily handle the newly created demands from homes and businesses. There is a lot of consensus among industry experts that a lot of the uses we've found for upload broadband are not going to go away when the pandemic is over. Many companies now understand that employees can be productive working from home, while saving the company from operating expensive office space. Telemedicine is likely going to become a routine way to connect with doctors for visits that don't require a physical examination. Video chat has now become a routine way for people to communicate. Gaming continues to grow explosively.

Improved Medical Care. The report discussed how telemedicine connections need a solid quality upload connection. Telemedicine is likely to become a routine facet of healthcare.

Broadband also is opening up new technologies that will benefit communities immensely. For example, good broadband can support a suite of monitoring and communications technologies that will allow the elderly to stay in their homes for more years. Good broadband is also proving to be beneficial for supporting monitoring devices after surgeries and procedures. A number of studies show significantly improved results for patients that are closely monitored after surgery by identifying problems early.

Superfast broadband on fiber enables doctors to review large medical files from home without having to travel to the office or the hospital in an emergency or the middle of the night.

Improved Education. It's likely after the pandemic that a lot of schoolwork will continue to be offered online. Already before the pandemic, 37% of all graduate degrees contained a significant portion of the coursework online. Fiber is one of the only technologies that allows for busy households with multiple family members to easily pursue online schoolwork or training.

Digital Divide/Affordability. In every city there are households that can't afford broadband. We won't know that percentage in your area unless you conduct statistically valid surveys. We see this percentage varying from 10% to 35% of all households.

A municipal network might afford the opportunity to bring broadband to these households. Cities that own fiber networks usually include solving the digital divide as one of their goals. Cities understand that the community will be stronger if everybody is connected to the Internet. That will be more important in the future as cities start implementing smart city technology to provide better digital access to city services.

Economic Development. Many cities claim huge economic development benefits from building fiber. Cities often tout how fiber was 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 seen in movies is now created there.

But the successes don't have to be that dramatic. The pandemic has convinced millions of people that they no longer want to live in major cities. Almost every rural community CCG is working with is seeing an influx of people looking to live in smaller and less hectic communities. A giant piece of the new economy are 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 few hundred high paying jobs. The same thing can be achieved by attracting the same number of high-paid workers who will work out of their homes.

Before the pandemic we rarely saw the percentage of people working from home to be more than 6% or 7% in most communities. That number if much higher during the pandemic but should return to levels much higher than the pre-pandemic levels.

A city with cheap and fast fiber is going to be an important tool to attract new residents and keep current ones from leaving.

And of course, cheap fiber also benefits traditional economic development and luring new businesses to the city. Cities without ubiquitous fiber are now at a major economic disadvantage compared to communities with fiber.

Keeping Profits at Home. The profits on telecom and broadband have always left the city into the coffers of the big telcos and cable companies. Economists universally estimate that keep such profits within the community has an overall multiplier effect of benefit of 7 to 9 times the cash that doesn't leave town.

Reduced City Communications Costs. With a fiber network all of the government locations within the city would be connected without paying for telecom services to outside ISPs. Most cities that provide fiber establish gigabit speeds within the city, which brings numerous benefits for working between departments and for connecting with the public.

Better Cellular Networks. 5G is going to eventually allow for faster cellular networks. However, the 5G spectrum that will be used must be closer to customers than today's cellular network and this is going to mean placing cellular transmitters on utility poles and light poles throughout the city. A city with a fiber network will be able to accommodate the best 5G network since cellular companies will be able to place small cell sites in the optimum locations.

Ubiquitous or Expanded Public WiFi. Many cities provide some WiFi access to citizens in places like libraries, city hall, and perhaps in a few locations like parks or other commonly used public spaces. However, with a fiber network a city could offer WiFi in many more places since the WiFi hot spot transmitters could be connected to almost any pole in the city. This idea also comes with a word of caution. Many cities have been sold on the idea that they can generate enough revenues 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 revenues to cover costs.

More Efficient Businesses. Almost every business we heard from in Farmington said that there are things they could do better and more efficiently if they had faster broadband.

Smart City. There are a lot of new digital technologies categorized loosely as "smart city" that are intended to allow cities to better serve their citizens. There are a wide variety of technologies being tried, many of which can be greatly benefit from having a community fiber network. Here are just a few examples of technologies that some cities are implementing:

- Smart Traffic. Many cities have had traffic controls that allow them to change traffic light patterns by time of day. Now cities are considering traffic control systems that analyze traffic in real time and can adjust traffic lights to best accommodate traffic flows. These systems can speed up the ability for traffic to navigate the city, which means a greener city, more efficient commerce, and numerous other benefits. Smart traffic can also be used to analyze dangerous traffic situations. For example, cameras can record and report "near-misses" in intersections between vehicles, bicycles, and pedestrians so that the city can understand dangerous traffic situations before a tragedy reveals it.
- Surveillance/Safety. Cities are installing cameras and other devices to enhance law enforcement. Surveillance cameras are now widely in many cities to solve crimes. This ability in enhanced with high-definition cameras fed by good broadband that can see in much more detail than older generations of camera technology. Cities are also installing systems like gunshot detectors that can pinpoint the location of a gunshot.
- Smart Grid. Smart grid is a set of monitoring technologies used to control electric and water utility systems. The technologies can be used to enhance efficiency and improve the quality of life in a community. For example, an electric smart grid system can be used to pinpoint the location of network outages, which can greatly speed up repairs and restore power outages. Monitoring water networks can pinpoint water leaks that can otherwise cost the community by wasting water. While most smart grid technology today uses wireless connections to smart grid devices, having a fiber network can benefit a smart grid deployment in the city.

- City Intranet. One interesting function provided by cities with fiber networks is the creation of a robust intranet for those connected to the city fiber. For example, in Lafayette, Louisiana all customers connected to the city-owned fiber network can communicate at gigabit speeds with anybody else on the city network. Even if a household buys a slower speed to connect to the outside Internet, within the city, workers can connect to the office or students can connect to the school with gigabit speeds.

More Grants? There is some chance that you could attract even more grant funding for the rural areas. As has been described in this report, there are parts of the rural county where ISPs claim speeds that are not really available – and this ha likely blocked parts of the rural area from seeking grants. This is something that can be tackled and corrected.

Creation of a Valuable Asset. Successful fiber businesses are a valuable asset that can be sold. We are aware of a few municipal fiber networks that have sold when the cities were offered prices they couldn't resist. There are not many things that a community can spend money on that can be eventually sold at a price that's higher than what they invested.

It's also worth noting that a fiber utility could eventually turn into a great source of revenue for a city. After bonds are retired in twenty or more years the business could provide significant cash flow to use in the utility or the city. Even the base conservative business model we created eventually spins off more than $12 million per year in cash after debt is retired. That's a long way into the future and cities should not build fiber strictly for the purposes of generating cash since the time involved before that happens is so long.

Risks of Creating a Municipal ISP

There are clear risks from creating a municipally owned broadband utility.

Competitive Risks. If a city builds a fiber network, there is always the risk of a significant response from existing service providers. For example, it hasn't happened many times, but there are a few examples where incumbent service providers engaged in a serious price war with a new ISP. In a price war, prices can go so low that all service providers in the market lose money. Large incumbents can ride out the operating losses in a price war, while a new operator can't. It's worth noting that neither Comcast nor CenturyLink has ever engaged in a price war. They more typically offer special rates and try to sign customers to long-term contracts.

There is also the risk that a competitor could overbuild a new fiber network. It doesn't happen often, but it has happened. For example, in Monticello Minnesota, the incumbent telephone company TDS reacted to a municipal fiber network by building a second fiber network. In parts of the North Carolina research triangle and in Austin, Texas, both the incumbent telephone company and the cable company built some fiber-to-the-home as a reaction to fiber built by Google Fiber. That means a few lucky households in that community are served by three gigabit fiber networks.

It seems like a small chance that Comcast or CenturyLink respond by building fiber – they've not done so in numerous other competitive markets.

What you will see is that the two incumbents will step up their game to make it harder for a new competitor to thrive. For example, they might offer low special rates and lock up customers in 2- to 3-year contracts before a new ISP is open for business. They often saturate the market with advertising and have been known to use negative advertising against new market entrants. They will improve customer service by reducing waiting times when customers call them and by responding more quickly to trouble calls.

Most communities view improved performance by the incumbents as a plus because it means that everybody in the community is better off.

Financial Risks. There are a number of financial risks for a city building a fiber network:

- Fiber networks are expensive, and any bond debt used to finance fiber will last for twenty to thirty years, which would tie up the borrowing capacity of the cities to fund other priorities.
- There is no guarantee that a new fiber business will make enough money to be financially self-sufficient. Most cities would be unhappy if they needed to provide an ongoing subsidy to support a fiber venture. A city needs to be prepared to dip into municipal funds to cover shortfalls. Cities with electric utilities sometimes cover these losses by using electric cash reserves or even by raising electric rates. Otherwise, cash shortfalls would have to be covered using tax revenues.
- We've enjoyed low and stable interest rates for over a decade. This could change quickly and has done so many times over the last century.

Financial risks can be mitigated by having a solid financial plan and sticking to it. But not everybody does this. For example, we know cities that have hired far more employees than predicted by the business plan, and then suffering smaller profits or even losses. We've seen cities that have allowed politicians to meddle with rates and lower broadband rates to a point that breaks the business model.

Operational Market Risks. The fiber business is highly technical and complicated. There is always an operational risk of failing to execute on the business plan. For example, a new ISP might build a world class fiber network but stumble badly in the sales and marketing process or some other key component of the business.

There is danger in botching the launch of a new network and of tarnishing the reputation of the new ISP business before it gets going. An example of this was the FTTH network in Lafayette, Louisiana that suffered from huge problems with their video product. This was due to their vendor Alcatel not delivering the product that was promised. The TV was so bad that many customers dropped the city ISP and word-of-mouth stopped a lot more customers from trying the new network. It took over a year to fix the video problems and during that time period the business fell significantly short of their business plan projections. Over time the city regained a reputation as a quality service provider and today is financially successful and is expanding into the surround suburbs. But that one mistake badly hurt the launch of the business.

The Cost of Success. In the telecom world there is a phenomenon CCG calls the cost of success. It's costly to add a new customer to a fiber network and if a new venture does better than expected, then a new ISP can find itself without the capital funds needed to add new customers. The alternatives are to borrow more money to fund the growth, or else make customers wait until the project generates enough cash to cover customers in a queue. It's often not practical for a municipality to borrow extra money past the original bond issue.

Local Rules and Regulations. Cities that build fiber are often surprised to find government barriers to the construction process. For example, the rules for building fiber along county, state, and federal roads might differ significantly from rules for city streets. There also can be challenging obstacles to building across bridges, across railroad tracks, or through Interstate exit interchanges.

Cities are also sometimes flummoxed by their own rules, when as a fiber builder they must follow the same processes they've required of other utilities.

Municipal Purchasing Rules. There is a big pile of contracts to negotiate and materials to buy in order to build a fiber network and we've seen cities who struggled badly with the process when coping with municipal purchasing rules. While these rules have the goal of making sure that a municipality doesn't overpay for good and services, the rules can add significant time when buying all of the needed components and service vendors involved in a broadband network launch.

We've also seen the municipal purchasing process add cost to purchased goods and materials. Most of the vendors in the telecom world are not used to dealing with the municipal purchasing process, so many of them pad their prices when bidding – fully expecting to negotiate the prices lower later, only to sometimes find that their bid price was accepted without negotiation. We also find that there are quality vendors that refuse to participate in the municipal purchasing process.

Market Forces. Every fiber business is subject to external market forces. These can hit in different ways:

- A local prolonged economic turndown might mean smaller revenues than expected – although many fiber ISPs swear that they do better in bad times.
- There is always that chance that the fiber market overheats and it becomes hard to buy fiber and electronic components. We're already seeing supply chain issues that are mostly due to the pandemic, but these same problems can arise if the overall fiber market gets busier than normal. Shortages of materials or construction crews are normally temporary, but this can be highly inconvenient and costly if it hits at the peak of trying to build a new network.

Political Risks. We always advise government entities to work hard at the beginning to shield a broadband business from day-to-day politics. Administrations and politicians change over time and a fiber business must be shielded against future politicians that want to interfere with or even dismantle the fiber business.

There is one anecdote that probably highlights the problem of mixing politics and operating a business. The City of Bristol, Virginia was one of the first cities to build a municipal fiber business. About a year after the business launch, the Bristol City Council voted to cut rates by 15% in response to an upcoming local election. As it turns out, this put the business underwater and into a quick dive in terms of cash creation, and in the year following the rate decrease, the City Council was forced to raise rates higher than the original rates to bail out the business. After this debacle, the City Council moved the fiber business to a standalone utility and killed the City Council's ability to affect rates.

Another political risk is that the incumbent providers may lobby against the broadband network long after it's been built. For example, a common tactic is to tell the public that a fiber business is losing money, when it's actually generating positive cash. This is easy to do because a fiber network generated a huge pile of depreciation expense. This is something cities don't usually care about since the primary purposes of depreciation is to offset income taxes. But depreciation means that there might be many years when the

business shows a book loss, when in fact the business might be successful in the eyes of the city. Cities generally judge businesses in terms of cash flow, and a municipal business that is cash self-sufficient generally is deemed to be a success. That's something that can be hard to explain to the public if there is a headline every budget cycle that the fiber business is losing money.

EXHIBIT I: SUMMARY OF THE RESIDENTIAL SURVEY

1. Do you have internet access to your home today?

	Number	Percent
Yes	393	89%
No	50	11%

2. If you don't have internet access at your home today, what are the reasons you don't have it?

	Number	Percent
It's not available at my home	40	80%
I can't afford the prices	17	34%
I don't have a computer	1	2%
It's too slow to use	3	6%

3. Who provides your Internet service?

	Number	Percent
Comcast/Xfinity	225	57%
Century Link	120	30%
Sacred Wind	2	1%
Advantas Internet Solutions	13	3%
Brainstorm Internet	1	0%
Satellite Internet	11	3%
Only use Cellphone data	18	5%
Other Fixed Wireless	4	1%

4. Who is your current TV provider?

	Number	Percent
Comcast/Xfinity	84	19%
Satellite TV	98	22%
Watch only Online (Such as Netflix)	139	38%
Do not have any TV Service	89	8%
Use Antenna	16	4%

5. If you have a telephone landline, who provides your telephone service?

	Number	Percent
Comcast/Xfinity	33	8%
Sacred Wind	3	1%
Century Link	42	10%
Do not have a Telephone Landline	344	80%
Other – Vonage, Ooma, Sangoma	5	1%

6. What do you currently pay for the following?

Bundle

`	Number	Percent
$0 - $50	42	24%
$51- $75	8	4%
$76 - $100	13	7%
$101 - $124	17	9%
$125 - $150	19	11%
$151 - $200	39	22%
$201 - $250	27	15%
$250+	14	8%

Standalone Internet

	Number	Percent
$0 - $10	12	6%
$11 - $20	2	1%
$25 - $40	7	3%
$41 - $60	68	33%
$61 - $75	37	18%
$76 - $90	29	14%
$91 - $110	20	10%
$111 - $125	12	6%
$126- $150	10	5%
$151+	8	4%

Standalone Cable TV:

	Number	Percent
$0 - $20	41	41%
$21 - $35	2	2%
$40 - $70	10	10%
$71 - $90	5	5%
$91 - $115	11	11%
$116- $130	6	6%
$131 - $150	12	12%
$151+	13	13%

Standalone Telephone

	Number	Percent
$0 - $20	46	54%
$21 - $40	6	7%
$41 - $65	6	7%
$66 - $90	5	6%
$91 - $110	6	7%
$111 - $135	2	3%

$136- $150	0	0%
$160 - $200	1	1%
$201+	13	15%

7. What Internet speed are you supposed to be getting today in your home?

	Number	**Percent**
1 – 6	18	8%
7 – 12	17	8%
13 – 20	21	10%
21 – 35	15	7%
36 – 50	18	8%
51 – 75	20	9%
76 – 100	5	2%
101 – 150	25	12%
151 – 200	18	8%
201 - 300	15	12%
301 – 500	10	5%
501+	17	8%
Don't Know	7	3%

8. Are you receiving the speed you are paying for?

	Number	**Percent**
Yes	80	23%
No	156	45%
I am not sure	112	32%

9. Using a scale from 1 to 5, where 1 is "very dissatisfied" and 5 is "very satisfied", how happy are you with:

Your Download Speed?

	Number	**Percent**
1	79	23%
2	54	16%
3	92	27%
4	80	23%
5	39	11%

The customer service provided by your service providers.

	Number	**Percent**
1	79	23%
2	59	17%
3	90	26%
4	67	20%
5	48	14%

. **The value I get compared to price I pay.**

	Number	Percent
1	108	32%
2	76	22%
3	91	27%
4	36	11%
5	29	8%

10. In general how do you feel about the idea of a new broadband network in the city?

	Number	Percent
I support the idea	269	73%
I do not support the idea	5	1%
I might support the idea but need more information.	97	26%

11. What are some of the reasons that you would support somebody building a new fiber network in the city? Please choose all that apply.

	Number	Percent
More competition and choice	205	46%
Lower Prices.	188	42%
Faster Internet Speeds	295	67%
Better Customer Service	124	28%

12. What factors would influence your decision to move your services to a new network?

	Number	Percent
Faster Speed for the same price	262	59%
Lower Price than I pay today	230	52%
Same price and better customer service	83	19%

13. Would you buy Internet service from a new network if it guaranteed faster speeds than the competition at rates similar to what is current available?

	Number	Percent
Yes, definitely	235	66%
Probably	74	21%
Maybe	37	10%
Probably Not	8	2%
Definitely Not	1	1%

14. Would you buy a landline telephone service from a new network in the city if they could offer affordable prices?

	Number	Percent
Yes, definitely	58	16%
Probably	35	10%
Maybe	71	20%
Probably Not	114	32%
Definitely Not	76	22%

15. Do you currently subscribe to cell service?

	Number	Percent
Yes	347	97%
No	9	3%

16. Is the cellular coverage at your home adequate?

	Number	Percent
Yes	277	78%
No	76	22%

17. Does anybody in your family ever work at home using Internet access?

	Number	Percent
Full Time	98	28%
A few times per week	107	30%
A few times a month	42	12%
Yes, very occasionally	33	9%
No	75	21%

18. Would you or your family work at home more if you had faster Internet?

	Number	Percent
Yes	184	53%
No	165	47%

19. Do you have school-aged children at home who need the Internet to do their homework?

	Number	Percent
Yes	174	49%
No	179	51%

20. If yes, is your Internet connection good enough to support homework?

	Number	Percent
Yes	114	57%
No	86	43%

EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Year 5 Assets	Take Rate	Loan	Grant	Year 10 Cash	Year 20 Cash
	Full Service Area						
1	**Base - No Grant**	$122.70 M	50% / 60%	$136.2 M		$17.85 M	$66.58 M
2	**With RDOF Grant**	$122.70 M	50% / 60%	$134.4 M	$ 3.18 M	$20.11 M	$70.88 M
3	**5% Higher Penetration**	$123.45 M	55% / 65%	$137.1 M		$24.86 M	$92.42 M
4	**5% Lower Penetration**	$121.93 M	45% / 55%	$135.4 M		$10.43 M	$40.03 M
5	**50% City 70% Rural**	$123.42 M	50% / 70%	$137.0 M		$24.20 M	$92.02 M
6	**45% City 75% Rural**	$123.33 M	40% / 75%	$136.9 M		$22.46 M	$86.02 M
7	**Breakeven**	$121.09 M	35% / 56%	$134.1 M		$ 1.60 M	$ 2.15 M
8	**Higher Prices**	$122.70 M	50% / 60%	$136.2 M		$25.41 M	$93.87 M
9	**Lower Prices**	$122.70 M	50% / 60%	$136.2 M		$10.29 M	$39.28 M
10	**No Rate Increases**	$122.70 M	50% / 60%	$136.2 M		$15.79 M	$44.06 M
11	**Higher Interest Rate**	$122.70 M	50% / 60%	$138.5 M		$13.69 M	$52.69 M
12	**Lower Interest Rate**	$122.70 M	50% / 60%	$134.0 M		$21.81 M	$79.72 M
13	**30-Year Loan Term**	$122.70 M	50% / 60%	$136.2 M		$25.85 M	$93.08 M
14	**20-Year Loan Term**	$122.70 M	50% / 60%	$136.2 M		$ 4.95 M	$76.44 M
15	**5% Higher Fiber Cost**	$127.47 M	50% / 60%	$141.5 M		$15.55 M	$58.45 M
16	**5% Lower Fiber Cost**	$117.93 M	50% / 60%	$131.0 M		$20.20 M	$74.65 M
17	**Base Retire Debt**	$122.70 M	50% / 60%	$136.2 M		$ 1.05 M	$81.74 M
18	**50%/70% Retire Debt**	$123.42 M	50% / 70%	$137.0 M		$ 1.00 M	$110.53 M

		Year 5 Assets	Take Rate	Loan	Grant	Year 10 Cash	Year 20 Cash
Total Rural Area							
19	**Base - No Grant**	$64.50 M	60%	$72.40 M		$ 1.25 M	$ 2.43 M
20	**With RDOF Grant**	$64.50 M	60%	$70.20 M	$ 3.18 M	$ 3.37 M	$ 6.97 M
21	**65% Penetration**	$64.85 M	65%	$70.60 M	$ 3.18 M	$ 5.61 M	$18.59 M
22	**55% Penetration**	$64.10 M	55%	$69.80 M	$ 3.18 M	($ 3.71 M)	($ 6.05 M)
23	**75% Penetration**	$65.61 M	75%	$71.20 M	$ 3.18 M	$12.73 M	$45.00 M
24	**Higher Prices**	$64.50 M	60%	$70.10 M	$ 3.18 M	$ 7.01 M	$20.29 M
25	**Lower Prices**	$64.50 M	60%	$70.20 M	$ 3.18 M	($ 0.36 M)	($ 6.01 M)
26	**No Rate Increases**	$64.50 M	60%	$70.20 M	$ 3.18 M	$ 2.37 M	($ 3.86 M)
27	**Higher Interest Rate**	$64.50 M	60%	$71.30 M	$ 3.18 M	$ 3.37 M	($ 0.08 M)
28	**Lower Interest Rate**	$64.50 M	60%	$69.00 M	$ 3.18 M	$ 5.39 M	$13.78 M
29	**30-Year Loan Term**	$64.50 M	60%	$70.20 M	$ 3.18 M	$ 7.49 M	$20.63 M
30	**5% Higher Fiber Cost**	$67.02 M	60%	$73.50 M	$ 3.18 M	$ 2.43 M	$ 2.49 M
31	**5% Lower Fiber Cost**	$61.98 M	60%	$67.40 M	$ 3.18 M	$ 4.59 M	$11.25 M
Urban Area Only							
32	**Base**	$58.99 M	50%	$66.50 M		$10.84 M	$37.87 M
33	**55% Penetration**	$59.45 M	55%	$66.90 M		$16.99 M	$57.89 M
34	**45% Penetration**	$58.55 M	45%	$66.10 M		$ 5.99 M	$19.48 M
35	**Breakeven Penetration**	$58.113 M	40%	$66.10 M		$ 1.08 M	$ 0.50 M