Broadband Strategic Plan

Sierra County, New Mexico

May 11, 2020

Finley Engineering
CCG Consulting

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PROJECT DESCRIPTION

Finley Engineering and CCG Consulting were hired to create a Broadband Strategic Plan for Sierra County. The original RFP that defined the project set the following goals:

> *The selected firm shall be responsible for the development of a broadband master plan for the County of Sierra, NM. The purpose of this Broadband Plan is to provide a comprehensive evaluation of existing broadband conditions and potential solutions to problems, both now and in the future throughout the entire county. This evaluation should include a comprehensive inventory, accurate simulation, problem area identification and problem source/cause, and a comprehensive list of capital improvement projects, including costs and funding mechanisms, designed to address the broadband deficiencies. Sierra County is a rural community with limited-to-no broadband services*
>
> *Project scope of work shall include:*
>
> - *To have clear communication on projects.*
> - *Establish a professional relationship with staff.*
> - *Assess available broadband/fiber optic studies and master plans, GIS Data, or other.*
> - *Data collection including limited survey, as required to verify existing conditions.*
> - *This project will identify current broadband infrastructure in rural county.*
> - *Identify gaps in service areas and identify infrastructures, hospitals, and schools.*
> - *Needs to provide broadband services to county-wide businesses and users.*
> - *Preparation of an overall model for the entire county-designs, installs and operations*
> - *Preparation of a Local Capital Improvement Plan (ICIP) program that includes budget estimates for proposed improvements.*
> - *Recommended prioritization of ICIP projects.*

We believe this report is responsive to all the requirements identified in the goals and the project scope of work.

EXECUTIVE SUMMARY

Finley Engineering and CCG Consulting submit this Broadband Strategic Plan that provides our findings and recommendations for bringing better broadband to Sierra County, New Mexico. The stated goal of the County in awarding the project is to "*provide a comprehensive evaluation of existing broadband conditions and potential solutions to problems, both now and in the future throughout the entire county.*"

The first phase of the study was to look at the need for broadband in the county. We tackled that task in two ways. We first communicated with residents and businesses through surveys, speed tests, and interviews to understand the broadband needs in the county. We also drove extensively through the county to identify the facilities used to provide existing broadband. Our two firms have worked extensively with rural communities all over the country and we observed almost immediately that the county has some of the worst broadband conditions we've witnessed anywhere. Outside of the county seat of Truth or Consequences and the town of Elephant Butte, which have broadband provided by a cable TV network, there is almost no broadband anywhere else in Sierra County that meets even the FCC's outdated definition of broadband as being a connection of at least 25/3 Mbps. The overwhelming and universal response we got through our market outreach was that homes and businesses are desperate for better broadband.

We were asked to specifically identify the broadband gaps in the county. We went about this in a number of different ways. For example, we compare the broadband situation in Sierra County to other places in the US and other places 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 mentioned above. 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 county today and compare them to other places. We discuss a number of ideas for overcoming the various identified broadband gaps.

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 in the county. Unfortunately, the faulty FCC maps are used by the FCC when determining the areas that are eligible for federal broadband grants. We discuss steps you might consider to get the FCC maps corrected.

The next phase of the study quantified the cost of bringing broadband to the county. Finley Engineering estimated the cost of building fiber to reach all parts of the county. For now, the engineering is summarized in two parts—the cost of building to just Truth or Consequences and Elephant Butte and the cost to build to the rural areas outside those two cities. Finley Engineering undertook the engineering analysis in such a way that they could generate the cost for building to any portion of the county if an ISP wants to consider coming to Sierra County. We think this might be one of the most important parts of our product, since knowing the cost of building a network is generally the number one question for any ISP considering serving there.

As we were writing this report, The Rural Utility Service (RUS) that administers broadband grants on behalf of the Department of Agriculture announced that Sacred Wind Communications of Yatahey, NM has filed for a grant under the ReConnect grant program to build broadband in parts of the Sierra County. There are no guarantees that they will win this grant, but if they are successful it would mean bringing fiber broadband to a section of the county—a great first step towards solving the rural broadband problem.

This wouldn't change any of the recommendations we've made in this report but would focus your attention on the areas that will not be getting fiber as a result of this grant.

Next, CCG Consulting created financial models that reflect the potential profitability for an ISP operating a broadband business in Sierra County. In the report we summarize these opportunities in three ways – serving just the rural areas, serving just Truth or Consequences and Elephant Butte, and serving the whole county. Just like with the Finley Engineering analysis, we could modify our work to fit some smaller footprint if an ISP is interested. These studies include assumptions that we think are representative for estimating the revenues and the costs from operating a broadband business.

We were not surprised to find out that grants would be required to finance construction in the rural parts of Sierra County. That was fully expected, and we've never seen a rural area where customer revenues fully support the cost of fiber without some grant assistance. Our analysis shows that if the customer penetration rate in the rural areas is 70%, then the needed grant would need to cover about 65% of the cost of the network. That percentage of needed grant is also pretty normal; we've studied rural places where the grant funding would have to be much higher. We also demonstrated that if more than 70% of households will buy broadband that the amount of grant funding required is less – at an 80% customer penetration rate the level of needed grant funding drops to 54%. Finally, we demonstrated that if an ISP is willing to build fiber to everywhere in Sierra County that the profitability from serving in the more densely populated parts of the county lowers the needed amount of grant assistance.

We conclude the report by providing a strategic plan in the form of a list of specific recommendations that Sierra County should consider after getting this report. The most obvious next step is to share this report with ISPs. This study is going to answer a lot of questions about serving in Sierra County and might bring interest from an ISP that might not have otherwise considered coming to the county. There are a number of other recommendations talking about ways that Sierra County can address the various broadband gaps.

FINDINGS

Following are our primary finding:

Existing Providers and Market Rates. The current broadband providers in Sierra County today are two incumbent telephone companies (Windstream and CenturyLink), an incumbent cable company (TDS), two WISPs – fixed wireless ISPs (Wi-Power and Fastwave), and two satellite broadband companies (Viasat and HughesNet). Some rural homes get home broadband using the cellular broadband from AT&T, Verizon, and T-Mobile, which recently merged with Sprint. Residents can also by satellite TV from DirecTV and Dish Networks. We looked at the key products and prices currently offered by the existing broadband providers.

Quality of Broadband. The broadband in Truth or Consequences and Elephant Butte is typical of what is available in county seat towns in rural counties. The cable modem service from TDS today delivers 100 Mbps broadband and the DSL from Windstream in the towns is much faster than what is available in the rural parts of Sierra County. There are complaints that broadband in the towns is sometimes inconsistent, but overall, there are reasonable alternatives for broadband. However, when looking even just a few years into the future, this broadband is not going to be adequate. The first way that the current broadband will likely begin feeling inadequate is with upload speeds.

Our two firms work all over the country and the broadband in the rural areas of Sierra County is among the worse we have ever witnessed. The alternatives in the rural parts of the county are extremely slow DSL with few homes seeing broadband speeds over 5 Mbps, fixed wireless broadband that can be a little faster than DSL (but not always), or satellite broadband that can have decent speed but which has high latency (delays) and small monthly data caps. The broadband in the rural area is not sufficient to support people working from home, for students to do schoolwork from home, or for businesses to operate normally. One of the most common complaint from rural businesses is the inability to consistently process credit cards. That's a function that requires low bandwidth but a steady upstream data path for the duration of a credit card transaction. To make matters worse, rural broadband in the county is expensive, particularly considering the poor bandwidth quality.

It's worth noting that all the problems with the quality of broadband were magnified during the COVID-19 crisis as employees and students tried to function from home.

The Study Areas. We studied three different study areas. The first was the two cities of Truth or Consequences and Elephant Butte. The second was comprised of all the rural areas outside of the two cities. The last scenario looked at bringing fiber to everybody in Sierra County. Finley Engineering undertook the network design in such a way that they could help interested ISPs look at other study areas comprising some smaller portion of the county.

Fiber Network Design. Finley Engineering considered several technologies before designing a reasonably efficient network for each of the scenarios studied. The chosen network design uses Passive Optic Network (PON) technology on fiber to bring gigabit broadband to every home and business in the county. 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 primarily on poles where other utilities are on poles but would 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.

The telecom industry uses the term passing to mean any home or business that is near enough to a network to be considered as a potential customer. Finley Engineering primarily used the county's GIS database to count passings. This is a very robust and expansive system that has data on structures, type, location, etc. Our engineers settled on the following as the count of potential passings for the study. Note that the two-cities scenario looks at serving only Truth or Consequences and Elephant Butte.

Passings	Rural	Two Cities	Total County
Residential Customers	2,756	5,469	8,225
Business Customers	169	730	899
Total	2,925	6,199	9,124

Miles of Fiber Construction

The study contemplated building fiber to every part of Sierra County where there are homes or businesses. Finley Engineering identified the following road miles of fiber required to bring fiber everywhere:

	Miles	Cost	Cost / Mile
Rural County	563.65 miles	$21,121,352	$ 34,572
Two Cities	105.56 miles	$12,584,135	$119,213
Total	669.21 miles	$33,705,487	$ 50,366

Asset Costs. Below is a summary of the cost of the needed assets to support each primary option that was studied. It's worth noting that these costs estimate a customer penetration in the rural areas of 70% and in the towns of 50%. The investments change as the number of customers change to recognize the cost of customer drops and electronics.

	Rural	Two Towns	Total County
Fiber & Drops	$23,373,224	$14,825,297	$38,180,705
Electronics	$ 1,814,770	$ 3,076,426	$ 4,811,601
Huts/Land	$ 0	$ 139,500	$ 139,500
Operational Assets	$ 383,185	$ 393,968	$ 731,677
Total	$25,571,179	$18,435,191	$43,863,482
Cost per Passing	$ 9,278	$2,974	$4,807
Cost per Customer	$12,498	$5,937	$8,514

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) for the scenario of serving Truth or Consequences and Elephant Butte, and a customer penetration rate of 70% for serving the rural area. each base model. We don't have any idea how many customers a new fiber business might win and chose these penetration rates as typical of other similar fiber markets.
- 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 in the county 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. The assumptions used in creating the various business plans are included in Section III.C of the report. The results of the financial analysis are included in Section III.E of the report. A summary of the financial results is included in Exhibit II. Following are the key financial findings of our analysis.

- To bring fiber broadband to all the rural parts of Sierra County will require substantial grant funding. For example, at a 70% customer penetration rate we calculated that a grant that covered 65% of the financing would be required. If the rural customer penetration rate climbed as high as 80% the required grant would be smaller, at 54% of total financing, but is still substantial. It's easy to understand the need for grants when seeing the cost of the rural network, shown above as $9,278 per passing. Customer revenues alone cannot pay for a network this expensive.
- We note that we have studied other rural counties where the funding needed from grants was as high as 80% of total financing – so the results of our analysis is not out of line with what we've seen elsewhere.
- It looks feasible to bring fiber broadband to Truth or Consequences and Elephant Butte, with no need for grant funding. Our analysis shows that a customer penetration as low as 45% of the market would be adequate to maintain a self-sufficient business in the cities. This is a typical result for county seat communities.
- The amount of grant money needed to build all of Sierra County is substantially lower than building just the rural areas. This is due to averaging together the low-cost and the high-cost parts of the county. The grant needed to build to the whole county is only 28.5% of total financing with a 70% penetration in the rural areas and a 50% penetration in the two cities. To the extent that the rural penetration rate would be even higher, the amount of grant funding drops significantly.
- A fiber broadband business in Sierra County will be highly sensitive to a few key variables. The most important is customer penetration rate, and it would be essential before building fiber in the county to better understand the number of customers likely to buy broadband. Another key variable is price, and even shifting broadband prices by a few dollars has a big impact on the bottom line.

The base studies in the analysis started with a base broadband product priced at $60. Any ISP that is going to serve the area will need to carefully consider prices. The financial performance is somewhat sensitive to interest rates on debt, but not nearly to the extent of the other key variables.

Funding Options. As mentioned above, any broadband expansion into the rural areas will require substantial grant funding. The most likely grant funding is going to come from various federal broadband grants. At this time there is no consistently available federal grant program and the amount of money available each year has been determined by Congress. There is a lot of talk in Washington DC about making more money available for rural broadband, so there is the chance of upcoming substantial broadband grants. Now that the county has this study in hand, especially the engineering cost estimates made by Finley Engineering, you are well-positioned to help ISPs consider any future grants.

There is a New Mexico state broadband grant program, but it is currently one of the smaller State grant programs, funded last year at $5 million. Hopefully the COVID-19 crisis will also prompt the state to find more money for broadband grants.

We believe there is sufficient loan funding available to any ISPs that find the needed grant funding. We are seeing ISPs getting funded at commercial banks, getting funded by taking advantage of federal loan guarantees that lowers the risks of bank loans, and through funding directly from the federal government.

Sierra County Has Been Harmed by FCC Decisions. Two specific actions by the FCC are harming the county's ability to get better broadband.

- First, the FCC determines that 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.

  There are several glaring problems with the ISP reporting. First, customers that live close to where there is good broadband are counted by the FCC as having fast broadband. For example, a customer just outside the TDS cable network is likely to be classified as being able to buy broadband from TDS, even though they can't. The bigger problem is that ISPs routinely overstate the broadband speeds available, and often report "marketing" speeds rather than actual speeds. Both Windstream and CenturyLink have overstated rural DSL speeds and often report that DSL speeds of 10/1 Mbps or 25/3 Mbps are available when actual speeds are slower than that. This report contains maps that show the speeds as reported by the ISPs to the FCC as well as a map we created that we think is more accurate and that shows much less rural broadband coverage.

  There are significant consequences of the poor FCC data since the FCC uses this information to decide areas that are eligible for federal broadband grants. There are many areas of Sierra County that should be eligible for grants, but which have been excluded from consideration to date.

- The next issue comes as a result of an FCC grant that was awarded in 2018 by a process referred to as a reverse auction. In that auction, ISPs were invited to bid for receiving grant money that covered specific rural Census blocks that didn't have broadband speeds of at least 10/1 Mbps.

  Unfortunately, the only ISP that bid for the grants in the county was Viasat, the satellite broadband company. Viasat is required by the terms of that grant to offer broadband speeds in the grant areas of at least 25/3 Mbps broadband. This is something that Viasat already offered, so the households in the grant areas are not going to see any improvement in broadband. Worse, the FCC now considers those areas as having adequate broadband and is excusing these areas from future FCC grants.

  Because of a faulty grant process, the grants went to a satellite broadband company – something that never should have been allowed to happen. As a result of that FCC blunder, the homes in those areas are likely not to be eligible for FCC grants for at least another decade, or perhaps even longer.

RECOMMENDATIONS / STRATEGIC PLAN

The following recommendations embody a strategic plan for getting better broadband in Sierra County. The description of each recommendation has been shortened and the full recommendations are included in Section IV. C. of the report. We view the list of recommendations as a broadband strategic plan for Sierra County. Following these recommendations will move the county towards achieving your goal of bringing good broadband to everybody in Sierra County.

Set a Broadband Goal

After reading this report, we recommend that Sierra County establish a specific broadband goal. The goal could be something simple, such as wanting to get fiber broadband to every home and business. There are many other possible goals. The goal that Sierra County chooses will then define how you approach the rest of the recommendations below.

Identify Staffing Resources?

If Sierra County is going to seriously pursue a lot of the recommendations made in this report, you're going to need staff resources tackle many of the tasks. This means identifying somebody for whom broadband is a primary job responsibility. Tasks of this magnitude will not get done if you layer the workload on somebody who is already full-time busy. This doesn't necessarily mean creating a full-time position to oversee broadband, but it does require giving sufficient priority to broadband if you want to see solutions.

It's also worth considering finding volunteers from the public to help with the effort. There are different ways that communities have used volunteers to good effect.

Attracting ISPs to Serve in Sierra County

Since the Sierra County government doesn't want to be an ISP, your best strategy is to take steps that make it as easy as possible for one or more ISP to bring better broadband. This might include the following steps:

Reach Out to Potential ISP Partners. The first step taken is to share this report with ISPs in the region. One or more of them might find things in this report that convinces them to consider Sierra County. Finley Engineering and CCG Consulting have seen these studies used to convince ISPs to look harder at opportunities that they were not considering.

After reaching out informally, you can also consider more formal ways of reaching out such as issuing an RFI or RFP to solicit ISPs. Just note that many ISPs are not going to willing to go through a formal solicitation process and would much prefer to sit and talk off the record about opportunities.

Offer to Help Quantify Demand. One of the biggest concerns for any ISP is that there is enough customer demand for broadband in order for them to be profitable. This study includes some of the needed research that ISPs will be interested in. However, ISPs ultimately will want to undertake a more formal process of understanding customer demand for broadband in the specific area they are considering building. Sierra

County could offer help at the appropriate time to conduct a statistically valid survey, a canvass, or a pledge card drive.

Review County / Town Policies Related to Fiber Construction. There may be existing policies in place in the towns or at the County that ISPs will view as an impediment to construction. We recommend having all of the government entities within Sierra County review policies for requirements like rights-of-way, permitting, locating of existing utilities, traffic control, franchise agreements, and inspection requirements with the goal of making it as easy as possible for ISPs to bring new solutions.

Be Prepared to Support Grant Filings. Most **s**tate or federal grant programs require a showing of local community support. Sierra County should be prepared to help an ISP by gathering government and resident support for the grant applications. This means soliciting as many letters as possible to support a fiber grant.

Educating the Public

This can take many different forms. Start by publishing this report online. Hold public meetings to discuss the findings of this report and to listen to public concerns about lack of broadband. Many communities create a broadband web site as a place to post informational resources and to keep the public informed about progress in finding a broadband solution. Other communities have created a broadband newsletter. One common practice is to hold outreach meetings to discuss broadband with interested groups such as the PTA or service organizations.

Lobby for Larger State Broadband Grants.

The state broadband grant program is smaller than similar programs in other states. Both the county government and citizens in the county should regularly lobby the state and state elected officials for more help to fund broadband solutions.

Be Prepared to Challenge the FCC Broadband Maps.

Many federal grant programs rely on the FCC "maps" that are derived from the Form 477 data that the FCC gathers from ISPs. We've shown in this study that the FCC broadband is lousy in parts of Sierra County where ISPs claim broadband coverage that doesn't exist. The only way we know to challenge the maps is by the use of speed tests.

We helped Sierra County to establish a speed application site that has been placed on the County's web page. We recommend that the speed tests remain in perpetuity and that the County periodically encourages homes and businesses to take the speed test. Accumulating speed test results is the best way we know of to help challenge the poor FCC mapping data.

Get Creative in Finding Grants.

The big obvious grants are those that help ISPs construct broadband networks, and those grants are awarded directly to ISPs. There are a number of grants that Sierra County can pursue to help promote broadband in other ways. For example, there are grants that can be used to expand WiFi hotspots. There

are grants that can help to get more computers for students. If the County gets creative enough, there may be grant funds available for addressing many of the items we've identified as broadband gaps.

Consider Providing Some County Funding.

We've seen that it's often easier to attract grant funding if a county puts some "skin in the game." Even small grants provided by Sierra County can make a big difference. The people who award big grants, including the giant federal grant programs like to see that there is local dollar support for programs.

Consider Finding Technical Assistance for Businesses.

We observed that there are businesses that are having current problems using their broadband connection that could benefit greatly with professional computer and networking advice. As an example, we talked to businesses that had problems holding the connection needed to make credit card payments. Sierra County might help to identify a local resource that could help such businesses, and you might even consider assisting them in the name of economic development. It's also possible to find grant money to assist businesses in this manner.

Push the Incumbents to do Better.

Asking the incumbent telephone and cable companies to do better often falls on deaf ears – but not always. It's sometimes easiest to start with small things like asking for help to create more public WiFi hotspots for students or to bring broadband to public housing. We've seen communities and ISPs work together to solve specific problems.

Push for More Participation in the FCC Lifeline Program.

Encourage every ISP that offers broadband and telephone service to enroll in and them promote the FCC's Lifeline program. This provides a $9.25 discount for broadband to homes that qualify by participating in various low-income programs. The program is done at no out-of-pocket cost to the ISP which collects the $9.25 subsidy from the Universal Service Fund.

Find Solutions for the Homework Gap.

The lack of broadband in Sierra County means that many students don't have broadband at home. This became abundantly clear during the COVID-19 crisis. Communities are tackling this issue in a number of ways. It starts with getting computers to students, be that a computer for every student or computers that students can use occasionally. Many communities have created new WiFi hot spots to provide locations closer to neighborhoods where students can do homework without the family having to travel.

Be Persistent.

It's the rare county where one ISP comes forward and provides a broadband solution for the whole county. That means that even if Sierra County finds a partial broadband solution to cover part of the county that the effort is not done, and the County will need to continue with the above tasks until everybody in the county has broadband.

I. MARKET ANALYSIS

A. Providers, Products, and Price Research

The eastern portion of Sierra County is covered by the White Sands Missile Range, with little or no existing coverage by telephone companies. The northern two-thirds of the rest of the County is served by Windstream. The southern portion of the County is served by CenturyLink.

TDS is the incumbent cable TV provider in Truth or Consequences and parts of Elephant Butte. The company upgraded to digital service in 2016 and offers speeds of up to 100 Mbps.

The FCC 477 data shows that there is some fixed wireless service in the county provided by Wi-Power (TWN Communications) and Fastwave.

Most rural 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 Sierra County 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 from most incumbents 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 average prices being charged today for broadband and the other triple play products.

Incumbent Telephone Company

Windstream Corporation. Windstream is a publicly traded telephone company created in 2006 with the merger of Alltel and Valor Telecom. The company is headquartered in Little Rock, Arkansas. The company offers telephone service plus broadband service provided by DSL. The company also offers a bundle that includes cable TV provided by Dish Networks.

The company operates in 16 states and had $1.27 billion in revenues for the third quarter of 2019, down from $1.38 billion the year before. At the end of 2019, the company had 1,049,300 broadband customers and had gained 28,300 broadband customers during the year.

As the incumbent provider, Windstream is considered the "provider of last resort" in its service areas. This means the company is required to serve all residential and business customers for basic telephone service, and it must provide facilities to all customers. The rules that govern the way that Windstream serves customers are embodied in their "General Customer Services Tariff," which is approved by the New Mexico Public Regulation Commission. This tariff contains all the regulated products and prices, along with the terms and conditions under which the company 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.

Windstream decided in January 2014 to spin off its assets into a REIT, which is a real estate investment trust, a formal kind of investment vehicle defined by law. Windstream was a traditional, mostly family-owned regulated telco. Windstream moved its fiber and copper assets to a REIT owned by the newly formed Uniti. In the split of assets, Robert Gunderman remained as CFO of Windstream while his brother Kenneth become CEO of Uniti. The Uniti REIT is attractive to investors because Windstream pays roughly $650 million per year in "rent" to Uniti for use of the network. Since formation, Uniti has added other assets to the portfolio, but the Windstream assets still represent 70% of its assets.

Windstream filed bankruptcy recently. This was triggered when Aurelius Capital, a lender to Windstream, filed a lawsuit claiming that the REIT arrangement was a violation of Windstream's corporate bonds. Windstream immediately filed for bankruptcy when a judge ruled in favor of Aurelius Capital. Windstream and Uniti immediately went to mediation to try to resolve the issues raised by the Aurelius Capital lawsuit. When the two companies could not resolve the issues, they took the dispute to court.

The two parties reached an agreement on the dispute in March 2020. The deal must still be accepted by the bankruptcy count. In the agreement the Windstream debt is to be reduced by more than $4 billion. Further, Uniti will provide Windstream with $1.75 billion over 10 years to make capital improvements, $490 million in cash now, and $285 million to buy unused and underutilized assets. This agreement will make Windstream stronger financially, but it's hard at this early stage to understand how the settlement might translate in improvements for broadband in Sierra County. It's likely that Windstream will use cash to improve broadband in larger markets.

Windstream has gotten poor reviews from several firms that rank ISPs. The JD Powers poll gives Windstream a ranking of 2 out of 5 and said they were the lowest rated telephone company in the South.

<u>Windstream Pricing</u>

Windstream offers 3 DSL speeds. The faster speeds may not be available to rural customers. The products and prices are as follows:

6/1 Mbps	$57.99
10/1 – 25/1 Mbps	$67.99
50/1 Mbps	$77.99
Modem for first two products	$ 9.99
Modem for 50/1 Mbps	$11.99
Installation	$35.00
Service Activation	$50.00
Inside Wire Insurance	$ 8.00

There are no data caps on the broadband products

Windstream does not advertise their telephone prices online. We found the following price at noncompany sites:

Phone with Unlimited Long Distance	$44.99

All telephone products are loaded with a number of fees that total to at least $7.50.

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 2019, the company had 4,678,000 broadband customers, having lost 134,000 customers during the year. 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 built 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 Sierra County faster than 12 Mbps. Generally, the faster speeds are available only in the metropolitan markets.

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

TDS is the incumbent cable provider within the city limits of Truth or Consequences. As such they operate a hybrid/fiber coaxial network that provides traditional cable services including the triple play of cable TV, broadband, and telephone service. TDS was founded in 1969 and is the seventh largest telephone company in the country, headquartered in Madison, Wisconsin. Most of the company's networks are based upon telephone copper or fiber-to-the-home and the company only owns a few coaxial cable networks like the one in Truth or Consequences. While the company operates in a few larger cities like Madison, Wisconsin, most of its properties are rural.

In additional to the typical array of residential services the company also offers business services, such as business Internet phone bundles, phone and VoIP solutions, Internet and security, managed services, data networking, and phone systems. In addition, it offers business resource centers. It connects rural and suburban communities in the United States. TDS Telecommunications Corporation operates as a subsidiary of Telephone and Data Systems, Inc. TDS had 455,200 broadband customers at the end of 2019 and had added 31,800 customers during the year.

TDS also owns US Cellular, a company that it founded in 1983. Between all of its subsidiaries the company now has over 6 million customers and had revenues of over $5 billion in 2017, with US Cellular providing $3.9 billion.

Broadband

TDS offers three broadband products on their coaxial cable networks.

100/10 Mbps	$ 62	(Web special - $39.95)
300/10 Mbps	$ 82	(Web special - $59.95)
600/20 Mbps	$102	(Web special – $79.95)

All broadband products come with a WiFi modem at $10.00 per month.

The web special prices are a reminder that TDS is willing to negotiate with customers. This means that customers willing to call every few years and negotiate can get prices lower than the list prices. Customers that don't negotiate will even be billed at the list prices.

Telephone

TDS Cable TV can be bundled with telephone service. With cable service telephone rates are:

Phone	$15.00 plus $.05 per minute long distance $35 with unlimited long distance

We couldn't find if TDS offers a standalone phone product – meaning a customer could buy telephone service and nothing else.

Cable TV

The survey indicated a small interest for buying cable TV from a new provider. We also know that a new ISP venture is not going to make any margins from selling cable TV, so we've left cable prices out of the analysis and out of the forecasts.

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 can be bought as a standalone service and is also available as a bundle for Windstream customers.

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 Sierra 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.

TWN Communications (Wi-Power)[1] is a fixed wireless provider that delivers broadband using radios on towers that connect wirelessly to homes and businesses. The business started in Indiana in 1988 and today covers 250,000 square miles in Indiana, Arizona, New Mexico, and Texas. The business partners with 115 electric cooperatives to offer broadband services. TWN has had a partnership with Sierra Electric Cooperative. During our work on the study we found that the relationship is coming to an end. We don't know if that means that TWN will cease business or else might act directly as an ISP outside the partnership.

Following is the residential broadband product line:

Wi-5	5 Mbps Down / 2 Mbps Up	$ 49.95
Wi-10	10 Mbps Down / 2 Mbps Up	$ 79.95
Wi-15	15 Mbps Down / 2 Mbps Up	$ 99.95 and Up
Wi-5 with Telephone Line		$ 75.00
Wi-10 with Telephone Line		$105.00
Wi-15 with Telephone Line		$125.00 and Up

The company doesn't list prices for businesses, but through the surveys and questionnaires we can see that business prices are higher than residential rates.

Fastwave[2] is a wireless ISP headquartered in Las Cruces. As a WISP they deliver broadband wirelessly from a tower to homes and businesses. On their web site they claim that the average speeds they deliver are between 2 Mbps and 5 Mbps. Their broadband allows for unlimited usage.

Basic WISP	3 Mbps Down and Up	$50
Premium 6	6 Mbps Down and Up	$65
Premium 9	9 Mbps Down and Up	$80
Premium 12	12 Mbps Down and Up	$95
Public IP Address		$15
Installation		$50

[1] The company's website is at https://www.twncomm.com/

[2] The company's website is https://fastwave.biz/

Satellite Broadband.

There are two satellite broadband providers available to homes and businesses in Sierra 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 Sierra 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

B. Surveys / Interviews

Residential Survey Results

The survey was conducted online using Survey Monkey. The survey was posted on Sierra County's website and was advertised on social media. Unfortunately, an online survey is not easily available to those with poor broadband. During the survey we talked to a few folks on the telephone while they tried to take the survey online, and some of them were not able to maintain a connection to the survey for long enough to complete it. We got 99 homes to take the survey. The survey produced some interesting results.

Broadband Customers

86% of survey respondents have some form of broadband. The ones without broadband took the survey using their cellphones or used broadband at their office.

The respondents used all of the available ISPs in Sierra County. 21% used Windstream, 27% used TDS, 22% used the fixed wireless WISPs, 17% used satellite broadband, 7% use their cellphones for home broadband access, and 1% used CenturyLink.

For the homes that don't have broadband, 50% said they can't afford broadband. 29% said broadband is not available at their home, and 7% said they didn't know how to use the Internet. While this was a small sample of respondents, these are typical of the responses we've seen in rural counties all over the country.

Cable TV Penetration

In an interesting response, only 44% of respondents said they have cable TV at home. That is significantly lower than the nationwide average, which dipped below 65% at the end of 2019. 35% of respondents 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 between around 20% (nobody has figured out how to count it on a national scale).

Telephone Penetration

Only 26% 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). In interpreting the results below it's important to note that TDS is the only company in the county that offers the triple play of Internet access, cable TV, and telephone service. That means that most bundles in Sierra County represent Internet service and telephone service combined. With that said, here is what customers say they are spending:

Customers buying a bundle of service	$89
Customers buying standalone broadband	$63
Customers buying standalone cable TV	$64
Customers buying standalone telephone	$50

Uses of Broadband

68% of respondents say that somebody in their homes uses the Internet to work from home. We note that the survey was mostly taken before the Covid-19 crisis when that number probably went even higher. That is made up of those that work at home fulltime (12%), those that work several days per week (31%), and those that work from home occasionally (25%). These are significantly higher percentages of people that work from home than we typically see in urban places. 59% of all respondents said they would work from home more if they had better broadband.

24% of respondents report having school-age children at home. Only 23% of them said the home broadband is adequate to support homework.

Satisfaction with Existing Broadband

53% of respondents say they are unhappy with their Internet download speeds at home, while 19% are satisfied.

48% of respondents are not happy with the customer service from their ISP, while 27% are satisfied with customer service.

62% of respondents say that they are unhappy with the value they get from their ISP compared to the price they pay. Only 10% 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 Sierra County attracting somebody to build a fiber network. 73% of households support the concept. Another 23% said they might support the idea but need more information. Nobody said they don't support pursuing a better broadband solution.

We asked the reasons why respondents support bringing a new network to the town. 63% said they hope for more competition. 57% of households hope for lower prices. An overwhelming 89% hope for faster speeds. 45% 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. 64% said they would definitely buy. Another 29% said they would probably buy service and 5% said they would consider buying service. Only 1% said they were unlikely to buy service.

When asked if respondents would buy a landline telephone, only 15% of the respondents said yes with another 19% saying probably. 44% said they were unlikely to buy a landline.

Cellular Service

95% of respondents say that they subscribe to cellular service – that's right at the national average of 95%. 32% of homes said the cellular coverage is not adequate at their homes – one the highest percentages we've ever seen.

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 Sierra County. 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. Half of respondents are unhappy with download speeds and with existing customer service. 62% don't think they get value for the price they pay. In our experience these are high results and show widespread dissatisfaction with the existing ISPs.

Support for a New Network. Every respondent was either in favor of attracting a new fiber network to the community or wanted more information. Nobody opposed the idea. This is the first time I can ever remember when somebody didn't oppose the idea.

Download Speeds. This seemed to be the predominant issue for respondents. 50% of respondents said they aren't happy with broadband speeds. An overwhelming 89% said that the primary reason they would consider moving to a new network is to get faster speeds. In the vast majority of communities where we've done surveys, the primary reason people are interested in a new network is to save money. I'm sure that is important in Sierra County, but speed is a more important factor since the quality of existing broadband is so poor.

Price Consciousness. You must read between the lines a bit, but I think price consciousness is still an important issue in the county. 57% said that lower prices would be a factor in getting them to change to a new network. It's likely that price consciousness is a factor for the lower than average penetration for both traditional TV and landline telephones.

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.

64% of all respondents said they would definitely buy from a new network. Another 21% said they would probably buy. 5% 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 64% 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, 29% 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 85% of the folks in the rural area would buy broadband.
- However, we can't forget that 99 responses on the survey don't represent the way that everybody in Sierra County feels about broadband. Since the survey measures sentiment, we can take the survey to mean that a lot of folks are unhappy with broadband in Sierra County. We universally got that same response in every interview we conducted.

  However, as mentioned earlier, the online survey is not a statistically valid survey. We know folks are unhappy with broadband, but we can't use these results to bravely say that 85% of folks in the rural areas will buy broadband on a new fiber network, because other issues come into play. In every community there are homes that can't afford broadband. There are always homes that don't use broadband either because they just aren't interested or because they don't know how to use it.

  In our studies we used a penetration rate of 50% in Truth or Consequences and Elephant Butte and a penetration of 70% 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 70% penetration in the rural areas is conservatively low. We have never worked in a county where the rural broadband was universally as poor as it is in Sierra County. It's conceivable that 85% of household would buy broadband if it came available – that's the national average penetration rate of broadband.

Business Questionnaire / Interviews

As part of the study, we interviewed a number of businesses in Sierra County. We also circulated a business questionnaire to businesses that asked them to tell us their broadband stories. Following is what we learned from the interviews and questionnaires:

Not every business has poor broadband. There are businesses in Truth or Consequences using the coaxial network from TDS for broadband that find the speeds to be acceptable. The primary complaint about TDS is that speeds tend to vary a lot during the day, but generally are still adequate.

We also talked to Baquera Grocery in Arrey. The store has a 100 Mbps connection from CenturyLink. Finley visited the store and they are getting fast broadband because they happen to sit directly across the street from a school that has a fast broadband connection. We don't know the technology being used – it could be paired VDSL circuits emanating from the tower at the school, or G.Fast, which is a superfast DSL product that is only good for up to 600 feet. The rest of the businesses in Arrey can only buy DSL from CenturyLink and the home broadband there is described as "very slow."

However, most of the stories we heard were about inadequate broadband.

- We talked to Bartoo Sand and Gravel. This is a 4-generation old business started in 1957 and that employs 50 people at their facility. The company specializes in creating "gradation" customer mixes of materials to be used to create asphalt. The company gets broadband wirelessly through Fastwave. While the connection is adequate most of the time, the broadband does bog down and even stop, and when that happens the business can't function. The plant communicates with the cloud in determining the right mix of materials, and when that process stops the business can't function. The company also uses broadband for other purposes such as measuring the gas used to fill trucks, reporting to OSHA, taking orders from customers, and participating in auctions to buy raw materials. The company would do a lot more with better broadband. As one example, they still use punch card timecards because they don't have enough bandwidth to automate time keeping. The business says they feel at times like they are in the dinosaur ages.
- We talked to Animas Creek Nursery that grows hardwood trees, conifers, and ornamentals most for highway projects. The farm has 4 employees. They business uses Windstream for broadband and the service is described as very slow. The biggest complaint with the broadband and telephone service is that it sometimes goes out of service for "days." The business uses the Internet to communicate with the main office in Santa Fe, and when the connection is down, they lose all record keeping, including payroll. They also use the Internet to look up instructions for using various chemicals and fertilizers. They routinely buy parts and materials from Amazon and other web vendors around fifteen times per week. They would like to use the Internet to do more advertising to grow the business, but that isn't possible today. Interestingly, the manager of the business owns a second home just across the border in Mexico, where the whole residential neighborhood is wired with fiber – something that doesn't exist in Sierra County.
- We talked to Elephant Butte Lake RV and Resort. The business has access to broadband, but the broadband is expensive and inadequate for their needs. In total the business pays $5,100 per month for telephone and broadband service with a connection from both Windstream and TDS. This includes 5 Mbps service to run the business, plus the RV park provides 2 Mbps service to RVs. The owner would obviously like to pay less for the broadband, but the major concern is that their speeds are inadequate. The business already loses a lot of customers when they find out the

broadband is slow – and that means lots of other businesses in the community lose out as well. The owner recently attended a nationwide RV convention and was told that visitors today expect at least a 10 Mbps connection. Experts at the show said that within a few years that will grow to a 60 Mbps connection needed for each guest. We agree with the prediction for the future because that's the same advice that's being given to hotels. Travelers today often want to work while they travel and expect the same kind of broadband connections they have at home.

- We talked to the mayor of Elephant Butte. The city's office had adequate broadband with a 40 Mbps connection from TDS for most of their purposes. The biggest concern of the businesses in the community is that there are 4 – 5 major citywide broadband outages per year where all the businesses lose service at the same time. Elephant Butte is a tourist town on a lake and these outages are massively disruptive to the business community. The community is frustrated with the outages and further frustrated by annual rate increases. The city communicates with the public mostly on Facebook. Outages often force them to have to post paper copy of city communications around the city. The city has incurred fines from the state in the past when broadband outages stopped them from making timely reports to the state. Outages also have impacted timely payroll for city employees.
- One of the issues we identified between the interview and questionnaire is that businesses outside of Truth or Consequences don't feel like they have a competitive choice of provider.
- A common thing we heard all over Sierra County was an inability to reliably process credit card transactions. A credit card transaction requires a steady internet connection for at least a minute. If credit cards don't work on a landline broadband connection it's due to either extremely slow speeds, or more likely due to a broadband signal that fluctuates wildly so that the connection won't hold. The situation is more complicated with satellite broadband. There are big numbers or rural businesses that use satellite broadband to process credit cards. For example, most rural gas stations use satellite broadband at the gas pumps. Satellite broadband has a very high latency, meaning a lot of delay in the signal. Rural businesses like gas stations that use satellite for credit cards generally don't use the same connection for anything else. It's possible that a way can be found to handle credit card processing better.
- We note that businesses in Sierra County don't use broadband in the same way that we see in other communities. For example, we only found one business that uses Voice over IP – Internet based telephone service. VoIP is generally less expensive than telephone service from the telephone company and comes with a host of features not available from the phone company. But you can't use VoIP over a poor broadband connection. We also noticed that very few businesses use cloud services, due no doubt to slow broadband speeds.
- About half of the businesses said there were functions they would tackle if they had better broadband. One common theme was that many businesses want the ability to post videos talking about their business or allow visitors to post videos to social media. A number of businesses had problems today connecting to various cloud services used for taking order, making reservations, ordering inventory, etc.
- Most businesses expressed dismay that they were unable to work from home due to slow residential broadband. One business had the opposite problem and had far better broadband at home in Truth or Consequences than the poor broadband at their rural business.
- We talked to half a dozen businesses that previously used HughesNet satellite broadband. They all said the broadband was slow but that the customer service was good. They all said they dropped HughesNet after the company moved customer service overseas and they could no longer resolve problems.

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 Sierra 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.

1. 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.[3] 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 Sierra 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

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

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.

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 600 and 1,200 homes. In a city a Census block might be a city block and in a rural area it might cover a large portion of a 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.

All these factors taken together mean that the FCC broadband databases and maps are generally dismal. The broadband speeds in towns might be reported reasonably correctly, although the speeds reported sometimes reflect marketing "up to" speed instead of actual speeds. Speeds for areas just outside of towns and cities are routinely overstated and often show broadband coverage where there is none. Rural areas served by DSL or fixed wireless generally overstate the broadband speeds – and these are the two technologies most widely used in rural America.

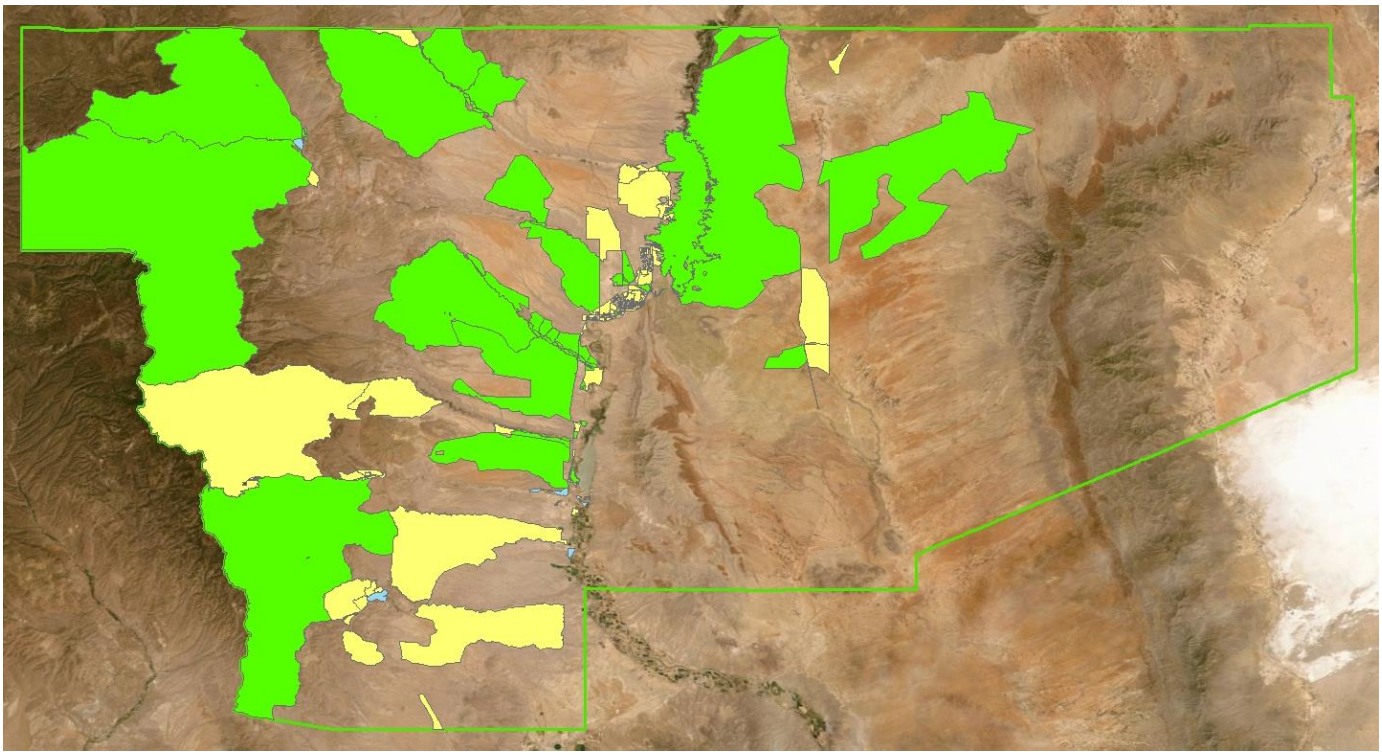
Following is a series of maps that demonstrate the inadequacies of the FCC mapping process and which show how broadband speeds have been overreported.

Windstream FCC Reporting – Data from FCC Form 477 for June 2019

= 10/1Mb Broadband or Less Census Blocks

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

= 25/3Mb Broadband or Greater Census Blocks



The yellow areas are likely accurate, and Windstream says in these areas they deliver broadband of 10/1 Mbps or slower. The problem is with the green areas where the company reports to the FCC that they can deliver speeds of 25/3 Mbps or faster.

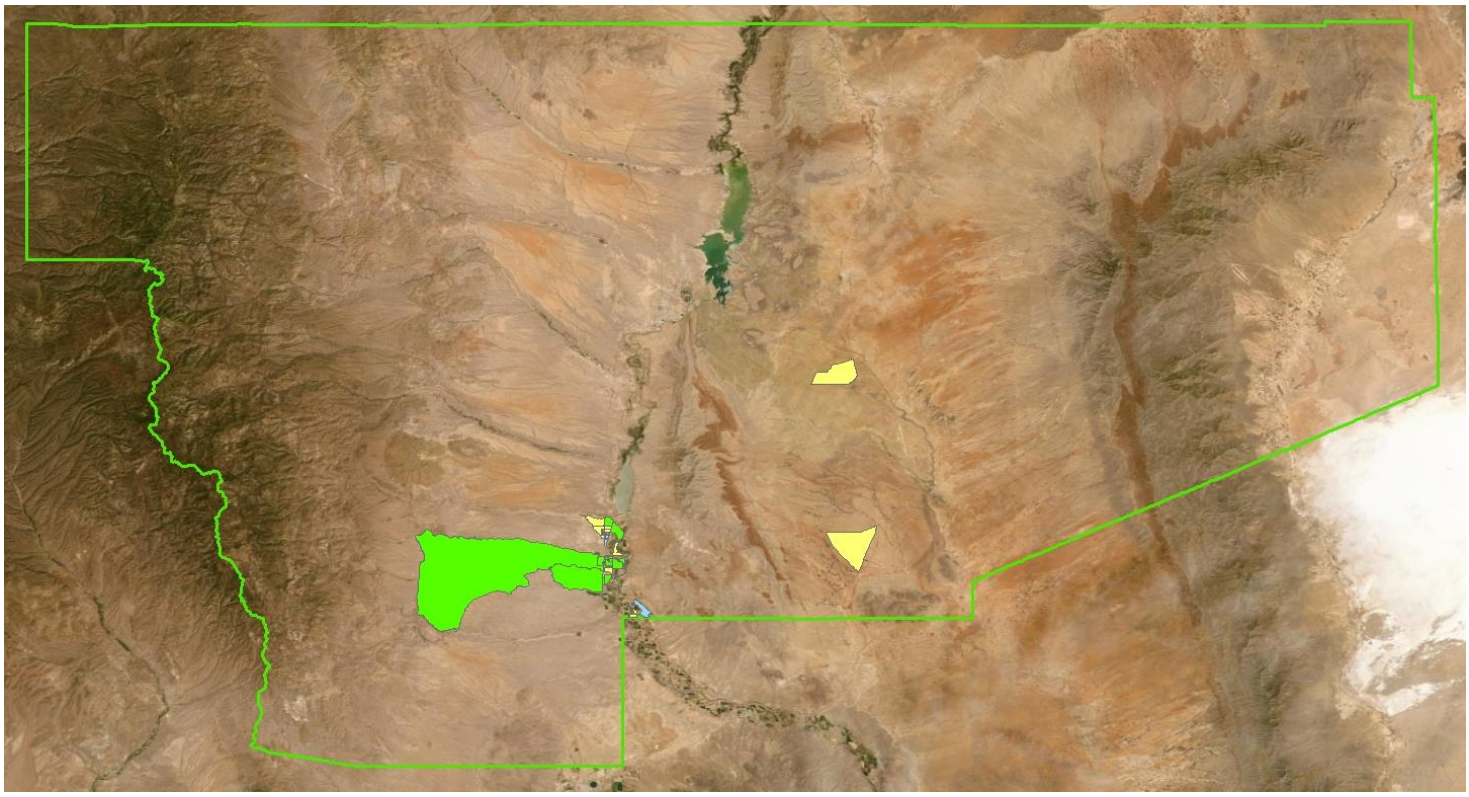
I won't repeat this with each map, but as a reminder from an earlier discussion, ISPs report broadband speeds by Census block. That means that if an ISP can deliver 25/3 Mbps to even one customer in a Census block that the ISP can report that block as having that capability. At the end of this section we'll show our version of speeds in Sierra County; we don't believe anybody in the rural areas can get broadband speeds of 25/3 from any of the ISPs.

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

= 10/1Mb Broadband or Less Census Blocks

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

= 25/3Mb Broadband or Greater Census Blocks

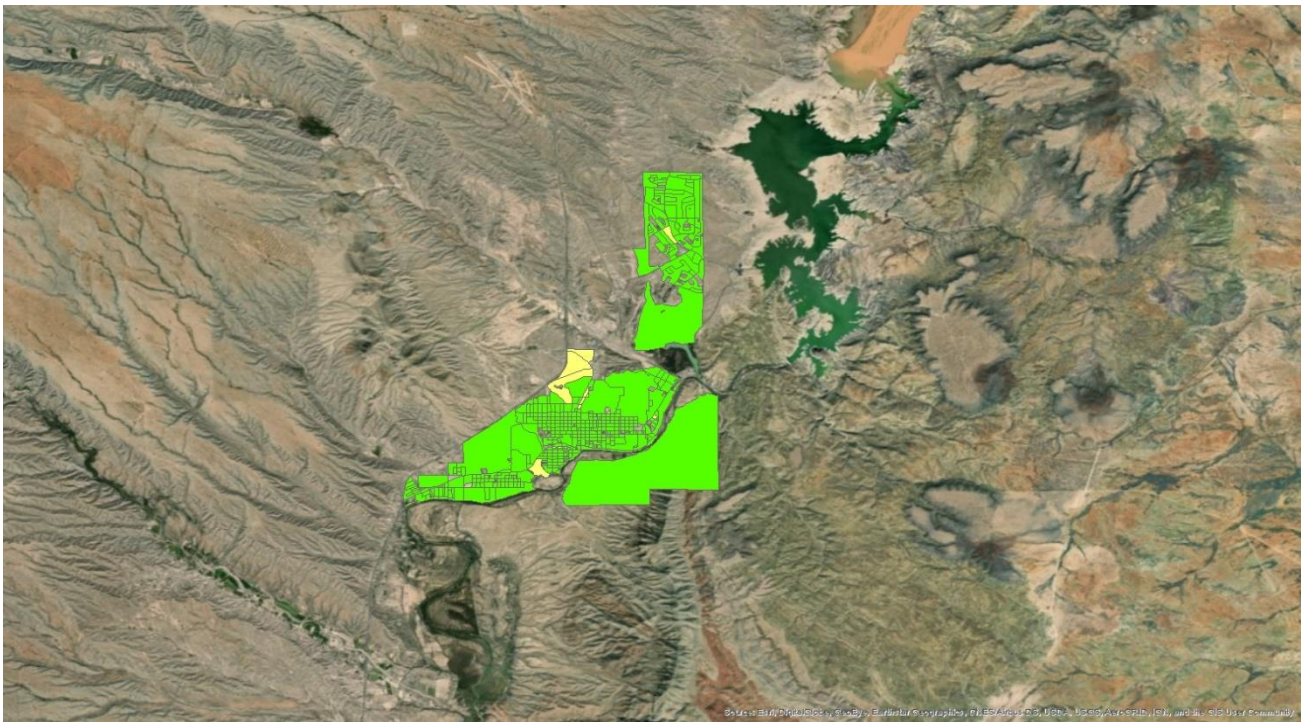


CenturyLink has a smaller service area, but they still have the same reporting issue as Windstream, in that we don't believe that the customers shown in the green area can get broadband speeds of 25/3 or faster.

TDS FCC Reporting – Data from FCC Form 477 for June 2019

= 10/1Mb Broadband or Less Census Blocks

= 25/3Mb Broadband or Greater Census Blocks



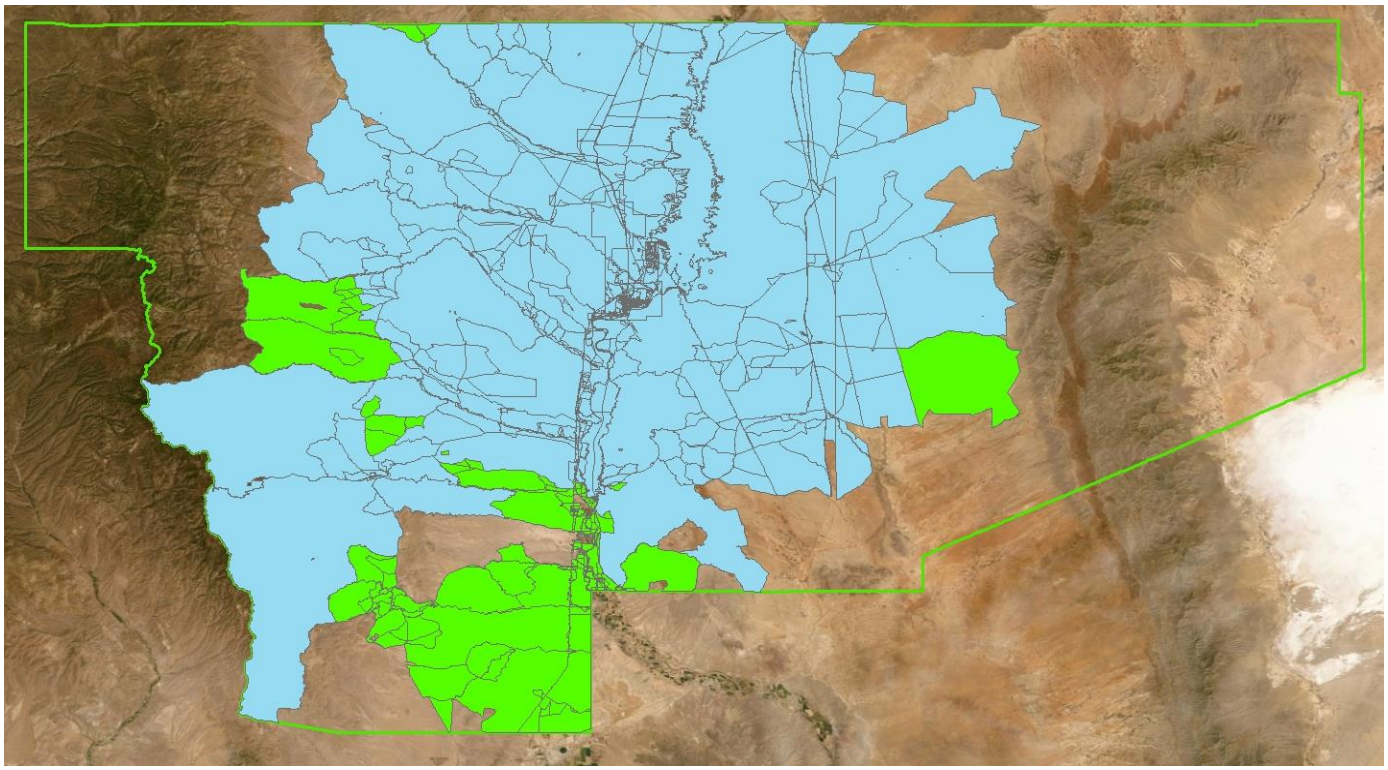
The TDS map is a close-up of Truth or Consequences and Elephant Butte. The TDS FCC maps are far more accurate than the maps of the telcos. However, it's likely that there are customers at the edge of the cities who are not covered by the TDS cable network, but which are shown on the map to have faster broadband available. This is due to the FCC requirement to report speeds by Census blocks.

Wi-Power FCC Reporting – Data from FCC Form 477 for June 2019

= 10/1Mb Broadband or Less Census Blocks

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

= 25/3Mb Broadband or Greater Census Blocks



Wi-Power is a WISP that uses fixed wireless technology to deliver broadband. It's always a challenge for WISPs to define their service area to the FCC because they can report places where they have customers today and places where they could reasonably serve customers if they got a request for service.

We know that a WISP network consists of radios on a tower and the WISP can service customer around that tower for some distance depending upon the technology used, the frequency used, and local barriers in topography that might block calls in some directions.

We don't believe Wi-Power can serve the whole area shown on the map from the existing towers, but a lot of the mapping issue comes from the FCC rule that if they serve one customer in a Census block, they show the whole Census block as served.

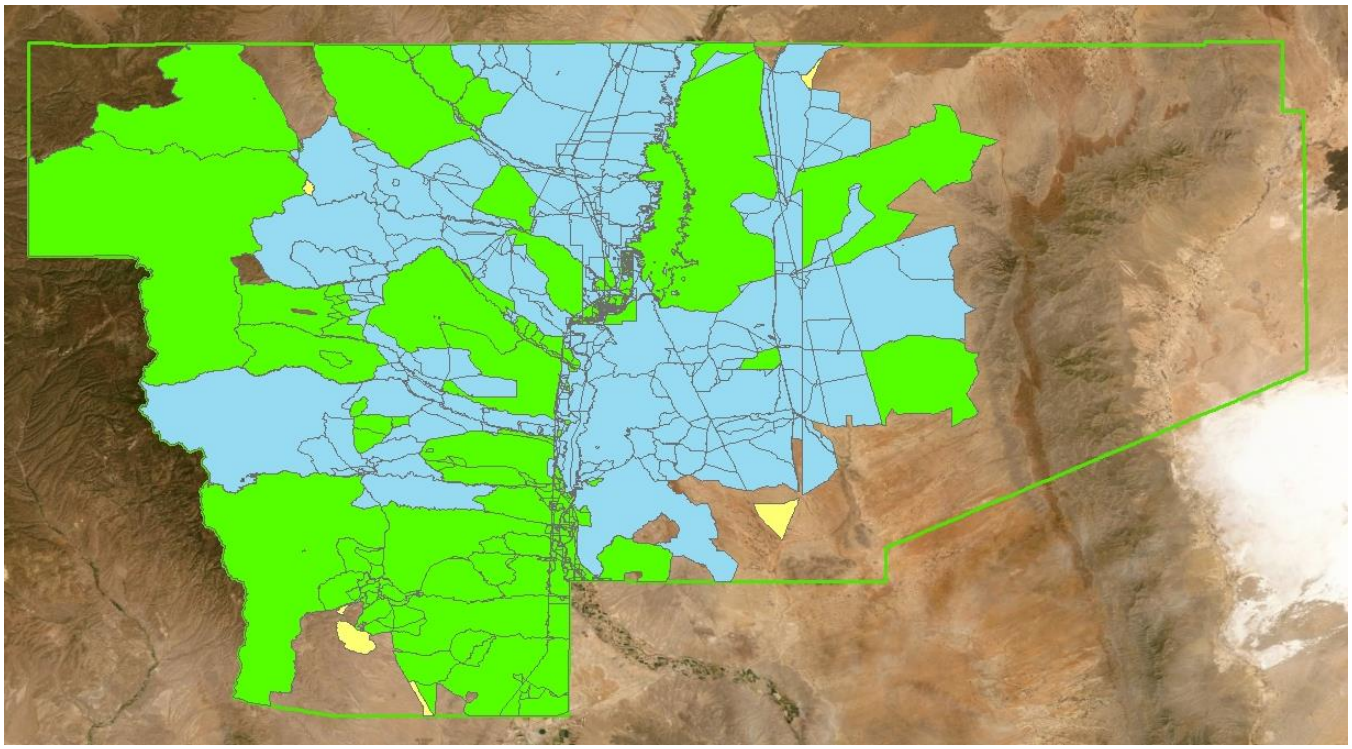
We also don't believe the speeds shown. Wi-Power only advertises speeds up to 15 Mbps, so the green areas have overstated speeds. They likely can deliver speeds greater than 10 Mbps to other areas (the blue areas), but we communicated with several customers getting speeds slower than that.

Composite FCC Map for all providers combined – Data from FCC Form 477 for June 2019

= 10/1Mb Broadband or Less Census Blocks

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

= 25/3Mb Broadband or Greater Census Blocks



This is the composite map when you overlay the reporting from every ISP that reports to the FCC. We note that Fastwave does not report to the FCC. Their fastest advertised speed is 12 Mbps and adding them to the map wouldn't likely change it.

When the FCC looks at the speeds that are reported to them, they believe that Sierra County is almost completely covered by broadband that is faster than 10 Mbps, and in the green areas above, faster than 25 Mbps.

The Real Broadband Speeds in Sierra County

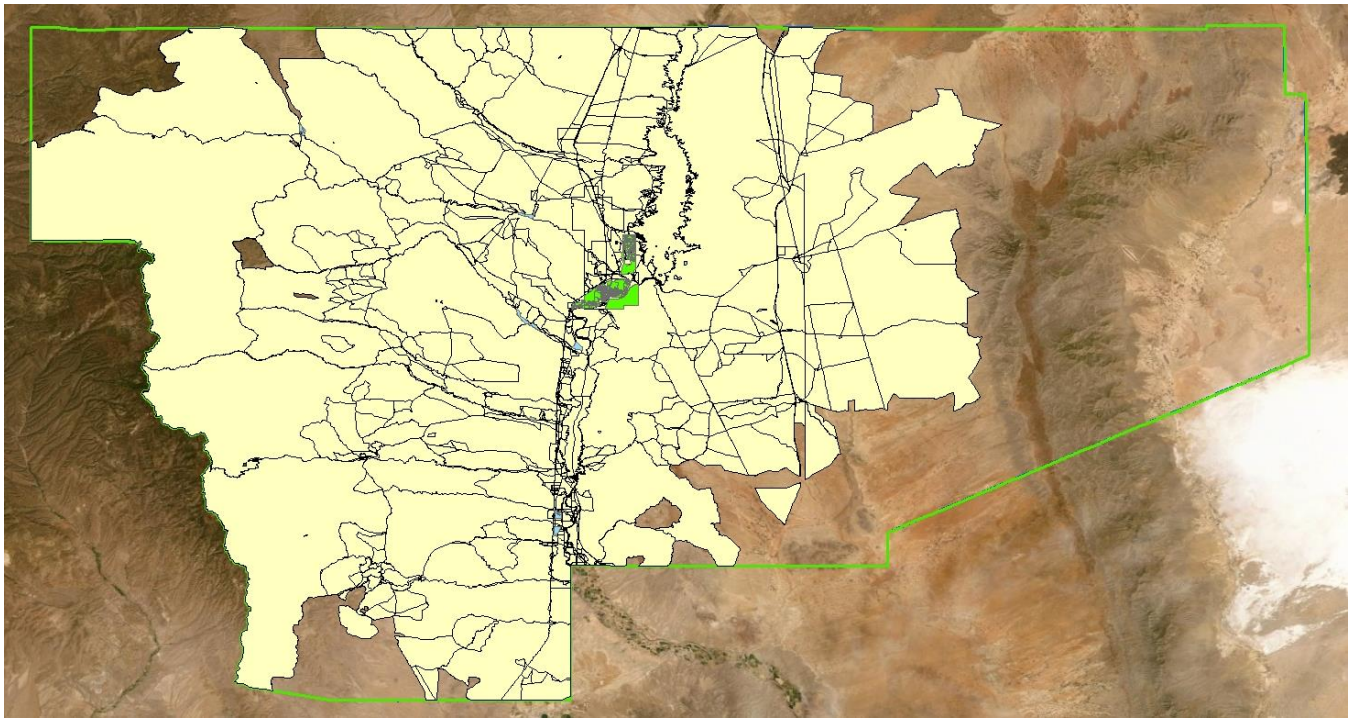
We believe that the reporting to the FCC covered above is largely a fiction. As requested by the RFP, we created our own version of a speed map for the county based upon our extensive field survey and other investigation. In a finding that we've discussed earlier, the speeds as reported to the ISPs are largely overstated. Most of what is shown as having 25/3 speeds in the above map of FCC data (in green) actually have speed at or under 10/1 Mbps.

The following map is our best attempt at mapping the broadband speeds currently available in the county.

= 10/1Mb Broadband or Less Census Blocks

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

= 25/3Mb Broadband or Greater Census Blocks



Sierra County is so large that some of the detail is not apparent on this map:

- Truth or Consequences and Elephant Butte are served by TDS and have speeds significantly faster than 25/3 Mbps
- There are small circles of DSL coverage of perhaps 1.5 miles around each fiber-fed CenturyLink DSL cabinet that likely can get DSL speeds of 25/3 Mbps (or something close to that).
- It's possible that there are a few wireless customers in the county who can get speeds over 25/3 Mbps, although both ISP advertise speeds significantly slower than that.

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 lousy 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. As can be seen by the CAF II coverage map below on page 44, the FCC funded too small of an area for CAF II. On that map, Windstream and CenturyLink were given money to upgrade the area in green – when in reality, most homes and businesses outside of Truth or Consequences didn't have speeds of 10/1 Mbps in 2015 (and most still don't).

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. Again, some areas of Sierra County were not eligible for these grants because the FCC believes the County already has adequate broadband.

Later in 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.

As can be seen by the map above on page 37, significant areas of Sierra County are considered 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 Sierra County, 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 parts of Sierra County. 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 parts of Sierra County 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.
- 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.
- 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.
- 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 Sierra County, TDS increased the speeds to roughly 100 Mbps.

That speed is drastically faster than the speed available to almost every other customer in Sierra County. In the industry we always talk about the "last home" served by the cable companies, because at every street emanating from a town 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 than that 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, cable company 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 are subscribing to data plans of at least 50 Mbps and 54% 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 only technologies that can deliver broadband faster than 100 Mbps are fiber-to-the-home and cable coaxial networks. Fixed rural wireless can serve a tiny number of homes with speeds up to 100 Mbps, but not on any mass basis. In big cities there are a few other technologies that can deliver fast speeds to apartment buildings such as metro Ethernet or direct microwave connections. The bottom line, though, is that people in cities are being offered fast data speeds of at least 100 Mbps per second. In rural areas this

only happens for those rural places lucky enough to have fiber-to-the home. That's still only a tiny fraction of rural America.

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 75.5% of the people in Sierra County had access to broadband of at least 25/3 Mbps. In September 2018 Microsoft said that only 13.1% 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

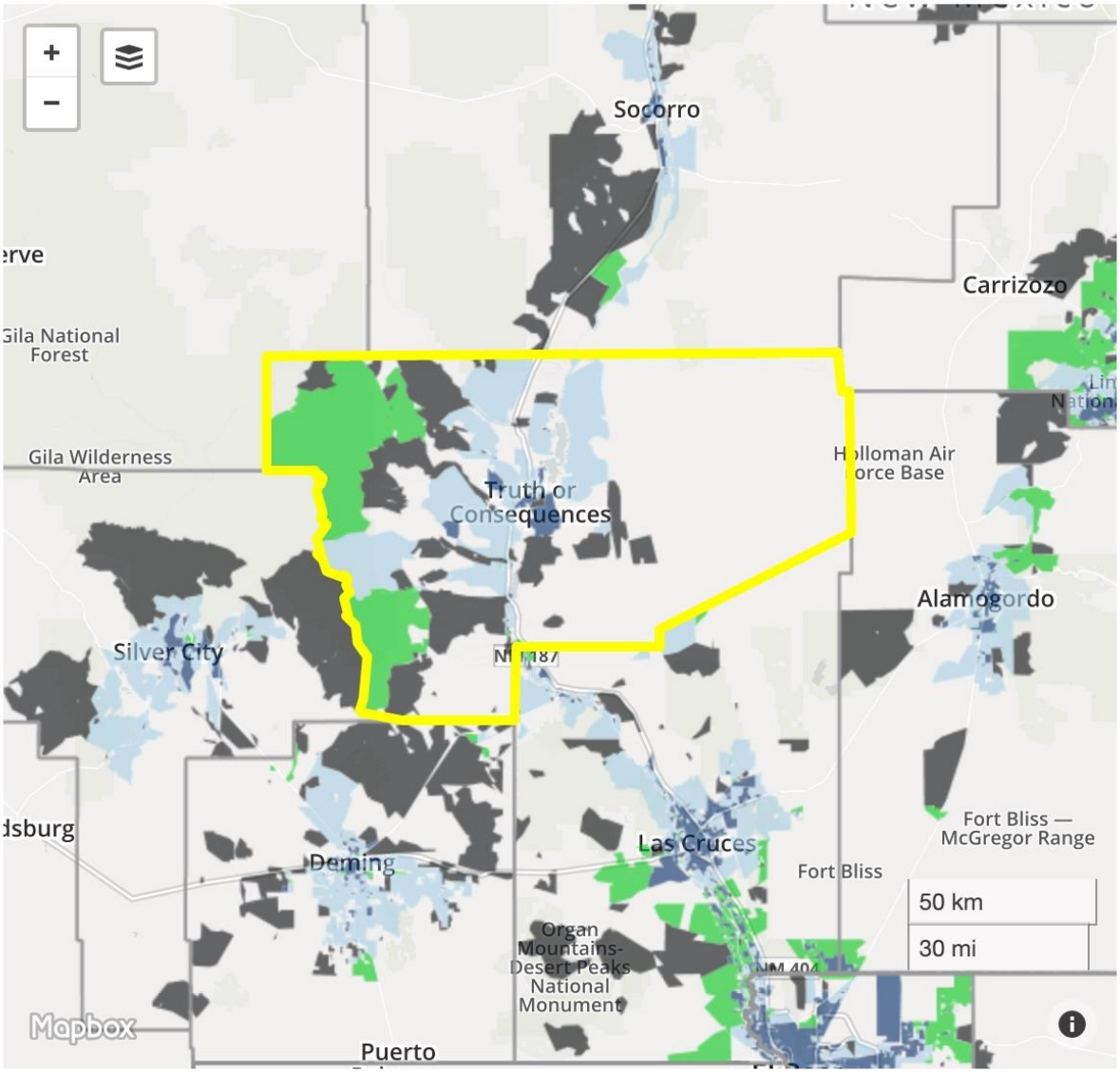
It's worth noting that both Windstream and CenturyLink participated in the original Connect America Fund II (CAF II). The FCC set aside $1.7 billion per year for the 6 years ending in 2020 for the big telcos to build or upgrade rural broadband. These funds were made available to census blocks that had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

The FCC awarded these funds to Windstream and CenturyLink in Sierra County as follows:

- Windstream accepted $66,851 per year, or $401,106, to bring better broadband to 194 rural customers - $2,068 per home.
- CenturyLink accepted $16,157 per year, or $96,942, to bring better broadband to 42 rural customers - $2,308 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 this year.

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. Following are maps that show the areas that are supposed to be upgraded by CAF II (the areas shown in green).



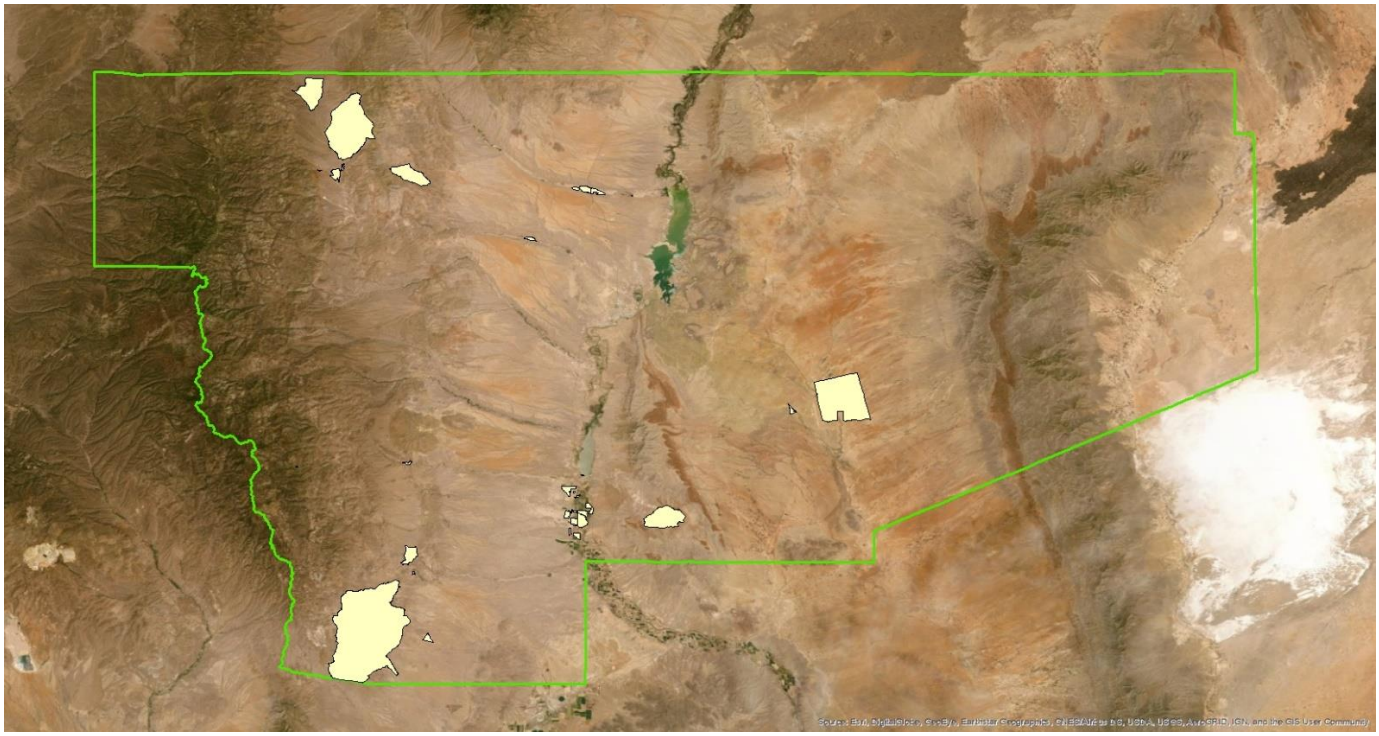
CAF II Reverse Auction

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.

Unfortunately for Sierra County, the only bidder for the funds was Viasat – the satellite broadband provider. Viasat won the funding to supposedly bring faster broadband to 123,000 homes in seventeen states. The grant program requires Viasat to offer speeds of at least 25/3 Mbps broadband to areas that didn't have it before the auction.

Following is a map showing the areas of Sierra County where Viasat won the broadband funding.

= ViaSat CAFII Award Census Blocks



One problem with this award is that Viasat already covers Sierra County and the other rural communities and has always been free to sell and market in these areas. The federal grant money doesn't bring a new broadband alternative to anybody in rural America.

Worse, the satellite companies aren't required to connect any specific number of new customers as a result of the grant awards. They are largely free to just pocket the grants directly as profits. Even when they do connect a new customer, they wouldn't be building any new and lasting broadband infrastructure, instead just installing an antenna at each new customer.

The biggest problem with these awards is that the FCC will not provide funding in the $20.4 billion RDOF grants to cover these same areas – the FCC now considered these areas to have a 25/3 Mbps broadband solution.

What we've learned during this and other studies is that rural residents don't seem to want satellite broadband. CCG has been doing broadband surveys for twenty years in rural America and we can't recall ever talking to a satellite customer who was happy with their broadband service. In every survey we seem to encounter more people who have dropped satellite service versus those that still have it. Customers complain that satellite costs too much - Viasat claimed in their most recent financial report that the average residential broadband bill is $84.26.

Customers also hate the high latency on satellite, which can be 10 to 15 times higher than terrestrial broadband. Latency is signal delay caused by the satellite being parked almost 22,200 miles above earth

– it takes a while for a round trip communication over that distance. High latency causes major problems with any web service that is real time. It's hard to make a voice connection with high latency. It's hard to connect to a school or corporate web server. It's difficult to watch live streaming video, although cached video like Netflix works fine.

The primary complaint about satellite broadband is the tiny monthly data caps. The company has products that satisfy the 25/3 Mbps speed requirements, starting with the Unlimited Silver 25 plan at $70 with speeds up to 25 Mbps with a monthly data cap of 60 gigabytes of data usage. The fastest plan is the Unlimited Platinum 100 plan for $150 with speeds up to 100 Mbps and a data cap if 150 gigabytes. Unlike cellular plans where a customer can buy more broadband, the Viasat plans throttle customers to speeds reported to be less than 1 Mbps once a customer reaches the monthly data cap. To put those plans into perspective, OpenVault announced recently that the average US home used 344 gigabytes of data per month in the fourth quarter of 2019. That was up an astounding 27% from a year early when average consumption was 275 gigabytes. The average cord cutting home uses 520 gigabytes per month. The satellite broadband is impractical for anybody with school students in the home, for anybody who works from home, or for anybody that does even a modest amount of video streaming.

Giving grant money to satellite providers makes no sense as broadband policy. They don't bring new broadband to anybody since the satellite plans are already available. The plans are expensive, have high latency and low monthly data caps.

2. 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.[4] 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.

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

Comparing Sierra County with the Rest of the World

There are numerous ways to compare Sierra 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 2019 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	44.7%
Homes buying at least 25/3 Mbps	42.8%
Homes buying at least 50/5 Mbps	36.4%
Homes buying at least 100/10 Mbps	12.6%
Homes buying at least 250/25 Mbps	0.8%

To put the FCC numbers into perspective, the percentage of homes that get at least 10/1 Mbps broadband (44.7%) ranks ahead of only Mississippi, which is last at 44.3%. The only other state with less than a 50% broadband deployment is Idaho. It's worth noting again that these numbers are based upon fault 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 Sierra County:

Urban population:	7,477
% that can buy at least 25/3 broadband	93.6%
% with 4G LTE coverage at 5/1 Mbps	100%
% with both	93.6%
Rural population:	3,639
% that can buy at least 25/3 broadband	45.5%
% with 4G LTE coverage at 5/1 Mbps	94.4%

% with both 41.9%

We know that everybody (or practically everybody) in Truth or Consequences can buy broadband from TDS at speeds faster than 25/3 Mbps. When the FCC shows only 93.6% 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 nearly half of the homes in the rural parts of the county can buy 25/3 Mbps broadband. We don't believe that any of the 2,756 homes in the rural parts of Sierra County can buy broadband that delivers 25/3 Mbps broadband or faster.

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.[5] 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.

Comparing Sierra 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 four counties in the state – Colfax, Hidalgo, Socorro, and Catron – for which the FCC say there is less than 5% broadband coverage (with zero coverage in Catron County). At the other end of the scale, the FCC says that Los Alamos County has a 96.7% coverage of 25/3 Mbps broadband, followed by 90.4% for Santa Fe County.

According to the FCC data, 44.5% of rural homes in Sierra County can buy 25/3 Mbps broadband. This ranks Sierra County as 18th in the state out of 33 counties in terms of homes in the rural areas that can buy 25/3 Mbps or faster broadband. The counties with the closest similar rankings are Chaves and Torrance counties. As mentioned throughout the report, the broadband coverage in the FCC report seems massively overstated for Sierra County, but it's likely that it's overstated for much of the rest of the state as well.

3. 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

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

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.[6] The second report is issued by the Quello Center and is authored by Bianca Reisdorf.[7] 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 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 Truth or Consequences 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.[8] 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

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

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

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

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, TDS, Windstream, and the various WISPs.

ISPs Bridging the Price Gap

Federal Lifeline Program

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

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

TDS also uses this program in markets where they are the incumbent telephone company. We don't know if they offer this in Truth or Consequences where they are the cable provider and not the telephone company.

FCC Modifies the Lifeline Program

In November 2019, the FCC announced major changes to the Lifeline program.[9] These rules make it harder for some companies to participate in the program, but it opens up the door to many new participants.

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

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).
- 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.

4. 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 all 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.

5. 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.

6. 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 Sierra 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 Sierra 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 Sierra County today should be ready to handle today's broadband needs as well as the expected broadband needs of the future.

7. 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 Sierra 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),[10] 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:

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

- 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.

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 Truth or Consequences 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 Sierra 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 Sierra 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 away 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 Sierra 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 Sierra 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.

The Reverse Donut Phenomenon. There is an interesting phenomenon to be aware of that CCG calls the reverse donut phenomenon. If Sierra County can attract fiber to the rural parts of the county, but not to Truth or Consequences and Elephant Butte, then the rural areas would have faster broadband than the cities. The tiny towns in the County also would have faster broadband. At first that wouldn't make much

difference. But over time, as the need for broadband keeps growing, fiber-based broadband in the rural areas would be better than the broadband in Truth or Consequences. That could have the effect of making people want to live in rural areas or small towns rather than in the larger town. Many counties find this problematical since they have structured the various services of the county based upon where people live today. Many counties also don't want their population to disperse to rural areas because it increases the cost for a host of services like road maintenance, school transportation, policing and public safety, and numerous other costs that falls to the county and the towns.

This is not an immediate issue, but the reverse donut is an inevitable outcome if the rural areas other than Truth or Consequences and Elephant Butte get fiber. This means that any broadband plan for Sierra County ought to have a goal for getting fiber-equivalent speeds everywhere. It makes sense to first concentrate on the areas without good broadband first, but the County needs to not forget about Truth or Consequences and Elephant Butte.

II. ENGINEERING DESIGN AND COST

This broadband study looks at three options for bringing broadband to:

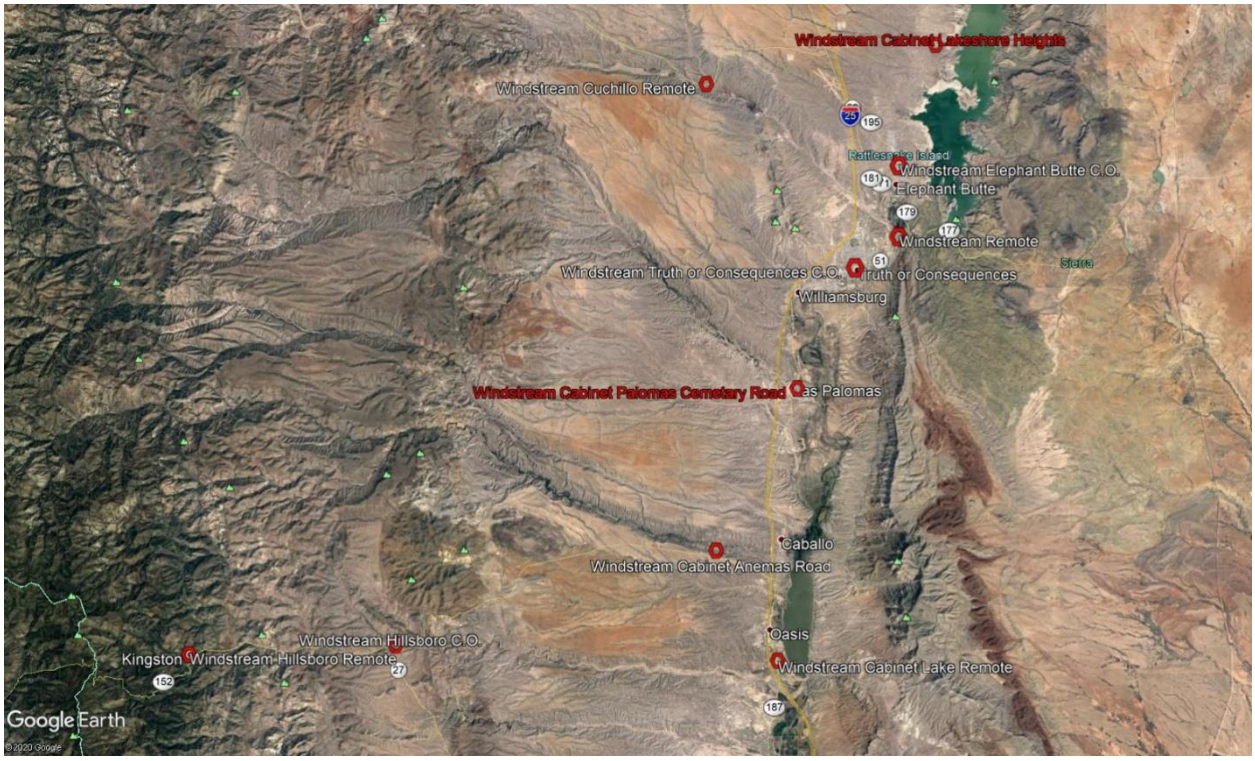
- Everywhere in Sierra County.
- Truth or Consequences and Elephant Butte only.
- The rural areas other than Truth or Consequences and Elephant Butte.

A. Existing Provider Analysis

Our analysis started with two field reviews in Sierra County by Andy Heins of Finley Engineering. Andy's goal was several-fold. First, he wanted to understand the broadband that was available today from the incumbent providers. Andy made an extensive drive through Sierra County and identified existing infrastructure that can support broadband. This meant looking at the various electronic sites supporting broadband in the Windstream and CenturyLink networks, and looking at towers and electronics deployed by the two wireless ISPs. Andy's goal with this review was to make his best guess about the broadband speeds available in various places across Sierra County. That effort is captured on a map included in Section I. C. of this report.

Andy was also looking at local factors that would impact the cost of building a new fiber network in Sierra County. One of his primary goals was to understand the conditions of existing utility poles that would be used to support a new fiber network. Andy's findings and conclusions are included below.

<u>Windstream</u>



Windstream is the incumbent telephone company in most of Sierra County where they predominantly have deployed copper-based DSL equipment capable of providing some basic internet capability. Windstream is a Price Cap Carrier subject to FCC Regulation and per FCC data did not receive any Connect America Phase II funds for the buildout of broadband in Sierra County.

Our review of Sierra County for facilities capable of deploying broadband concluded that Windstream in many cases has deployed DSL technology for offering internet services. We believe the DSL platform is only capable of providing a maximum of 10/1Mb broadband, and that would only be available within approximately 8,500 feet of street miles from a Windstream central office (C.O.) or field equipment cabinet.

In Truth or Consequences and Elephant Butte Windstream operates two central office locations that act as the central hub for all copper distribution cables that serve the communities. We did not find any DSL remote equipment locations in Truth or Consequence or Elephant Butte, meaning that the fastest Internet speeds on DSL in the towns would only be within a little more than miles from each central office. The lack of DSL equipment locations in Truth or Consequences is consistent with the low broadband speeds reported by Windstream to the FCC in Truth or Consequences and Elephant Butte.

As you can see on the map on the prior page, Finley found several older DSL hubs in rural Sierra County. We don't think the speeds from these hubs is higher than 10/1 Mbps due in part to the vintage of the electronics being used and also because of inadequate backhaul. It looks like the rural DSL network in the county is served with repeated DS3 that provides a total of 45Mbps of bandwidth. This is not adequate bandwidth to provide fast broadband to the many customers connected the DSL network.

We did find some newly deployed DSL cabinets with fiber backhaul at Cuchillo, Champagne Hills, Palomas, Animus Road, and at the north end of Truth or Consequences. These new hubs are fed by fiber backhaul, which means that they are likely capable of delivering speeds as fast as 25/3Mb broadband to homes and businesses within a mile or so of each new cabinet. The speeds that can be achieved are also affected by other factors such as the quality of local fiber connecting to homes, so it's impossible to tell from a field review the actual speeds that might be delivered.

Our understanding and review showed that there is a single fiber connection connecting the Truth of Consequences C.O. to the Elephant Butte C.O. A single fiber path means no redundancy and it would be possible for all of Elephant Butte to lose service from a fiber cut or an electronics failure between the two locations. We were told by locals that there have been some significant outages.

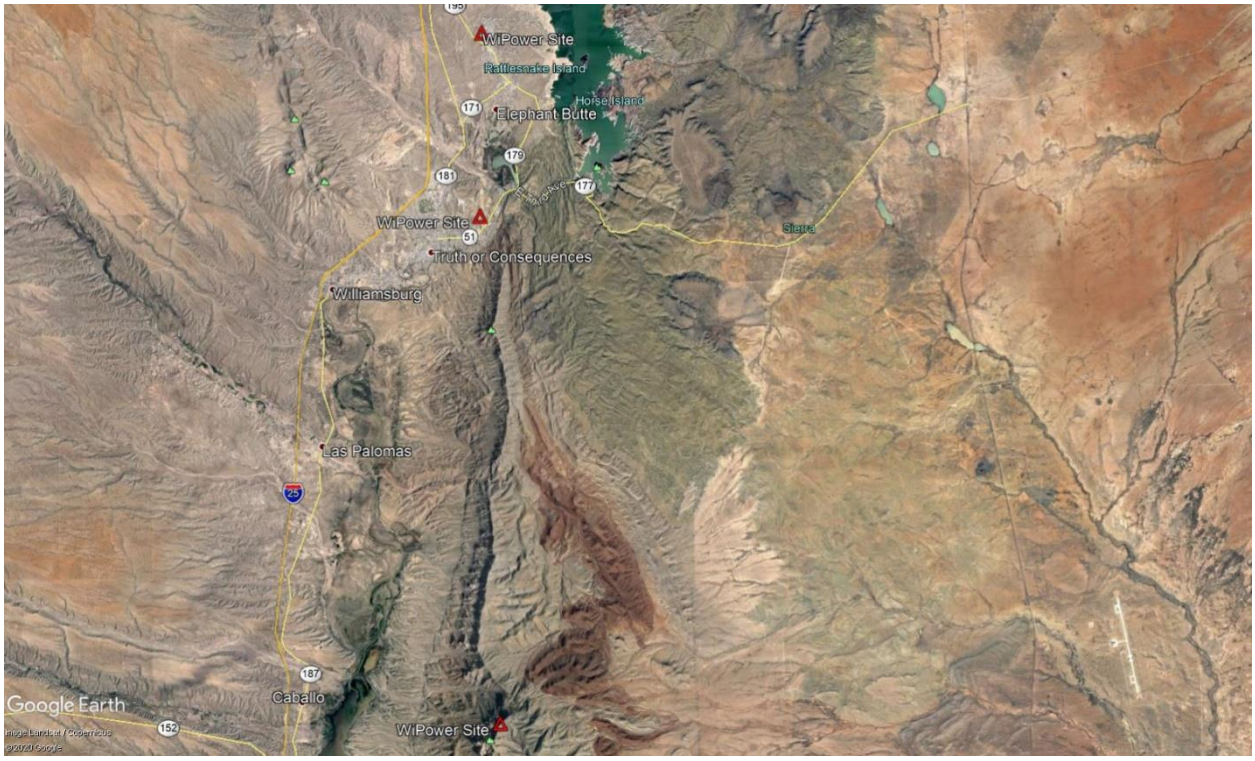
CenturyLink

CenturyLink is the other incumbent telephone company in Sierra County and offers service in the southern Portions of the County; primarily from near Arrey and further south. CenturyLink has deployed copper-based DSL equipment capable of providing some internet capability. CenturyLink is a price cap carrier subject to FCC regulation and per FCC data has deployed some location with Connect America Phase II funds for the buildout of broadband in Sierra County.

CenturyLink does not have any central office locations in Sierra County but does have DSL Remote equipment locations fed from outside of Sierra County. It is our understanding that the broadband from the DSL sites is connected by fiber to Hatch. We also believe that Windstream is connected to the CenturyLink fiber at the Arrey School, which provides Windstream a connection to the outside world and the Internet.

All the DSL equipment locations we found in the CenturyLink served areas are connected with fiber backhaul. We found these DSL remote locations in Arrey, near the Caballo Dairy and near Old Hot Springs Road. Fiber backhaul to these DSL remotes can provide adequate backhaul for broadband services and CenturyLink may be able to offer DSL service package of up to 25/3Mb broadband to a few locations within approximately 8,500 feet of road miles of an equipment cabinet.

Wi-Power



Wi-Power is a fixed wireless internet service provider in Sierra County. We located Wi-Power fixed wireless equipment at several locations in and near Truth or Consequences and Elephant Butte.

Based on these locations, we believe that the Wi-Power coverage area is significantly smaller than what is reported on the FCC Form 477 data. This is partially due to FCC reporting method that would allow showing coverage for an entire Census block even if only one customer can be served there.

We also don't think the speeds offered by Wi-Power are as fast as are reported on the FCC 477 data that shows some areas with speeds of at least 25/3 Mbps broadband available. While there is at least one fiber connection as part of the Wi-Power network, the connections between towers is provided by microwave wireless connections. As shown elsewhere in this report, the company isn't advertising any speeds above 15 Mbps.

Wi-Power has had a marketing arrangement and relationship with Sierra Electric Cooperative. As we were writing this report, we saw a notice that this arrangement has ended. We're not sure what that means in terms of Wi-Power continuing to offer services.

Fastwave

Fastwave is another fixed wireless internet service provider in Sierra County. We located Fastwave fixed wireless equipment at several locations in and near Truth or Consequences and Elephant Butte as evidenced by the above map. Fastwave does not report broadband coverage to the FCC (they are supposed to) so we have no information other than their web site about the speeds they are claiming to offer. The web site shows the fastest speed of 12 Mbps download.

Fastwave operations are based in Las Cruces and it appears that they have a fixed wireless backhaul connection from Caballo Peak back towards their operations in Dona Ana county. It also appears they have a fiber connection to the Windstream central office in Truth or Consequences.

TDS

TDS is a cable network operator located solely in Truth of Consequences and Elephant Butte. Per our review TDS has recently upgraded the coaxial cable system to a hybrid fiber/coax system. We observed multiple cable nodes in their system; these nodes convert optical fiber signals to RF signals which operate on the coaxial cables. There is a fuller description of the technology used by TDS below.

We have no reason to not believe that TDS is delivering the speeds that they are claiming on the FCC Form 477. That is not to say that every customer in the market can get their best speed due to the local network conditions.

TDS has a fiber connection to the Verizon Point of Presence (POP) in eastern Sierra County. This connection is presumably for backbone reliability and price competitiveness. We don't know if TDS also connects to CenturyLink.

B. Network Design

Evaluating the Network Options

In our evaluation of Sierra County, 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 beans 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 often 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.
- Radios used for this purpose today are largely software tunable and we envision networks that use both 3.65 GHz and WiFi, and which might be able to accommodate future frequencies allowed by the FCC.
- There is another wireless technology that will be available in a few years for rural wireless broadband. 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 recently finished an auction 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.

Unfortunately, this technology is not 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 foliage and hills and the terrain and trees in Sierra County service area makes this technology unusable to serve any significant number of customers. There would likely be some customers that could be served from any tower, but the technology could not deliver a broadband product to everybody (or even not to a significant percentage of households), which doesn't fit the goals state by the RFP for this project.

Our physical inventory of Sierra County shows that there are a few wireless providers using this technology in the area today, and the slow broadband speeds they 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 aren't 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 3 – 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 in each of the three scenarios. Fiber broadband networks have been around as an end user delivery platform since the late 1990's. 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 will 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 Sierra County 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 which communicate to and from the Internet.

Overall Design Criteria

In Sierra County, 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.

The collaborative nature of the pole owners in Sierra County make aerial fiber construction the best choice. Finley Engineering utilized GIS data provided by the Sierra Electric Cooperative and the Truth or Consequences Electric Utility for FTTP designs on those systems and used aerial imagery to route the small segment of the FTTP network on El Paso Electric pole lines. We also used address point data from Sierra County GIS records to understand all the locations in Sierra County for a complete FTTP design.

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 Sierra County, Finley worked with Sierra County 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 Sierra County records, we selected the following passing's for the study:

Passings	Rural	Two Cities	Total County
Residential Customers	2,756	5,469	8,225
Business Customers	169	730	899
Total	2,925	6,199	9,124

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. 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 Sierra County.

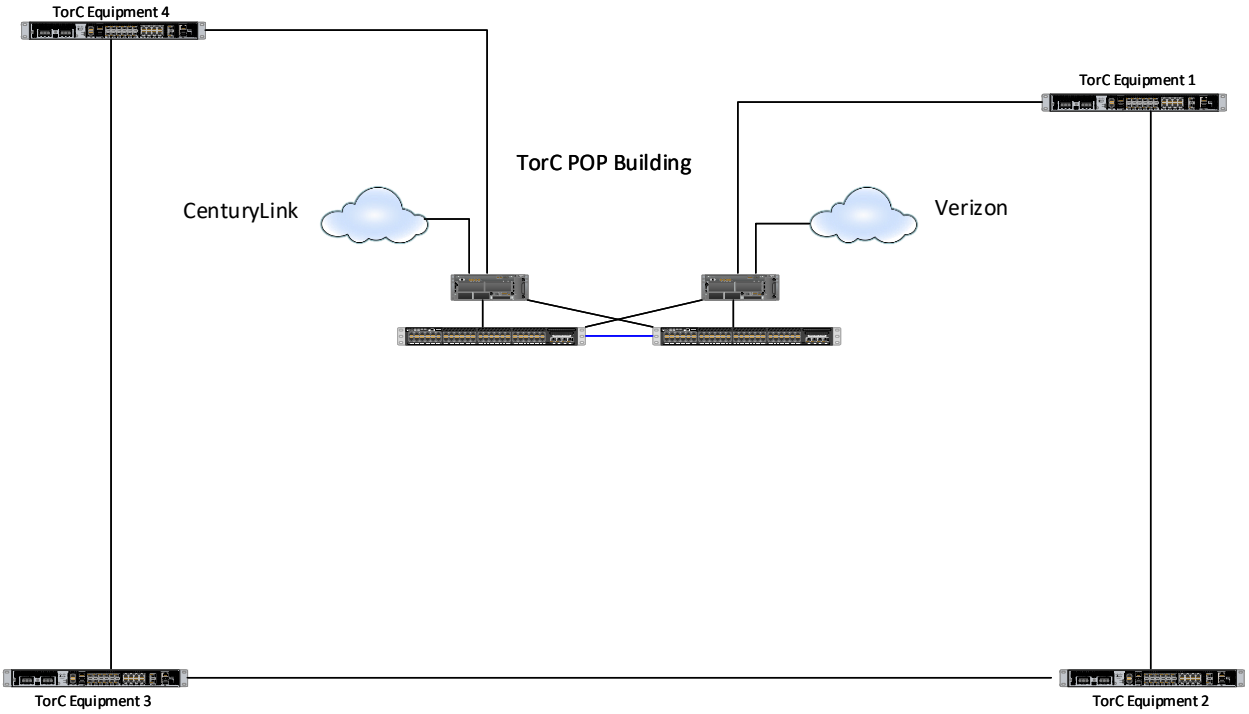
Fiber Network Design

There are two components of the fiber network design:

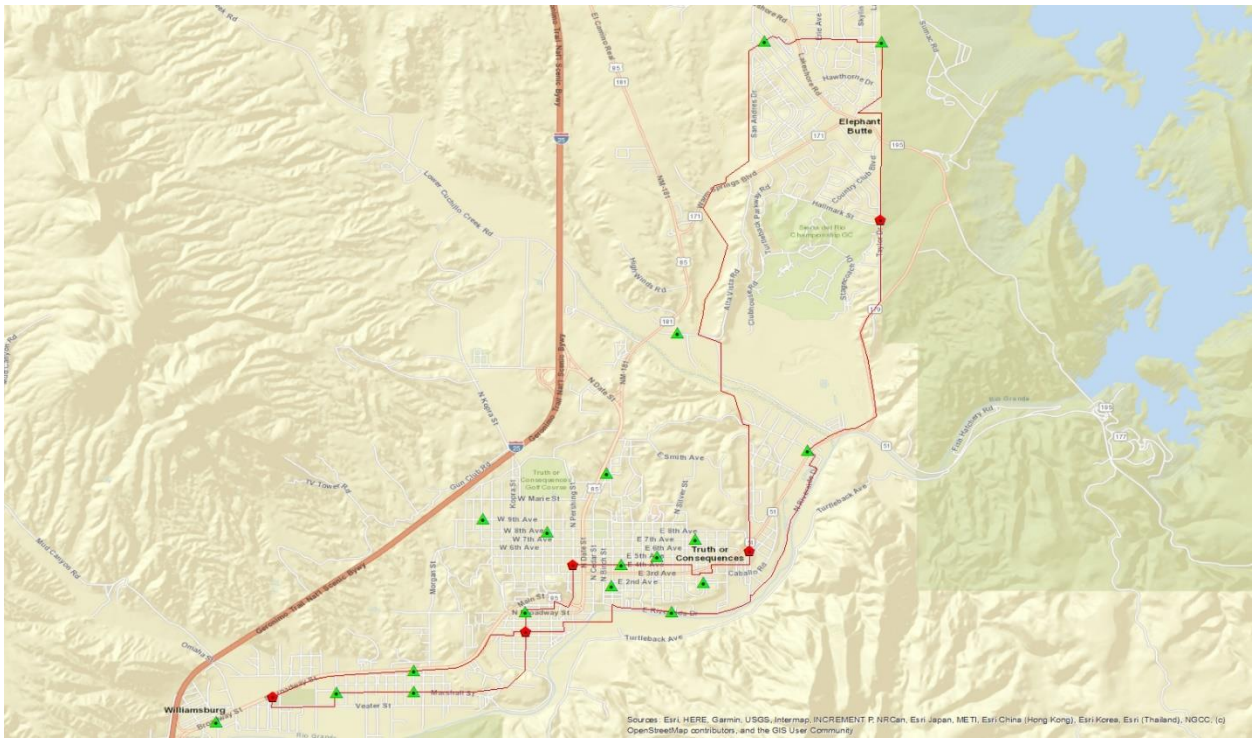
Backbone Fiber. Our network design includes nine (9) locations that will house electronics. These locations include a primary central office location in Truth or Consequences and seven (8) remote hub site; (4) located in rural Sierra County and (4) located in Elephant Butte and Truth or Consequences.

We are able to engineer a ring within Truth of Consequences and Elephant Butte 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 the six 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.

Due to the geography in the rural area of Sierra County, a network in the rural parts of the County would have to be a "spoke and wheel" configuration which allows for electronic redundancy but not physical redundancy. Initially only two of the 12 fibers are needed to connect to the redundant network. The additional fibers can be used for future electronic upgrades, for creation of a transport network specifically for smart grid purposes, for new transport connections outside of Sierra County, or for other future endeavors. Following is a diagram of the basic fiber ring.



Following is a map of this same backbone fiber overlaid onto a map view of Truth or Consequences.



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 Sierra County 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 poles in Sierra County include 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 $3,550 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 $4,550 per mile. We have estimated urban make-ready costs as $8,350 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 $9,350 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 that a steel messenger will be placed 40 inches below the power neutral (or at the lowest point of the electric network per NESC code) and an all dielectric cable will be lashed to the steel messenger. 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.

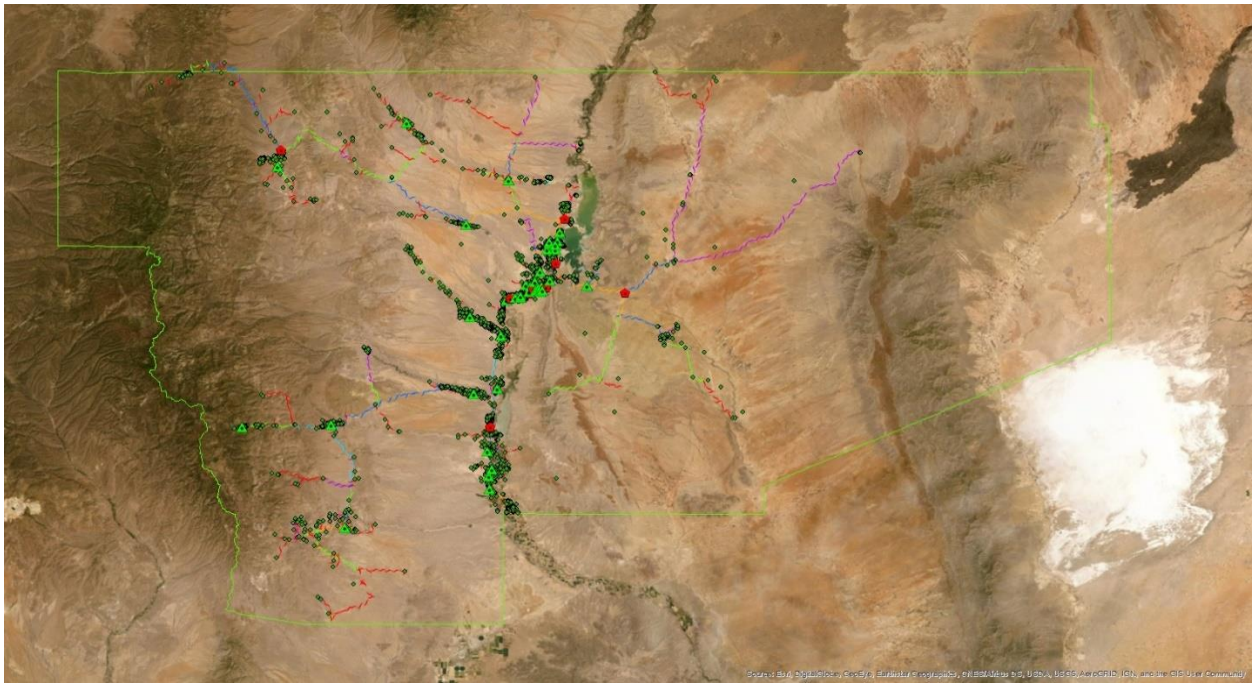
The most significant change in the rules is a new classification of poles as either simple or complex make-ready. The order defines how to make this classification. In real life practice, the new attacher will suggest this determination, although it could get overturned by the pole owner.

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.

Below is a map image of the complete Sierra County FTTP network design. We created the FTTP network design in an all GIS format and is available to Sierra County for future purposes.



Miles of Fiber Construction

The total miles of fiber in the network design is as follows:

	Miles	Cost	Cost / Mile
Rural County	563.65 miles	$21,121,352	$ 34,572
Two Cities	105.56 miles	$12,584,135	$119,213
Total	669.21 miles	$33,705,487	$ 50,366

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 Sierra County 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.

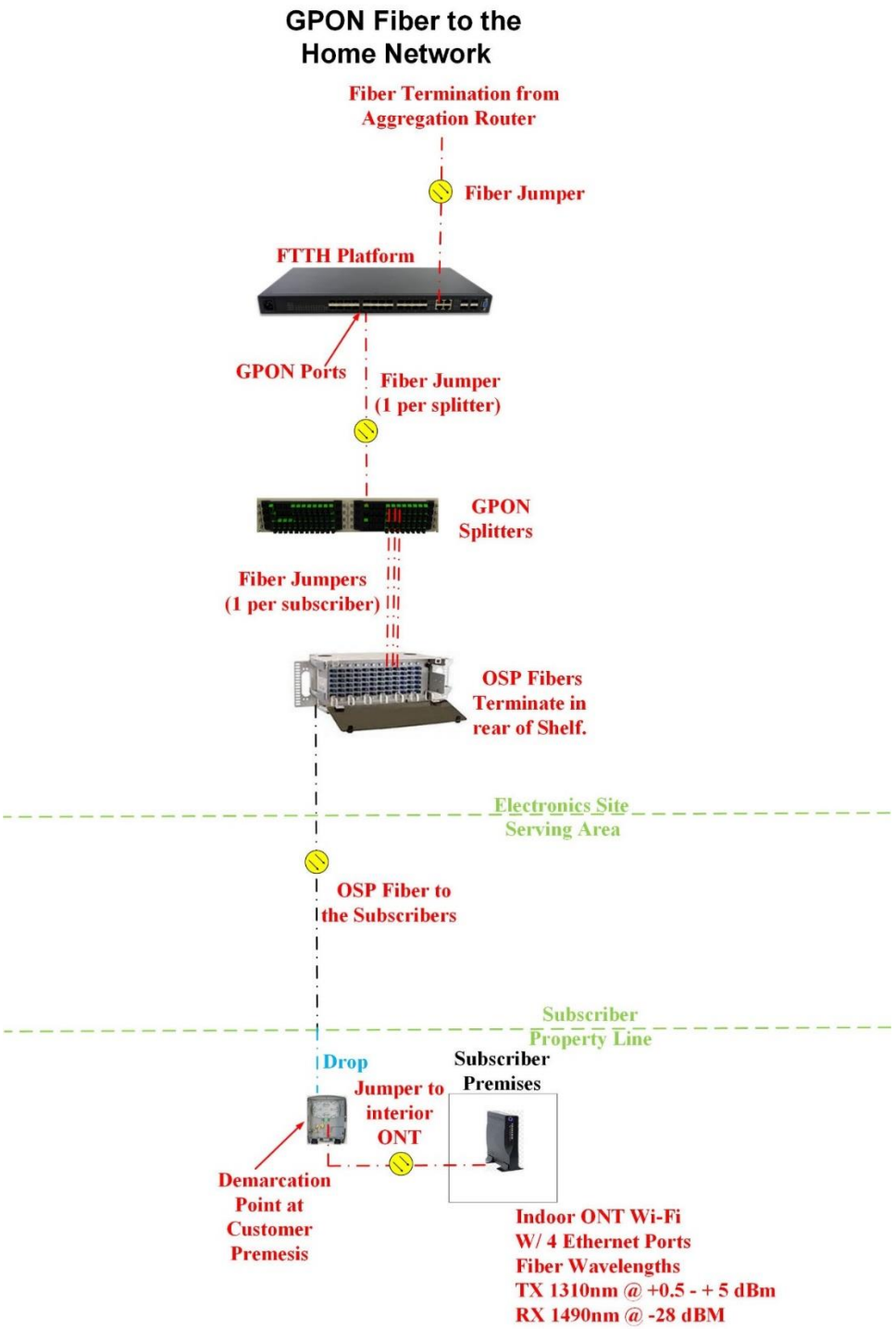
Our design provides the ability to serve 100% of Sierra County locations. The design is also scalable so that future customer or future electric meters could easily be incorporated into the network.

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 central office (C.O.) located in Truth or Consequences is the primary core location for the whole network. In Truth or Consequences will be two redundant and diversely routed fiber connections to the Internet. These connections could tie to the Verizon Technologies Point of Presence (POP) on the east side of Sierra County and to CenturyLink in the southern end of Sierra County.

While more desirable backbone internet connections would be ideal, due to the remote nature of Sierra County these are the best options to provide redundancy. With the addition of fiber assets to the East side of Sierra County and the location of Spaceport America in the vicinity it may be possible to attract additional investment in order to complete a ring connection to in the southeast part of Sierra County and make an additional backbone network connection. We have designed an additional 12 fiber connection to Spaceport America for this purpose.

Central Office & IP Core Network

As shown in the Basic Fiber Ring Diagram of this report, 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 Sierra County providers 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 Sierra County 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 Sierra County providers 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 Sierra County, 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 Sierra County 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 Sierra County 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. This companies also 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 Sierra County'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). If fewer customers are served from the same light source there is more potential bandwidth for each customer.

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.

- Windstream and CenturyLink serve Sierra County with copper telephone wires using DSL technology. There are many rural residents who live outside the range of DSL.
- TDS uses hybrid fiber/coaxial (HFC) technology to provide the triple play services in Truth or Consequences.
- There is a small amount of active Ethernet technology used to bring fiber directly to large businesses, schools, cell towers, etc.
- Fastwave uses Point-to-point microwave technology to connect to their core hub in Las Cruxes as well as connecting directly with Windstream in Truth or Consequences.
- There are several Wireless ISPs (WISPs) that are 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.
- There are likely at least a few households that still us dial-up to reach the Internet.

DSL over Copper Wires

Windstream and CenturyLink provide broadband using DSL (Digital Subscriber Line). DSL is used to provide a broadband path over the copper. Most of the geographic areas of Sierra County is served with telephone company copper wires. 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 and Windstream. At some point the copper networks will die even though regulators continue to act like they will keep working forever.

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 single telephone wire. Most of the DSL in Sierra County is of older varieties and delivers slower speeds.

The most important characteristic of DSL is that data speed delivered to customers decreases with the distance the signal travels. 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 Sierra County are more than 2-3 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 Sierra County are likely to be 50 or more years old and have outlived their original expected service life.

Windstream and 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.

Hybrid Fiber Coaxial Network

TDS purchased the existing small cable company that serves Truth or Consequences. 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.

TDS upgraded the technology used on the purchased system, and built fiber to cut down on the size of neighborhood nodes. TDS also likely replaced some of the coaxial cables during that upgrade. Parts of the wiring are still old, but overall, the upgrades resulted in a significant improvement in the network.

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.

Since the TDS network delivers around 100 Mbps of broadband it's likely that TDS has upgraded the network to DOCSIS 3.0. There might be a lot of additional cost to upgrade to the latest DOCSIS 3.1 that could involve changing the power taps in the cable network and even replacing a substantial amount of coaxial cable.

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. CableLabs has developed an upgrade being 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 not often built in rural areas this rarely 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 in Sierra County to deliver fiber today to cell towers, and possibly to a few other places like schools that require a significant amount of bandwidth. This technology is often also referred to as active Ethernet.

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 Metro Ethernet using a wireless technology instead of fiber. We know there are microwave links being used in Sierra County to bring in broadband connections from outside the County. 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, such as atop the many mountains found in Sierra County.

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.

Satellite broadband also comes with tiny data caps, meaning a customer is highly limited by the amount of data they can send or receive during a month.

Cellular Broadband.

There are rural homes in Sierra County using their cellphone data plans for home Internet access. There are a number of issues with this, First, 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.

AT&T and T-Mobile have started to offer what they call 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 probably not in Sierra County today. Currently, AT&T only offers this plan in places where they are the incumbent telephone company. T-Mobile has said they will offer this nationwide if they are allowed to merge with Sprint – so we'll have to see if this shows up in Sierra County over the next few years.

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. This is the technology being deployed by WISPs (wireless ISPs). 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 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 3 - 4 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 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 too expensive and since it has not yet been accepted widely in the industry it might never get long-term support by vendors.

However, 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. However, 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 - 5 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 late 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. The 5G specification calls for 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.

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. 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. 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 outside since there are no high bandwidth applications for cellphones.

Gigabit Cellular – Millimeter Wave Hot Spots

There are numerous articles on the web that talk about gigabit cellphone speeds. Ultrafast cell phone data speeds rely on 5G hotspots using millimeter wave spectrum, with each cell site fed by fiber. This technology does not provide what is typically considered as cellular coverage. This technology is being deployed today in small downtown corridors in major cities.

There are characteristics of millimeter wave spectrum that make this an unusual broadband product. It can be fast, and in ideal conditions a customer can receive a gigabit of cellular data speed. However, the conditions are rarely ideal. The spectrum only travels a few hundred feet from a transmitter – meaning that good coverage means having a cell sites perhaps every 600 feet. The spectrum is also only usable outdoors – these high frequencies don't penetrate anything. When a customer has a millimeter wave connection, just walking into a building reverts to a 4G connection. The millimeter wave spectrum also requires line-of-sight, meaning there must be an unobstructed path between the transmitter and the cell phone. The signal will be lost by walking around a corner of a building and can even be lost of a customer's body blocks the signal.

Millimeter Wave Point-to-Multipoint Broadband

Another new technology that got a lot of press in 2018 is 5G point-to-multipoint radios using millimeter wave spectrum. Verizon built this technology in a few neighborhoods in Sacramento and a few other cities in 2018. The technology consists of deploying small cell sites on telephone or power poles and then beams broadband to a small receiver attached to homes. To get fast speeds, this network requires building fiber to feed the small cell sites. Verizon achieved speeds in the trials of 300 Mbps – with a hope over time that they can get speeds up to a gigabit.

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 only other common use of this spectrum has been in the full-body scanners at airports. 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 is deploying this and it doesn't seem like a good fit for the topology in Sierra County.

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 cell site 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 have to 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 Truth or Consequences or throughout Sierra 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 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 SkyLink (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
SkyLink	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 SkyLink have the early lead. The company launched two test satellites in 2018 and launched 60 satellites in May of 2019. At the end of April 2020, the company had 440 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. 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 includes other investors like Virgin, Airbus, SoftBank, and Qualcomm. The company's plan is to launch an initial constellation of 650 satellites that will blanket the earth, with ultimate deployment of 1,910 satellites. They plan to deploy 30 of the 65-pound satellites with each launch. That means 22 successful rocket launches are needed just to deploy the first round. The company is doing a polar orbit instead of an equatorial orbit and plans to start its marketing effort in Alaska. As we were writing this report, OneWeb declared bankruptcy due to lack of working cash. The company is

looking for a buyer, but if one doesn't materialize the company may join a list of other failed satellite ventures.

Another interesting entrant into the market is Jeff Bezos and Amazon. They recently filed plans 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.

The most recent announcement made at Christmas 2019 is that Apple is considering launching satellites that will provide only data for cellphones. This could free apple phones from having to rely on a cellular carrier.

We still know nothing about proposed broadband speeds or prices. Elon Musk recently acknowledged that he is likely to limit his business to serve only rural areas where he can charge a premium price. 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 doubting if the companies 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 plans created are detailed and contemplate all aspects of operating a broadband business. The business plan assumptions represent our best estimate of the operating characteristics for such a business. As a firm, CCG consults to hundreds of communications entities that provide rural broadband. This has given us a lot of insight into how rural ISPs operate. We believe that the financial results shown in these models are characteristic of similar operations elsewhere and we believe our assumptions are realistic.

The primary goal of the business models is to look at the various scenarios from the perspective of an ISP that would operate the business. The purpose of these models is to provide a way for ISPs to understand the broadband opportunities in Sierra County. We've learned with experience that almost every ISP is theoretically interested in expanding. However, no ISP is really interested until they understand the numbers. Only then can they decide if the opportunity is something they can get financed and that meets their requirements as an investment opportunity. These studies help the ISPs understand the opportunity of expanding broadband into the rural parts of the counties.

A. Operating Models

CCG considered the following business plan scenarios. Every scenario used fiber-to-the-premise technology, described earlier in the report.

Retail Model – Single Provider as the ISP

This scenario considered the network being built and operated by a single entity. The results would be similar if the operator was the County government or a single ISP. The goal of this scenario is to understand if there are reasonably achieved scenarios that result in a sustainable business plan – defined as permanently cash self-sufficient.

CCG has learned from experience that if a market can't be profitable with one provider, then other options like partnerships and open access also can't be successful. By definition, those scenarios divvy up profits among multiple entities. If there's not enough profit for one provider, there's not enough to support multiple parties.

Open Access

This scenario would open up the market to multiple ISPs, which would then provide retail products to customers. Under this scenario, the Sierra County government would build and operate the fiber network and the ISPs would sell to and provide services to customers. A county's only source of revenue is fees collected from the ISPs for providing access to the fiber network.

Public-Private Partnership

In this scenario Sierra County would partner with a single commercial ISP to operate the business. There are almost endless variations on this concept and the studies examined a few of the most common relationships:

- At one extreme, the County builds the whole network but hires an ISP to operate the network.
- The County builds the fiber network and fiber drops and the ISP partner provides customer electronics and everything inside the home.
- The County builds only the fiber and the ISP supplies everything from the street to connect to the customer.
- At the other extreme, the County owns none of the network. Instead Sierra County would take steps to help an ISP succeed. That might mean being an anchor tenant and giving all your business to the ISP on a long-term contract. It might mean contributing land, building space or other hard assets. It might mean relaxing construction requirements such as permitting, locating, and inspections to lower the cost of building the network.

There are also numerous models of how two partners share revenue, risks, and profits.

Pros and Cons of the Operating Models

The following discussion examines the pros and cons of each of the various operating models described above. There are significant differences between a retail ISP, an open access arrangement and a public-private partnership.

Retail ISP

A retail ISP is a single entity that operates a retail broadband network. A retail ISP normally owns the network, hires the staff, operates the business, and benefits from any profits.

Advantages

Profits. A single owner/operator can make all the profit from a fiber business.

Flexibility. A single owner/operator can make instant decisions to change products or prices or to respond to competition that seem needed.

Disadvantages

Risk. The flip side of the ability to make all the profits is that a single owner/operator also takes all the risk. If the business doesn't succeed the ISP can lose their investment.

Financing. The primary impediment to building and operating a fiber ISP is the cost of building the fiber network. Cities often wonder why commercial ISPs don't build fiber network if the business plan to do so looks profitable. The fact is that there are not many entities capable of borrowing the money needed to finance multiple fiber networks. Most small ISPs are limited by

the amount of equity they can bring to a new market and by the collateral they can pledge to a borrower.

Open-Access Model

Open access refers to the business model where a municipal entity builds a network and then sells access to multiple ISPs. The government's only revenues come from selling access to the various ISPs. ISPs have the relationship with customers – ISPs sell, provide services, bill, and provide customer service.

The open-access model thrives in Europe but has had a more difficult time succeeding in the US. Europe has seen success with open-access networks because a significant number of the large ISPs there are willing to operate on a network operated by somebody else. This came about due to the formation of the European Union. Before the European Union, each country on the continent had at least one monopoly telephone company and a monopoly cable TV company. The formation of the European Union resulted in a change in law that opened existing state-run monopolies to competition. All the state-owned telecoms and ISPs found themselves in competition with each other and most of these businesses quickly adapted to the competitive environment. This contrasts drastically with the US market where there is no example of any large cable company competing with another and only limited competition between large telephone companies.

When a few cities in Europe considered the open-access operating model they found more than a dozen major ISPs willing to consider the model (large companies that would be equivalent of getting Comcast, AT&T, or CenturyLink agreeing to use the new fiber network). There are now open-access networks in places like Amsterdam and Paris as well as in hundreds of smaller towns and cities. The biggest networks have over a hundred ISPs competing for customers—many of the ISPs with niche businesses going after a very specific tiny slice of the market. Due to that level of competition, the European fiber networks get practically every customer in their market since even the incumbent providers generally jump to the new fiber network.

That hasn't happened in the US. There is not one example in this country of a large telco or cable company agreeing to operate on somebody else's network to serve residential customers. The large ISPs in the US will lease fiber outside of their footprint to serve large business customers, but they have never competed for smaller businesses or residents in each other's monopoly footprints.

This means that open-access networks in the US must rely on small ISPs. These small ISPs are generally local and mostly undercapitalized. The small ISPs have all the problems inherent with small businesses. They often don't have the money or expertise to market well. They often have cash flow issues that put restraints on their growth. In addition, many of them don't last beyond the career of their founder, which is typical of small businesses in general.

Open access network operators have struggled in this country due to the nature of the small ISPs on their network. Consider the example in Chelan County, Washington that today has only one primary local ISP that is selling to residential customers. The network originally had almost a dozen ISPs, but over the years the ISPs either folded or were purchased by the remaining ISP. It's hard to even call the Chelan County network open access any longer.

A similar thing happened in Provo, Utah before the city sold the network to Google Fiber. The network had originally attracted eight ISPs, but over time they ended up with only two. It's hard to make an argument that a network with so few choices is actually open access—because the whole purpose behind open access is to provide customer choice.

Examples of Open-Access Networks. Following is a list of some of the other municipal open-access networks in the country.

- The Public Utility Districts (PUDs) in Washington State. These are countywide municipal electric companies. The PUDs are restricted to offering open access due to legislation passed several years ago. There are numerous different open-access models being tried at various PUDs, with the largest networks in Chelan County PUD, Grant County PUD, Douglas County PUD, and Pend-Oreille PUD.
- Utah has a similar law that applies to municipalities. This led to the creation of an open-access fiber business in Provo and another network called Utopia that serves several small towns. The Provo network was losing a lot of money and the city decided to sell the network to Google Fiber for $1. Utopia is still operating a wholesale business but had significant financial problems since inception.
- A similar law was passed in Virginia after Bristol Virginia Utilities (BVU) built a retail fiber network. The legislation grandfathers BVU as a retail provider but only allows other cities to operate open-access networks. So far, the wholesale model has been adopted by a few cities, the largest being Roanoke, which offers open access on a limited basis to only parts of the city.
- Tacoma, Washington chose an open access model where the city is the retail provider of cable TV, but connections to the network for telephone and broadband are sold wholesale to ISPs.
- Ashland, Oregon operates an open-access network, but the city also operates as a retail ISP on the network and competes against a few local ISPs that sell on the network.
- There are a number of municipal networks that have built fiber rings, and which are promoting "open access" to carriers. For the most part these networks only service business customers.
- Other communities have tried to build open-access networks but then were unable to find any ISP partners. For example, Longmont, Colorado tried to launch an open-access network, but when they were unable to find ISP partners, they now offer full retail services directly to residents.

Advantages

Customer Choice. The most appealing aspect of an open-access network for a community is that it offers a variety of choices to customers over the same fiber network. The further hope on an open access network is that having greater competition will lead to lower prices and better customer service.

Disadvantages

Retail/Wholesale Revenue Gap. There is a big difference in the revenue stream between collecting the retail revenue stream from customers versus collecting only the fees charged to ISPs. For example, the average retail revenues on a fiber network serving residential customers might be over $120 per customer per month. The average revenues on an open access network are far smaller, at perhaps $30 per customer per month.

There are some cost savings for the network owner in an open access environment. They don't have to provide the triple play products. They don't have to see or bill customers, or provide customer service. But it's still extremely difficult for the network owner to be profitable with open access. The network owner still must cover the full cost of debt. The network owner still has to maintain the fiber network and provide the core electronics. In most scenarios the network owner must continue to install fiber drops and/or customer electronics.

Not Many Quality ISPs. Every open-access network that has been tried in the US has had trouble finding and retaining ISPs on the network. Some examples are discussed above. The ISPs willing to operating in this environment are generally small and undercapitalized. Open access then forces these ISPs to compete against other small competitors, which holds down end-user rates, but which then also puts pressure on ISP earnings. Two of the largest open-access networks in Chelan County, WA and Provo, UT essentially lost most of the ISPs on their network over a decade of operations.

Leads to Cherry Picking. The open-access model, by definition, leads to cherry picking. If ISPs are charged to use the network, then these fees will generally lead them to not want to sell to low-margin customers. All the open access networks listed above report this as an issue. The only way to get broadband to everybody in an open access network is for the network owner to lower their fees – and that makes it impossible to pay for the network. CCG has never seen an open access network that has a customer penetration rate as high as would be expected if the same community had a municipal retail provider. Cherry picking means fewer customers on the network.

No Control over Sales Performance. The network owner in an open-access network has no control over the customer sales process. That means they only do as well as the ISPs on the network. In CCG's experience, having talked to many of the ISPs that operate on open access network, the ISPs tend to not have the resources for major marketing efforts or else they only want to serve a niche market and don't try to mass market. A retail ISP that owned the same network would try to sell to everybody – but that never happens on an open access network.

Stranded Investments. One interesting phenomenon that especially affects open-access networks is stranded investments at customer premises. When a customer moves or stops service with a network operated by one entity there is usually a big push to reestablish service at that location. However, in an open-access network many ISPs don't make this same effort. Therefore, over time there grows to be an inventory of homes and businesses with a fiber drop and ONT that are no longer used and are not contribution to the cost of the business. CCG knows of one of the larger open-access networks with 25,000 active customers that has 5,000 locations where the fiber has been abandoned with no current service.

Public-Private Partnership (PPPs)

PPPs initially arose internationally as a way to finance infrastructure needs that local, regional, or national governments could no longer pay for up front or could only insufficiently finance from taxes, bonds, or other methods of raising government monies. Taken as a whole, governments in the US are today unable to fund all the needed infrastructure and so more and more PPPs are being formed to finance infrastructure. There have been estimates that collectively there are several trillion dollars more of needed infrastructure

projects in the country than could be financed by the combined borrowing power of all the state and local governments added together.

There are three major ways that a fiber PPP can be structured depending upon who pays for the network. A fiber network could be mostly funded by the government, mostly funded by a commercial entity, or funded jointly by both.

PPP Funded Mostly by a Government. There are not many examples of this in the US. This scenario means that a government takes all of the financial risk of building a network and then hands the operations to somebody else. This is the arrangement that is in place in the Google Fiber partnership with Huntsville, Alabama. Reports are that Google Fiber is responsible for the costs inside the customer premise and the city for the rest. There are similar partnerships between Ting and Charlottesville, VA and Westminster, MD. CenturyLink has reached a similar arrangement with Springfield, MO.

PPP Funded Mostly by the Commercial Provider. There are many examples where a commercial provider built a fiber network and doesn't consider the venture to be a PPP. Generally, any ISP that uses the normal avenue of obtaining rights-of-way and then adheres to the franchise and permitting processes in a city are free to build fiber.

It's also not a PPP if a government gives concessions to attract an ISP. The first few markets for Google Fiber are reported to have this arrangement. It's widely believed that Kansas City granted major concessions to Google Fiber to get them to build fiber there. This may have been things like free rights-of-way, expedited permitting, use of city land for placing facilities, etc.

For this kind of arrangement to be a traditional PPP, a municipal entity would have to get something in return for the concessions they make to an ISP. This could be almost anything that is perceived to be of value. It might be free or reduced telecom prices provided to government buildings or fibers connecting government locations together. It could also be the ISP agreeing to help the city meet some social goal, such as building out to poorer parts of the city that a normal commercial ISP might otherwise would not have considered.

PPP Funded Jointly. When a municipality and an ISP both contribute cash or hard assets to a venture then it's clearly a PPP. There are several examples of telecom PPPs working in the country today. Such partnerships are structured in many ways and following are a few examples.

- Zayo partnered with Anoka County, MN. This is a suburban county just north of the Twin Cities. Each party contributed money to build a fiber network together. The county received access to a 10-gigabit network connecting all its facilities and Zayo received connections to all of the major business districts. Zayo owns the network, but each party has affordable access to the whole network as needed. Each party is also allowed to build outward from any point on the jointly built network at their own cost.
- Nashville, TN partnered with a commercial fiber provider to build fiber to city locations as well as to commercial districts. Both parties made capital contributions. The city eventually sold its interest in the network but still retains fiber to most city buildings.
- There are dozens of small cities where the city built an initial fiber network to connect to schools, water systems, etc. and now allows commercial providers to build spurs from the

city-owned ring. The financial arrangements for this vary widely. Sometimes the two parties just swap access to various locations on each other's network and in other cases they each pay to lease access on the other's network. However, both parties share the same network, portions of which each has funded.

- In Sibley and Renville Counties, MN, the counties, cities, and townships together contributed an economic development bond which is being used to fund 25% of the cost of a fiber-to-the-premise network.
- Several of the Public Utility Districts (PUDs) in Washington have built fiber into business and residential neighborhoods but then allow ISPs to build fiber loops and electronics and connect to the core network.
- There are hundreds of examples of government entities that have built fiber routes jointly with some commercial enterprise. This is referred to in the industry as fiber sharing and generally each contributor to the fiber route will get some specific number of pairs of fiber for their contribution. For example, this is a common practice with school system fiber networks.

There are several kinds of contributions that a government can make to somebody else's fiber network. This could include cash, real estate, excused fees, or sweat equity. Governments can allow a commercial provider to use parcels of lands or give them an existing building. Excused fees might mean not charging for something that would normally be due such as permitting fees or property taxes. The government could excuse payments for poles, conduit, existing fiber, or towers. It could mean the commercial provider might not need to pay taxes or fees for some period, as is often done in many economic development projects. Sweat equity is assigning a value to the time contributed by the city. For example, we've seen a city assign extra employees for free for tasks like the permitting process during a major fiber construction project.

There are almost unlimited ways to model and form a public-private partnership. The underlying requirement is that the business must be profitable for the private commercial partner. Commercial providers expect a healthy rate of return on any investment they make in the business. Most commercial companies won't invest in a business that doesn't return at least a 20% to 30% return on their investment.

Advantages

Smaller Government Investments. The extent to which the private partner funds the network reduces the needed investment from the public partner. A private equity partner can bring cash to the business that might be hard to raise elsewhere.

Disadvantages

Matching Goals and Expectations. One of the primary reasons why there are not a lot of telecom public-private partnerships is that it's often difficult to reconcile the differing goals of the two sides. The commercial partner is generally going to be very focused on the bottom line and returns while the community part of the business often has goals like community betterment and lower rates. One of the biggest sticking points in creating PPPs is that cities want fiber built past every home, which ISPs prefer to build to only selected neighborhoods. It's often very difficult to put together a structure that can satisfy all of the different goals.

Expensive Money. Since commercial partners generally want to make at least a 20% return on equity investments this can be expensive funding.

Tax Free Funding Issues. It's difficult to obtain tax-free bond funding to support a PPP. Tax free financing can't be used for a project that benefits a commercial entity.

Process Driven by Commercial Partner. Communities seeking equity partners for a public-private partnership fiber optics project will have fewer choices for the structure of the business since the external partner will probably demand a for-profit business structure as a likely pre-condition for investment.

Length of Partnership. Many commercial investors only make investments with a mind to eventually sell the business to realize the cash value. This may be difficult to reconcile with the long-term desires and goals of a community-based fiber optics project.

Governance Issues. It's a challenge to develop a governance structure that can accommodate the government decision-making process. Governments generally must go through a defined deliberative process including holding open meetings to make any significant decisions. This does not match well with the decision-making process and timeline for a commercial partner. A commercial partner might want to decide in days when the process can't be any faster than weeks.

B. Services Considered

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 (in excess of 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.

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 TDS or Windstream.
- 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 Sierra 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.

Products

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.

There are only minor wholesale revenues included in the studies. There is a chance over time for greater revenues than we have projected.

C. Financial Assumptions

Incremental Analysis

It's important to note that 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 any 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.

All scenarios anticipate that the first customers will be added to any new networks in October of the first year after starting the project. It could be possible for an existing ISP with customers in the region to start customers a little earlier.

Following are the major milestones as predicted by these forecasts:

- Financing. All the forecasts assume that the financing is available in January 2021. This is illustrative only and could be changed to any other future date.
- Construction. Fiber construction is assumed to last for two years in both the rural-only or the towns-only scenarios. Construction of the whole county is estimated to last for three years.

Pricing Strategy

We assumed that the products would be as simple as possible. The incumbent telephone companies offer a wide range of different telephone products. We assumed that an ISP would offer only a few telephone options. For example, for residential service we have assumed only two products - a basic telephone line and a telephone line with unlimited long distance. Broadband is also simplified with only three tiers of speeds for residential or business customers. Businesses could buy customer speed packages as negotiated.

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. This asks the important question of what people are willing to pay for broadband. As somebody who works for a lot of ISPs, I observe that a lot of ISPs are not good at this. 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 of 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 the price for the basic product low. 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.

  CCG Consulting has access to the prices and the resulting customer counts from nearly 200 ISPs and what we have learned is that most customers will buy the basic broadband product if the speed is okay. A basic product set at 5 Mbps likely wouldn't sell, but in today's market a product with a decent speed like 50 Mbps or greater will be perceived as acceptable to most households.

  As mentioned above, it's debatable if an ISP with low rates captures more of a market – 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 Sierra County. 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:
  - Windstream pricing begins at $57.99, but that only delivers a 6/1 Mbps product. Windstream then charges $67.99 for "up to" 25 Mbps and $77.99 for 50 Mbps. It's unlikely that anybody except a few businesses close to the Windstream core switch in Truth or Consequences could get 50 Mbps speeds.
  - 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. From what we see around Sierra County, nobody is seeing speeds even as fast as 12 Mbps on CenturyLink.
  - The list price for TDS residential 100 Mbps service is $62. Prices step up to $82 for 300 Mbps service and $102 for 600 Mbps service. We don't think there are many customers in the towns that can receive 300 Mbps speeds.
  - Wi-Power starts at $50 for 5 Mbps broadband. They charge $80 for 10 Mbps and $100 for 15 Mbps broadband.
  - Fastwave pricing starts at $50 for 3 Mbps, and steps up to $65 for 6 Mbps, $80 for 9 Mbps, and $95 for 12 Mbps.

  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 buying a 5 Mbps service for $50 is usually willing to pay a little more for service that is twenty times faster.

In the models for this study we used $60 as the starting price for broadband. That's slightly below TDS and significantly better than the other ISPs. Even where the existing ISPs charge less, they deliver extremely slow speeds – which we know are not wanted in the county. Recall that the survey said that 89% of people want faster speeds.

- 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 a $60 broadband product:

	Rate 1	Penetration	Rate 2	Penetration	Rate 3	Penetration
100 Mbps	$ 60.00	95%	$60.00	80%	$60.00	60%
250 Mbps	$ 90.00	4%	$75.00	15%	$70.00	30%
Gigabit	$120.00	1%	$90.00	5%	$80.00	10%
For 1,000 Customers:						
Revenue	$61,800		$64,000		$65,000	
Increase			4%		5%	

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 is psychological. Consider in the examples above that more customers are likely to buy the gigabit product in Rate 3 for $70 than will buy the 200 Mbps product in Rate 1 for $80. Since both speeds are faster than what households likely need you might think there would be a small difference between the public reaction to the prices – but our experience is that the penetration rates of different products act much like the above tables.

We have seen that having too many price tiers confuse customers. The above examples have tiers with three prices. 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.

- 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 incumbents 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 ISPs. 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.

- Rate Bundles. The large cable companies are well-known for having bundles of products where they provide a discount to customers buying more than one product. Generally, customers have no idea which products the discount applies to. I would estimate that no more than 15% of the small ISPs that CCG works with provides a similar bundling discount. Most smaller ISPs set prices at rates they perceive to be competitive and don't discount them further. We know a few ISPs that built a business plan and forecasts upon list prices and then found themselves in financial stress when a marketing person at the company decided they could sell more by offering discounts that weren't in the business plan.

  Interestingly, Verizon recently announced that they are doing away with bundled rates for new customers. It will take a few years for customers with older plans to migrate to unbundled rates. Verizon describes the new rates structure as more open and honest and say that this is what customers want.

- Introductory Rates. The big telcos and cable companies are also well-known for advertising low introductory rates that increase dramatically after a term contract of one to three years. Most of the rates you'll see from these companies on the web or in advertising are the introductory rates, and the real rates of these companies are generally buried in the small print, if shown anywhere.

  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 two 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. A few medium-sized cable companies have made this same change.

Most small ISPs have decided to not offer introductory rates. Such rates require having customers signing contracts and then ties up staff when those contracts end, and customers want to negotiate low rates again.

- 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.

Rates Used in This Study

Telephone Rates

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

Basic Local Line	$25.00
Line with Unlimited Long Distance	$35.00

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.

It's worth noting that customers buying landlines from Windstream can call other Windstream customers inside Sierra County for free but calls to CenturyLink or outside of the county are still long-distance calls. CenturyLink customers can call to Hatch, NM for free but everything else, including calls to Truth or Consequences are long-distance calls.

These calling scopes matter to rural customers who don't have good cellular coverage at home. Such households still must pay long distance on landline phones to place calls outside of their local free calling scope as well as calls to the rest of the country. Homes with good cellular coverage can avoid long distance fees using cellphone calling.

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 are less specific with business phone rates. The models have assumed an average monthly telephone revenue of $50 per business. There are a few larger businesses that would pay more than this, so the financial projections are conservative. It's worth noting that home businesses, including farms usually buy residential products for both broadband and telephone service.

Cable TV Products

Offering competitive cable TV in a new rural market is a challenge. The study areas being considered by this study are all areas that are not wired today by a cable company. That means anybody with cable in the study area is buying from a satellite provider.

We decided to not include cable TV in the feasibility study. First, none of the ISPs in your region offer cable TV today. Even should you find an operator willing to offer cable TV, there is little margin on the product, so adding cable TV would make little difference to the financial analysis. Finally, it's nearly impossible for a small ISP to compete on price with the satellite TV providers and small ISPs that offer TV generally have significantly higher prices. That makes it hard to attract customers to the product even if it's delivered on fiber.

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	80%
Tier 2	$ 75.00	17%
Tier 3	$ 90.00	3%
Business Fiber Broadband		
Tier 1	$ 75.00	75%
Tier 2	$ 90.00	15%
Tier 3	$105.00	10%

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

These would all be shared data products, meaning that the overall bandwidth to provide them is shared among multiple customers. This is not to say that the data path to a given customer is not secure, because the transmission to any specific customer is encrypted for privacy purposes. Still, there might be some business customers that will want a dedicated data product that is not shared with anyone else. The fiber network can accommodate this by providing such customers with 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. The only provider in the county today with a data cap is CenturyLink DSL, but it's been widely reported that the company often doesn't bill for data overages.

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 carrier-class WiFi routers in the home that are placed and operated by the ISP. High quality routers, and the placement of multiple routers for larger homes usually means better broadband coverage throughout a home. ISPs often assist customers when adding a new device to the wireless network. The managed WiFi routers provide a secondary benefit to an ISP because they provide a network monitoring location inside the home, meaning that the ISP is more easily able to pinpoint problems.

The studies assume a monthly rate for managed WiFi of $7.00 for residences and $10.00 for businesses. It's further assumed that 70% of residents would buy this product and 80% of businesses.

Large Broadband Products

There are potentially customers in Sierra County 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, electric utility locations, or large businesses.

Cell towers are an interesting challenge. In some parts of the country we have clients with rural fiber networks that get almost every cellular tower as a customer. But we have other similarly situated clients that get none of this business. 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.

The new opportunity for cell towers will be for small cell sites. These are smaller cellular transmitters that are placed on utility poles or light poles and that bring improved cellular service into neighborhoods. We are already seeing small cell site popping up in towns the size of Truth or Consequences, and over time this should be a growing market opportunity.

There is a unique new opportunity for somebody building rural fiber in that it will often make it easy for a cellular provider to put up a new tower in areas that have poor broadband. As we worked on this study the FCC announced a new initiative to provide $9 billion in grants to cellular companies to expand cellular coverage to the many places in the country that don't have it today. 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.

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 of the three primary scenarios. These represent the capital expended during the first 5 years, by which time most of the customers have been connected. The scenarios assumed different customer penetration rates. The rural scenario uses a 70% customer penetration rate. We assumed a 50% penetration rate for Truth or Consequences and Elephant Butte. The Total County scenario is a combination of those two different scenarios.

	Rural	Two Cities	Total County
Fiber & Drops	$23,373,224	$14,825,297	$38,180,705
Electronics	$ 1,814,770	$ 3,076,426	$ 4,811,601
Huts/Land	$ 0	$ 139,500	$ 139,500
Operational Assets	$ 383,185	$ 393,968	$ 731,677
Total	$25,571,179	$18,435,191	$43,863,482
Cost per Passing	$ 9,278	$2,974	$4,807
Cost per Customer	$12,498	$5,937	$8,514

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. Burying fiber is a lot more expensive. The lower cost is also because there isn't as massive of a road grid in Sierra County compared to many other counties around the country – fewer road miles equates to lower fiber cost.
- The scenario for serving Truth or Consequences and Elephant Butte works without the need for a grant since the cost per passing is a reasonable $2,974.

Customer Costs

Residential Fiber Electronics Costs: The model assumes that the hardware electronics for an ONT cost $433, including the cost of the labor for installation at the home, including inside wiring. In the projections it was assumed that the installation would be done by external contractors. It might be less expensive to do installations using existing company personnel or local contractors who can install at a lower cost.

We've also assumed that most businesses use the same ONT electronics used to connect to homes. Only larger business would require a larger ONT with more data ports.

We've assumed that the service provider will supply a WiFi router for customers that want one. We've assumed these routers cost $115.

Fiber Drops: Fiber drops are the fiber that connects from the street to the customer premises. In this study the cost of fiber drops is significant. The assumption has been made that with the volume of drops needed plus the anticipated speed of network deployment the drops during the first four years of the project would be installed by external contractors.

Drop costs vary according to the length of the drop. The fiber drops in the two primary towns are shorter than rural drops and thus less costly to connect. The cost for fiber drops in the towns are estimated to be $682 for residents and $768 for businesses. The rural drops are assumed to cost $1,048 for residents and $1,133 for businesses.

The prices included in the study represent recent pricing being paid in for projects in your region. The drops are the one portion of the fiber network where an ISP might be able to save significant cost compared to our study. For example, an ISP might be able to assemble their own construction team to build drops for less. They might find a local contractor that will build the drops for less.

Customer Penetration Rates

One of the most important variables in the study is the customer penetration rate, or the percentage of the homes and businesses in Sierra County that will buy broadband service.

The analysis looks at customer penetration rates in several different ways. The base scenario begins with what we call expected rates. We used an expected penetration rate for the rural areas of 70% and used 50% as the starting point for the two cities scenario. CCG has witnessed the roll-out of broadband in several rural markets in the last few years and we have seen customer penetration rates in those markets

range between 65% and 85%, with a few even higher. We arbitrarily chose 70% as a starting point for rural area as a level that we think is reasonably conservative. Everything we've looked at tells us that broadband quality is worse in Sierra County than in many other places. The rural DSL from Windstream and CenturyLink is slow and unreliable. Customers tell us that major outages are routine and last from several days to a week. Even the WISPs offer slow speeds. We don't think there are a lot of rural residents seeing speeds much faster than 10 Mbps – there are some, but there are a lot more households with speeds much lower than that.

It's a lot harder to predict penetration rates in towns like Truth or Consequences, so we chose 50% as an average penetration rate we see for similar county-seat markets. The success in competing in county-seats vary a lot according to the quality of the network and the strength of the ISP. The TDS network in Truth or Consequences and Elephant Butte is not as fast as many the networks found in other places in the country that have upgraded to DOCSIS 3.1. While most customers in the town can get speeds in the range of 100 Mbps download, the network can't produce speeds up to 1 gigabit like are available in many other places. The DSL in the two cities is older technology and not nearly as fast as the TDS network.

The best way to understand the potential broadband penetration rates would be to do a statistically valid residential survey or a canvass to quantify the potential customer interest in buying broadband from a new network. In this study we offered an online canvass, but we didn't get enough results to have faith in the results. With that said, the surveys we got were universally in favor of somebody bringing faster broadband and download speeds were the most-requested improvement for broadband. In a county with over 8,000 homes you'd want to get 2,000 or more online surveys to begin having faith in the results.

The alternative is a statistically valid survey. We have found that surveys are a great tool for understanding customer interest and are a good way to predict future customers. Surveys are not perfect, but the results obtained from a survey done properly generally provide a good prediction of customer demand. We think that it's likely that any ISP interested in coming to Sierra County will want to better understand broadband demand, so the County might get a request for conducting a survey (unless the ISP conducts their own). We've listed this possibility under the next steps to take after receiving this report. It's always important for a survey to be current. For example, if we would have done a survey for this study before the COVID-19 crisis the results would likely be invalid – we are sure that almost every market that the percentage of homes wanting good broadband has increased after people were asked to work from home and do schoolwork from home.

Since there are so many residents of Sierra County today without good broadband there are a lot of potential customers for an ISP that builds broadband. The new customers assumed by the end of the fifth year as are follows for the three primary scenarios:

	Rural	Two Cities	Total County
Residential Customers	1,928	2,737	4,665
Business Customers	118	368	486
Total	2,046	3,105	5,151

D. Expense Assumptions

As a reminder, unless otherwise noted, all scenarios are created from the perspective of a small ISP offering the services. There is one scenario that compares small ISPs to a municipal ISP. The assumptions listed below are for the small ISP scenarios.

The following assumptions also assume that the same ISP owns the network and operates the business.

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. It's often less costly for an existing service provider to add a new market than what is shown in these projections.

As mentioned earlier, expenses are estimated on an incremental basis, meaning that the models only consider new expenses that would be needed to open the new market for an existing ISP. In an incremental analysis it's assumed, for example, that the existing ISP is already paying for positions like a general manager, an accountant, etc. and that the ISP only needs to hire employees needed to open a new market and add additional 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 an ISP will need to hire additional staff to take care of the new customers. We have assumed salaries at market rates with an annual 2.5% inflation increase for all positions. We've assumed that the benefit loading is 40% of the basic annual salary. That would cover payroll taxes and other taxes like workers' compensation, as well as employee benefits.

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 two additional types of employees:

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	2 new CSRs
Two Towns	3 new CSRs
Total County	5 new CSR

Install/Repair Technician: These technicians provide maintenance and repair calls. The technicians would maintain both network electronics and facilities as well as customers. We've assumed the business will require the following new positions:

Rural	2 new technicians
Two Towns	2 new technicians
Whole County	5 new technicians

The scenarios all assume that other positions are already staffed by an ISP. That might include such functions as a general manager, marketing staff, accountants, etc. The whole-county opportunity is large enough that some ISPs might hire an additional marketing person and perhaps a regional supervisor for this opportunity.

We assumed that construction contractors will build the fiber network. We've also assumed that customer installations will be outsourced during the construction process and for the first few years thereafter. However, once the bulk of customers has been added the forecasts assume that future installations will be done by company technicians.

Start-Up Costs: To be conservative, there are some 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 we have included them as start-up costs. There are start-up costs even for an existing ISP when entering a new market. In all three scenarios we've assumed the start-up costs are $150,000.

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. There have been rural start-ups that have been able to sign up customers using community volunteers, so it's possible that the marketing costs could be lower than assumed in the models.

The marketing budget for the first 5 years of operations for the three scenarios are as follows:

Rural	$297,000
Two Towns	$357.000
Whole County	$522,500

Delivery of Products: The projections assume that the new business will not construct a headend to provide the services. It's likely that any ISP tackling Sierra County is already buying and providing triple play products to customers.

The studies assume that a wholesale basic telephone line can be purchased wholesale at $5.00 per month. A line with unlimited long distance is assumed to be $9.00. It's possible to buy telephone lines for less than these estimates.

The studies assume there is no cable TV product.

Maintenance Expenses: There are a number of routine maintenance expenses that the new business would incur on an incremental basis. These include:

- Vehicle expenses to maintain the vehicles required for the field technicians.
- Computer expenses to support the computers used by employees.
- Tools and equipment expenses.
- Power expenses to provide power to the network.
- General maintenance and repair of the outside plant network and the electronics to repair damaged or nonfunctional electronics.
- Internet Backbone. Since this is an incremental analysis, we have shown only incremental increases in the cost of internet bandwidth. If this business were served by a new ISP then the cost of bandwidth would be higher to also cover the cost of transport to reach the Internet.
- 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. The models assume a monthly cost of $4 per customer. That is a conservatively high number and anticipates buying a whole suite of outsourced services. This could be done for less and some of these functions can also be done by ISP employees.

Software Maintenance: Triple-play providers 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.

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 that the business that operates the business will pay state and federal income taxes. These taxes would not apply if this were operated as a municipal business or as a nonprofit.

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.

Overhead Expenses: The forecasts include various overhead expenses. Again, since this is an incremental model it does not include allocated expenses such as an allocation of the general manager's salary. But there are incremental costs attributable directly to the new business. This would include things like legal expenses, accounting audit expenses, consulting expenses, business insurance, and other similar expenses that are 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.

E. 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 look at the amount of cash generated over the life of the plan as well as at the years when each plan achieves positive net income and debt breakeven. Those two new terms are defined as follows:

Positive Net Income: The year when the business shows a positive profit defined in the normal accounting sense. This uses the taxation and public accounting definition of profitability and includes depreciation and amortization, which are not cash expenses. The net income also does not consider repayment of debt principle and annual operating capital. Reaching positive net income is an important milestone for a new business and is one of the ways that the public will judge your success. Just note, though, that the business can have a positive net income and still not have enough cash to operate the business. But it's even more common for an asset-intensive business like this one for a business to reach positive cash flow but still have a negative net income—due almost entirely to depreciation expense on the network, which is a non-cash expense.

Debt Breakeven: The year when the business has generated enough excess cash that would enable the retirement of the remaining debt. Many loan and bond covenants don't allow excess cash from a business to be used for anything else, like dividends, until the debt has been retired.

The way to measure profitability in a new business is going to differ according to the structure of the business. A municipal business, for example, generally measures success by the ability of the business to generate enough cash to operate without any external subsidy. While for-profit business would generally use something like net income to measure profits.

It is important that a business always has cash in the bank to meet its obligations. In this particular business plan the ideal situation would be to always have at least $300,000 in the bank to have a cushion against nonlinear monthly expenditures. Not all expenditures are spent evenly throughout the year and a business

must maintain a cash cushion to allow for those times of the year when the expenses are higher than normal or when the revenues are lower than normal.

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:

- If the network is constructed by "edging out" from an existing ISP there could be some savings for ISPs in the cost of building fiber.
- In the model, we show an increase in the cost of wholesale bandwidth over time. However, industry costs for raw data might be less than we are projecting and might even drop over time.
- 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.
- There are steps that the new business could take to improve upon these 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.
    - More Concentrated Build Schedule. It's always possible to build faster than shown in these forecasts if the ISP can execute on a faster construction schedule. The amount of network that can be built in a given time period increases by adding more construction crews.
    - Get Temporary Help. There are often other bottlenecks at small companies that can slow down customer installations. This could mean the need for more sales and marketing staff, additional customer service reps, or inside technicians needed to provision new customers. Service providers should strongly consider using temporary employees during the roll-out of a major new market.

Rural County

This scenario looks at the feasibility of bringing fiber to all rural parts of Sierra County outside of Truth or Consequences and Elephant Butte.

Base Study	No Grant	Breakeven Grant	Grant & Bond Financing
Asset Costs	$25.57 M	$25.57 M	$25.57 M
Grant	$ 0.00 M	$17.22 M	$17.22 M
Equity	$ 4.49 M	$ 1.38 M	$ 0.00 M
Bank Debt / Bond	$25.43 M	$ 7.83 M	$10.60 M
Total Financing	$29.91 M	$26.42 M	$27.82 M
Passings	2,925	2,925	2,925
Penetration Rate	70%	70%	70%
Years until Positive Net Income	Never	Never	Never
Years until Cash Covers Debt	Never	Year 22	Never
Cash after 20 Years	(-$24.46 M)	$1.07 M	$ 1.03 M

This project covering the rural area is not feasible without grant funding. The breakeven grant represents 65% of total financing. Breakeven is defined as a scenario where the project never runs out of cash. We've studied rural areas where the amount of grant funding needed was as high as 80%, so this result is not unusual or unexpected. The challenge will be finding a grant program that will cover more than 50% of the cost of funding a project – they exist, but some grant programs cap the amount of grant be setting some fixed level of matching funds.

The third column shows the impact of financing with municipal bonds, like would be required in a public / private partnership where Sierra County owns the network. The financial results are almost identical to financing the project with commercial debt. This is not always the case and the difference between bank and bond funding differs case-by-case. In this scenario the amount borrowed with bonds is higher due to having to cover capitalized interest and a debt service reserve fund. The primary reason this works with municipal funding is the large amount of grant funding in the project. Had this project been 100% funded by debt, then the commercial debt scenario would have generated more cash.

We know that the County government doesn't want to float large debt and doesn't want to be an ISP. What these results show is that if all else fails that this could work as a public / private partnership with the County owning the network and an ISP operating it. The impact to the bottom line for the various other scenarios, such as increasing prices would have the identical impact regardless of the method of financing.

Sensitivity Analysis

Every financial forecast is based upon numerous assumptions, but only a few of the assumptions have the potential to significantly change the results of the analysis. For example, the results of a study would

change only slightly by changing the assumed salary of one of the employees. Following are the sensitivity results looking at the impact of changing the most sensitive variables, compared to the study above that includes a breakeven grant.

Increasing Customer Prices: In this scenario, the broadband prices are increased by $5 per month for both residents and businesses.

	Base Case	Increase Price
Asset Costs	$25.57 M	$25.57 M
Grant	$17.22 M	$17.22 M
Equity	$ 1.38 M	$ 1.34 M
Bank Debt	$ 7.83 M	$ 7.60 M
Total Financing	$26.42 M	$26.16 M
Passings	2,925	2,925
Penetration Rate	70%	70%
Years until Positive Net Income	Never	Never
Years until Cash Covers Debt	Year 22	Year 17
Cash after 20 Years	$1.07 M	$4.77 M

This shows that the business is sensitive to prices. In this case, increasing the price of the broadband products by $5 increases the cash by a little more than $3.7 million over 25 years.

This raises the question of the right pricing for broadband. In order for the broadband product to be competitive, it must be reasonably priced compared to the competition. However, if broadband is underpriced it has a big negative impact on cash flow.

It's not easy to compare a 100 Mbps product on fiber to the products available in the rural market today. Comparing to products that are advertised as having at least 10 Mbps download shows Windstream at $68, CenturyLink at $52, and the WISPs at $80 or higher. Realistically, almost no rural broadband product in Sierra County is delivering the advertised speed.

The base analysis for this study sets the base broadband price at $60 per month for 100 Mbps symmetrical on fiber. That's far more speed and at a price that is in the middle range of the various existing broadband products in the rural area. The above scenario of raising prices to $65 is still not an unreasonable broadband product.

It's worth noting that lowering prices by $5 would reduce cash flow over 25 years by the same amount of a little more than $3.7 million.

Changing Customer Penetration Rate: The following shows the impact of increasing the customer penetration rate from 70% to 75%. Shown next is the impact of increasing penetration to 80% along with the amount of grant funding required to finance the project at an 80% penetration.

	Base Case	75% Penetration	80% Penetration	80% Breakeven
Asset Costs	$25.57 M	$25.81 M	$26.06 M	$26.06 M
Grant	$17.22 M	$17.22 M	$17.22 M	$14.67 M
Equity	$ 1.38 M	$ 1.39 M	$ 1.39 M	$ 1.85 M
Bank Debt	$ 7.83 M	$ 7.82 M	$ 7.88 M	$10.48 M
Total Financing	$26.42 M	$26.45 M	$26.48 M	$26.99 M
Passings	2,925	2,925	2,925	2,925
Penetration Rate	70%	75%	80%	80%
Years until Positive Net Income	Never	Never	Never	Never
Years until Cash Covers Debt	Year 22	Year 18	Year 15	Year 22
Cash after 20 Years	$ 1.07 M	$ 3.98 M	$ 6.75 M	$ 1.85 M

As would be expected, adding customers increases the needed capital (cost of the electronics and drops needed to add customers to the network).

The bottom-line impact to cash of improving the penetration rate to 75% is an increase in cash flow over 25 years of a little more than $2.9 million, or $582,000 increase for every 1% increase in customer penetration.

The increase in cash for achieving an 80% penetration rate is almost $5.7 million. Perhaps the most important change from a higher penetration rate is how the higher customer revenues impact the need for financing. At a 70% penetration rate the project required 65% of the financing to come from grants. If 80% of the customers in the rural area buy broadband, the need for grant financing is reduced to 54% of total financing, and the amount of grant money is reduced to $14.7 million, a reduction of over $2.5 million. While finding 54% grant funding is still a challenge, it's easier than finding 65% grant financing.

Paying a Lower Interest Rate: This looks at the impact of lowering the interest rate by 50 basis points from 5.0% to 4.5%.

	Base Case	Revised
Asset Costs	$25.57 M	$25.57 M
Grant	$17.22 M	$17.22 M
Equity	$ 1.38 M	$ 1.36 M
Bank Debt	$ 7.83 M	$ 7.70 M
Total Financing	$26.42 M	$26.27 M
Passings	2,925	2,925
Penetration Rate	70%	70%
Years until Positive Net Income	Never	Never
Years until Cash Covers Debt	Year 22	Year 21
Cash after 20 Years	$1.07 M	$1.77 M

The impact of changing the interest rate is not as large as might be expected, mostly due to the fact that such a large percentage of the project is funded with grants. In this case, lowering the interest rate by one-half of a percentage (50 basis points) increases the cash generated over 20 years by $700,000 – which is the saving on interest expense.

Using a Longer Loan Term: This examines the impact of increasing the loan term from 20 years to 25 years. The primary change from increasing the loan is lower annual debt payments.

	Base Case	Revised
Asset Costs	$25.57 M	$25.57 M
Grant	$17.22 M	$17.22 M
Equity	$ 1.38 M	$ 1.36 M
Bank Debt	$ 7.83 M	$ 7.73 M
Total Financing	$26.42 M	$26.30 M
Passings	2,925	2,925
Penetration Rate	70%	70%
Years until Positive Net Income	Never	Never
Years until Cash Covers Debt	Year 22	Year 24
Cash after 20 Years	$1.07 M	$0.79 M

Increasing the loan term has two impacts on cash flows. First, the annual debt payments are lower, but the debt extends for five additional years in this case (meaning extra interest expense). The net impact is a slight decrease in cashflow of $280,000 over 25 years.

Adding a 5% Construction Contingency: This examines the impact of adding a 5% contingency to the cost of building the fiber network. In this case that adds approximately $900,000 to the cost of the capital.

	Base Case	Revised
Asset Costs	$25.57 M	$26.47 M
Grant	$17.22 M	$17.22 M
Equity	$ 1.38 M	$ 1.54 M
Bank Debt	$ 7.83 M	$ 8.75 M
Total Financing	$26.42 M	$27.51 M
Passings	2,925	2,925
Penetration Rate	70%	70%
Years until Positive Net Income	Never	Never
Years until Cash Covers Debt	Year 22	Never
Cash after 20 Years	$1.07 M	N/A

Adding to the construction contingency without finding additional grant money pushes the project into the red with as much as a $1.5 million shortfall. This shows that it's vitally important not to spend more on capital than was originally financed.

Two Cities - Truth or Consequences & Elephant Butte

This scenario looks at the feasibility of bringing fiber to the city limits of Truth or Consequences and Elephant Butte.

Base Study	Base	Breakeven Penetration
Asset Costs	$18.44 M	$18.04 M
Grant	$ 0.00 M	$ 0.00 M
Equity	$ 2.98 M	$ 2.94 M
Bank Debt	$16.88 M	$16.65 M
Total Financing	$19.85 M	$19.59 M
Passings	6,202	6,202
Penetration Rate	50%	45%
Years until Positive Net Income	Year 5	Year 6
Years until Cash Covers Debt	Year 19	Year 21
Cash after 20 Years	$ 9.14 M	$ 4.86 M

It looks profitable with a 50% customer penetration to build a fiber network inside of the two cities. No grant funding is required. The key for anybody thinking about doing this would be the ability to compete against TDS and the expected TDS reaction to competition.

This scenario can reach a cash breakeven with a 45% customer penetration rate – a goal that a lot of ISPs would be more comfortable with than a 50% rate. There is still no guarantee that an ISP can do this well in the towns, but we've seen fiber overbuilders achieve penetrations this good or higher in similar markets.

Sensitivity Analysis

Every financial forecast is based upon numerous assumptions, but only a few of the assumptions have the potential to significantly change the results of the analysis. For example, the results of a study would change only slightly by changing the assumed salary of one of the employees. Following are the sensitivity results looking at the impact of changing the most sensitive variables, compared to the study above that includes a breakeven grant.

Changing Customer Prices: In this scenario, the broadband prices are increased and then decreased by $5 per month for both residents and businesses.

	Base Case	Higher Prices
Asset Costs	$18.44 M	$18.44 M
Grant	$ 0.00 M	$ 0.00 M
Equity	$ 2.98 M	$ 2.92 M
Bank Debt	$16.88 M	$16.53 M
Total Financing	$19.85 M	$19.44 M
Passings	6,202	6,202
Penetration Rate	50%	50%
Years until Positive Net Income	Year 5	Year 5
Years until Cash Covers Debt	Year 19	Year 17
Cash after 20 Years	$ 9.14 M	$13.06 M

This shows that the business is sensitive to prices. In this case, increasing the price of the broadband products by $5 increases the cash by more than $3.9 million over 25 years, or about $784,000 for every $1 change in price.

Paying a Higher Interest Rate: This looks at the impact of increasing the interest rate by 50 basis points from 5.0% to 5.5%.

	Base Case	Revised
Asset Costs	$18.44 M	$18.44 M
Grant	$ 0.00 M	$ 0.00 M
Equity	$ 2.98 M	$ 3.02 M
Bank Debt	$16.88 M	$17.13 M
Total Financing	$19.85 M	$20.15 M
Passings	6,202	6,202
Penetration Rate	50%	50%
Years until Positive Net Income	Year 5	Year 6
Years until Cash Covers Debt	Year 19	Year 20
Cash after 20 Years	$ 9.14 M	$ 8.07 M

The impact of changing the interest rate is not as significant as other variables. In this case, increasing the interest rate by one-half of a percentage (50 basis points) decreases the cash generated over 25 years by almost $1.1 million. The decrease in cash is due almost entirely from paying more for interest expense during the life of the borrowing.

Using a Longer Loan Term: This examines the impact of increasing the loan term from 20 years to 25 years. This would decrease the annual debt payments but add debt payments for five additional years.

	Base Case	Revised
Asset Costs	$18.44 M	$18.44 M
Grant	$ 0.00 M	$ 0.00 M
Equity	$ 2.98 M	$ 2.86 M
Bank Debt	$16.88 M	$16.20 M
Total Financing	$19.85 M	$19.06 M
Passings	6,202	6,202
Penetration Rate	50%	50%
Years until Positive Net Income	Year 5	Year 5
Years until Cash Covers Debt	Year 19	Year 19
Cash after 20 Years	$ 9.14 M	$ 8.61 M

Increasing the loan term to 25-years reduces cash flow by $530,000 over 25 years. This is due to paying interest expense for additional years.

Adding a 5% Construction Contingency: This examines the impact of adding a 5% contingency to the cost of building the fiber network. In this case that adds approximately $620,000 to the cost of the network.

	Base Case	Revised
Asset Costs	$18.44 M	$18.97 M
Grant	$ 0.00 M	$ 0.00 M
Equity	$ 2.98 M	$ 3.08 M
Bank Debt	$16.88 M	$17.43 M
Total Financing	$19.85 M	$20.50 M
Passings	6,202	6,202
Penetration Rate	50%	50%
Years until Positive Net Income	Year 5	Year 5
Years until Cash Covers Debt	Year 19	Year 19
Cash after 20 Years	$ 9.19 M	$ 8.39 M

Adding the construction contingency means borrowing an additional $530,000. This lowers cash flow over 25 years by $800,000. It's also worth noting that this pushed cash slightly negative in a few later years – something that could be handled in several ways., The primary takeaway from this result is that it's vital to get a good engineering estimate of network costs before construction so that projects don't unexpectedly run over budget.

Total Sierra County

This scenario looks at the feasibility of bringing fiber to all of Sierra County including Truth or Consequences and Elephant Butte.

Base Study	No Grant	Breakeven Grant
Asset Costs	$43.86 M	$43.86 M
Grant	$ 0.00 M	$13.07 M
Equity	$ 7.26 M	$ 4.91 M
Bank Debt	$41.15 M	$27.80 M
Total Financing	$48.41 M	$45.77 M
Passings	9,127	9,127
Penetration Rate	50% / 70%	50% / 70%
Years until Positive Net Income	Never	Year 13
Years until Cash Covers Debt	Never	Year 22
Cash after 20 Years	(-$11.49 M)	$ 8.28 M

Like the first scenario above, this scenario can't be financed without a grant. However, the size of the needed grant is reduced by building the whole County since the positive cash flows generated by operating in the two cities helps to offset the costs of operating in the rural parts of the county. The needed grant in this scenario is just over $13 million, which represents 28.5% of the total required financing. There have been numerous broadband grants that have financed up to 50% of a project, so this is reasonably achievable.

Sensitivity Analysis

Every financial forecast is based upon numerous assumptions, but only a few of the assumptions have the potential to significantly change the results of the analysis. For example, the results of a study would change only slightly by changing the assumed salary of one of the employees. Following are the sensitivity results looking at the impact of changing the most sensitive variables, compared to the study above that includes a breakeven grant.

Increasing Customer Prices: In this scenario, the broadband prices are increased by $5 per month for both residents and businesses.

	Base Case	Revised
Asset Costs	$43.86 M	$43.86 M
Grant	$13.07 M	$13.07 M
Equity	$ 4.91 M	$ 4.80 M
Bank Debt	$27.80 M	$27.23 M
Total Financing	$45.77 M	$45.10 M
Passings	9,127	9,127

Penetration Rate	50% / 70%	50% / 70%
Years until Positive Net Income	Year 13	Year 9
Years until Cash Covers Debt	Year 22	Year 19
Cash after 20 Years	$ 8.28 M	$16.56 M

This shows that the business is highly sensitive to prices. In this case, increasing the price of the broadband products by $5 increases the cash by almost $8.3 million over 25 years, or $1.66 million for every $1 increase in prices.

Adding 5% to the Customer Penetration Rate: The following shows the impact of increasing the customer penetration rate from 50% / 70% to 55% / 75%. The middle column shows the impact of getting 5% more customers in both the towns (55%) and the rural areas (75%). The third column shows that the amount of grant needed for the project could be lower if there were more expected customers.

	Base Case	Add 5%	Breakeven Grant
Asset Costs	$43.86 M	$44.50 M	$44.50 M
Grant	$13.07 M	$13.07 M	$ 8.73 M
Equity	$ 4.91 M	$ 4.92 M	$ 5.70 M
Bank Debt	$27.80 M	$27.88 M	$32.33 M
Total Financing	$45.77 M	$45.86 M	$46.76 M
Passings	9,127	9,127	9,127
Penetration Rate	50% / 70%	55% / 75%	55% / 75%
Years until Positive Net Income	Year 13	Year 9	Year 13
Years until Cash Covers Debt	Year 22	Year 19	Year 22
Cash after 20 Years	$ 8.28 M	$16.34 M	$ 9.62 M

As would be expected, adding customers increases the needed capital (cost of the electronics and drops needed to add them to the network), and this slightly increases the needed amount of financing.

The bottom-line impact to cash is an increase in cash flow over 25 years of just over $8 million, or $1.61 million increase for every 1% increase in customer penetration.

It's also worth noting that if customers are expected to be in the range of 55% / 75% penetration that the needed grant becomes drops to $8.73 million and would only be 19% of the total financing. There is perhaps no better way than this to demonstrate how all of the key variables are interrelated. You can't answer questions about the needed financing without also understanding other variables such as the expected number of customers.

Adding 10% to the Customer Penetration Rate: The following shows the impact of increasing the customer penetration rate from 50% / 70% to 60% / 80%. The middle column shows the impact

of getting 5% more customers in both the towns (60%) and the rural areas (80%). The third column shows that the amount of grant needed for the project could be lower if there were more expected customers.

Effect of this Change	Base Case	Add 10%	Breakeven Grant
Asset Costs	$43.86 M	$45.14 M	$45.14 M
Grant	$13.07 M	$13.07 M	$ 4.57 M
Equity	$ 4.91 M	$ 4.92 M	$ 6.45 M
Bank Debt	$27.80 M	$27.88 M	$36.58 M
Total Financing	$45.77 M	$45.86 M	$47.60 M
Passings	9,127	9,127	9,127
Penetration Rate	50% / 70%	60% / 80%	60% / 80%
Years until Positive Net Income	Year 13	Year 6	Year 9
Years until Cash Covers Debt	Year 22	Year 17	Year 22
Cash after 20 Years	$ 8.28 M	$22.94 M	$10.30 M

Increasing customer penetration rates by 10% would improve cash over 25 years by almost $14.7 million, or a little more than $2.9 million increase for every 1% increase in customer penetration. Like with the previous example, raising customer penetrations to this level would further reduce the size of the needed grant to only $4.57 million, which is 14.5% of total financing. This scenario might not be possible, particularly in the two cities because these penetration rates are possibly too high to achieve. But this scenario demonstrates that the amount of needed grant funding can be reduced by increasing expected cash flow. For example, a combination of changes such as a high expected penetration rate, slightly higher prices, and lower interest rates could conceivably result in a whole-county scenario that would not need a lot of grant.

Paying a Lower Interest Rate: This looks at the impact of lowering the interest rate by 50 basis points from 5.0% to 4.5%.

Effect of this Change	Base Case	Revised
Asset Costs	$43.86 M	$43.86 M
Grant	$13.07 M	$13.07 M
Equity	$ 4.91 M	$ 4.83 M
Bank Debt	$27.80 M	$27.38 M
Total Financing	$45.77 M	$45.27 M
Passings	9,127	9,127
Penetration Rate	50% / 70%	50% / 70%
Years until Positive Net Income	Year 13	Year 13
Years until Cash Covers Debt	Year 22	Year 21
Cash after 20 Years	$ 8.28 M	$10.76 M

The impact of changing the interest rate is not as large as might be suspected, mostly due to the fact that such a large percentage of the project is funded with grants. In this case, lowering the interest rate by one-half of a percentage (50 basis points) increases the cash generated over 20 years by a little less than $2.5 million.

Using a Longer Loan Term: This examines the impact of increasing the loan term from 20 years to 25 years. The primary change from increasing the loan is lower annual debt payments.

Effect of this Change

	Base Case	Revised
Asset Costs	$43.86 M	$43.86 M
Grant	$13.07 M	$13.07 M
Equity	$ 4.91 M	$ 4.85 M
Bank Debt	$27.80 M	$27.48 M
Total Financing	$45.77 M	$45.39 M
Passings	9,127	9,127
Penetration Rate	50% / 70%	50% / 70%
Years until Positive Net Income	Year 13	Year 13
Years until Cash Covers Debt	Year 22	Year 23
Cash after 20 Years	$ 8.28 M	$ 7.19 M

Increasing the loan term decreases the cashflow by just over $1 million, almost entirely due to the extra years of interest payments.

Adding a 5% Construction Contingency: This examines the impact of adding a 5% contingency to the cost of building the fiber network. In this case that adds approximately $1.5 million to the cost of the capital.

Effect of this Change

	Base Case	Revised
Asset Costs	$43.86 M	$45.29 M
Grant	$13.07 M	$13.07 M
Equity	$ 4.91 M	$ 5.16 M
Bank Debt	$27.80 M	$29.25 M
Total Financing	$45.77 M	$47.48 M
Passings	9,127	9,127
Penetration Rate	50% / 70%	50% / 70%
Years until Positive Net Income	Year 13	Never
Years until Cash Covers Debt	Year 22	Never

Cash after 20 Years	$ 8.28 M	N/A

In this example, the capital increases by over $1.4 million but the grant remains the same. The extra interest expense in this situation means that in this scenario the cash goes as much as $2.1 million negative. While changing capital doesn't have a drastic change on the cash flow of the project – it's vitally important not to spend more on capital than is originally financed. Cost overruns can kill a project.

What Conclusions Can We Draw from the Financial Results?

There are a number of conclusions we can draw from the results of the business plan analysis:

Building in Rural Areas Requires Significant Grant Funding.

Building fiber in the rural parts of Sierra County requires a grant of over $17.2 million, or 65% of the cost of the financing for the project to be feasible – at a customer penetration rate of 70%

This is not an atypical finding. The cost of building rural broadband in areas with low customer density translates into a high cost of the network per potential customer. Over the last few years CCG has looked at other rural counties where the percentage of grant funding needed was as high as 80%, so the requirement of a 65% grant for Sierra County is typical.

With all of that said, there are factors that can lower the amount of needed grant money. As will be seen below, some of the variables that drive the financial results – such as customer penetration rates and broadband prices – can significantly alter the financial outlooks of a fiber business and could result in lowering the amount of needed grants.

For example, in Sierra County the requirement for grant financing would drop drastically to $14.7 million if the business is expected to achieve an 80% penetration rate. Changing other key variables also changes the amount of grant needed – with broadband prices having the largest impact.

Fiber Could Work in the Two Cities without Grant Funding

The analysis shows that it is financially feasible to build fiber in Truth or Consequences and Elephant Butte, and that such a business plan would be self-sustaining as long as the project was able to get at least 45% of the customers in the two cities. Getting 45% of the customers is no sure thing, but we know plenty of ISPs who do that well or better in towns of that size when competing against a cable company.

I think ISPs are going to be interested in this finding, because being able to be profitable in these cities would help to offset the high costs of serving the rural areas.

One of the primary uses of this feasibility study is to demonstrate to ISPs that it's feasible and profitable to build bring to Sierra County. We strongly recommend sharing this finding with ISPs.

Will Require Significant Equity.

One of the issues highlighted by the analysis is that the size of commercial loans needed to build the rural areas would be substantial, even with large grants. Banks rarely make commercial loans for 100% of the cost of funding a project. In recent years, commercial loans have required between 10% and 20% equity from a commercial borrower.

In the scenario to build the whole rural area, this required equity is likely to be in the range of $1.4 million. While that might not sound like a lot of money, most ISPs typically don't sit on very much free cash and many ISPs that might be interested in operating in Sierra County could find this requirement to be a problem. It is possible that a bank would consider grant funding as equity and determine that no additional equity is required – but that's not an automatic thing.

The Business is Sensitive to a Few Key Variables. All the scenarios are sensitive to changes in a few key variables:

- Penetration Rate: The most important variable is customer penetration rate. We began our analysis using an estimate of penetration in the rural areas of 70% and in Truth or Consequences and Elephant Butte of 50%. These are fairly typical penetration rates we are seeing on fiber networks built into similar markets.

  The impact of achieving higher penetration rates is significant and could produce a big upside to all the business plans. We've seen rural overbuilders that have achieved penetration rates between 60% and 85%, and one of the next steps the county should contemplate is to try to pin this number down. This can be done using a statistically valid survey or else a canvassing effort, which will be described in the recommendations of next steps to take after this study.

  The studies show that there is a significant financial upside and improved cash flows by achieving penetration rates higher than our starting best guess.

- Broadband Prices: The financial results are also highly sensitive to broadband prices. The studies all used an assumed starting price of $60 for the basic broadband product. Our studies don't say what that speed might be, but many fiber networks begin with a base product of 100 Mbps symmetrical (same speeds up and down). That product is magnitudes faster than the broadband products available in the rural areas of Sierra County today.

  There are rural ISPs in the state charging a lot more than $60 and it's worth more research if you do a survey to look at price sensitivity in the rural part of Sierra County. There is always a trade-off between making sure that the business is successful and sustainable versus keeping rates low to keep them affordable for the largest numbers of homes.

- Interest Rate: The financial analysis does not show a big sensitivity to interest rates. One reason for this is that most of the scenarios we considered have significant grant funding, which reduces the amount of money that is borrowed. However, the impact of interest rates could become significant should interest rates ever move outside the current range of interest rates. We've been somewhat spoiled in the US by historic standards by having some of the lowest interest rates over

the last decade. There have been plenty of time in the last fifty years where interest rates were significantly higher than today, and if interest rates increase dramatically there would be a large impact on the ability to finance a fiber network.

- Loan Terms. The project doesn't seem to be very sensitive to a longer loan term. The loan term is the length of the loan. We used a base assumption of 20-year financing. It didn't seem to make a lot of difference by moving the loans to 25-years. That move lowers the annual debt payment in early years, but overall costs of financing are increased due to adding on 5 additional years of financing costs.

  In the rural areas it doesn't look possible to shorten the loan term to 15-years. The annual debt payments are too high for a loan repayment period that short. However, if somebody were to build fiber in the two cities it looks like that could be financed over 15 years.

It is essential before deciding to get into the business to pin down these key variables. This means that an ISP can't take the financial results listed above or in Exhibit II as the straight answer, because these variables can change the result of any financial projection. 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 in a real business plan. The more the ISP knows about things, like specifically how a project would be financed, the more concrete any projection becomes.

IV. OTHER ISSUES

A. Funding for Broadband Networks

For a large percentage of broadband projects, the biggest challenge is finding the funding. This section of the report looks at the various ways that other communities have been able to fund broadband networks. If a community wants fiber badly enough, there probably is a way to pay for it.

There are a number of different financing option to consider. Below we look at the following:

- Private Financing (loans)
- Public Financing
- Grants
  - Federal Programs
  - State Programs
- Loan Guarantees
- Customer Financed
- Public Private Partnerships

Private Financing Options

When commercial ISPs build networks, they must rely on traditional private financing, meaning loans. Following are the key elements that determine the cost of bank financing:

> **Equity**: Most forms of private financing require some equity. Equity means that the borrower brings some sort of cash or cash equivalent to the business as part of the financing package. The amount of equity required will vary according to the perceived risk of the venture by the lender. The higher the risk, the more equity required.
>
> Equity can take a number of different forms:
>
> - Cash: Cash is the preferred kind of equity and lenders like to see cash infused into a new business that can't be taken back out or that doesn't earn interest.
> - Preferred Equity: For a stock organization (like an LLC or other type of corporation) the business can issue some form of preferred stock that then acts as equity. Preferred equity usually gets some sort of interest rate return, but the payments are not usually guaranteed like they are for bank loans. If the business gets into a cash crunch, they must pay bank loans and other forms of debt before they pay preferred equity interest.
> - Assets: It's possible to contribute assets as equity. For example, a new fiber venture might be seeded by having one of the partners contribute an existing fiber route or another valuable asset to the business. In such a case the contributed asset often must be assigned a market value by an independent appraiser.
> - Non-recourse Cash: Non-recourse cash means accepting a contribution to the business that is not guaranteed to be paid back. To give an example, in Sibley and Renville counties in Minnesota, a fiber business was launched in the form of a cooperative. The local government provided an economic development bond to the business as a non-recourse

loan. This means that the new fiber business will make their best effort to make the bond payments, but if they are short of cash then the government entities that issued the bonds would have to make the bond payments. The banks involved in that project looked at the contributions from the bonds to be the same as equity.

Bank Loans: The banking industry as a whole does not like to finance long-term infrastructure projects. This is the primary reason why the country has such an infrastructure deficit. Fifty or more years ago, banks would fund things like power plants, electric and water systems, telephone networks, and other long-term revenue-generating assets. But various changes in banking laws have required banks to maintain larger cash reserves which makes them less willing to make long-term loans. Banks have also increased their expectations over time to want to earn higher interest rates. Many attribute this to the fact that giant publicly traded banks have captured most of the banking market. Banks don't like long-term loans since the interest rates get locked in for many years, possibly depriving the banks from earning more on their own equity.

Most banks prefer not to make loans with a term much longer than 12–15 years, and many telecom projects can't generate enough cash in that time period to repay the loans.

There are exceptions. A few of the large banks like Key Bank and Bank of America have divisions that will make bank loans to municipal ventures that look a lot like bonds. These loans will have long payment terms of 20 years or more and reasonable interest rates. However, most of these loans go for things like power generation plants and other projects that have a strong guaranteed revenue stream. These banks have done a tiny handful of telecom projects, but they view most broadband projects to be too risky.

Banks are also averse to start-ups and prefer to make loans to existing businesses that already have a proven revenue stream. It's extremely hard for a first-time borrower to be able to borrow the kind of money needed to build a telecom project.

There is one unique banking resource available to companies who want to build fiber projects. This is CoBank, a boutique bank and a cooperative. This bank has financed hundreds of telecom projects, mostly for independent telephone companies and for electric cooperatives. CoBank is a relatively small bank and has strict requirements for financing a project. They are leery of start-ups and we can't think of a start-up they have financed recently. They also expect significant equity to be infused into a new venture. They tend to have somewhat high interest rates and somewhat short loan terms of 10–12 years.

Cooperatives also have another bank that lends only to cooperatives. This is RTFC (Rural Telephone Financing Cooperative) that is owned by cooperatives.

One interesting source of bank financing is local banks. Historically local banks were the source in many communities for car and home loans. But over the last few decades those loan portfolios have migrated to other lenders and local banks have been struggling for a decade to find worthwhile projects in their regions. We know of many commercial projects for small telcos that have been financed by local banks.

The biggest challenge of borrowing from a local bank is that they typically have a relatively small lending limit. Most local banks won't make an individual loan for more than a few million dollars. That obviously doesn't go far in a fiber project. However, local banks have become adept at working in consortiums of multiple banks to make larger loans. This spreads the risk of any one loan across many banks. A banking consortium usually begins with a local bank in the area of the project, with the local bank taking the role of finding other banking partners and of servicing the loan. This approach requires a lot of extra effort from a local bank, but the approach has been used to finance good telecom projects.

Collateral. The biggest issue that banks have in lending to broadband projects is the lack of collateral, which is the assets they inherit if the project should fail. Banks like hard collateral like buildings, vehicles, shares of stock, and things they know they can readily sell for a reasonable price. Banks don't like broadband networks as collateral, because even a little bit of web searching shows them that networks are sometimes sold for pennies on the dollar.

It's important understand the importance of collateral. Communities often ask an ISP operating nearby to come build fiber in their town. What they generally fail to realize is that the ISP likely had to pledge their entire business as collateral in order to secure the loan to finance a new market – meaning that if the new venture fails they can lose the whole business.

Return on Bank Equity. Banks don't only consider the interest rate when making loans. A bank concentrates on its return on equity and will consider a combination of factors like interest rates, up front and monthly loan fees, the likelihood that a borrower will pay a loan off early or default on a loan, etc. A bank will look at a dozen financial parameters before making an offer of interest rate and term – all based up their analysis of return on bank equity. There is a misperception that interest rates are negotiable, but the same project offered to multiple banks is likely to get a nearly identical financing package offered by all of the banks.

Federal Loans

Rural Utility Service (RUS): This is a part of the Department of Agriculture and is the only federal agency that makes direct loans to broadband projects. The Rural Broadband Access Loan and Loan Guarantee Program (Broadband Program) furnishes loans and loan guarantees to provide funds for the costs of construction, improvement, or acquisition of facilities and equipment needed to provide broadband in eligible rural areas. These loans can't be used for any town with a population over 20,000. The RUS acts much like a bank and follows similar lending practices. I like to describe the RUS as a bank from the 1950s, because their lending rules were set by Congress to loan money for rural electrification and have never been modernized.

RUS makes broadband loans and loan guarantees to:

- Finance the construction, improvement, and acquisition of facilities required to provide broadband including facilities required for providing other services over the same facilities.
- Finance the cost of leasing facilities that are required to provide broadband if the lease qualifies as a capital lease under Generally Acceptable Accounting Procedures (GAAP). The financing of such a lease will be limited to the first three years of the loan amortization period.

- Finance the acquisition of facilities, portions of an existing system, and/or another company by an eligible entity, where acquisition is used in the applicant's business plan for furnishing or improving broadband. The acquisition costs cannot exceed 50 percent of the broadband loan amount, and the purchase must provide the applicant with a controlling majority interest in the equity acquired.
- Finance pre-loan expenses, i.e., any expenses associated with the preparation of a loan application, such as obtaining market surveys, accountant/consultant costs for preparing the application, and supporting information. The pre-loan expenses cannot exceed 5% of the broadband loan excluding any amount requested to refinance outstanding telecommunication loans. Pre-loan expenses may be reimbursed only if they are incurred prior to the date on which notification of a complete application is issued.

RUS is allowed to make loans to a wide range of entities. Borrowers can be either nonprofit or for-profit and can be one of the following: corporation; limited liability company (LLC); cooperative or mutual organization; Indian tribe or tribal organization as defined in 25 U.S.C. 450b; or state or local government, including any agency, subdivision, or instrumentality thereof. Individuals or partnerships are not eligible entities.

To be eligible to receive a loan under this program, the entity must:

- Submit a loan application. We note that the loan application requires a lot of work including such things as pre-engineering, surveys, mapping, financial business plan models, environmental impact studies, and other things which make the application expensive to get prepared externally;
- Agree to complete the build-out of the broadband system described in the loan application within 3 years from the date the borrower is notified that loan funds are available;
- Demonstrate an ability to furnish, improve, or extend broadband in rural areas;
- Demonstrate an equity position equal to at least 10% of the amount of the loan requested in the application; and
- Provide additional security if it is necessary to ensure financial feasibility as determined by the administrator.

In practical terms here is how the RUS loans have been administered over the past few decades:

- The rules say that a project needs at least 10% equity, but in reality, this is often expanded to be anywhere from 20% to 40% at the discretion of the RUS. In effect, the RUS acts as a bank and they will require enough equity that the project can adequately cover debt payments.
- The loan terms are generally in the range of 12 years, sometimes up to 15 years for fiber projects. This is much shorter than the terms available on bond financing, meaning the annual payment would be higher under a RUS loan than with a bond.
- It is exceedingly hard to get a project funded for a start-up business. The RUS typically wants the whole company of the borrower pledged as collateral. Thus, the bigger and the more successful the existing company, the easier to meet their loan requirements.
- Their collateral requirements are overreaching in other ways that make them hard to work with for municipal projects. For example, if the project is going to share fiber with some existing network, such as one built by a school system, they would want that asset as collateral. This is generally not possible.

This makes the RUS a very unlikely funding source for a municipal venture or for any start-up venture. To the best of our knowledge, the RUS has never yet successfully funded a municipal venture and they rarely approve a project for a start-up business unless it is extremely well funded by a demonstrably successful company.

The other big drawback of these loans is that they take a long time to process. They often have a backlog of loan applications at the RUS of 12–18 months, meaning you have to wait a long time after application to find out if they will fund your project. Very few existing companies are willing to wait that long unless they are certain they will be funded. And if you are coordinating these loans with other forms of financing this wait is not practical. The loans are granted by using a very detailed checklist and rating system. This system gives a big preference to making new loans to existing RUS borrowers.

However, the loan fund is quite large and currently sits at more than $1 billion. Congress generally has been adding additional funds to the RUS pot each year. The RUS also has some discretion and they have it within their power to make a grant as part of the loan. This is something that can't be counted on, but we know of projects where the borrower only had to pay back 80% of what they borrowed. The interest rates can be lower than market in some cases, but for the last several years, with low interest rates everywhere, the RUS loan rates were not much cheaper than commercial loans.

These loans also require a significant paperwork process to drawdown funds along with significant annual reporting requirements.

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.

Comparing Bond and Bank Financing

Benefits of Bond Financing: There are several major benefits for using bond financing:

- 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 to 30 years. It's difficult to finance a commercial loan longer than 15 years. The longer the length of the loan, the lower the annual bond payments.

- Bonds can be used to 100% finance a project, meaning there is no need for cash or equity to fund the new business. Lack of cash equity is generally the requirement that creates a challenge for traditional commercial financing.
- Bonds often, but not always, have lower interest rates than commercial debt. The interest rate is dependent upon several factors including the credit worthiness (bond rating) of the borrower as well as the perceived risk of the project.
- It's generally easier to sell bonds than to raise commercial money from banks. Sometimes bonds require a referendum, but once bonds are approved there is generally a ready market for buying the bonds and raising the needed funds.

Benefits of Commercial Financing: There are also a few benefits for commercial financing.

- Generally, the amount that must be borrowed from commercial financing is lower, sometimes significantly lower. This is due to several issues associated with bond financing. Bond financing often contains the following extra costs that are not included with commercial loans:
    - Surety: Bonds often require a pledge of surety to protect against default of the bonds. The two most common kinds of surety are the use of a debt service reserve fund and bond insurance. A debt service reserve fund (DSRF) borrows some amount of money, perhaps the equivalent of one year of bond payments and puts it into escrow for the term of the bond. They money just sits there to be used to help make bond payments should the project have trouble making the payments. Bond insurance works the same way and a borrower will pre-pay and insurance policy at the beginning of the bond that will cover some defined amount of payments in case of a default.
    - Capitalized Interest: Bonds typically borrow the interest payments to cover bond payments for some period of time, up to five years.
- Construction Loans: Another reason that commercial financing usually results in smaller debt is through the use of construction financing. A commercial loan will forward the cash needed each month as construction is done, and interest is not paid on funds until those funds have been used. However, bonds borrow all of the money on day one and begin accruing interest expense on the full amount borrowed on day one. Construction loans also means that a borrower will only draw loans they need while bond financing is often padded with a construction contingency in case the project costs more than expected.
- Deferred Payment: Commercial financing often will be structured so that there are no payments due for the first year or two. This contrasts with bonds that borrow the money required to make these payments. Fiber projects, by definition, require several years to generate revenue and deferring payments significantly reduces the size of the borrowing.
- Retirement of Debt: It's generally easy to retire commercial debt, which might be done in order to pay a project off early or to refinance the debt. This contrasts to bonds that often require that the original borrowing be held for a fixed number of years before it can be retired or refinanced.

Grants

It's hard imagining the construction of fiber networks in rural areas without some grant support. This is particularly true in Sierra 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. 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.[11] 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.[12] 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.[13] 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.

State Grant Programs

New Mexico Broadband Program.[14] 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 Sierra 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.[15]

[11] https://www.usda.gov/reconnect
[12] https://www.rd.usda.gov/programs-services/community-connect-grants
[13] https://www.broadbandusa.ntia.doc.gov/new-fund-search
[14] https://www.doit.state.nm.us/broadband/index.shtml
[15] http://www.nmprc.state.nm.us/utilities/telecommunications.html

Loan Guarantees

Another way to help finance broadband projects is through federal loan guarantees. A loan guarantee is just what it sounds like. Some state or federal agency will provide a loan guarantee, which is very much like getting a co-signer on a personal loan. These programs guarantee to make the payments in the case of a default and thus greatly lower the risk for a lending bank. In return for the lower risk, the banks are required to offer a significantly lower interest rate.

These guarantees are not free. There is an application process to get a loan guarantee in much the same manner as applying for a bank loan or a grant, meaning lots of paperwork. And then the agency making the guarantee will generally want a fee equal to several interest "points" up front. To some extent, this process works like insurance and the agency keeps these fees to cover some of the cost of defaults. If they issue enough loan guarantees, then the up-front fees can cover eventual losses if the default rates are low. These points are a payment to the agency for issuing the guarantee and are not refundable.

There are several federal agencies that might be willing to make loan guarantees for telecom projects. The following agencies are worth considering:

HUD 108 Program: The Department of Housing and Urban Development has a loan and loan guarantee program that is allotted for economic development. There is both federal money under this program as well as money from this program given to the state to administer. While these loans and loan guarantees generally are housing related, the agency has made loan guarantees for other economic development projects that can be shown to benefit low- or moderate-income households. If enough of a fiber project can be said to benefit low-income residents, then these loans can theoretically be used for a fiber project.

Small Business Administration 504 Loan Program: This program by the SBA provides loans or loan guarantees to small start-up businesses. These loans or loan guarantees must be made in conjunction with a bank, with the bank providing some loan funds directly and with the SBA loaning or guaranteeing up to 50% of the total loan.

USDA Business and Industry Guaranteed Loans (B&I): The Department of Agriculture provides loan guarantees through the B&I program to assist rural communities with projects that spur economic development. Such a project must, among other things, provide employment and improve the economic or environmental climate in a rural area. These loan guarantees are available to start-up businesses. The program can guarantee up to 60% of a loan over $10 million or greater percentages of smaller loans.

Opportunity Zones. Congress created a new 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 most of Sierra County 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.

Any ISP building a network in Sierra County 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.

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

When no ISP or municipality is able to finance a project, we've seen citizens to step up and agree to somehow fund directly some or all of a broadband project. When you consider that the cost of building

rural fiber can be $15,000 or more per home passed, getting some assistance directly from potential customers is sometimes the only solution that can attract the rest of the needed funding. 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 a bond. This is different than most bonds for a broadband network where the network would be secured by revenues of the broadband venture. But a pledge of some other kind of tax revenue is one of the easiest ways to get a bond. There are some real examples of this kind of financing:

- Lyndon Township, Michigan: This is a township of about 1,000 homes that voted to raise property taxes to fund 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. The township provides free access to the network to the cooperative which is charging about $25 for broadband – making the total cost of getting broadband about $50 per month. 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.

Direct Customer Contributions: It's also possible to pay for some of a broadband project through direct contribution of possible customers. This has never been done on a large scale because it would be exceedingly difficult to get a lot of residents to agree to write a check to fund a network. But there are some examples to consider:

- Contribution to Aid in Construction: Most utilities have a program where they will agree to extend their network to customers if those customers agree to pay the cost of the connection. We are aware in the broadband area of numerous cases where small pockets of rural home raised the needed money to get connected to a nearby broadband network.
- Ammon, Idaho: This is the only municipal attempt at funding a network in this way. The City of Ammon will connect customers to a fiber network if they will contribute $3,500 up-front to cover the cost of construction.

Public Private Partnerships

A public private partnership (PPP) is formed when a government entity and commercial entity fund a project together. 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 payment 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 large projects and the required funds can easily exceed the ability of a government to fund it 100%.

Following are two examples of this type of PPP, both from Minnesota:

- RS Fiber: RS Fiber is a new broadband cooperative that was formed in Renville and Sibley counties. The project was funded from various sources including a loan for 25% of the project supplied by a bond backed by the cities and counties involved in the project. The Cooperative raised the other money with a combination of bank loans and grants.
- Swift County: The county government there contributed a significant percentage of the cost needed to construct a broadband network in the county. The bond proceeds were loaned to Federated Telephone Cooperative and are expected to be paid back over time.

Other Sources of Financing

We've seen entities get very creative in finding sources of financing. Take the example of the RS Fiber Cooperative formed in Sibley and Renville Counties in Minnesota. Their financing includes two unique revenue sources we have not seen used before:

- **Loans from Individuals**: The Cooperative borrowed money directly from people and businesses in the service area. These loans had loan contracts and covenants like any other loans. The money borrowed in this manner reduces the amounts that must be borrowed from the larger external sources, and generally these loans avoid the large fees associated with external financing.
- **Loans from Other Cooperatives**: Since RS Fiber is a cooperative, they found that they were able to borrow from an electric cooperative at low interest rates. Cooperatives are a unique type of business that is required by law to either invest their profits back into the business or else return it as dividends to members. Because the level of dividends is limited by law, cooperatives often find themselves with large cash reserves. They are allowed to loan out these cash reserves, but only to other cooperatives.

B. Partnering Potential

This section of the report discusses how to find ISP partners to bring broadband to Sierra County, As this report was being written the Rural Utility Service (RUS), part of the US Department of Agriculture, announced that Sacred Winds Communications of Yatahey, New Mexico has proposed a ReConnect grant to bring fiber to some portion of rural Sierra County. There is no guarantee that they'll win the grant, and in the last round of grant filings there was $3 in grant requests for every $1 of grant that was awarded.

The following discussion on partnerships assumes a true partnership between Sierra County and an ISP – meaning one where the county is somehow contributing to the venture.

The Best Characteristics for an ISP Partner

Experience. We know of several investor-driven ISPs looking to invest and operate broadband networks, but which have never built or operated a network. This isn't to say that such a group can't be a good partner, but it's a higher risk to work with an ISP that doesn't already have customers and that hasn't worked in a partnership before.

There are a few horror stories in the industry of public/private partnerships that went awry because of lack of experience by the ISP partner. In the following two examples the ISP management team was made up of folks with industry experience but who had never worked together as a team before.

- The first example is Utopia in Utah. This is a collaboration of small towns that are working together through the Utopia organization to create economy of scale for the business. State law in Utah doesn't allow municipalities to be an ISP, so Utopia works as an open access network where the cities build the network and various ISPs compete for customers.

  Utopia started by hiring an external management team that had not worked in the open access environment before. Several things went wrong – the networks were late in getting constructed and came in over budget. The ISPs did not sell as aggressively as the business plan had supposed. Utopia ran out of cash before construction was complete and almost folded, but the business was eventually saved through several rounds of refinancing and is now large enough to be financially stable. It took almost a decade of the business being in financial duress to get to that point.

- Another example is Lake County, Minnesota. The county decided to borrow money to build a county-wide fiber network. This is one of the northernmost counties in the state and quite remote. There are 11,000 residents in 2,100 square miles. They hired an outside firm to construct the network and run the ISP. The project went way over budget and the project ran out of money with a backlog of almost 1,000 customers they couldn't connect to the network.

  The project was funded through a combination of a $10 million federal grant and a low interest government loan for $56 million. The county also bonded over $7 million locally for the project plus floated loans to keep the project afloat. The project went completely underwater financially and didn't make enough money to cover debt payments. In 2019 the county sold the network to an

ISP for $8.4 million. The federal government had to write off about $40 million in debt and the county still must cover the original bonds plus the internal loans made to the project.

Experience Working with Municipalities. It's somewhat important to work with an ISP that has worked with local governments before. CCG has witnessed a number of public private partnerships with the recurring theme that the two parties get frustrated with each other over time. This is due to two factors – frustration with the decision-making process and a difference in goals and expectations.

Commercial ISPs become quickly frustrated with the municipal decision-making process. Most local governments have a specified legal process that must be followed to make certain kinds of decisions. This might mean listing the topic for a public meeting, waiting for a period of time, and allowing public comment on the issue. Commercial ISPs are used to making decisions quickly and they don't like the drawn-out processes that government requires. Government entities get frustrated as well since their commercial partners push them to make decisions quickly when they can't.

A more fundamental issue in public private partnerships is a fundamental difference in goals. The issue commonly arises when the two parties didn't thoroughly discuss their long-term goals for broadband before a partnership began. Commercial ISPs are often most worried about cash flow and profit margins. If they've invested equity in a broadband network, they become unhappy if the business doesn't meet their earnings goals. Governments often have a different set of goals – serving every household, offering low-priced broadband to low-income houses, providing subsidized broadband to nonprofits and anchor institutions. In many cases, these kinds of fundamental differences can't be overcome and eventually ends up in a dissolution of the partnership.

The differences between the two kinds of entities often surfaces when there is a discussion of rates. Cities often push back against rate increases – particularly in election years. Cities push partners for low rates in general, and often want an ISP to give low rates for low-income households and even free rates to groups like nonprofits.

These kinds of issues are less likely to be a huge problem if the ISP has worked successfully with other municipalities before. A government entity that is working with an ISP that has not partnered in this manner before should have an in-depth discussion up front about expectations. It's a lot easier if the two parties decide up front that they aren't compatible instead of getting a divorce after the partnership has been launched.

Financial Strength. Municipal entities often have a hard time judging the financial strength of partners. Unfortunately, most public/private partnerships are not with big well-financed ISPs. The more typical partnerships are with telephone companies, electric cooperatives, or fiber overbuilders. It's typical for commercial ISPs of this type to overstate their financial security – and they may even believe what they say in doing so. But there are a few fundamental things about ISPs that a city should understand:

- Almost every ISP has a natural borrowing limit. There is only so much debt that bankers and other lenders will allow them to carry. By definition, when an ISP nears that lending limit it means that bankers think the company is pushing its financial limitations. Any ISP that has borrowed to its limit can't afford to make financial mistakes, and that means the partnership and all their other ventures need to perform as expected. It's not unusual to see budding partnership be dependent upon obtaining financing, and it's not uncommon for the ISP to not get the hoped-for funding.

- The biggest issue with ISPs and borrowing is collateral. Banks don't look at fiber networks as good collateral for loans because there is very little value from repossessing a fiber network. This means the only good collateral that most ISPs have is the value of their existing company. Even surprisingly large ISPs might have to pledge their entire company in order to borrow a sizable amount of money to build an expensive network. It's often necessary for owners of ISPs to make personal guarantees on loans, meaning that both their business and their personal assets are on the line with a new fiber project. ISPs are highly unlikely to disclose to a government partner the details of how they raise money – among other reasons they fear public disclosure laws and don't want their personal financial position discoverable as a public record.

Capacity to Grow. One of the hardest things to judge is the ability of an ISP to grow quickly. A traditional ISP like a telephone company may have a lot of customers – but they acquired them slowly over decades. ISPs (and all other types of businesses) often get stressed to the breaking point when they try to grow too fast. It's not unusual for an ISP to somehow assume that existing middle and upper management can handle a growth scenario while still somehow handling the existing responsibilities they've always had.

Just because a company is a great ISP doesn't mean that the company is capable of growing quickly. Unfortunately, there is no way to judge this unless the ISP has already been growing prior to the creation of the partnership.

Fair Recognition of Value. One of the important attributes of a good partnership is the full and fair recognition of the value that each party brings to the partnership. Municipalities should be wary of a partner that overvalues what they bring to and undervalues what you bring. A government can create value for a public/private partnership in a number of ways:

- Funding. Any amounts paid towards funding a broadband network are valuable. Governments often don't know how to set a value for cash contributions – something that commercial partners routinely figure out. It's been my experience that ISPs don't value government funding as much as they do other funding sources. I think this is because government funding doesn't come with the same stringent strings and responsibilities. A local government is not likely (or even able) to require things that a bank might require such as collateral or a lien on a partner's assets. If an ISP gets into financial trouble, the first entity they will try not to pay is a government partner. This can be dealt with in creating a partnership agreement, but to some degree that requires a government to think like a bank.
- Anchor Tenant. Government entities often make good anchor tenants – which is pledging to be an early customer of a network and guaranteeing to buy services with a long-term contract. It's not untypical for a government entity to be one of the largest broadband and telecom customers on a network.
- Other Assets. Governments often have other assets that can benefit a partnership. This could be land for placing equipment; It could be a building to create a central office or a storefront. It might mean towers, empty conduit, or spare existing fiber that can be used to defray the cost of constructing a broadband solution. The value of such assets should be set according to what the partnership would pay to get the same thing from a third party.
- Easier Construction Processes. Local governments often take a significant role during the construction process. They might have to approve permits for rights-of-way. They might be the entity that locates existing utilities. They might require inspection of construction work sites, during and after construction. They might require things like traffic management during

construction. Before tackling a major fiber construction project with a partner, a government might review these various requirements to see if they can be streamlined to make it easier to build fiber. Note in doing so that this likely means making any relaxed rules available to any other entity that wants to build fiber.

- Contributed Labor. A government can contribute labor. Using the last example above, a government could agree to conduct permits, locating, or some other service for free as a way to contribute to launching a partnership project.
- Tax Abatements. Tax abatements have always been a tool for economic development. Governments often have it within their power to excuse certain taxes to entities that bring something of economic value to the community. For example, it's common to not charge a large new business any property taxes for some period to lure them to locate in the community. There are numerous taxes and fees that might impact a new broadband network such as property taxes, sales taxes, right-of-way fees, etc. that a government might be willing to waive to help a new network get established.

The bottom line to this discussion is that a government can bring significant value to a partnership, and that contribution should be fairly valued. Even when a government brings tangible value, such as contributing funding, it's not unusual for an ISP to undervalue that contribution. It's even more prevalent for an ISP to not assign a realistic value to the more intangible contributions.

How do You Find Potential Partners?

We've seen almost every partnership we know of come through three different processes:

- Request for Information (RFI). It's typical for communities that want broadband to issue an RFI aimed specifically at soliciting potential ISP partners. These RFIs typically describe the situation in the community, typically describe whatever work has already been accomplished (such as this feasibility study) and describe the role the municipality wants to take in a partnership.

  The RFI then asks ISPs to describe themselves and their capabilities. The RFI generally doesn't go so far as to request a specific solution, but rather asks the ISPs to discuss how they might tackle broadband issues in the community.

  And RFI is generally a first step to determine which ISPs might be interested in partnering. After the RFI the process typically moves to one of the two processes described below.

- Request for Proposal (RFP). And RFP is typically a lot more in depth. In addition to asking ISPs to introduce themselves, an RFP might ask for specific proposed solutions. It might go further in detail asking about the financial strength of the ISP business and details of how they operate in other market.

- Direct Negotiation. It's routine for governments to interact directly with potential ISP partners rather than go through an RFI or RFP. This might involve a local government reaching out to ISPs in the area, or it might be in response to an ISP making an unsolicited proposal to a local government to bring broadband.

Comparing the Three Options.

It's first worth considering the issue from the perspective of an ISP. ISPs are leery of public records laws. They are often highly reluctant to provide financial information, customer lists, or other information that they feel is confidential. They don't trust that local governments will fight to keep such information confidential. ISPs are even more leery of spelling out specific details of their business plan and how they approach a broadband market – they don't want that information to be available to their competitors.

Many ISPs are not willing or able to respond to an RFI or an RFP that asks for lengthy written responses to a long list of questions. Businesses that sell equipment and services are used to the idea of making proposals and usually have a pile of pre-prepared canned responses to the typical questions they are asked by a prospective customer. However, an ISP may never have been asked to make a proposal in writing in the specific and detailed way that might be needed to respond to an RFI or an RFP. There are ISPs that refuse to participate in an RFI or RFP for this and related issues. We know there are ISPs that eliminate cities from consideration if they insist on going through the formal RFP process. They know there are other communities that will talk to them directly without the formal process.

ISPs prefer direct discussions where nothing is put into writing during the negotiation stage. That's the same process that ISPs typically use when they partner with other ISPs – they sit and talk out the pros and cons and mutually decide if there is a potential for a partnership. As often as not, such discussions end up with the realization that a partnership is not a good idea, and the parties amicably go their separate ways and nothing they discussed is in writing.

Here is the process that I like best, having been through a lot of discussions between governments and ISPs:

> For most local governments, the best first step is to invite known ISPs for a high-level discussion about whether any kind of partnership makes sense. This process might involve several meetings where an ISP might come back with ideas, and then another meeting where the local government reacts. For smaller cities and for rural governments this is likely the only approach that will work since small and rural communities are unlikely to attract ISPs from a distance.
>
> I like the RFI process when it makes sense. For example, I was working with a geographically isolated community where there was no local ISP candidate within fifty miles. An RFI made sense since the community didn't have a wish list of local ISPs to consider. An RFI also might make sense for larger communities. In this case I define larger to mean that the cost of the project is large – perhaps more than $25 million. I've known communities that found an ISP partner through an RFI that they would never have otherwise found.
>
> If a community issues an RFI it should ask for basic information only. That might include asking an ISP to provide their history, telling about the products they normally sell, and talking about the management team. While cities might have a hundred questions for a prospective partner, the ISP is going to be a lot happier if the details of their business are not put into writing at the early stage of meeting and negotiating.
>
> I think RFPs only make sense for larger cities – probably those with network costs over $100 million. It's not likely that a small ISP will respond to such an RFP. Even in an RFP, I recommend

not asking for sensitive financial information about the ISP – that can always be provided if the likelihood of a partnership develops.

Establishing Compatible Goals

At some point during the early stages of the process it's vital for both sides to thoroughly discuss their goals for the project. Misalignment of goals is the number one issue that plagues any partnership eventually. Both parties need to fully hear, understand, and be fully comfortable with the goals of the other partner.

Goals generally can be stated simply and don't have to be complicated. Goals for a municipality might be things such as serving the entire community, not needing to subsidize the project, keeping rates low, and so forth. Goals for an ISP might be to generate a specific target of cash flows / profits. It wouldn't be unusual for an ISP partner to eventually want the option to buy the business. An ISP also might want just the opposite and might want to capitalize on the success of the business by selling out after some period of time.

It's important to not only see each other's goals, but it's vital for a municipality to understand the ISP's goals. This is one situation where a municipality might want to discuss these goals with a consultant or somebody with broad industry experience. It's not unusual for two partners to be talking a different language when discussing financial issues and it's vital to fully comprehend what a partner is telling you about their goals.

Alignment of goals is a make-or-break point in a potential partnership. Many of the differences that a municipality and an ISP might have can be negotiated, but you can't negotiate a difference in philosophy. If an ISP has a goal that a municipality can't live with, such as selling out in ten years – then our advice is to not pursue the partnership. When an ISP tells you a goal of that nature, they mean it.

How to Rank Potential Partners?

There are hundreds of questions that a local government might ask an ISP that might range from big important questions like, "Can you bring funding to this project?" to questions that are important but have lesser impact on creating a partnership such as, "What's your process of disconnecting customers who don't pay?"

I advise prospective partners (government or otherwise) to place their questions into three categories, 1) make or break questions, 2) questions that might disqualify a potential partner, and 3) all other questions.

Every community will have its own list of make or break questions based upon their own priorities for what a partner should bring to the table. Make or break questions might be things like 1) "How much funding can you bring to the project?", or 2) "Are you willing to serve everybody in the community?"

Questions that might disqualify a potential partner might be similar questions, again based on the specific priority and goals of a given community. Keep in mind that some of the items in this category might be subject to negotiation – something that should be asked.

The first two categories of questions are the important ones that should be used to qualify and rank potential partners. Other less critical questions are important, but probably don't get considered unless it's close between two candidates. You choose a partner based upon the most important aspects of the relationship.

There are several techniques that are used to compile rankings. Most rankings of this sort are done by compiling the rankings by a team of reviewers. The most important questions might get weighted somehow to have the biggest impact on the composite answer. At the end of this process is a numerical answer that reflects the composite opinion of those doing the ranking. It's likely that such rankings are not even the final answer and often the ranking process will send a government back to ask more questions. Since this is not a purchase of service, but a partnership, it's also highly unlikely that it would be mandatory to take the ISP that ranked the best.

Defining the Roles of Each Partner

It's vital to define the specific roles and responsibilities of each partner. Ideally, this should be done before formalizing the partnership arrangement.

CCG has often used a technique that seems to work ideally in defining a partnership. It starts with a list of all of the tasks needed for launching and operating the upcoming broadband business. The level of detail usually become readily apparent. For example, it it's clear that the ISP is going to have 100% of the interactions with customers, then having a task called "Interface with customers" would be sufficient rather than listing all of the various ways that somebody might interface with customers.

The items on the list would include financial and other contributions as discussed earlier, issues having to do with construction the new network, issues having to do with governance, issues having to do with operating the business.

A responsibility must be assigned for each task on the list. The choices for each task are 1) the task is the responsibility of the government, 2) the task is the responsibility of the ISP, 3) the task is a joint responsibility of both parties (in which case that needs to be fully described), or 4) the task is the responsibility of some third party (like an outsourced arrangement). This kind of process quickly shows if the two parties are aligned and agree on all of the responsibilities and if there are tasks where the two sides have a different view. The example used earlier involved setting of rates – this is a good way to get it in writing from both parties about the roles in setting rates.

Making this list serves two purposes. It's a great tool for getting both parties to acknowledge the specific roles of each partner. It also then serves as a great template for developing a contract between the partners.

Maintaining Local Control

The RFP for the project asks how a community can maintain local control to insure long-term responsiveness to local needs. This is one of the most challenging aspects of a partnership. The following issues all have bearing on the level of control a municipality might have for an ongoing broadband business.

Before answering the question, I would challenge a municipality to make a list of items they would like to have some control over. It's likely that a list will include major aspects of operating the business such as rates, installation intervals, business hours, priorities of repairing customers after an outage, etc. I then ask the municipality to change hats and look at these same issues from their perspective of the ISP, who is trying to run a profitable business. This exercise often highlights requests for control that are unreasonable.

One of the stories I tell about politics and the broadband business concerns Bristol Virginia Utilities, which was one of the first cities to enter the broadband business. The business was operated by the electric utility, which was a branch of the local government, but which had a full standalone operating authority. The bonds were fully backed by the electric utility, but since the city had to approve any bond issue, the city reserved the right to set and approve rates. A few years after launching the business, and during an election year, the city council voted to slash all the rates by 15%. The utility warned them this would put the business underwater, and sure enough they were unable to meet a bond payment due six months later. The city got the message and ended up raising the rates to a higher level than the original rates to correct the shortfall, and the city also changed their ordinances so that no future city council could change rates.

There are numerous other examples of negative ways that local governments have meddled in a broadband business. Politicians might make promises to constituents on behalf of the ISP. Politicians often press to give special rates to friends or to forgive bad debts for a constituent. It's not unusual for politicians to go further and interfere in things like personnel decisions. It's incredibly important to have clearly defined boundaries and lines so that an ISP can say no to meddling.

ISPs are highly wary of ceding any control to a government entity. ISPs fully comprehend that a partnership with a municipality is always tentative and can change drastically after an election. There are plenty of examples of a council or board that changed from pro-broadband utility to anti after an election. Political changes can put a huge strain on the business relationship even if there are no control issues. ISPs know that the municipality they partner with today may not be the same in the future.

This is not to say that a municipality shouldn't have any control over the business. One of the more obvious aspects to maintaining control depends upon who funds the network. A municipality is going to get little or no say in how to operate a network that includes significant funding from a commercial ISP. If an ISP brings money to a project, they generally will not take the risk of letting a municipality tell them how to operate the business – since the ISPs primary goal will be in getting a good return on their investment.

But even funding doesn't always determine control. Many ISPs will only partner if they get to make all the business decisions – even if the government funded the network. This is why potential partners need to ask all of these questions before they create the partnership.

The only sure-fire way for a municipality to have control is to fund and operate the network. It's going to be difficult to find an ISP partner that will want a city to influence business decisions once the business is operating. This is a case where a little authority is a bad thing. If a municipality has any authority to control the business, then eventually somebody at municipality will go too far, either today or in the future as the government changes.

C. Our Recommendations / Strategic Plan

Following is a long list of recommendations that come from our analysis of the broadband landscape in Sierra County. This is one of the longest lists of recommendations that we've ever made, but that is driven by the fact that the County has a bigger broadband gap than any other place we've worked. You don't have to go very far outside Truth or Consequences or Elephant Butte 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 that Sierra County 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.

Set A Broadband Goal

It's hard to focus the public on broadband unless the Sierra County government has set a clear broadband goal for the County. We strongly recommend that the County government adopt a clear and easy-to-understand broadband goal. This will provide for a focal point when talking about broadband. We've seen many different goals established by counties. Here are a few examples:

- Every student should have broadband adequate to let them do online homework.
- Every household should be connected with broadband of at least X speed. (We've seen these goals set at different speeds such as 25/3 Mbps which is the FCC's definition of broadband to 100 Mbps.
- No home that wants or need broadband should be without it.

Any goal that's set should then become part of the daily conversation within the County government. The goals should be repeated often to state and federal legislators. The goal should be mentioned to the public often. It might sound trite, but one of the ways to find a broadband solution is to always be talking about it in public. This shows that broadband is a priority and that can be a big step towards activating the public to help find solutions. We've seen that a county government that constantly talks about better broadband has a better chance of attracting an ISP than a county that never mentions it.

Identify Staffing Resources

If Sierra County is going to seriously pursue the recommendations made in this report, you're going to need staff resources to tackle many of the tasks. Finding a broadband solution takes a focused and persistent effort, so it's important to identify staffing for pursuing broadband and to fund the effort required. We've seen many efforts to get broadband fizzle when nobody was dedicated to the community engagement tasks. 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.

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 only priority. This one person met with everybody imaginable in the county including city governments, county governments, state representatives, and every civic and social group imaginable. After two years of tireless effort the county found a broadband solution. This would never have happened without this one dedicated staff position.

- Volunteers. Volunteers are also 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. In the example given above of the Minnesota county, the one staffer assembled a group of active volunteers who helped with the effort to engage 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. The County need to be prepared to fund efforts that the volunteers think are needed. In the case of the Minnesota county, the volunteers engaged in several rounds of postcard mailings asking homeowners to pledge support for broadband.

- 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 generally is 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 County government 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.

Reach out to Potential ISP Partners

We always recommend that the first step after undertaking this kind of study is to reach out to potential ISP partners. That begins by sharing the results of this study. ISPs will be interested in much of the research we've done. ISPs that have not undertaking any engineering analysis in Sierra County will be interested

in the network cost estimates calculated by Finley Engineering. ISPs that haven't created financial business plans will be interested in the financial analysis that demonstrates how well they might perform in Sierra County.

It's rare for counties in the US to become ISPs and we can't think of a single example of a county that has decided to build and operate a municipal fiber network. The preferred business plan is to attract one or more ISPs to bring broadband. I like to use the example of Cortez, Colorado, which is near Four Corners. The city is geographically isolated and didn't have any local ISPs interested in tackling bringing better broadband. The city issued an RFI and got four serious responses from ISPs located elsewhere, including one as far away as Nebraska. It's possible for Sierra County to attract ISPs interested in coming to the county. This is aided hopefully by the availability of grants to help them build a broadband solution.

We should that it might be difficult to find an ISP willing to serve all of Sierra County. As can be seen by the engineering and financial analysis in this report that is an expensive undertaking. What we most normally see are ISPs that tackle some corner of a county first. If you don't find a solution for everywhere, then Sierra County will have to keep working to find solutions for the remaining areas that are not served. It would not be surprising for it to take many years to find a broadband solution for everybody in any rural county, and Sierra County is no exception.

Sometimes the potential ISPs that are interested in a given county are obvious, and most broadband solutions come from local ISPs. However, we have been surprised at times when an ISP comes to a county that is not local, so Sierra County might want to consider a wider search for ISPs. There is a more thorough discussion of this process in Section IV.B. of this report.

Offer to Help Quantify Market Demand. One of the most important ways that a community can help attract ISPs is to help them understand the potential for operating a successful broadband business in the area. The biggest concern that every ISP has about a new market is knowing if they can get enough customers to be successful. Rural areas differ widely in the willingness of people to subscribe to broadband. We've worked in rural communities in just the last few years where the demand for broadband varied between 60% and nearly 90% - and it's vital for an ISP to understand where your communities fall within that wide range.

We've seen local governments undertake research to help ISPs understand the market better. There are several techniques that communities have used to understand market demand:

> Statistically Valid Surveys. The goal for doing a residential survey is to be able to predict the most likely range of customer broadband penetration should somebody build a broadband network. We've found over the years that if a survey is conducted in a way to be statistically valid that the results provide a good prediction of the likely customer penetration rates.
>
> 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.

Surveys have gotten a bad name due to political surveys. There are several reasons that a political survey can produce different results than what are seen in an election. The primary reason is that respondents might not truthfully answer all of the questions for many different reasons. We've found that we don't see this kind of bias in broadband surveys because the topic doesn't trigger emotional responses – folks generally tell the truth about the topic.

The last factor to consider is a phenomenon called survey fatigue. If the survey asks too many questions or takes too long, then a lot of people will hang up in the middle of the survey. In ideal survey is done in 5 minutes, and no longer than 10 minutes.

There are only two ways to conduct a statistically valid survey of a whole community – either by knocking on doors or by telephone. The effort required to knock on doors is massive, especially in a rural area. You'd have to go to homes randomly, meaning hitting all corners of the rural areas. You have to knock on door of all types from the smallest poorest home to the mansions.

It's far easier to administer the survey by telephone, but makes no sense these days to do a telephone survey using the white pages and calling just landlines. We know that the households keeping landlines are older and more conservative and their responses on a survey probably don't represent all households in an area. A valid telephone survey needs a list of telephone numbers that includes cellphone numbers.

Canvass. If you can't get the needed list of phone numbers, the next best approach is to tackle a canvass. In a canvass, you try to reach everybody, and since a canvass isn't random, you need to gather considerably more completed responses. Ideally, you'd want to get 25% of homes to participate in a canvass – a big challenge. Canvasses can be done in several ways. This can include online surveys, although this exclude homes with no broadband. You can mail surveys. You can engage groups like the PTA and other volunteer organizations to circulate canvasses.

Pledge-Card Drives. A more specific form of a canvass is a direct question if a household would buy broadband if a new network were built to them. A pledge card drive works best when you can cite specific products and prices. For instance, if an ISP was partnering with a county to come to a certain area, then naming that ISP and disclosing their products and prices provides a more believable response. We've seen communities do pledge card drives and then see more than 95% of homes that said they would buy broadband actually buy it when it became available.

Review County / City Policies Related to Fiber Construction. One of the other factors that worry ISPs is that there will be local rules, ordinances, and processes that will slow down the construction process and add cost to the fiber construction process.

Sierra County and the various cities and towns in 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 a new ISP should also then apply to the incumbent ISPs operating in the County. Some of the areas that should be investigated include:

- 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 is following 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.

It's likely that different parts of the county have different local rules governing these kinds of tasks. We always recommend that the various local governments get together to review any such requirements, with the goal of modifying ordinance or processes that would hinder fiber construction. The localities want to make it was easy as possible to build fiber.

Be Prepared to Support Grant Filings. Most state or federal grant programs require a showing of local community support. Sierra County should be prepared to help an ISP partner by gathering government, resident, and business support for the grant applications. This means soliciting as many letters as possible to support a fiber grant.

We've seen counties go even further – for example, we've seen counties that have undertaken a local pledge drive to gather large number of signatures supporting a fiber project.

Educating the Public

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 the 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 that are looking for broadband solutions 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.
- 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 – this could be one of the tasks assigned to a Broadband Task Force or given to willing volunteers.

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 century 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 be 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 Sierra County. This includes:

- The Governor's Broadband for Education[16] 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[17] to leverage federal grant dollars to help support rural healthcare facilities.

Be Prepared to Challenge the Lousy FCC Maps

One of the most effective ways Sierra County can help to close the availability gap is by challenging the lousy FCC broadband maps. Much of Sierra County is not currently eligible for broadband grants due to the errors in the FCC maps. There are also rural areas where the FCC awarded grant money to Viasat to provide satellite broadband that are not eligible for other federal grants.

[16] http://www.broadband4education.nm.gov/
[17] http://www.nmtelehealth.org/

The state government in New Mexico has done enough work in the last few years that they understand that the FCC maps are terrible and that the maps are hurting funding of broadband in the state. It doesn't look like they've made much headway in helping counties develop your own broadband maps.

There are only two ways to challenge the broadband maps. One way is to have an experienced field engineer look at existing broadband deployments around Sierra County. We undertook that effort as part of this broadband study with Andy Heins of Finley Engineering. An experienced field engineer can drive around and can identify every broadband asset in the field. They can precisely identify where the cable TV networks end, down to the house. They can identify field DSLAMs that generate DSL signals out of rural cabinets – and they can often precisely identify the flavor of DSL and know the maximum speed capability of a given unit. They can identify the location and height of wireless transmitters and can map out the likely wireless coverage areas. We used this effort to create what we think is a good broadband map of Sierra County. This kind of engineering effort is also effective at identifying areas where there is no broadband – there is no broadband where the incumbents have not built the needed infrastructure. Andy and Finley have provided information in this report than can be used to challenge broadband coverage claimed by the incumbents.

The only other effective way to challenge the FCC maps is with significant numbers of speed tests. As part of this study we created a speed test site for Sierra County that you've added to your web site. In the short time allotted to this study we obtained some speed test results, but not enough to mount challenges to the FCC mapping data. We strongly recommend that the County build upon the effort we started and continue to collect speed test data – you really can't gather too much data in this case. You should use whatever methods you have available to ask citizens to take the test – while making sure the understand that this is an important step towards finding the funding needed to bring a broadband solution. We know of counties and towns that have convinced a significant portion of their citizens to take the tests.

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 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.[18] 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

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

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 periodically map the results. We've mapped the result from the speed tests obtained during this study period, but these are not enough results to make a definitive map. The map created by Andy Heins is far more accurate for now. But over time, with enough speed test results you'll paint a detailed picture of the real broadband coverage in Sierra 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. For example, they might find a few homes in the database that are not their customers and then claim that all the results are invalid. Speed test results that are ultra-precise also violate the privacy of the people taking the speed tests. There is nothing wrong in knowing the results precisely, but when you map them, you'll want to somehow embed the data into pdf files to disguise the identify of each specific speed test. If you are concerned about having the identity of citizens in the data, you could have the results collected by a third party that doesn't disclose the details to you. That's worth considering anyhow since it's a lot of work for county employees to monitor and occasionally map the speed test results. We can suggest several solutions if you want to continue to speed efforts and want to outsource the mapping effort.

- There is value in collecting speed tests even where there is broadband. It's never a bad idea, for example, to collect data on TDS's performance in Truth or Consequences. Such data can tell you if their broadband is fast as they are marketing. It can also identify if some neighborhoods have worse broadband than others. And over time it can identify new problems in the network.

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 Sierra 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

Any ISPs that are going to bring broadband to Sierra County are going to pursue the big federal broadband grant programs to help fund the network.

However, Sierra County should pursue other kinds of grants that can help solve the various broadband gaps. There are numerous grants available from government agencies and from private foundations that could be used for such issues as getting more computers into homes with students, and technical assistance for businesses to better use the broadband they have today and to take the best advantage if better broadband is available.

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.

Consider Providing Technical Assistance for Businesses

We encountered businesses that were having problems with issues for which there are likely workable technical solutions today. As an example, we talked to several rural businesses that have problems with consistently being able to process credit card payments. There are other businesses that would benefit by having somebody help them maximize the use of the broadband that is available in Sierra County today. The County might want to consider identifying local technical resources that could assist business with broadband and connectivity issues. There are likely grants that could be used to help to fund such an effort, although at least some of the costs should be borne by businesses that receive assistance.

Push the Incumbents to do Better

This sounds like a bit of a lame suggestion, but we've seen cases where this has worked. For example, it might be possible to convince TDS to extend their network past the existing network boundaries to add more households. It's also possible that TDS could bring broadband to some other parts of Sierra County if suitable middle-mile fiber is made available. These suggestions are generic and not intended to put TDS on the spot – but rather to remind the County that one of the incumbents could become your best partner.

For example, we know of rural cities that helped the incumbent cable companies get grants to build to lesser populated areas of the county. Grants can change the math and make building network to less densely populated areas more attractive – and it might be something the incumbent haven't considered.

Tackle the Affordability Gap

This is probably the hardest gap to solve. Broadband is priced too expensively for many homes, and affordability efforts look for ways to bring less expensive broadband to the homes that most need it.

<u>Inform the Public About Available Programs from Incumbents</u>

Both local telcos – CenturyLink and Windstream - 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.

Sierra County could undertake an education campaign to notify citizens about these plans. This would mean that the County needs to fully understand the details of each plan – who qualifies and what documentation does a home need to enroll. Armed with that knowledge Sierra Cunty could mount an education campaign to get more subsidized broadband into homes that need it.

TDS might have a similar program, and it not, the County should lobby them to create one. TDS supports such programs where they are a telephone incumbent.

<u>Find Broadband Solutions for Public Housing</u>

Many communities have found ways to bring broadband to public housing. A common model is to buy one high-speed connection to the public housing complex and then use WiFi to distribute broadband to

individual living units. Such connections often include low-cost or even free connections from local ISPs as a public service.

There is one national nonprofit that concentrates on this effort. ConnectHomeUSA[19] 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.[20] 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 was discussed above which is to provide portable WiFi hotspots that are distributed from libraries. Mobile Beacon has 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.

An interesting study[21] 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.
- 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.

Bridging the Broadband Skills Gap

Even if better broadband becomes available 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.

[19] https://connecthomeusa.org/

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

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

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's clear that Sierra County has a huge homework gap – homes with students without good broadband or homes without computers. The COVID-19 crisis showed that the county needs 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, Sierra County would need 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.

One such program is the nonprofit E2D[22] (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

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

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.

The whole concept got started in 2012 when 12-year-old Franny Millen asked her father how kids without computers can keep up with schoolwork. She wanted to know what could be done about the problem and resolved to fix it. Her father, Pat Millen, founded E2D as a result of her challenge.

Another organization that works nationwide to fund computers is Minneapolis-based nonprofit PCs for People[23]. They provide PCs to households that need them and work with other entities including Mobile Beacon and E2D.

Sierra County, or 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. Sierra County can 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. Sierra County can start this process by extending the WiFi at County 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.

Consider the Possibility of Providing Some County Funding

The financial analysis shows that any broadband solution is going to require significant grant funding. Sierra County should consider contributing funding for the right opportunity. Even a small amount of County-provided grant funding might impress other grant programs that the you are serious about finding a broadband solution.

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

We've also seen relatively small local grants make a huge difference when ISPs are seeking large federal grants. For example, some federal grants award extra points for having local participation, and nothing demonstrates local desire for broadband more than the local government providing some funding for a project.

It's worth noting that counties around the country are stepping up in trying to find a broadband solution. Minnesota has had a state grant program for 5 years and many counties in the state are pledging local grants to those that win state grants. These county grants range from a few hundred thousand dollars to as much as six million dollars being offered by two counties in the state. These are not rich counties and they will have to bond and borrow to support the grants. The citizens of these counties have made it clear that they are willing to increase taxes to fund better broadband. It's always a big challenge for a county to find this kind of grant money – county governments tend to be relatively low in cash and borrowing capacity. But when a county does this it can be extremely effective and give Sierra County an edge over other counties in the state who are also competing for ISP partnerships and federal grants.

Be Persistent

It's the rare county where one ISP comes forward and provides a broadband solution for the whole county. That means that even if Sierra County finds a partial broadband solution that you're not done, and you'll need to continue with the above tasks until everybody in Sierra County has broadband.

EXHIBIT I: SERVICE AREAS OF THE INCUMBENT TELEPHONE COMPANIES

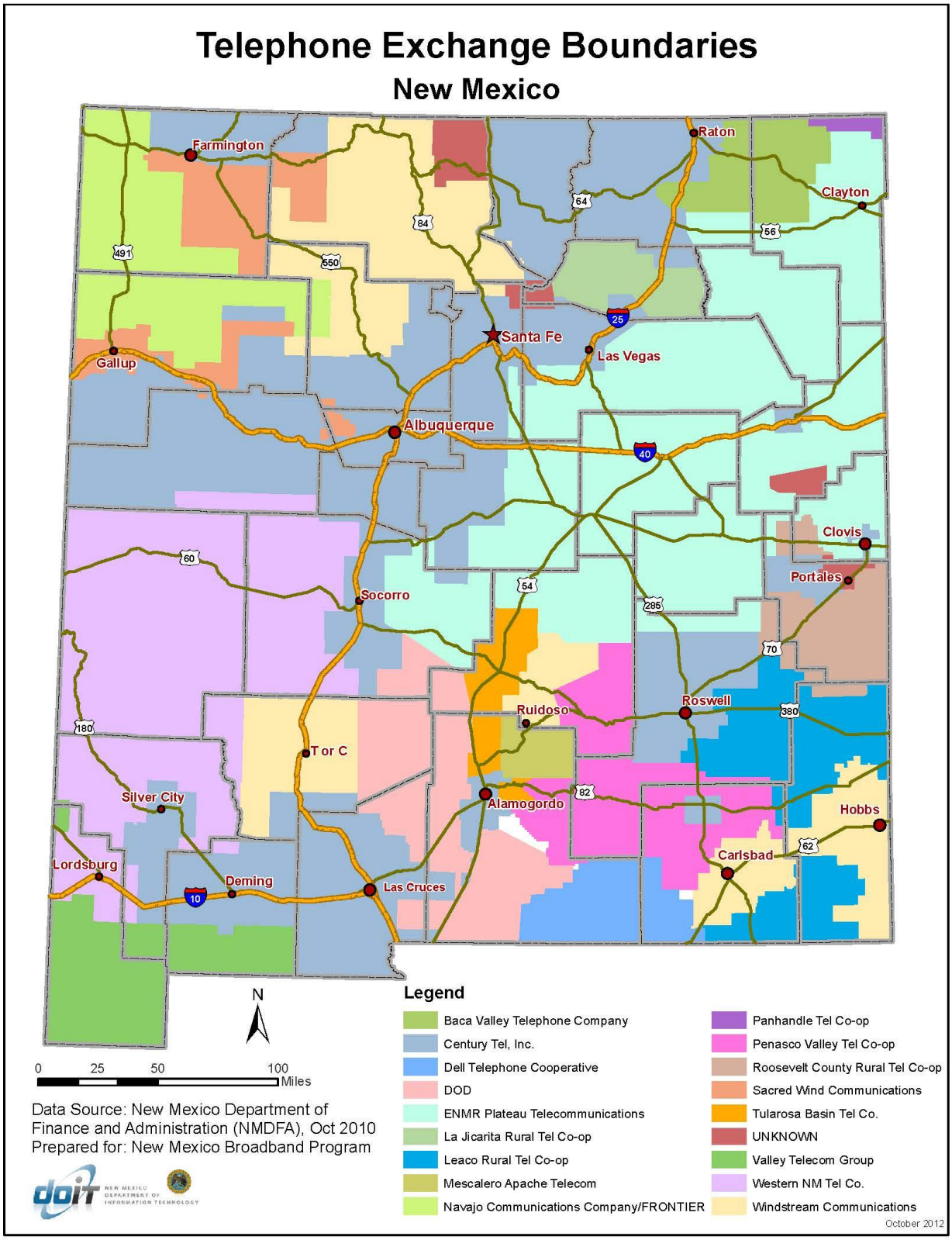


EXHIBIT II: SUMMARY OF FINANCIAL RESULTS

		Assets	Take Rate	Fiber Passings	Debt	Equity	Grant	Total Financing	Cash End of Loan	Net Income Positive	Cover Debt
	Rural County										
1	**No Grant**	$25.57 M	70%	2,925	$25.43 M	$4.49 M		$29.91 M	-$24.46 M	Never	Never
2	**Breakeven Grant**	$25.57 M	70%	2,925	$ 7.83 M	$1.38 M	$17.22 M	$26.42 M	$ 1.07 M	Never	Year 22
3	**Breakeven + Bond Financing**	$25.57 M	70%	2,925	$10.60 M		$17.22 M	$27.82 M	$ 1.03 M	Never	Year 24
4	**No Equity**	$25.57 M	70%	2,925	$ 9.53 M		$17.22 M	$26.74 M	N / A	Never	Never
5	**Higher Prices**	$25.57 M	70%	2,925	$ 7.60 M	$1.34 M	$17.22 M	$26.16 M	$ 4.77 M	Never	Year 17
6	**5% Higher Penetration**	$25.81 M	75%	2,925	$ 7.85 M	$1.39 M	$17.22 M	$26.45 M	$ 3.98 M	Never	Year 18
7	**Lower Interest Rate**	$25.57 M	70%	2,925	$ 7.70 M	$1.36 M	$17.22 M	$26.27 M	$ 1.77 M	Never	Year 21
8	**25-Year Loan Term**	$25.57 M	70%	2,925	$ 7.73 M	$1.36 M	$17.22 M	$26.30 M	$ 0.79 M	Never	Year 24
9	**5% Contingency**	$26.71 M	70%	2,925	$ 8.75 M	$1.54 M	$17.22 M	$27.51 M	N / A	Never	Never
10	**10% Higher Penetration**	$26.06 M	80%	2,925	$ 7.88 M	$1.39 M	$17.22 M	$26.48 M	$ 6.75 M	Never	Year 15
11	**Breakeven Grant for Line 10**	$26.06 M	80%	2,925	$10.48 M	$1.85 M	$14.67 M	$26.99 M	$ 2.25 M	Never	Year 22
	Two Cities										
12	**Base**	$18.44 M	50%	6,202	$16.88 M	$ 2.98 M		$19.85 M	$ 9.14 M	Year 5	Year 19
13	**Higher Prices**	$18.44 M	50%	6,202	$16.53 M	$ 2.92 M		$19.44 M	$13.06 M	Year 5	Year 17
15	**Higher Interest Rate**	$18.44 M	55%	6,202	$17.13 M	$ 3.02 M		$20.15 M	$ 8.07 M	Year 6	Year 20
16	**15-Year Loan Term**	$18.44 M	50%	6,202	$16.20 M	$ 2.86 M		$19.06 M	$ 8.61 M	Year 5	Year 19
17	**5% Contingency**	$18.97 M	50%	6,202	$17.43 M	$ 3.08 M		$20.50 M	$ 8.39 M	Year 5	Year 19
18	**Breakeven Penetration**	$18.04 M	45%	6,202	$16.65 M	$ 2.94 M		$19.59 M	$ 4.86 M	Year 6	Year 21

Total County

15	**No Grant**	$43.86 M	50% / 70%	9,127	$41.15 M	$ 7.26 M		$48.41 M	-$11.49 M	Never	Never
16	**Breakeven Grant**	$43.86 M	50% / 70%	9,127	$27.80 M	$ 4.91 M	$13.07 M	$45.77 M	$ 8.28 M	Year 13	Year 22
17	**Higher Prices**	$43.86 M	50% / 70%	9,127	$27.23 M	$ 4.80 M	$13.07 M	$45.10 M	$16.56 M	Year 9	Year 19
18	**Lower Interest Rate**	$43.86 M	50% / 70%	9,127	$27.38 M	$ 4.83 M	$13.07 M	$45.27 M	$10.76 M	Year 13	Year 21
19	**25-Year Loan Term**	$43.86 M	50% / 70%	9,127	$27.48 M	$ 4.85 M	$13.07 M	$45.39 M	$ 7.19 M	Year 13	Year 23
21	**5% Contingency**	$45.29 M	50% / 70%	9,127	$29.25 M	$ 5.16 M	$13.07 M	$47.48 M	N/A	Never	Never
22	**5% Higher Penetration**	$44.50 M	55% / 75%	9,127	$27.88 M	$ 4.92 M	$13.07 M	$45.86 M	$16.34 M	Year 9	Year 19
23	**Breakeven Grant for Line**	$44.50 M	55% / 75%	9,127	$32.53 M	$ 5.70 M	$ 8.73 M	$46.76 M	$ 9.62 M	Year 13	Year 22
24	**10% Higher Penetration**	$45.14 M	60% / 80%	9,127	$27.88 M	$ 4.92 M	$13.07 M	$45.86 M	$22.94 M	Year 6	Year 17
25	**Breakeven Grant for Line**	$45.14 M	60% / 80%	9,127	$36.58 M	$ 6.45 M	$ 4.57 M	$47.60 M	$10.30 M	Year 9	Year 22