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Broadband Feasibility Study

Prepared for:

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1 EXECUTIVE SUMMARY

Broadband networks, while once an emerging technology and luxury service, today can be looked at as the 4th utility alongside water, gas, and electricity[1]. It is critical to the functionality of everyday needs, providing access to information, increasing home safety, and enhancing the overall quality of life. It is also still a technology, evolving in its form and function and inspiring innovation in its application as a foundational aspect of other technological advancements.

The Coronavirus Pandemic and Winter Storm Uri highlighted the necessity for online/remote interaction and generated a sense of urgency to enhance access to this critical infrastructure for millions of Americans, especially in communities experiencing high growth rates and transitioning from rural to urban areas like Fort Bend County. With this understanding and the goal to improve access to reliable, available and affordable high-speed broadband internet services, Fort Bend County officials decided to develop a Broadband Feasibility Study. This study aims to identify the broadband needs and gaps within the County and provide a high-level design and strategy, with associated cost estimates, to demonstrate a potential broadband infrastructure build plan which can be implemented through federal grant programs and partnerships.

Given the critical nature of this infrastructure and the reality that broadband networks have not been equally nor adequately deployed across communities, there has been a historic investment of funding from Federal, State, and Local levels in addressing the issues to close the digital divide and promote digital equity. The Infrastructure Investment and Jobs Act (IIJA) has prioritized broadband infrastructure allocating $65 billion in federal funds to be administered across several federal agencies working on broadband deployment. Of the total allocation, $45 billion will be administered by the National Telecommunications and Information Administration (NTIA) through the "Internet for All" programs to provide affordable, reliable high-speed internet to every American across the country[2].

These federal agencies developed standards for determining adequate broadband access and therefore associated eligibility for funding. Unserved areas are considered anywhere receiving below 25 Mbps download and 3 Mbps upload speeds followed by Underserved areas being anywhere with speeds below 100 Mbps download and 20 Mbps upload. Community anchor institutions should have speeds of at least 1 Gbps symmetrical (1/1 Gbps). CobbFendley's base recommendation for this Broadband Improvement Initiative is a network solution that meets or exceeds a minimum of 100Mbps symmetrical (100 /100Mbps) speed for residential service.

The proposed network design seeks to construct Middle-Mile infrastructure to provide adequate capacity for Last-Mile connectivity. Our analysis shows that the main fiber backbone and distribution, once built, will allow for network infrastructure to reach Unserved and Underserved communities, paving the way to incentivize internet service providers with a less costly Last-Mile build. This solution suggests the application for several grants and promotes partnerships with private sector providers who have a vested interest within this region. Construction of the proposed network infrastructure is recommended to be completed in phases, aligning with grant funding timelines with consideration for densification and prioritization of needs.

The benefits to be realized from investing in this infrastructure will have immediate and long-term effects on Fort Bend County. From a workforce and economic development perspective, there will be immediate job opportunities for the construction, operations, and maintenance of the network expansion, as well as the opportunities for economic development with increased access and reliability of high-speed internet. For the long-term, investing in this infrastructure is a key component to future-proofing the County to be able to expand its digital transformation footprint, promote growth throughout the County and provide foundational critical access for the residents of Fort Bend County to enhance their overall quality of life.

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[1] Rethinking the Fourth Utility Connectivity Conundrum. Bbcmag.com. https://www.bbcmag.com/multifamily-broadband/rethinking-the-fourth-utility-connectivity-conundrum. Published 2022. Accessed June 1, 2022.

[2] Biden-Harris Administration Launches $45 Billion "Internet for All" Initiative to Bring Affordable, Reliable High-Speed Internet to Everyone in America. U.S. Department of Commerce. https://www.commerce.gov/news/press-releases/2022/05/biden-harris-administration-launches-45-billion-internet-all-initiative. Published 2022. Accessed June 1, 2022.

2 VISION

The vision for the County-wide broadband solution includes the following three major elements:

- Addressing the digital divide by implementing solutions to create robust broadband access and enhance digital equity.
- Constructing Middle-Mile infrastructure to incentivize service providers to build affordable Last-Mile connectivity in Underserved areas, increasing the overall broadband coverage, and providing more options for broadband services and applications for residents and stakeholders alike.
- Connecting public facilities and critical infrastructure, and supporting public services, with a reliable, secure, and modernized broadband network.

3 STUDY ORIGIN AND OVERVIEW

The Broadband Feasibility Study was developed in three stages with constant communication between the consultant team and County staff. An initial presentation was given in November 2021 to discuss the study development and the consultant team also presented at the Mayor and Council Dinner on April 28th 2022, discussing the status of the project and promoting engagement for the public survey and speed test. Throughout the study key County staff and officials met to review the study findings, High Level Design (HLD) recommendations, and explore options the County could exercise towards implementation.

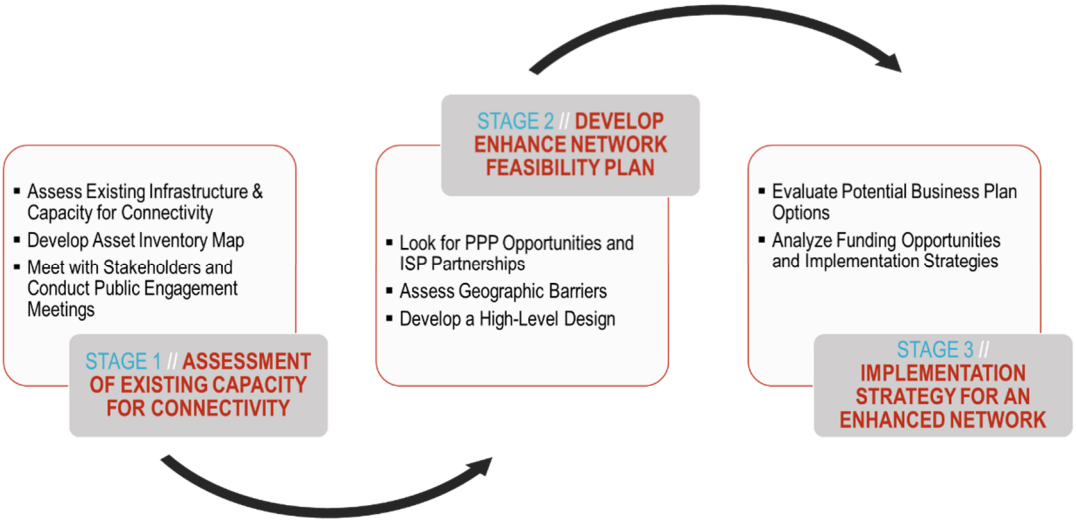

Figure 1: Broadband Improvement Initiative Workflow Process

4 RECOMMENDATIONS

As a concluding element of Phase I: Broadband Feasibility Study, CobbFendley has developed several recommendations for the County to consider moving towards implementation in Phase II of the Broadband Improvement Initiative. Our recommendations are as follows:

1. **Conduct Preliminary Engineering of the High-Level Design for Middle-Mile:** A HLD was developed as a part of the Broadband Feasibility Study, presenting the necessary network infrastructure required, based on an understanding of the access and capacity needs, to establish high-speed broadband connectivity across the County. Our recommended Middle Mile-focused design utilizes fiber-optic transport and distribution to existing and proposed fixed wireless tower sites, and we believe this converged architecture will minimize the level of effort and costs associated with Last-Mile connections while maximizing the coverage and access for residents. We recommended simplified fiber routing along TxDOT roadways reducing external environmental factors such as jurisdictional permitting and timelines while maintaining design considerations that ensure future-proof capacity and redundancy in a ring-based topology. Limited to a HLD in the Feasibility

Study scope, there are additional details and further network architecture and topology considerations that need to be explored by concluding the study and through evaluation, selection, and collaboration with a private partner(s). The initial design recommendations and associated cost-estimates in the study should be further refined with input from specific providers that are willing and able to implement the network. Through this refinement with partners, further design and cost estimations can be performed providing the necessary detail required for grant application and implementation. The preliminary engineering activities for this effort would include:

- Conducting a detailed route analysis to review network architectures, topology, routing, constructability, sustainability, fiber, and conduit capacity.
- Conducting a detailed jurisdictional analysis identifying the permits required for implementation.
- Evaluating material and labor specifications for major line-item materials required for construction and assisting in procurement discussions.
- Developing a detailed engineering schedule and cost estimate for detailed design and permitting.

2. **Distribute a Request for Information (RFI) to identify potential Public-Private Partnerships (PPP)):** AfterPhase I: Broadband Feasibility Study, a recommendation is to move into Phase II: Engineering and Implementation to work with providers and broadband services partners to determine the optimal network build and structure of a public/private partnership (PPP) to apply for funding for implementation. There is a range of providers operating within Fort Bend County currently, with several others seeking to invest in the near term. An RFI process will enable the County to further explore applicable business models and expand on potential PPP contract structure and terms, allowing for a well-informed determination by the County on partner selection and implementation plans. The goals of the RFI would be to:
   - Evaluate the potential for developing public/private partnerships with providers and broadband services partners.
   - Evaluate the various applicable broadband solutions presented in relation to the Study findings and recommendations based on the existing conditions in Fort Bend County.
   - Understand the financial model structure and overall costs for the project(s) and relative share financial risk and benefits within the partnership.
   - Identify Last-Mile providers to be included in a larger Middle-Mile project.

   Evaluation criteria and requirements from potential bidders would include:
   - If a respondent is an internet service provider, they must participate in (or are actively applying to) the Affordable Connectivity Program (ACP).
   - If submitting information for Middle-Mile or Last-Mile, provide evidence of past performance and ability to execute.
   - Ability to supply levels of service in accordance with NTIA requirements for Middle-Mile and Last-Mile.
   - Documentation of existing assets in and around the County, preferably in relation to updated Fixed Broadband Deployment Data for FCC Form 477.
   - Documentation of any funding applied for in and around the County.

3. **Apply for Competitive Funding Sources for Implementation:** The IIJA provides an unprecedented amount of funding for municipal infrastructure projects that impact our daily lives including specific funding sources for expanding broadband access across the Country. An in-depth analysis of the various funding sources that can be utilized for broadband infrastructure can be found in Section 7- Funding Analysis including three key programs for Fort Bend County to consider:

Table 1: Competitive Funding Sources for Implementation

Grant Program	Funding Agency	Description	Timeline	Total Allocation
Middle-Mile Grant Program[3]	National Telecommunications and Information Administration (NTIA)	National awards will be issued on a technology-neutral, competitive basis to eligible entities for the construction, improvement, or acquisition of Middle-Mile infrastructure.	Sept. 30, 2022	$1 Billion
Capital Projects Fund[4]	American Rescue Plan Act (ARPA)	For payments to states, territories, and tribal governments to complete capital projects directly enabling work, education, and health monitoring, including remote options, in response to the public health emergency	Sept. 24, 2022 (State to submit plan)	$10 Billion, ($500 Million to Texas)
Broadband Equity, Access, And Deployment (BEAD) Program[5]	National Telecommunications and Information Administration (NTIA)	Through state allocation and planning, this program intends to expand high-speed internet access by funding planning, infrastructure deployment, and adoption programs.	Spring 2023	$42.5 Billion

The consultant team would like to thank County officials, community stakeholders and the Fort Bend County IT Department that lead this initiative, providing input and guidance throughout the process.

5 ABOUT COBBFENDLEY

CobbFendley is a civil engineering and surveying firm with expertise in providing planning and design services related to communications infrastructure. Now in its 41st year of providing broadband consulting to the municipal and private sector, CobbFendley understands the importance of broadband infrastructure and formed an internal Broadband Department to focus on the planning, design, and technology associated with these important projects. The team includes dedicated personnel who have worked with public and private clients to plan, design, and make operational fiber networks that improve the lives of businesses and residents in their communities. CobbFendley supports their clients with leading feasibility studies, business planning/strategy advising, engineering and implementation support services across a full range of functional areas. Clients include existing broadband operators as well as entities considering deploying these systems, with services and expertise covering the full potential of the industry including local telephony, video entertainment, high-speed Internet access, and smart grid systems across a full range of broadband network technologies.

[3] Enabling Middle Mile Broadband Infrastructure Program | Internet for All. Internetforall.gov. https://www.internetforall.gov/program/enabling-middle-mile-broadband-infrastructure-program. Published 2022. Accessed June 1, 2022.
[4] Capital Projects Fund. U.S. Department of Treasury. https://home.treasury.gov/policy-issues/coronavirus/assistance-for-state-local-and-tribal-governments/capital-projects-fund. Published 2022. Accessed June 1, 2022.
[5] Broadband Equity, Access, and Deployment (BEAD) Program | InternetforAll.Internetforall.gov. https://www.internetforall.gov/program/broadband-equity-access-and-deployment-bead-program. Published 2022. Accessed June 1, 2022.

6 CURRENT STATE OF BROADBAND IN FORT BEND COUNTY, TX

Section Highlights

- CURRENT BROADBAND STANDARDS OF 25 MPBPS/ 3 MBPS ARE OUTDATED
- THE RURAL INTERNET OFFERINGS ARE UNDERSERVED IN COMPARISON TO THE URBAN PARTS OF THE COUNTY
- INCUMBENT PROVIDERS DO NOT HAVE COMPREHENSIVE COVERAGE

In Fort Bend County, like much of rural America, access to affordable, reliable high-speed internet is a major concern and negatively impacts the quality of life for residents. Outside of the main population centers, including Katy, Sugarland, Houston, etc., there is an even greater lack of access to even basic broadband networks. Our analysis found that investment in networks, specifically direct fiber or fiber-fed fixed wireless networks, has not occurred consistently throughout the various city and County market areas. With the rurality of population density in the County and the added factor of today's markets; rising inflation, supply chains, and labor markets together make solely private sector investing cost-prohibitive for internet providers. However, with the historic amount of funding being allocated to broadband and synergy with local partners currently investing in infrastructure in the region, these factors can be addressed with a Public-Private Partnership (PPP) approach. To examine how to best propose a new broadband infrastructure for residents and businesses of Fort Bend County, the current conditions must be reviewed in relation to industry standards and the funding eligibility requirements.

In 2015, the FCC set the minimum speeds for broadband to be adequately served at 25/3 Mbps based upon perceived sufficient internet usage at the time and mainly focused on internet browsing, email, and limited streaming media (i.e., primarily download-focused). While in 2015 those levels may have been adequate and may still be for certain households' usage, the rise in videoconferencing and other common applications in recent years has created a need for higher bandwidths for uploads and downloads. For example, at the home of a family of four, if two children are attending classes using Zoom and two adults are using their broadband connections to attend meetings, send e-mail, and do research, their combined required bandwidth could easily exceed the minimum level of broadband service set. Add on the additional bandwidth needs of smart devices and other technologies operating on a household's network, it becomes clear that today's technology dependence requires a higher capacity threshold.

Recognizing this trend in usage, the minimum speed requirements were revised to now define *Unserved* areas as anywhere receiving below 25 Mbps download and 3 Mbps upload speeds followed by *Underserved* areas being areas with speeds below 100 Mbps download and 20 Mbps upload. Community anchor institutions should have speeds of at least 1 Gbps symmetrical (1/1 Gbps). These levels will not only dictate industry standards but are all the benchmarks for funding eligibility. For this study, while 100 Mbps symmetrical is ideal to look at "future-proofing" communities, 100/20 will be the minimum standard used to evaluate the existing data and develop an implementation plan.

Note: When discussing internet speeds, the written form may occasionally be seen in the format of "YxZ" or "Y/Z" where Y is the download speed (typically with units of Mbps), and where Z is the upload speed (also typically with units of Mbps).

6.1 Internet Service in Fort Bend County

The following figures and table depict the available internet services offered in Fort Bend County based on information gathered from ConnectedNation and the FCC's Form 477 data from December 2020 and analyzed based on the level of service standards described above. At the time of the study, 2021 data was not publicly available for analysis. The form 477 data is self-reported by the providers and has several limitations that impact the information represented within existing data sources like ConnectedNation. In the current forms, providers are able to include infrastructure they plan to construct, in addition to already deployed networks. This projection of intended infrastructure leads to potential over-reporting in coverage and therefore does not reflect the actual infrastructure currently in operations. In addition, the level of detail requested by the FCC in the current forms does not require providers to delineate who they provide service to down to each household but instead is reported at the census block level. This can lead to an over-representation of coverage if a provider offers coverage in one section of a census block, then the entire block will show up as served by that level of coverage even if there are households not served by that

provider specifically.

The FCC is aware of the limitations of the current reporting format in the form 477 and in response is currently conducting an overhaul of the mapping system. At the time of this study the FCC is currently conducting a Broadband Data Collection (BDC) program to give the FCC, industry, state, local and Tribal government entities, and the general public the tools needed to improve the accuracy of existing maps.[6] During the BDC process will be opportunities for providers and the public to provide feedback to the data presented with the goal of having granular data maps that accurately reflect the broadband coverage across the Country. Given, these updated maps are not complete at the time of this study, the previous limitations discussed should be taken into consideration when reviewing the data of this study.

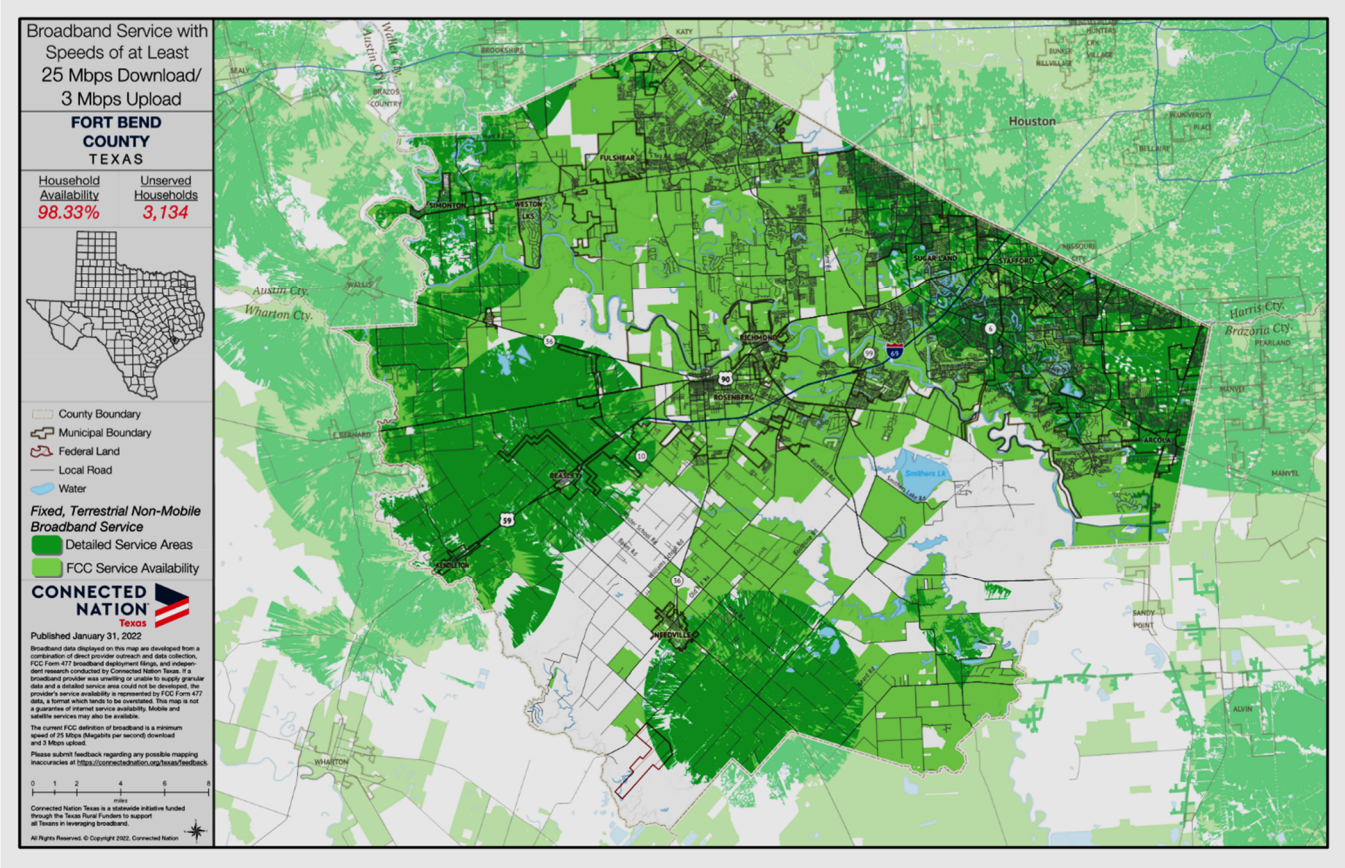

Figure 2: ConnectedNation Showing 25 Mbps/ 3 Mbps Coverage in Fort Bend County

[6] Broadband Data Collection. Federal Communications Commission. https://www.fcc.gov/BroadbandData. Published 2022. Accessed June 1, 2022.

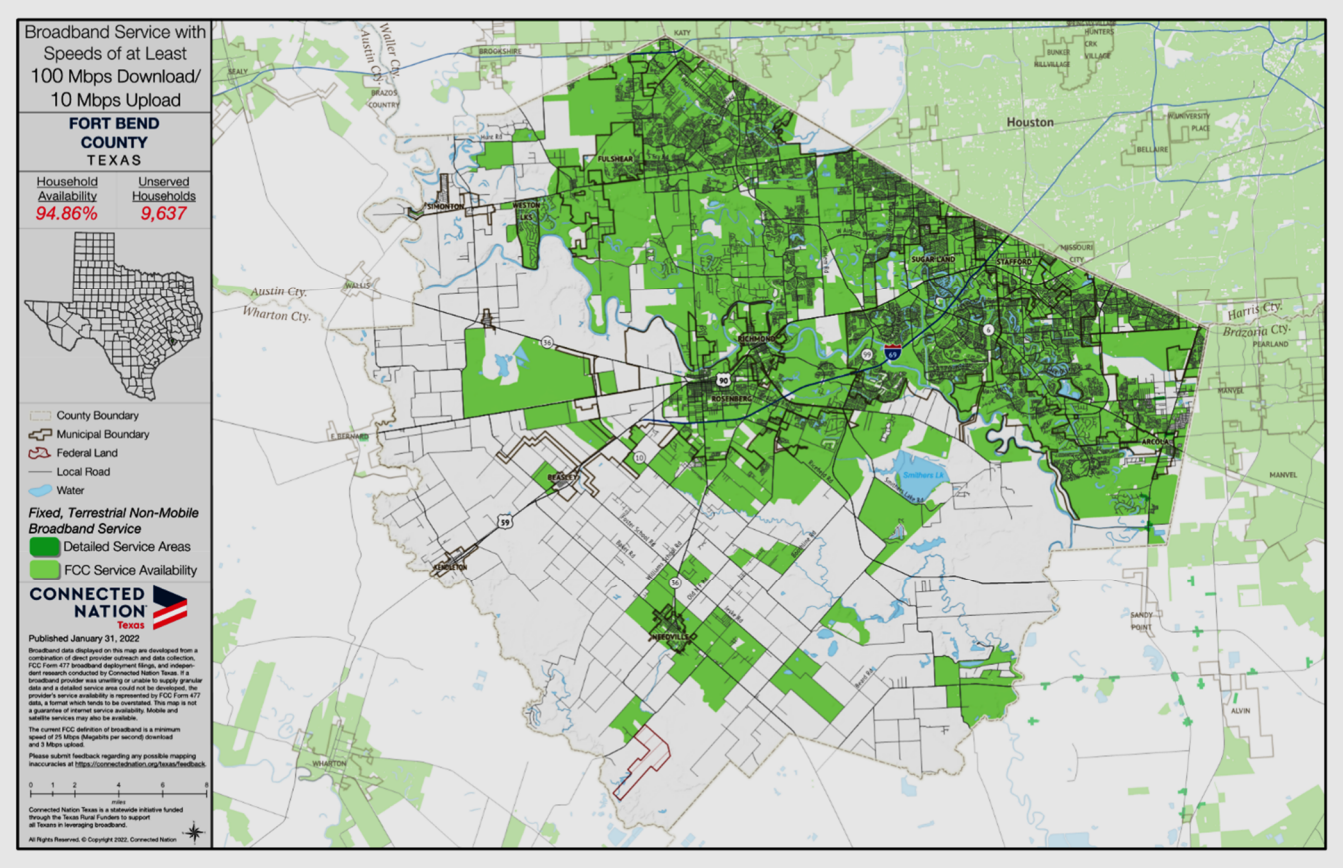

Figure 3: ConnectedNation Showing 100 Mbps/ 10 Mbps Coverage in Fort Bend County

Both Figure 2 and Figure 3 above help showcase the available service options by providers in the greater County area, as developed by ConnectedNation. Figure 2 examines the served parts of Fort Bend County, where 25/3 services are offered, and Figure 3 displays the areas that currently offer 100/10 services. It should be noted that many of the criteria for the upcoming available funding is requiring a minimum of 100/20 Mbps. Both the FCC and ConnectedNation do not offer those as viewing sources, but through data extraction and analysis, the CobbFendley team has helped create these maps, as seen in Figure 4 and Figure 5. However, upon initial review of the figures above, Fort Bend County is experiencing many gaps within its modern solutions, and the existing offerings for broadband services are limited overall in Fort Bend County. While many, but not all, communities within the County are available to receive 25/3 coverage, the same cannot be said about the 100/10 offerings. The southwestern half of the County does not currently have access to the high-speed broadband offerings that residents in the greater Houston area do, and even residents around the Thompsons and Needville area cannot access the outdated services of 25/3. As the greater Houston area continues to expand through population growth within Fort Bend County (about 585K residents in 2010, 823K residents in 2020)[7], many of these communities have an influx of new residents that cannot get adequate broadband service.

[7] QuickFacts. United States Census Bureau. https://www.census.gov/quickfacts/fortbendcountytexas. Published 2022. Accessed June 1, 2022.

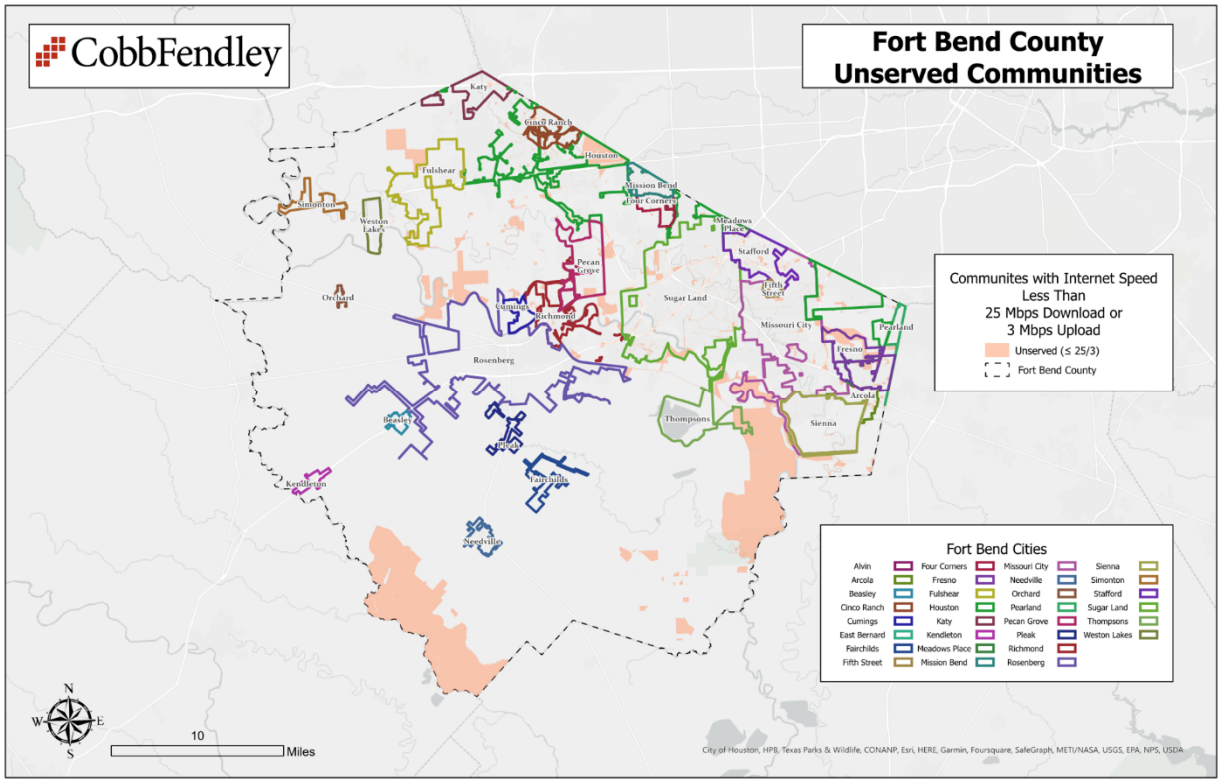

Figure 4: Unserved Areas Lacking 25 Mbps/ 3 Mbps Coverage in Fort Bend County

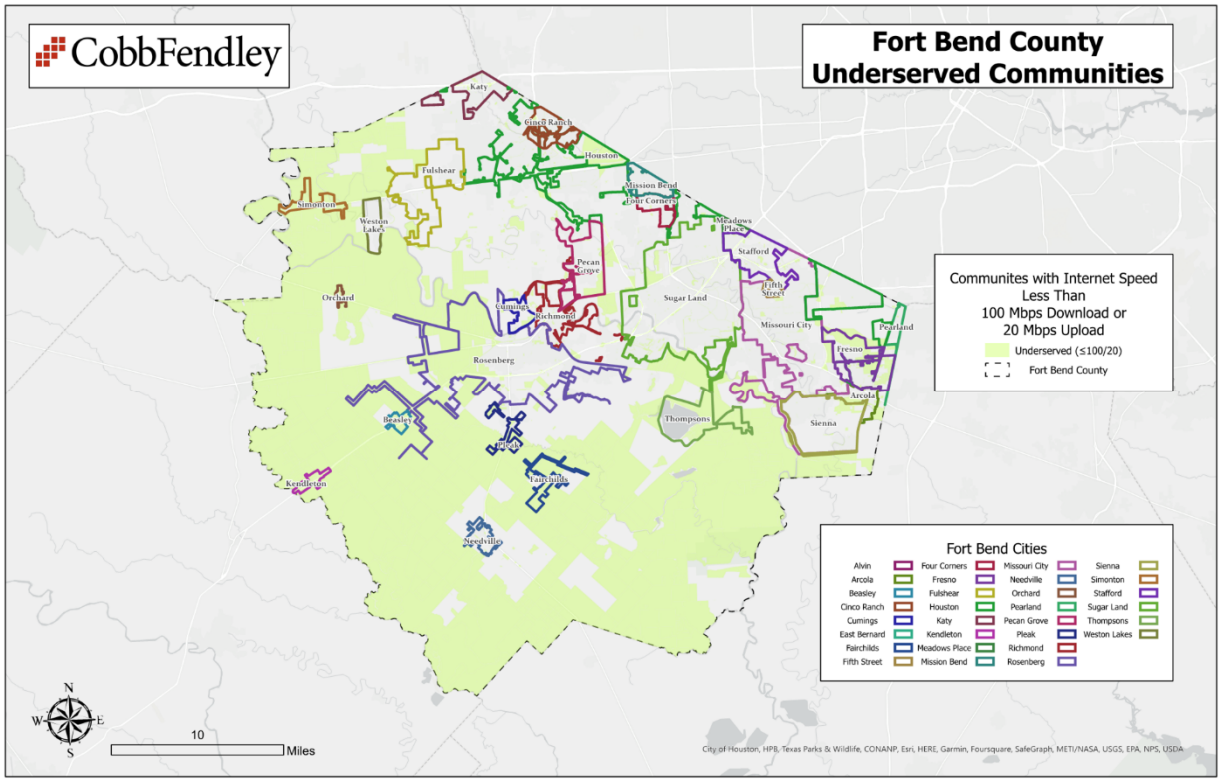

Figure 5: Underserved Areas Lacking 100 Mbps/ 20 Mbps Coverage in Fort Bend Count

As previously mentioned above, Figure 4 and Figure 5 are custom maps created by the project team. These maps appropriately reflect the existing conditions of Fort Bend County as required by various funding sources soon to be available at the federal and state level. Through these figures, the city limits are also shown to better understand which communities are most impacted by the lack of coverage. The Unserved areas in Figure 4 indicate a greater need by a lack of existing infrastructure and service, but the information shown in Figure 5 also needs addressing. While Needville appears to be covered with broadband opportunities, the remainder of the southwestern half of the County would be considering Underserved, including half of Rosenberg. To better understand what services are offered where, CobbFendley met with many stakeholders which helped provide context to this FCC data.

Table 2: Current Internet Offerings in Fort Bend County

PROVIDER NAME	TECHNOLOGY	MAXIMUM DOWNLOAD SPEED (Mbps)	MAXIMUM UPLOAD SPEED (Mbps)
Comcast	Fiber	1000	1000
Consolidated Communications	Fiber	1000	1000
En-Touch Systems, Inc.	Fiber	1000	1000
Grande Communications	Fiber	1000	1000
AT&T Southwest	Fiber	1000	1000
Suddenlink Communications	Cable	1000	50
Windstream Kinetic	Fiber	1000	1000
Comcast	Cable	987	35
Grande Communications	Cable	600	35
NewWave	Cable	300	10
En-Touch Systems, Inc.	Cable	115	20
AccessMedia3	Cable	100	10
Consolidated Communications	DSL	100	100
Frontier	DSL	100	10
AT&T Southwest	DSL	100	20
Windstream	DSL	100	100
GHz Wireless	Fixed Wireless	50	5
Rise Broadband	Fixed Wireless	50	50
Particle Communications	Fixed Wireless	25	10
Texas Windstream Inc.	DSL	25	1.5
theSPECnet, Inc.	Fixed Wireless	15	3
Skynet	Fixed Wireless	15	3
EBTX Wireless, LLC	Fixed Wireless	10	3
AT&T Southwest	Fixed Wireless	10	1
Valor Telecommunications of Texas LP	DSL	10	1
LEGEND	Meets Future Standards	Meets Current Standards	Does Not Meet Current Standards

CobbFendley communicated with various stakeholders throughout the course of this study to better understand the existing infrastructure within the Fort Bend County area, and with stakeholder input and FCC/ ConnectedNation data Table 2 shows what providers are currently offering based on technology and speed. From the collected data, it was discovered that 19 (76%) providers meet the current FCC broadband standard, and eight providers (32%) have service offerings that meet or exceed the benchmark download speed but fails to offer a symmetrical upload speed. Effectively, should the minimum 25/3 be expanded to the modern 100/100 benchmark, there would be eight service offerings that qualify as broadband in Fort Bend County. It is important to note that the listed internet services were pulled from a representative sample of locations across the entire County. The limitation of the FCC's Form 477 data is that the service provider's exact service areas are not granular and instead are based on census tracts or blocks. Service offerings may vary depending on where the search for internet occurs.

Another consideration when reviewing current internet offerings is the network type or platforms and inherent limitations when it comes to future-proofing the broadband infrastructure. There are currently six direct fiber services available for residential services, in addition to numerous long-haul and international networks that pass through the County (seen below in Figure 6). There are seven (28%) fixed wireless offerings that may utilize fiber backhaul, in which case the reliability of the network and potential to increase speeds becomes more feasible. The future of broadband is through the convergence of multiple network types and platforms but, at the core, modernization requires a strong fiber backbone and wireless infrastructure that can deliver heavy bandwidth services.

With future-proofing of the network in mind, it is important to recognize that existing communication technologies are limited to meet the increasing capacity demands. A recent site article by Brookings raised the concern that the funding efforts to bridge the divide cannot be limited to the minimum broadband standard and goes further into why the proposed symmetrical standard will change the way we need to look at existing broadband infrastructure. "By stipulating the deliverable must be 100Mbps symmetrical, the legislation leaves the door open should other technology come along. But the reality today is that only fiber can provide high-speed 100Mbps in both directions"[8]. In many of the areas showcased in Table 2, the internet plans offered do not meet the current or proposed broadband criteria, let alone the recommended speeds. It should also be noted that these speeds are typically only obtainable under perfect conditions which cannot typically occur in the home or the business. In the locations that do offer broadband services, many of the plans could be unaffordable for these communities (as can be seen in later figures). The broadband networks proposed in this study will allow and promote more ISPs with more advanced network architectures and will fill in the gaps of the current services offered to help serve more of the disproportionately impacted communities at affordable pricing.

[8] Wheeler T. Don't replace the digital divide with the"not good enough divide". Brookings. https://www.brookings.edu/blog/techtank/2021/06/21/dont-replace-the-digital-divide-with-the-not-good-enough-divide/. Published 2022. Accessed June 1, 2022.

6.2 Fiber Network Infrastructure in Fort Bend County

In Figure 6 and Figure 7, the public records for existing fiber can be seen for both Long Haul Networks and for Metro Networks. While these fiber network lines may not be responsible for directly providing fiber to the home, it does help highlight where essential infrastructure is currently located within the County. As seen in Figure 6 it is understood that all the long-haul networks follow the major highways through the County. For a fiber company to reach the rest of the state, these routes are essential as they help connect and expand from Houston and then continue to run throughout the state.

Comparing the information from Table 2, AT&T and Windstream do offer Last-Mile services from the listed providers in Figure 6, Level 3 was bought out by CenturyLink but neither offer residential services in Fort Bend County and neither does SCT Broadband, and Telia Carrier (now known as Arelion) offers enterprise and wholesale services across the entire world but does not offer residential services within Fort Bend County directly. Tier 1 carriers like Telia/ Arelion would primarily be using this infrastructure as transport to expand across the country as Middle-Mile, as well as providing the enterprise options, but it cannot be determined at this time if they have a Last-Mile provider partner to reach additional home based customers. While many of these network owners run fiber through the County, the impact on home services for County residents cannot truly be determined based on long-haul carriers, if impacted at all.

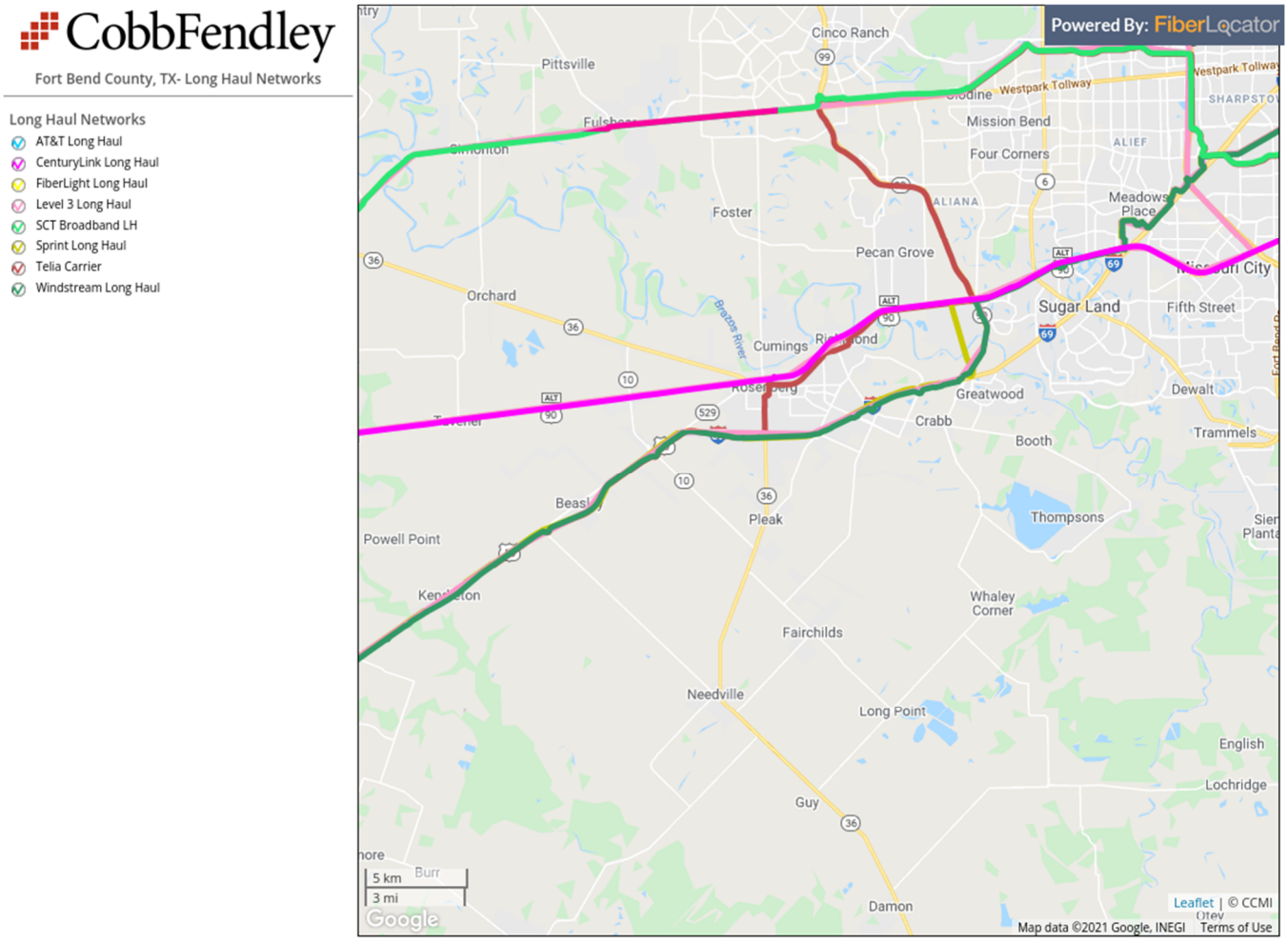

Figure 6: Long Haul Networks Within Fort Bend County

In review of Figure 7, the business-related metro network helps indicate a better understanding of the fiber distribution infrastructure conditions throughout the County but may be additional information to consider for possible residential services. As previously mentioned, the rural and urban gap is a huge factor in understanding the limits of broadband networks in the County. The Sugar Land/ Houston or Katy/ Cinco Ranch areas, for example, are dense with core broadband infrastructure that facilitates expansion and densification. As extending southwest throughout the County, similar to the figures presented above, the infrastructure diminishes for business services as well as residential services.

Leaving the Houston or Katy area, networks expand south and west but it is only a small selection of networks in the general region. These main network providers in the rural parts of Fort Bend County outside of what is shown in the Long Haul Networks in Figure 6, consist of PS Lightwave, a Middle-Mile and enterprise provider; Consolidated/ Fidium, a Last-Mile provider shown in Table 2; and Zayo Metro, a dark fiber and Tier 1 network. While Consolidated was proven to be providing residential services in Fort Bend County, none of these other fiber network providers shown in Figure 6 & Figure 7 provide residential services directly. While, at present, the bulk of the fiber infrastructure in the County does not serve residential broadband services, it is promising that some of these dark fiber providers could potentially be leveraged for Last-Mile services. While there are some gaps in the Middle-Mile infrastructure that prevent certain areas like Thompsons from receiving broadband services, which needs to be addressed, proposing Middle-Mile infrastructure in Fort Bend County would also be minimal.

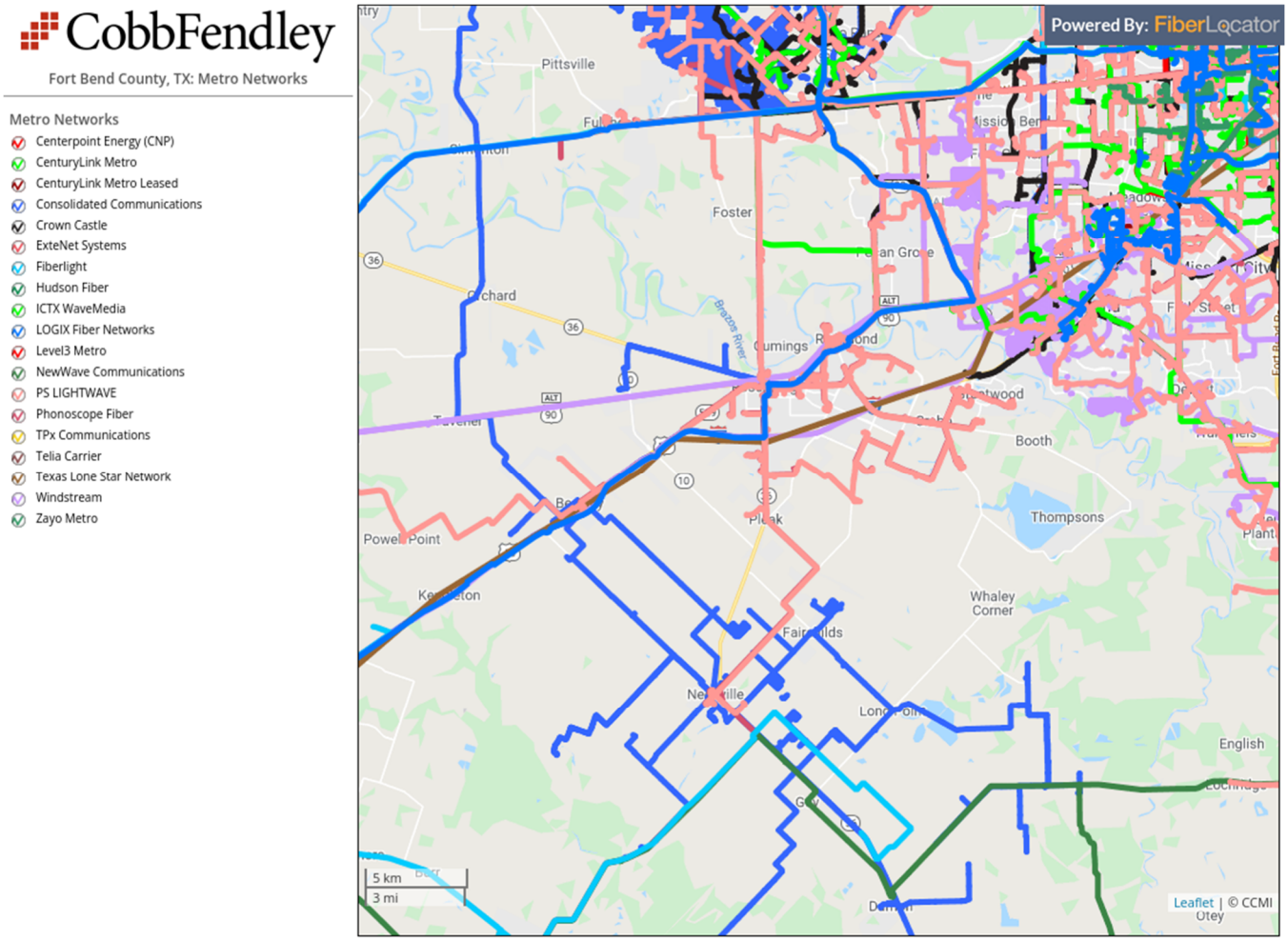

Figure 7: Metro Networks Within Fort Bend County

Table 3: Broadband Availability Estimates by Technology Type

Texas County-Level Broadband Availability Estimates by Technology Type									
County	Number of Households	25 x 3 Mbps (Percent of Households Served)				100 x 10 Mbps (Percent of Households Served)			
		Cable	DSL	Fiber	Fixed Wireless	Cable	DSL	Fiber	Fixed Wireless
Fort Bend	187,384	93.09%	77.10%	50.14%	75.58%	93.09%	48.16%	50.07%	0.00%

Finally, based on the data collected by ConnectedNation[9] as seen in Table 3, additional context can be provided towards residential services in Fort Bend County, specifically through fiber. Nearly 50% of households in the County have fiber technology available at both 25/3 and 100/10 services, which as mentioned before is due to the scalability of fiber, but these are assumingly dedicated to the dense areas shown in Figure 7 of Houston and Katy. This percentage reaffirms the information shown throughout the figures above that indicates Underserved areas and metro networks present, but half of the homes in the County, which mostly are located in the rural southwest half, cannot subscribe to fiber-based broadband services.

Based on the other percentages of households that can receive other technologies for internet options, cable is the predominant option for both 25/3 and 100/10. This is expected as cable was the main source for internet options as it was deployed for decades before fiber was being implemented throughout the country. Cable is still used as a hybrid method for high-speed broadband when used alongside fiber where fiber is the backbone of the infrastructure, but since there are so many existing cables to the home connections, then cable is still used for Last-Mile connectivity to residents. Due to the limiting factors of cable as an internet source, scalability and symmetrical speed options are not achievable. This is a solution that has been adequate for modern needs but is not sufficient for future needs. Furthermore, especially when reviewing the differences in fixed wireless options, it appears that most of the County's infrastructure has not been updated to meet modern standards thus far. Fiber is still required for fixed wireless solutions to operate through the use of fiber backhauled towers. As these fiber-fed towers then use wireless spectrum to reach additional towers and then eventually the home, it still indicates the need for fiber infrastructure somewhere in the process. As more fiber infrastructure is constructed in the future then additional fixed wireless solutions could also be implemented for Last-Mile broadband services.

[9] Planning | Connected Texas. Connectednation.org. https://connectednation.org/texas/planning/. Published 2022. Accessed June 1, 2022.

6.3 Potential Barriers to Additional Infrastructure

Physical and geographic barriers are often overlooked as having an impact to broadband services, but they can be a valid deterrent to utility construction as the natural and manmade boundary features can be costly to build across and significantly delay the project in permitting. In reviewing Figure 8, Figure 9 and Figure 10, there could be barriers that may limit or prevent additional infrastructure or could at least impact the implementation and construction process.

In Figure 8, the plethora of water bodies within Fort Bend County is visualized. Most of these represent smaller creeks, but there are quite a few large rivers that naturally divide the County. The Brazos River runs right through the Richmond area from Northwest to Southeast, and the various segments of Oyster Creek run parallel to the Brazos River. Near Thompsons, Oyster Creek meets Steep Bank Creek and Brazos River, all while being near Smithers Lake. The abundance of these water features could have an impact on these areas regarding the developing of new broadband infrastructure. However, when reviewing Figure 8 it appears that the more urban side of the County has more water features to account for while also having the largest source of broadband infrastructure. For that reason, while it is important to keep in mind that for permitting and engineering, these water features do not appear to play a significant role in preventing additional infrastructure in Fort Bend County.

Additionally, it is worth noting that the Brazos River separates the eastern portion of the County, specifically Thompsons from Sienna Plantation. There are no roads crossing this river and all routes lead back to Highway 59 near Richmond and Highway 36 near Guy. Any potential crossings would need to be through pole attachment where applicable, or proposed routes for fiber will need to be routed back towards the highway from this potential barrier at expansion.

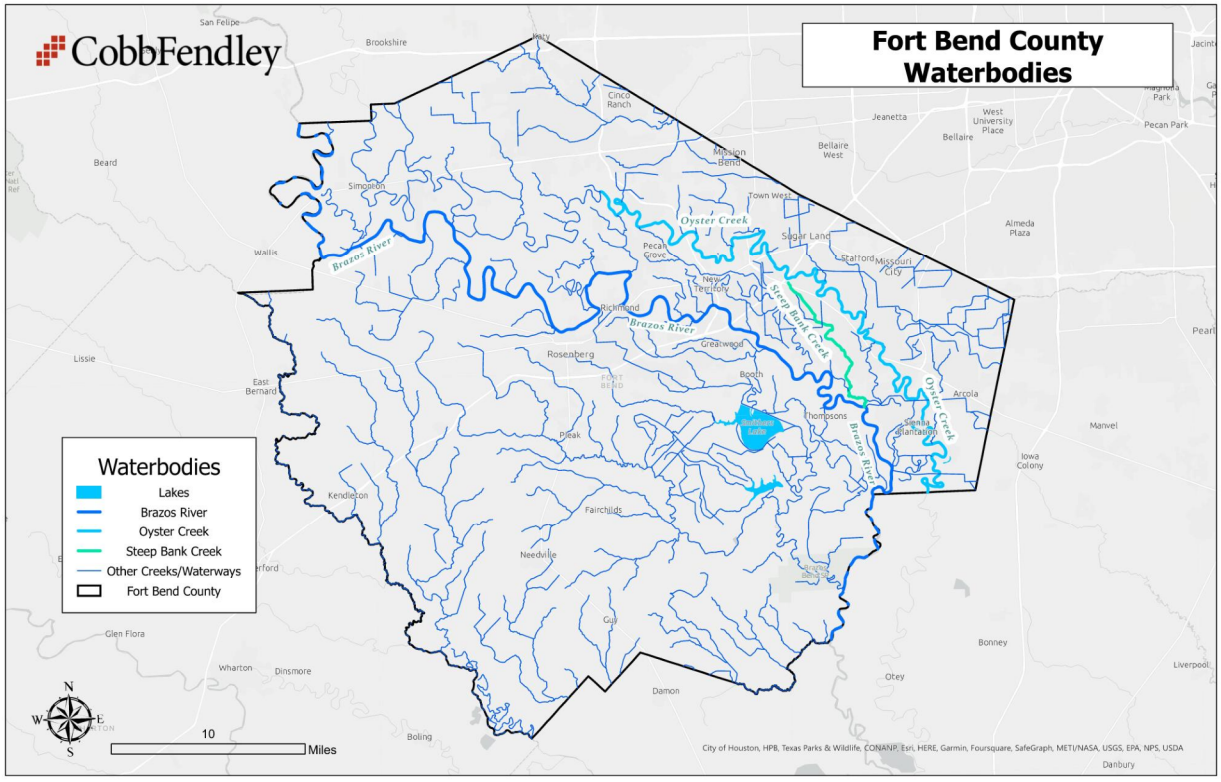

Figure 8: Water Bodies Within Fort Bend County

In Figure 9, the existing railroad network infrastructure is presented within the limits of the County. The most notable congestion of these railroads within the County is that in Rosenberg the Union Pacific Railroads (UPRR), the BNSF Railway Company, and the Kansas City Southern Railway (KCSR) appear to follow major roadways in and out of town. Coincidentally, this is also approximately where the County splits between the urban and rural designation, as will be shown in later figures. As they do follow the major highways out of the County, permitting and construction of fiber infrastructure crossing railroads could potentially disrupt any potential broadband expansion that would be proposed heading West from Rosenberg. Another important feature to note is that near Thompsons it can be seen that there is also a convergence in railroads on top of the water features congregating there as well. This may also be an impact on any infrastructure around the Thompsons area. While railroad networks were instrumental in early long-haul fiber deployment, they can also be a deterrent to fiber distribution infrastructure.

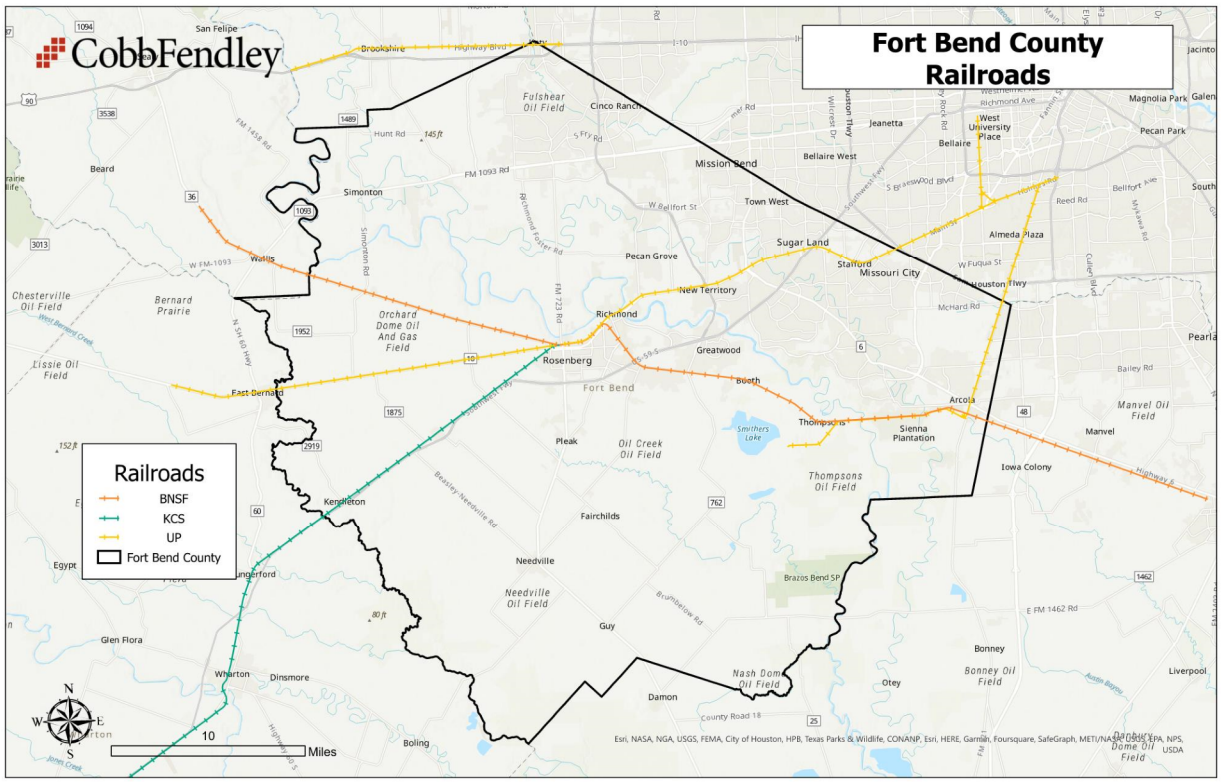

Figure 9: Railroads within the Fort Bend County

Figure 10, below, indicates where expected municipality and entity permitting may occur. For Middle-Mile proposed solutions, whether buried or aerially ran, it would be expected that the TXDOT right of ways (ROW) to contain the majority of the infrastructure. Outside of the TXDOT ROW, either city specific or County ROW would be expected for permitting. Based on the size of some of these towns or cities, it should be expected that there may not be enough staffing or up-to-date standards for the proposed construction. In those instances, and for however many permitting entities are required to address based on proposed ROW usage, permitting times could be lengthy and time consuming. Scheduling should be planned accordingly. Where applicable, TXDOT ROW should be used for proposed infrastructure.

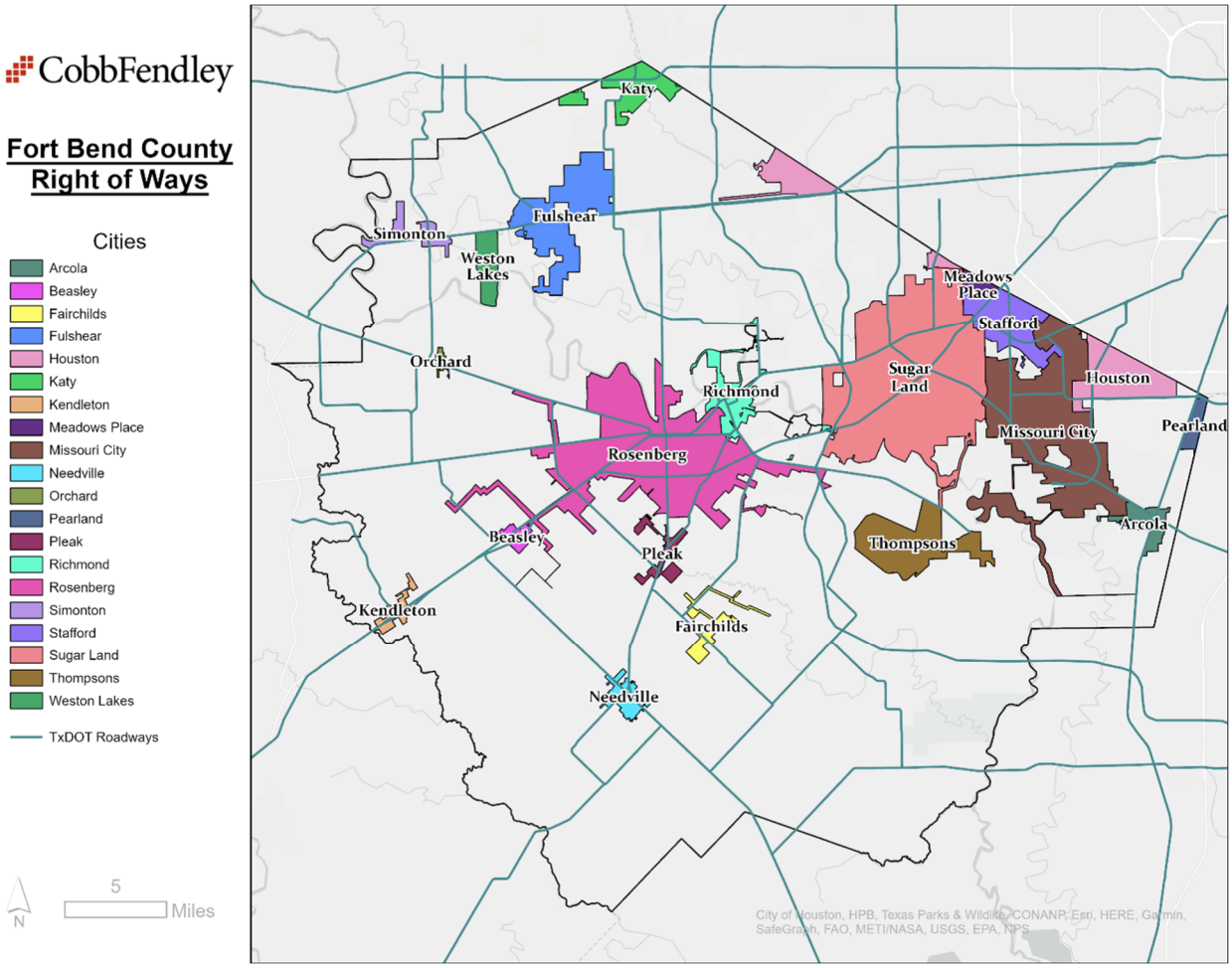

Figure 10: Additional ROW Considerations for Fort Bend County

7 PUBLIC OUTREACH

As a part of Fort Bend County's Broadband Improvement Initiative, collaboration and meaningful discussions with the community, which includes both public and private entities, is an essential step in the study of a needs and gap analysis. This public outreach includes both stakeholder engagement, which helps CobbFendley evaluate everything from existing conditions to potential partnerships; but also includes feedback from the community and its current residents through implementing resident and business surveys with an accompanying speed test. These engagements facilitate focused discussions that directly contribute to the determination of the feasibility of potential broadband projects.

Section Highlights

- THERE ARE PLANS FOR ORGANIC SATURATION OF THE FORT BEND COUNTY MARKET FROM NEW PRIVATE PROVIDERS
- AREAS OF LOW ADOPTION REMAIN A PRIORITY THAT NEEDS TO BE ADDRESSED
- ALL STAKEHOLDERS ARE SUPPORTIVE OF BROADBAND TO ENABLE WORKFORCE AND ECONOMIC DEVELOPMENT

7.1 Stakeholder Engagement

The project team from Fort Bend County was actively engaged in the process, relaying their known contacts, proposed demand points (facilities needing broadband service), preliminary research, and observations, all of which contribute to the understanding of the needs of the County and the communities it serves. An internal meeting between CobbFendley and the IT Committee occurred on a bi-weekly basis to discuss updates, potential options for implementation, and funding opportunities.

Stakeholder discussions addressed the goals for the projects, state of the current broadband infrastructure footprint, perceived service and application needs, potential for future expansion, and any concerns or constraints that would help formulate recommendations. Engagements with local public entities focused on understanding their needs and gaps, while engagements with providers, operators, and other potential focused on existing assets and future growth plans. The Stakeholder Engagement, while one of the first tasks of the study to begin, happens throughout the study process as ideas for potential projects and partnerships develop and new stakeholders emerge. A summary of the engagements, separated by the type of stakeholder, can be seen below.

7.1.1 Municipalities and Entities

The following municipalities and entities were met with for discussions as it relates to the Fort Bend County Broadband Improvement Initiative:

7.1.1.1 Fort Bend County

Fort Bend County is the client for this Broadband Improvement Initiative, and more specifically, is led by the Information Technology Department. Working with the I.T Department throughout this process has allowed for a comprehensive review of existing infrastructure and conditions and allowed for a thorough understanding of what the County wanted to achieve through this entire process with an extensive highlight of network and technological needs.

The County helped CobbFendley understand that due to the unique characteristics of the communities, different areas had different needs as it relates to broadband. To meet these needs, the County wanted to have access to the network and try to create an open access network but did not have any interest in becoming its own internet service provider (ISP). To address the needs of the Unserved, the Underserved, and the Underutilized areas, the plan was to create as many projects as necessary that could use applicable state or federal grants to help pay for this initiative.

Biweekly meetings were set up throughout the duration of this process to help align the County side with CobbFendley's progress. Additional support and personnel have engaged in this study as developments occur and help apply solutions to advance this study.

7.1.1.2 Fort Bend County Precinct Commissioner Staff

From the beginning of this initiative, it was made known that discussions with the Precinct Commissioner Staff for each of the four precincts in the County would help CobbFendley understand where the gaps are as it relates to broadband in the community. While redistricting had just recently occurred, the staff was able to help point out the various areas of need to see how this initiative could positively impact their communities. These areas included: Fulshear, Simonton, Arcola, Fresno, Needville, Sienna, and even Lamar Consolidated ISD. Whether the need for further discussions with these locations was due to growth and expansion or lack of existing infrastructure, these areas became a higher priority for developing applicable broadband solutions.

7.1.1.3 Fort Bend County Mayor and Council Dinner

As hosted by the city officials of Simonton, TX this year, CobbFendley was invited to the annual Fort Bend County Mayor and Council Dinner to discuss this Broadband Improvement Initiative. In attendance included officials from Fulshear, Kendleton, Meadows Place, Pleak, Richmond, Simonton, Stafford, Sugar Land, Thompsons, and Weston Lakes. This was an opportune time for the CobbFendley team to meet and discuss the needs and gaps discovered as a result of this study as well as the next steps for what the County could do moving forward. The officials in attendance were optimistic about the scope of work and potential for improvements across the County and were excited to help share the news with their constituents. With the help of their efforts, the results gathered within the administered survey, can be found later within this section. The results accumulated more than 800 responses in total with more than 500 coming after that dinner.

7.1.1.4 Lamar Consolidated Independent School District (LCISD)

LCISD is one of the largest school districts in the state of Texas, and their growth for students and school infrastructure is expanding rapidly. When CobbFendley spoke with the LCISD, that's what the focus of the discussion turned towards. The schools have adequate service all across the County, but as highlighted by the COVID-19 pandemic, the need for sufficient internet at the home of students quickly became the priority. The growth that the LCISD is experiencing can largely be attributed to the new communities popping up all over the County. Providing Middle-Mile to unincorporated areas was deemed a priority, and then through review of the demographic report that is completed annually for the district, CobbFendley was able to include the areas of need within the High-Level Design (HLD).

7.1.1.5 Fort Bend Independent School District

Fort Bend ISD is in a similar position to LCISD in terms of the broadband needs that the district is experiencing. However, many areas in the FBISD district region do not have the infrastructure in place to have adequate internet, but for areas that do have a network in place, many residents cannot afford the services. The district provided hotspots to students who requested one during the COVID-19 pandemic, but even those could not provide adequate service for students. Specific areas within the district zoning were highlighted during the conversation that were determined to be a priority based on need to broadband access, which primarily focused on the greater Fresno area.

7.1.2 Potential Infrastructure and Service Provider Partners

The following telecommunication infrastructure owners and services providers, shown in alphabetical order, were met with for discussions as it relates to the Fort Bend County Broadband Improvement Initiative. It should be noted that specific details were either omitted during meetings or within this study due to proprietary information.

7.1.2.1 Comcast

Comcast has expressed interest in expanding County-wide and help bridge the digital divide. While funding and existing infrastructure prevented the full plan from coming to fruition, the western and more rural communities of Fort Bend County were deemed the priority areas for Comcast to target to bring internet to. The finished plan is expected to be used by residents in

these communities within the next few years, will be primarily aerially routed, and will aim to offer discounted services to those who need it.

In an effort to better promote low cost services in the area, Comcast is working with the Affordable Connectivity Program (ACP) alongside their own program called the Internet Essentials Program. Residents who qualify are able to enroll in both programs, and according to Comcast, one can "Sign up for Internet Essentials for only $9.95/month + tax with no contract and free equipment – then enroll in the Affordable Connectivity Program (ACP) to get your service for FREE"[10].

7.1.2.2 Ezee Fiber

Ezee Fiber provides everything from fiber to the home (FTTH), to dark fiber, to private enterprises in the greater Houston area. With a presence in Brazoria County, Montgomery County, and Harris County, Ezee Fiber is looking to expand their fiber presence in Fort Bend County as well to help the network extend from Conroe to Galveston. Ezee Fiber noted that partnership with Fort Bend County is a welcomed opportunity and have experience with how to make that work, regarding factors from capital investment to multi-trench builds.

7.1.2.3 PS Lightwave

PS Lightwave has a large existing presence in Fort Bend County with an infrastructure that currently expands over 5,000 miles. Services offered range from education, to government, to healthcare, to non-profit services, but this does not include FTTH. They do, however, currently engage in partnerships that help complete the FTTH process for residents. For the County, PS Lightwave has expressed the willingness to partner which helps provide an additional option for the County to choose from.

7.1.2.4 Consolidated Communication

With a fiber presence seen throughout rural Fort Bend County, it was important to meet with Consolidated to see what exactly is being offered and where, but also to see what comes next for their scope in the County. CobbFendley learned that the biggest presence that Consolidated has in the County is in the Katy and Needville areas, due to their specific incumbent local exchange carrier (ILEC) boundaries. After being awarded census blocks within the County by the Rural Digital Opportunity Fund (RDOF) Consolidated is committed to offer 1 GB by 2026-2027 to those select communities. Additionally, for those that qualify, Consolidated has partnered with the ACP to help residents in financial need purchase internet services for as low as $1 per month. The majority of Consolidated infrastructure within Fort Bend County is buried fiber, which has overlashed the existing copper, and can offer fiber to the home (FTTH) with plans regularly priced between $35-70 per month.

[10] Internet Essentials from Comcast. Internetessentials.com. https://www.internetessentials.com/. Published 2022. Accessed June 1, 2022.

7.1.3 Additional Stakeholders

Outside of service providers and municipalities, other entities shared varied interest in this Broadband Improvement Initiative and were eager to learn more. The stakeholder summaries from those conversations are as follows:

7.1.3.1 Fulshear Development Corporation

The City of Fulshear has already completed a feasibility study for upgrading broadband services in their city, and the city officials and partners are anxious to implement these newer technologies. The Fulshear Development Corporation reached out to CobbFendley so that discussions of mutual benefit could be acknowledged to see how best not to duplicate efforts. Through economic and workforce development backgrounds, the Fulshear Development Corporation helped inform the project team of other studies that are going on in the region, various policy perspectives, and various resiliency efforts that should be included within the project.

7.1.3.2 TetraTech

TetraTech is an existing partner that County officials suggest CobbFendley meet with as a stakeholder for this initiative. Both CobbFendley and TetraTech have the same goal at looking to see how broadband improvements could be funded with the plethora of federal and state grants that are coming soon. Funding opportunities are discussed more in detail later in the section, but discussions primarily centered around the Middle-Mile Grants Program, Broadband Equity, Access and Deployment Program (BEAD), Digital Equity Act (Planning, Capacity, and Competitive), and Distance Learning, Telemedicine, and Broadband Program: Reconnect Program.

7.2 Community Engagement

Fort Bend County made it clear that the involvement of stakeholders is paramount to the success of this initiative. In addition to the extensive discovery sessions with regional partners and private companies, an important group for input included the residents and business owners themselves. CobbFendley helped design a public engagement pursuit with an ongoing opportunity for feedback to educate and invite commentary through implementing a residential-specific survey, a business-specific survey, and a speed test. This survey, as well as additional information relevant to the overall Broadband Improvement Initiative were hosted on the County's website at https://www.fortbendCountytx.gov/your-County/broadband-improvement-initiative. This website will be updated regularly to include information for residents to learn about improvements in their community and resources to help access broadband.

7.2.1 Public Residential Survey

The survey results helped provide a better understanding of the current market situations and helped inform residents that they are not in this situation alone. With large sums of people agreeing that there is a problem with the current services offered, it was made clear that a fix is required for the County and its residents as soon as possible. The results of the survey confirmed the issues that were determined through the analysis of the existing conditions.

The following information shows the questions and answers that were administered by CobbFendley to the residents of the greater Fort Bend County area.

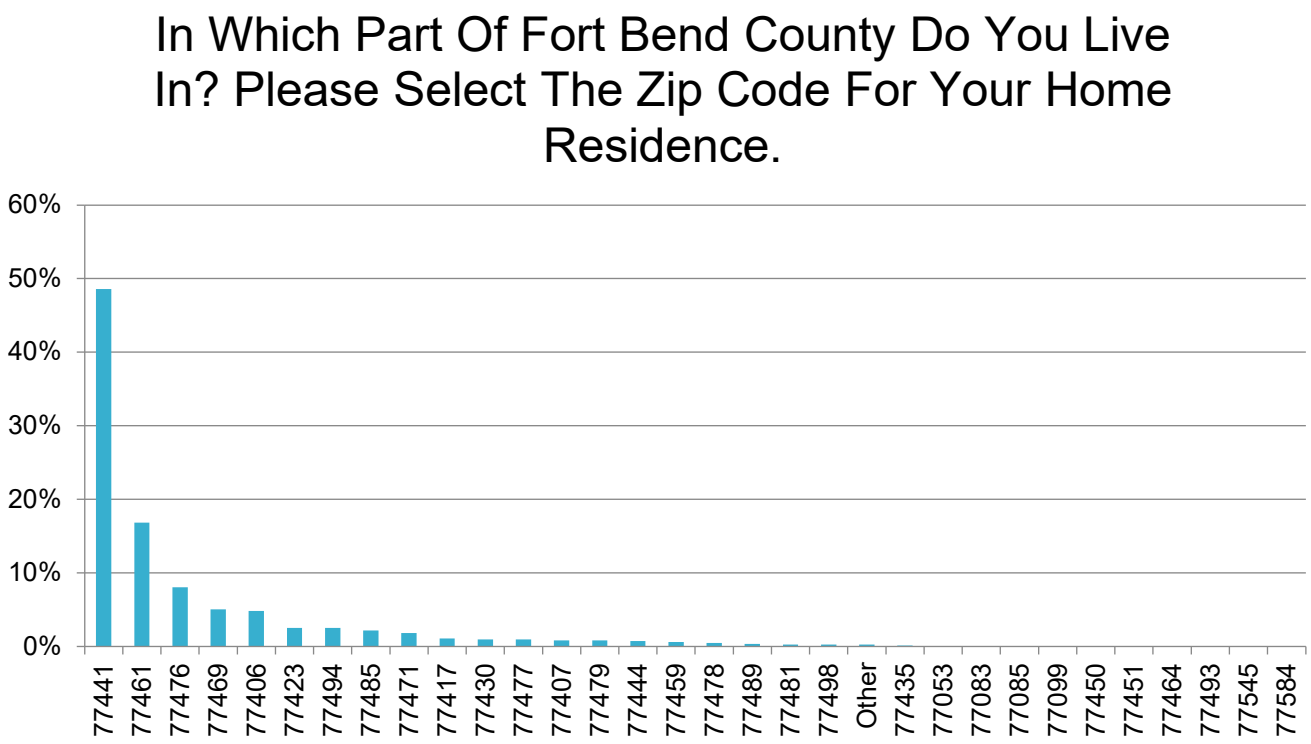

Figure 11: Survey Question - In Which Part Of Fort Bend County Do You Live In?

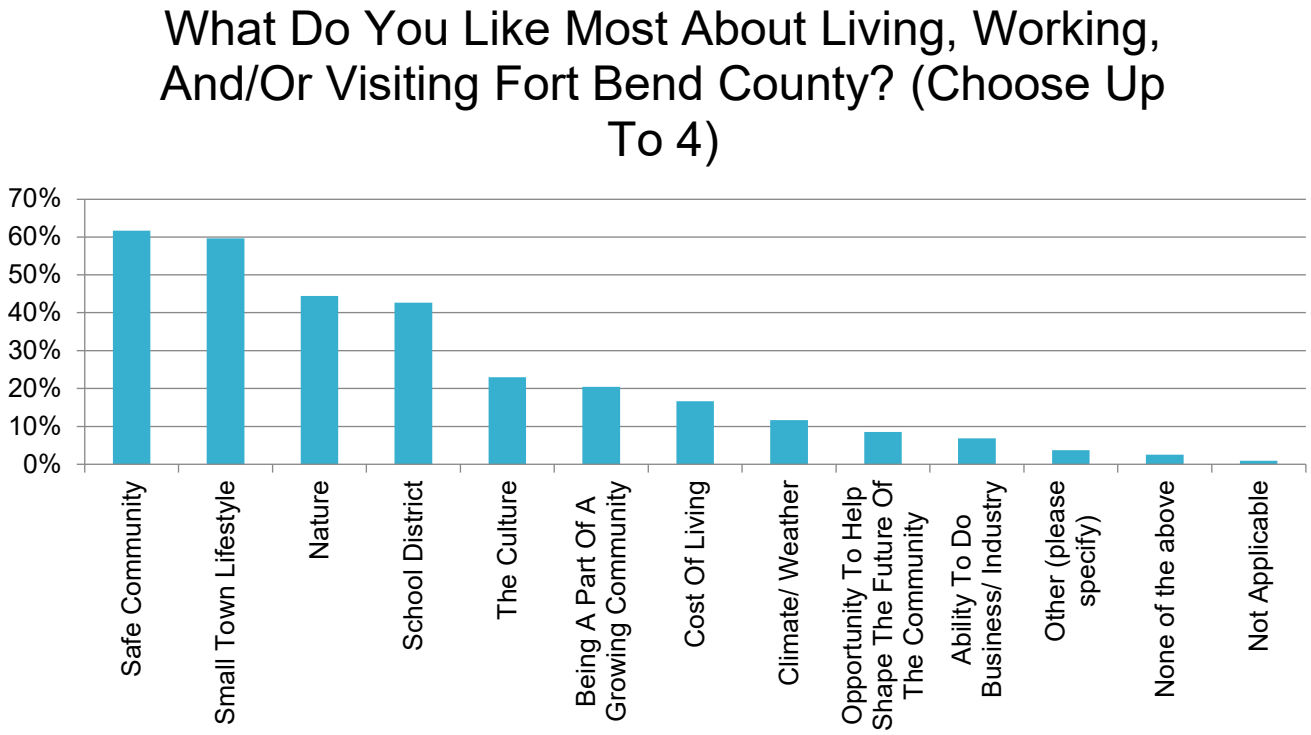

Figure 12: Survey Question - What Do You Like Most About Living, Working, And/Or Visiting Fort Bend County?

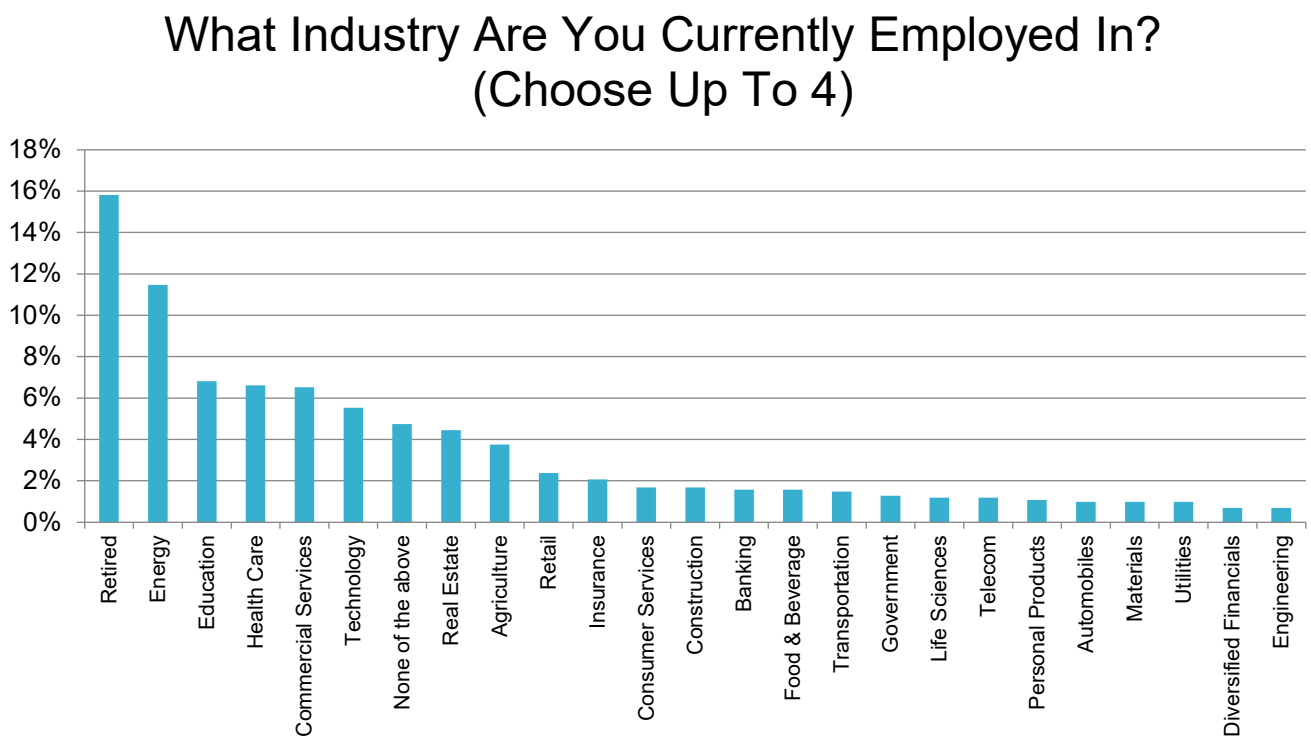

Figure 13: Survey Question - What Industry Are You Currently Employed In?

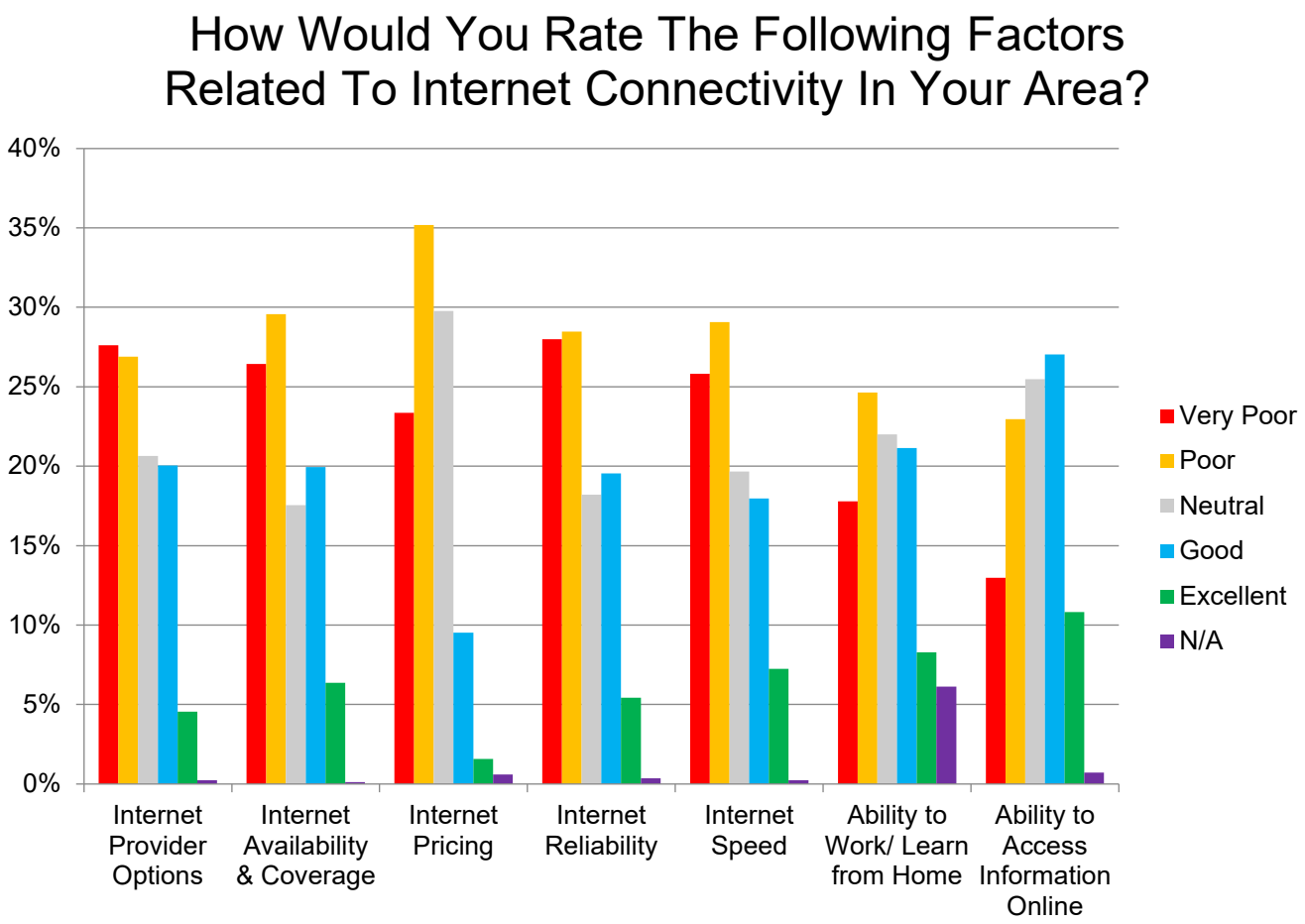

Figure 14: Survey Question - How Would You Rate The Following Factors Related To Internet Connectivity In Your Area?

Table 4: Survey Score Based on Internet Connectivity Factors

Survey Score	
Internet Provider Options	-441
Internet Availability & Coverage	-414
Internet Pricing	-575
Internet Reliability	-448
Internet Speed	-400
Ability to Work/ Learn from Home	-187
Ability to Access Information Online	-2

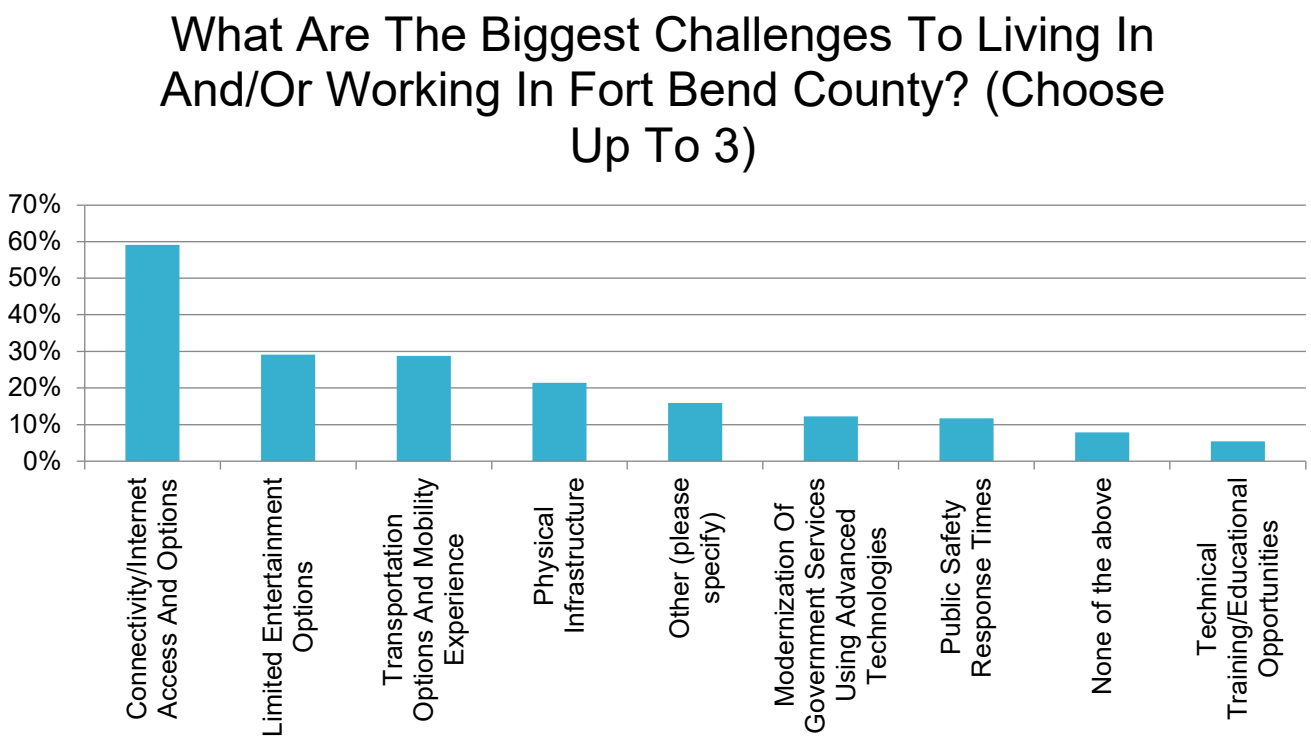

Figure 15: Survey Question - What Are The Biggest Challenges To Living In And/Or Working In Fort Bend County?

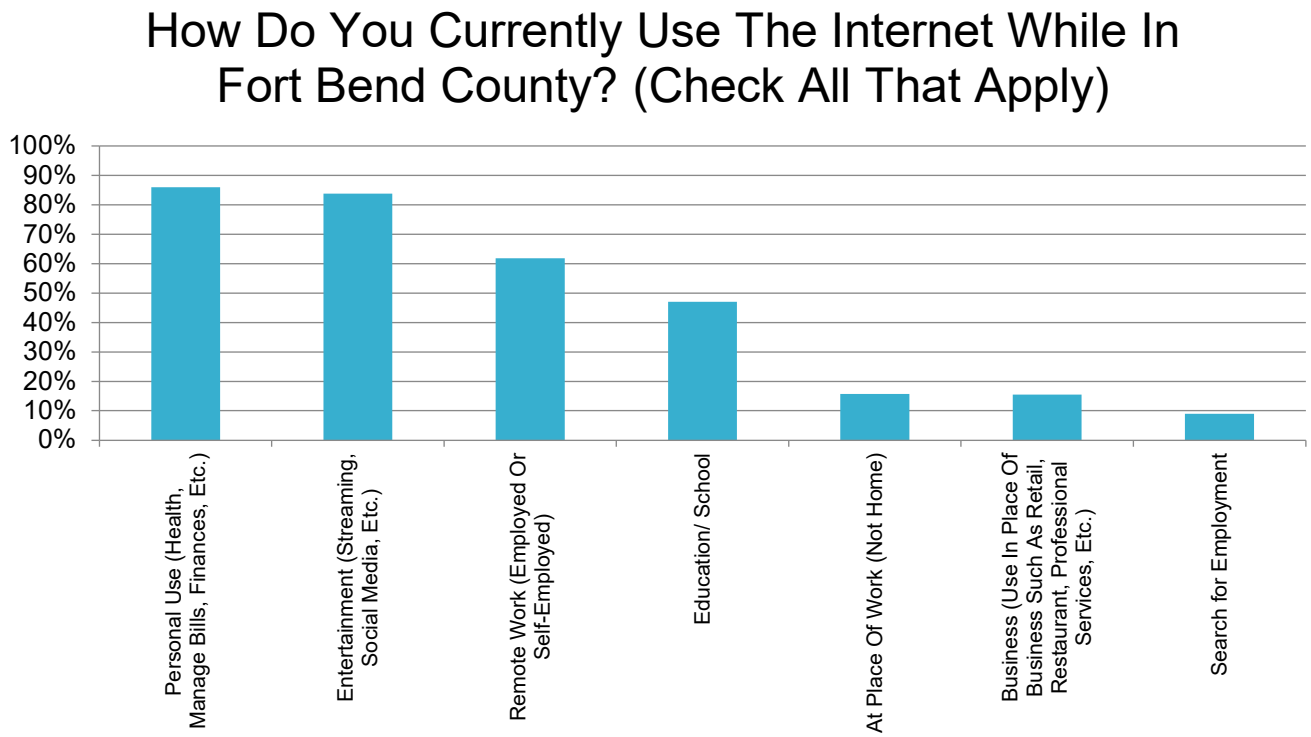

Figure 16: Survey Question - How Do You Currently Use The Internet While In Fort Bend County?

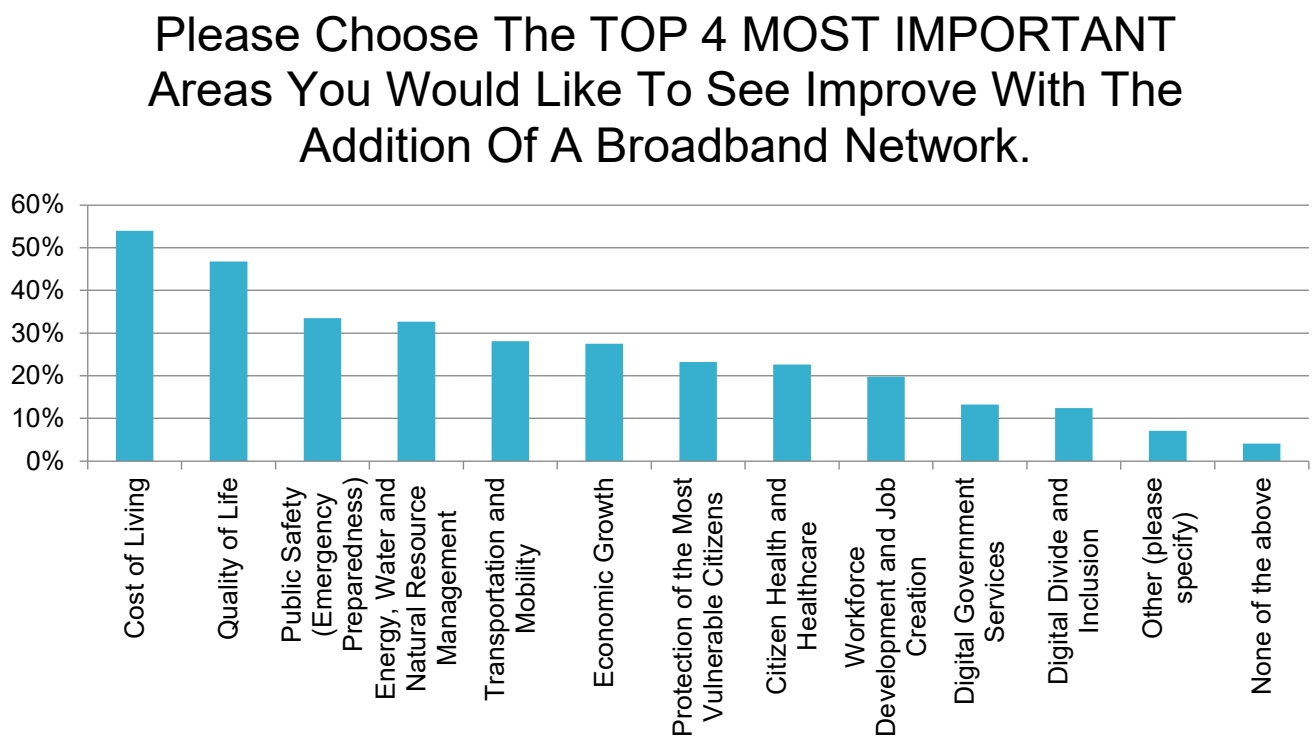

Figure 17: Survey Question - Please Choose The TOP 4 MOST IMPORTANT Areas You Would Like To See Improve With The Addition Of A Broadband Network.

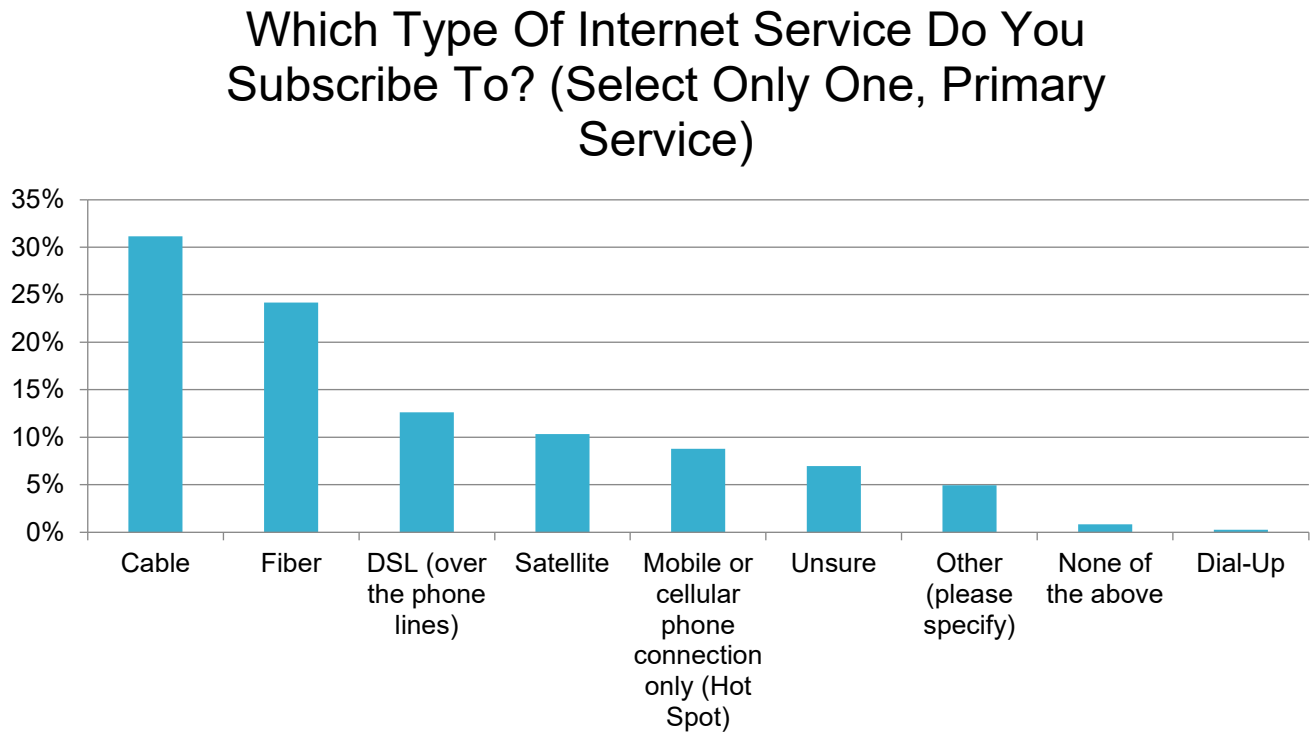

Figure 18: Survey Question - Which Type Of Internet Service Do You Subscribe To?

7.2.1.1 Residential Survey Analysis

Starting with Figure 11, a total of 834 respondents for the survey helped relay information to the project team to gather information about real-world situations for broadband in Fort Bend County, TX. Nearly half of the responses were collected from Zip Code 77441 residents which includes Fulshear and Weston Lakes areas. While this survey was intended to be an overall review of the needs of all Fort Bend County residents, the responses recorded are primarily that of rural Fort Bend County. It should be noted that the responses don't represent the entire County because of that, however, they do represent the communities that have been determined in other sections of this study to have the greatest need for modern and future-proof broadband services.

Table 5, below, is a full list of cities and zip codes within Fort Bend County. Figure 19 represents a modified version of Figure 11 but only includes answers that recorded at least 1% of the responses. However, Figure 19 does not include responses from 77441, it helps show where most of the additional responses were collected. The residents of Needville, Pleak, Simonton, Richmond and Rosenberg followed the residents of Fulshear with the remaining bulk number of responses.

Table 5: Zip Codes in Fort Bend County

Fort Bend County Zip Codes			
Location	Zip Code	Location	Zip Code
Arcola	77583	Missouri City	77545
Beasley	77417	Needville	77461
Cinco Ranch	77450	New Territory	77479
Cinco Ranch	77494	Pearland	77584
Cumings	77471	Pecan Grove	77406
Fairchilds	77461	Pleak	77461
Fairchilds	77469	Pleak	77469
Fifth Street	77477	Pleak	77471
Four Corners	77083	Richmond	77406
Four Corners	77498	Richmond	77469
Fresno	77545	Rosenberg	77469
Fresno	77583	Rosenberg	77471
Fulshear	77406	Sienna Plantation	77459
Fulshear	77441	Sienna Plantation	77583
Fulshear	77494	Simonton	77476
Greatwood	77479	Simonton	77485
Katy	77494	Stafford	77477
Kendleton	77417	Sugar Land	77469
Meadows Place	77477	Sugar Land	77478
Mission Bend	77083	Sugar Land	77479
Missouri City	77459	Sugar Land	77498
Missouri City	77479	Thompsons	77469
Missouri City	77489	Weston Lakes	77441

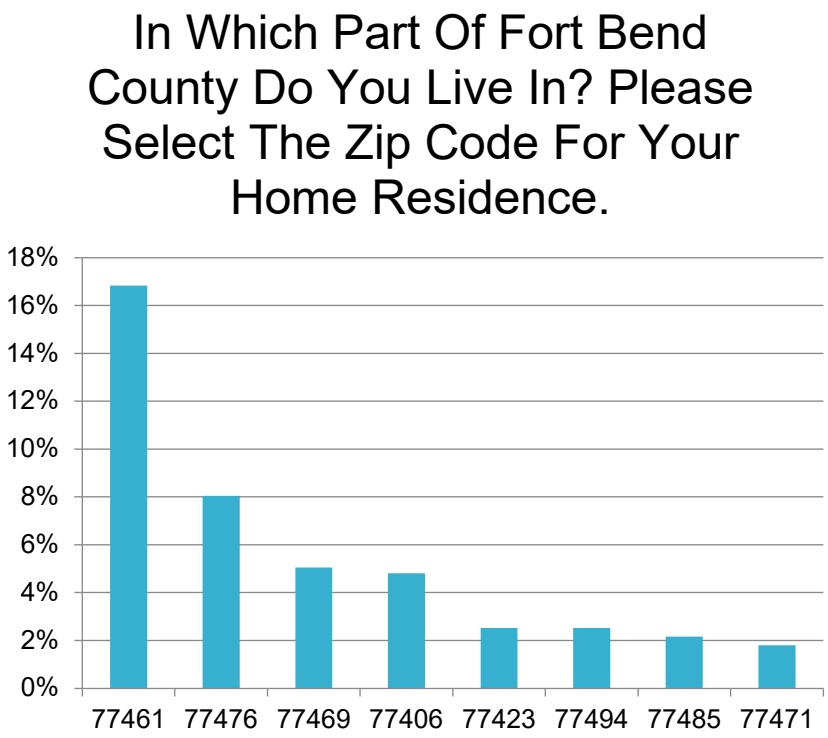

Figure 19: Survey Question-In Which Part Of Fort Bend County Do You Live In?

In both Figure 12 and Figure 13, an approximate understanding of why someone chooses to live in a specific city or area is suggested. Using the data based on this survey alone, we might expect that many residents of Fort Bend County are living there to settle down, whether that's moving there after deciding to retire or just having never left the County after settling down. Through various discussions, high-speed internet coverage is often seen as a luxury that small towns and rural areas don't typically experience. The small town lifestyle, and the benefits that come from that, are a big reason people enjoy their time in Fort Bend County, as highlighted from the bulk of the responses. This is why implementing these upgrades now is a big priority for places like Fort Bend County since these federal and state funds for broadband specifically are not likely to come again for a long time. The retired folks who love their communities deserve these modern services as much as anyone else. As seen in later figures, as well as in additional sections of this report, these communities are just not receiving adequate service or options. If providers thought serving residents in communities that are as rural as Fort Bend County was a good business decision, it would have happened already.

Figure 14 and Table 4 help highlight the ultimate need for this study. The information within Table 4 is sourced from the survey and Figure 14 specifically but is represented numerically instead of graphically. In this question, residents were asked their opinion on provider options, coverage, pricing, reliability, speed, ability to work or learn from home, and the ability to access information, all as it relates to the internet in Fort Bend County, where respondents were able to choose from "Very Poor", "Poor", "Neutral", "Good", "Excellent", or not applicable. The overwhelming response to all of the questions overall was "Poor", and this is where Table 4 provides additional context to the overall response. Table 4's data was created by giving a score to each response of "Very Poor", "Poor", "Neutral", good, "Excellent", or not applicable with the values of -2, -1, 0, 1, and 2, respectfully (where not applicable did not receive scoring). Based on the number of responses, these values were then calculated. To get a sense of where overall opinion would be, a negative score in Table 4 would be on the "Poor" side, a positive value would be on the good side, and something close to zero would be on the "Neutral" side. As can be seen in Table 4, many of the responses provided a very low or poor score, with the ability to access information online as the closest answer to "Neutral", especially as seen in Figure 14. Relatively, provider options, coverage, pricing, reliability, speed, and the ability to work from home all scored abysmally. As a reference, in other locations where this survey was administered, the data from Table 4 never went as low as -297, and even usually provide an overall positive score for the choices like the ability to work and learn from home or from the ability to access information. Regardless of what providers are advertising for this region, Fort Bend County residents are not content with the current broadband options and responded appropriately to relay that information.

In Figure 15 and Figure 16, the questions asked help provide insight as to what the internet is currently being used for and its overall impact on the community. While the internet has become a primary source of entertainment for many people, it has also become a method of creating a living or education. Both of these factors can be seen as the main influence in the mentioned figures. Personal use, entertainment, remote work, and education/ school are the primary uses of internet and the biggest challenges to living or working in the County are internet access, entertainment, infrastructure, and mobility. Currently, many households in the County cannot connect to a high enough internet speed to conduct business or continue their education and are forced to exclude that from their current options. With connectivity being the highest response by nearly 30% compared to the next highest response, and physical infrastructure is the fourth highest, the residents believe that upgrades are needed to these services. Once these broadband upgrades are completed, remote work and education can become a larger priority for those in need.

It is well documented that access to high-speed broadband increases your overall quality of life. When respondents answered the question stated in Figure 17, residents are aware of the current focus at the national and state levels to provide quality, affordable broadband to communities across the country. Quality of life upgrades will absolutely be improved by the addition of a broadband network, and that can also be addressed by the other areas that were voted on which include public safety, cost of living, economic growth, healthcare, workforce development, and so on. For public safety, advancements like Next Generation 911 (NG911, or Next Gen 911) can be implemented. Next Gen 911 improvements include, "enhance[d] emergency number services to create a faster, more resilient system that allows voice, photos, videos and text messages to flow seamlessly from

the public to the 911 network. NG911 will also improve public-safety answering point (PSAP) ability to help manage call overload, natural disasters, and transferring of 911 calls and proper jurisdictional responses based on location tracking."[11] Furthermore, the weather is known to contribute to the damage of physical infrastructure in Texas by means of hurricanes, freeze storms, flooding, and more. Should a buried fiber line be implemented, where applicable, then communication between public safety facilities and community leaders will continue through times to be of the utmost importance for residents. This aligns with healthcare as well. Telehealth is a viable medical option, where accessible. With the rurality of Fort Bend County, the nearest medical facility could take hours to reach a medical professional after completing drive times and waiting times. With a viable internet solution, telehealth can help reduce inpatient demand on medical facilities and can help residents receive the care they need in a shorter time frame, as proven by the Hartman Executive Advisors, "the average wait time for a new patient appointment is 24 days compared to just 20 minutes for a telehealth appointment."[12] Finally, the workforce development and overall economic impact from an addition to the broadband network are immensely valuable. Hiring locally for projects like this help reduce construction times and helps diversify workforce opportunities through outlets such as construction, network design, information and technology (IT), and more.

Finally, Figure 18 helps identify what most residents choose for their internet services. Expectedly, most residents use cable-based services at just over 30% of total responses while fiber is around 24% after that DSL, Satellite, and Cellular hover around 10%. What is optimistic is that the second highest recorded response is for fiber-based services. Based on previous figures, it is known that Consolidated offers residential fiber service in the Needville area, where a majority of responses to this survey were recorded. This helps prove that as fiber becomes available, communities are ready for newer technology to adopt.

In addition to these questions, the survey also included an opportunity for residents to leave any questions or comments they thought would be valuable for the County to know. Nearly 200 respondents left a comment, but in summary, these are a selection of the comments that were reiterated throughout the entirety of the responses.

- "Internet service and cell service are poor where I live. Internet is especially bad during rush hour times."
- "Broadband access in north Fort Bend County relies on both fiber AND cellular access, both of which are neither consistent nor reliable, especially in poor weather - need better for resilient communities!"
- "None of the providers deliver the speeds they sell."
- "When we moved here in 2010, internet and data was consistent and had no issues. Over the last few years, we've noticed "dead zones" throughout our neighborhood and internet has little outage blips all the time."
- "Currently we pay $160 for high-speed internet through Viasat satellite. Too much money for average speed."
- "We have been in the area for 20 plus years and have tried T-1 lines, Hot Spots, sat internet and for the past 8 years Via A tower. With the growth in Fort Bend County, it is time for reliable high-speed broadband internet. This will enable and facilitate education, training, job development, communications, work from home and remote learning and access. This will also permit telehealth services for those with limited mobility or access to healthcare."
- "Download speed is slow, upload speed is almost nonexistent"

[11] Governance | TRANSFORM911. Transform911.org. https://www.transform911.org/resource-hub/transforming-911-report/governance/. Published 2022. Accessed June 1, 2022.
[12] Team T. What Are The Advantages Of Telehealth For Patients? - Hartman Executive Advisors. Hartman Executive Advisors. https://hartmanadvisors.com/what-are-the-advantages-of-telehealth-for-patients/#:~:text=Telehealth%20has%20proven%20to%20be,minutes%20for%20a%20telehealth%20appointment. Published 2022. Accessed June 1, 2022.

7.2.2 Business Specific Survey

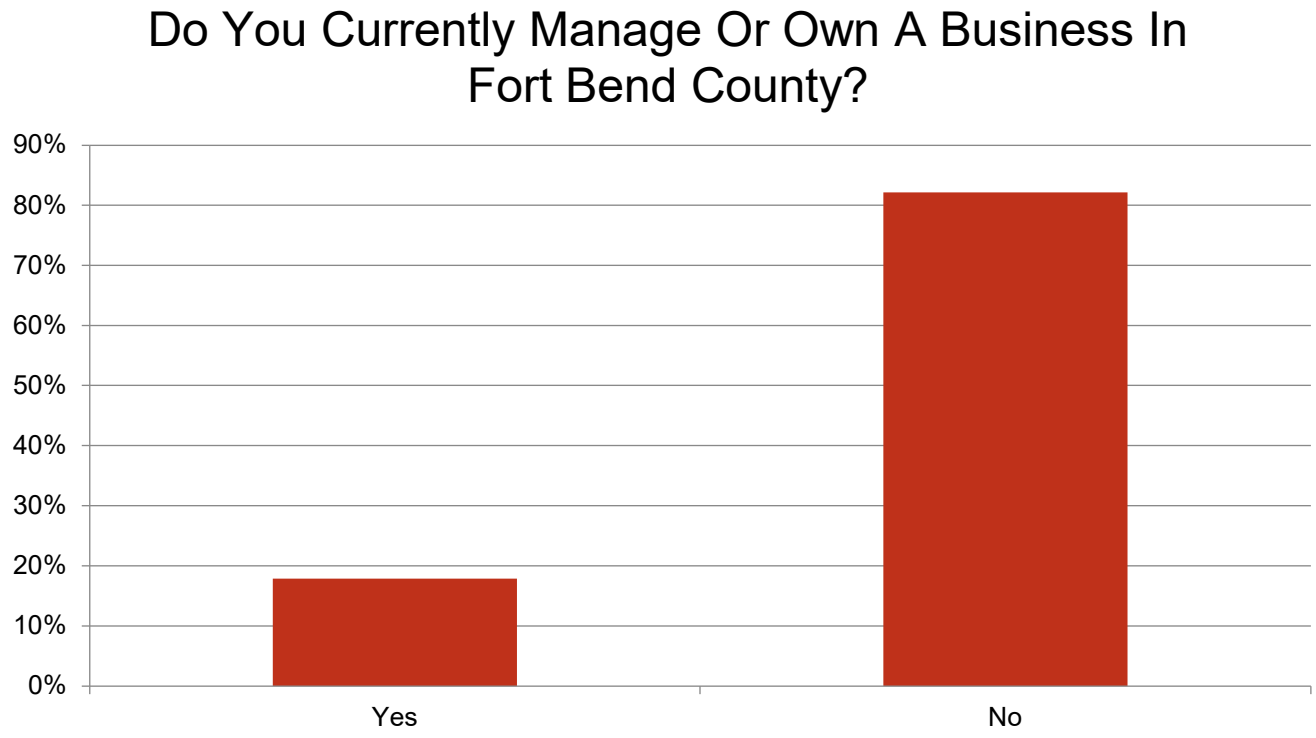

Figure 20: Survey Question - Do You Currently Manage or Own a Business in Fort Bend County?

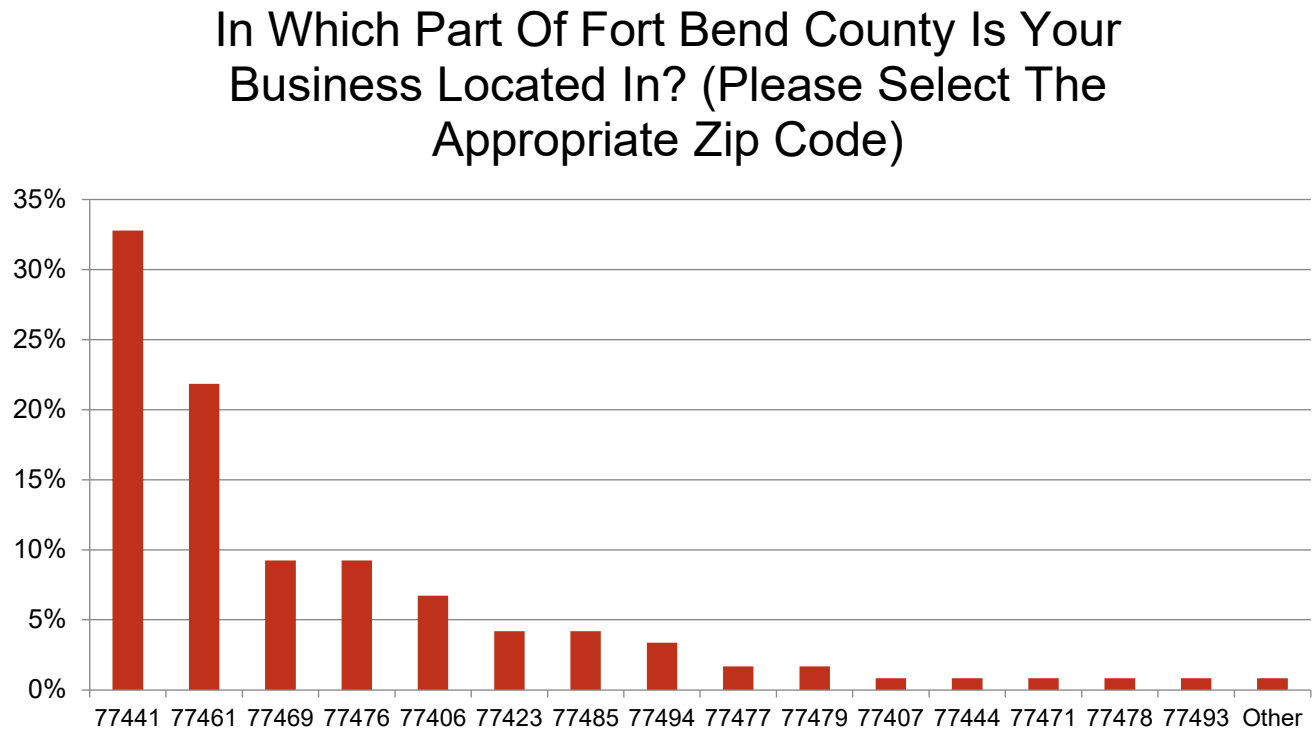

Figure 21: Survey Question - In Which Part Of Fort Bend County Is Your Business Located In?

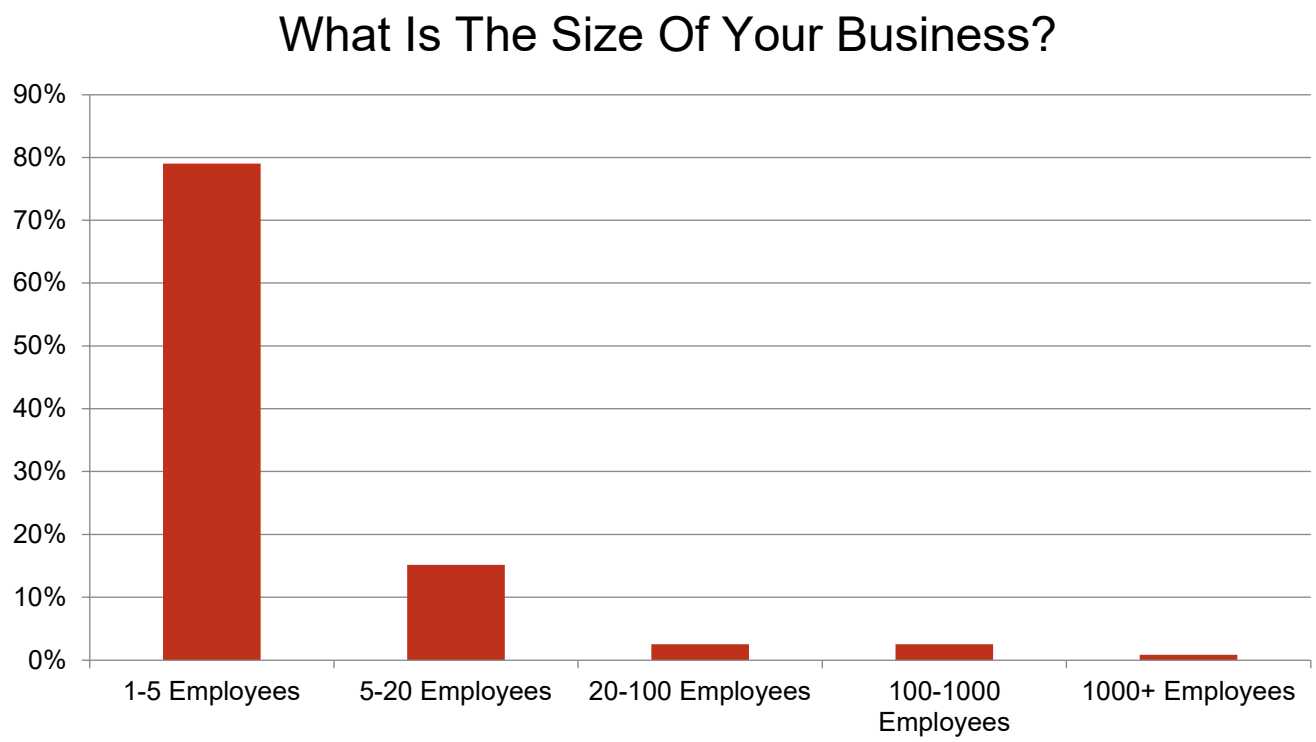

Figure 22: Survey Question - What Is The Size Of Your Business?

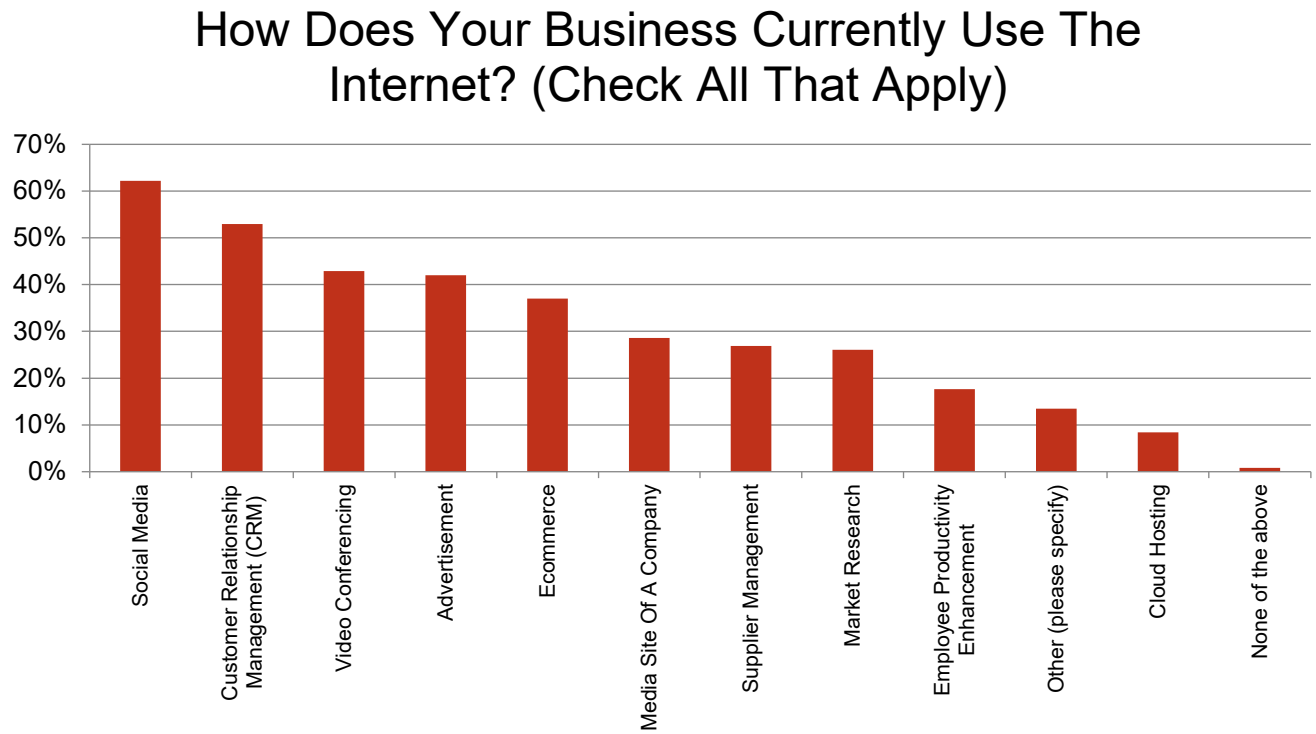

Figure 23: Survey Question - How Does Your Business Currently Use The Internet?

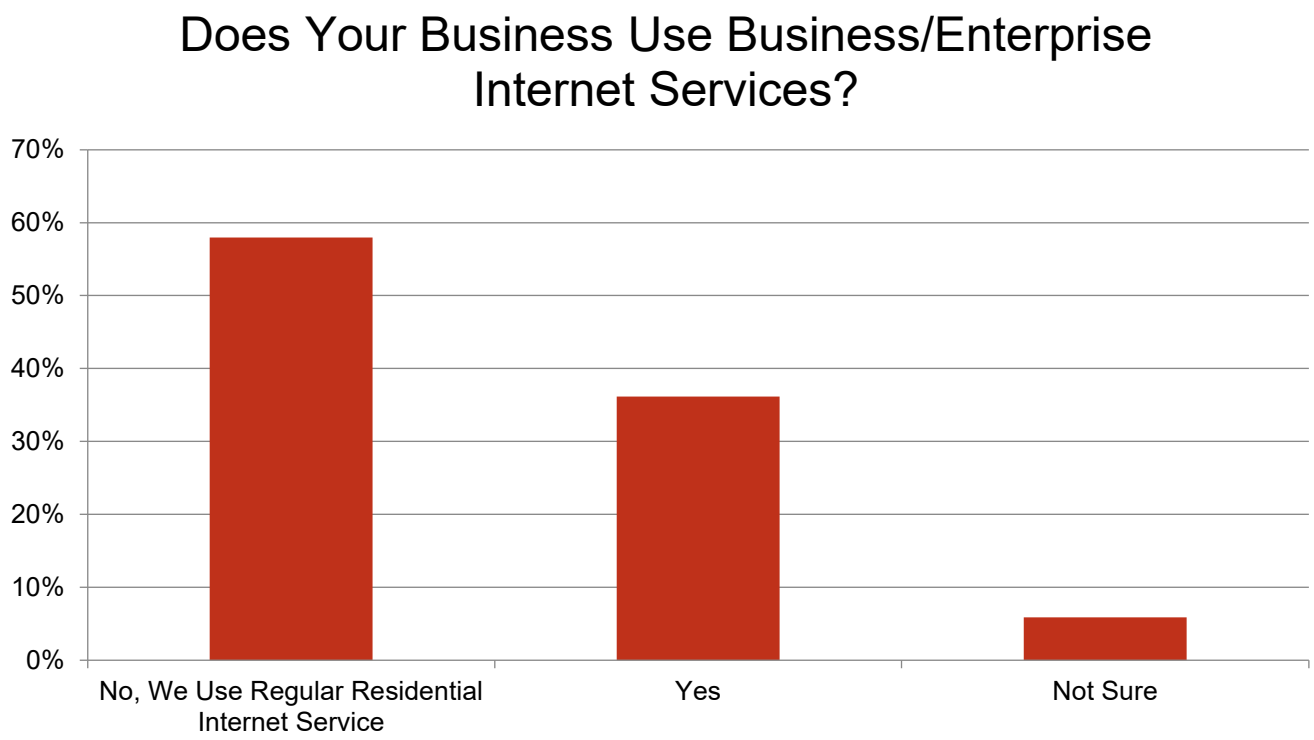

Figure 24: Survey Question - Does Your Business Use Business/Enterprise Internet Services?

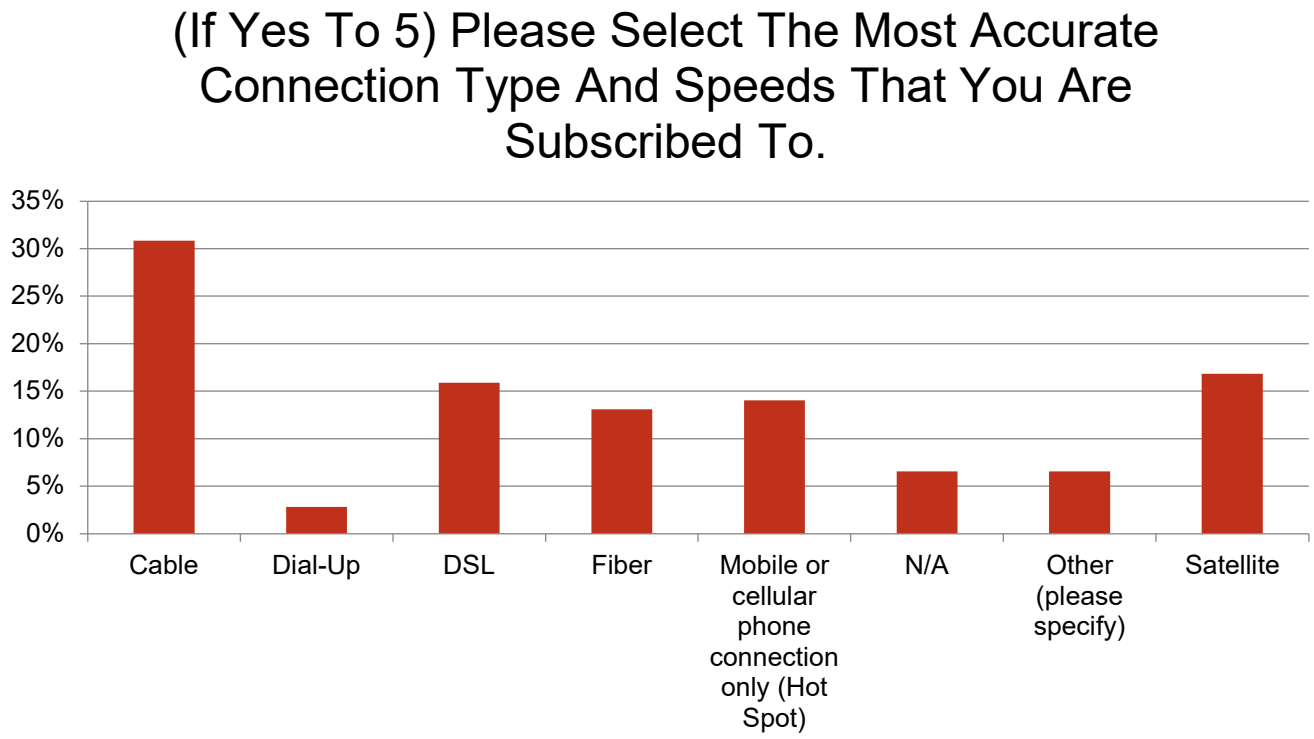

Figure 25: Survey Question - Please Select The Most Accurate Connection Type That You Are Subscribed To.

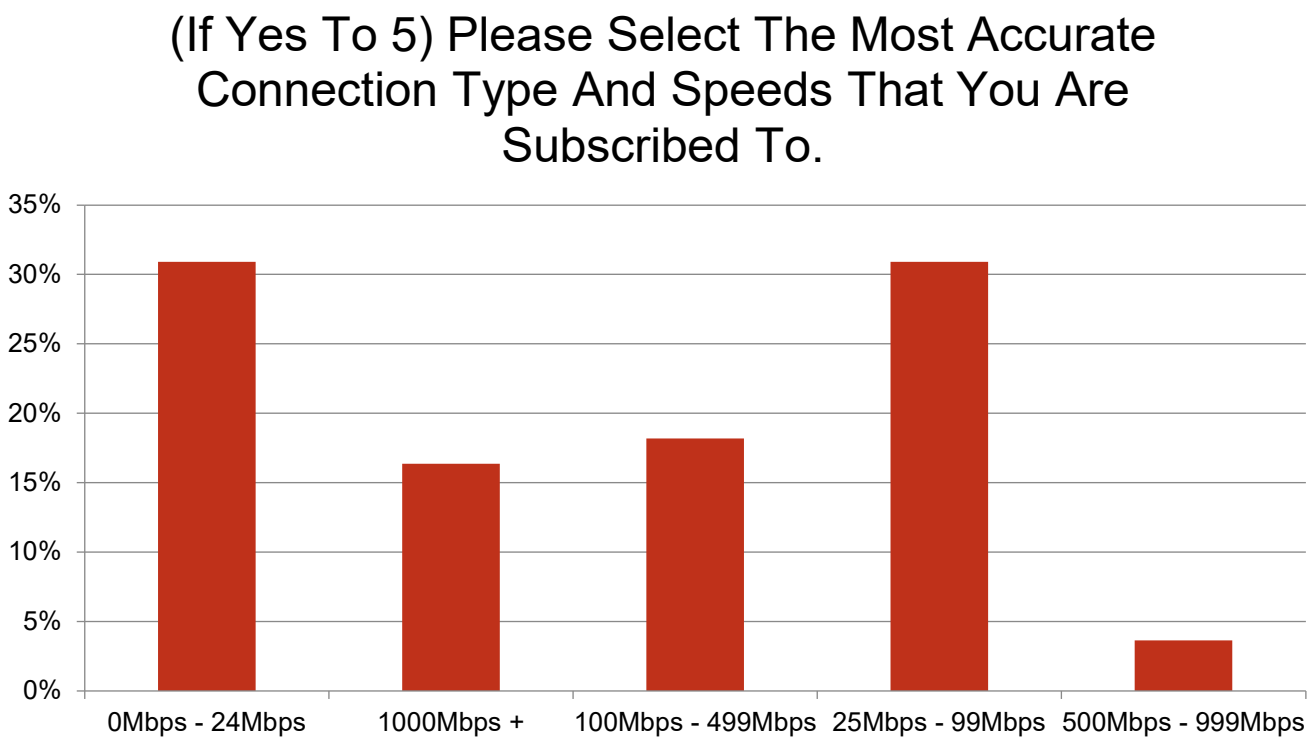

Figure 26: Survey Question - Please Select The Most Accurate Connection Type and Speeds That You Are Subscribed To.

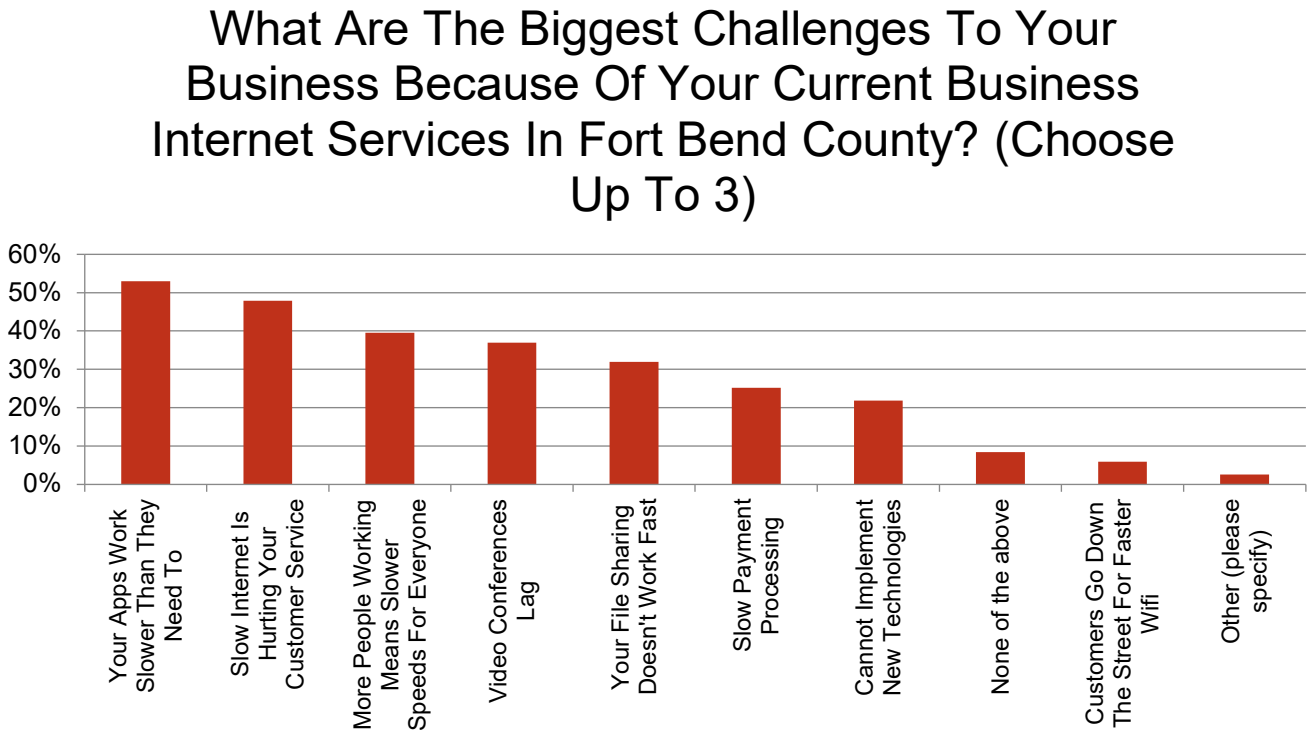

Figure 27: Survey Question - What Are The Biggest Challenges To Your Business Because Of Your Current Business Internet Services In Fort Bend County?

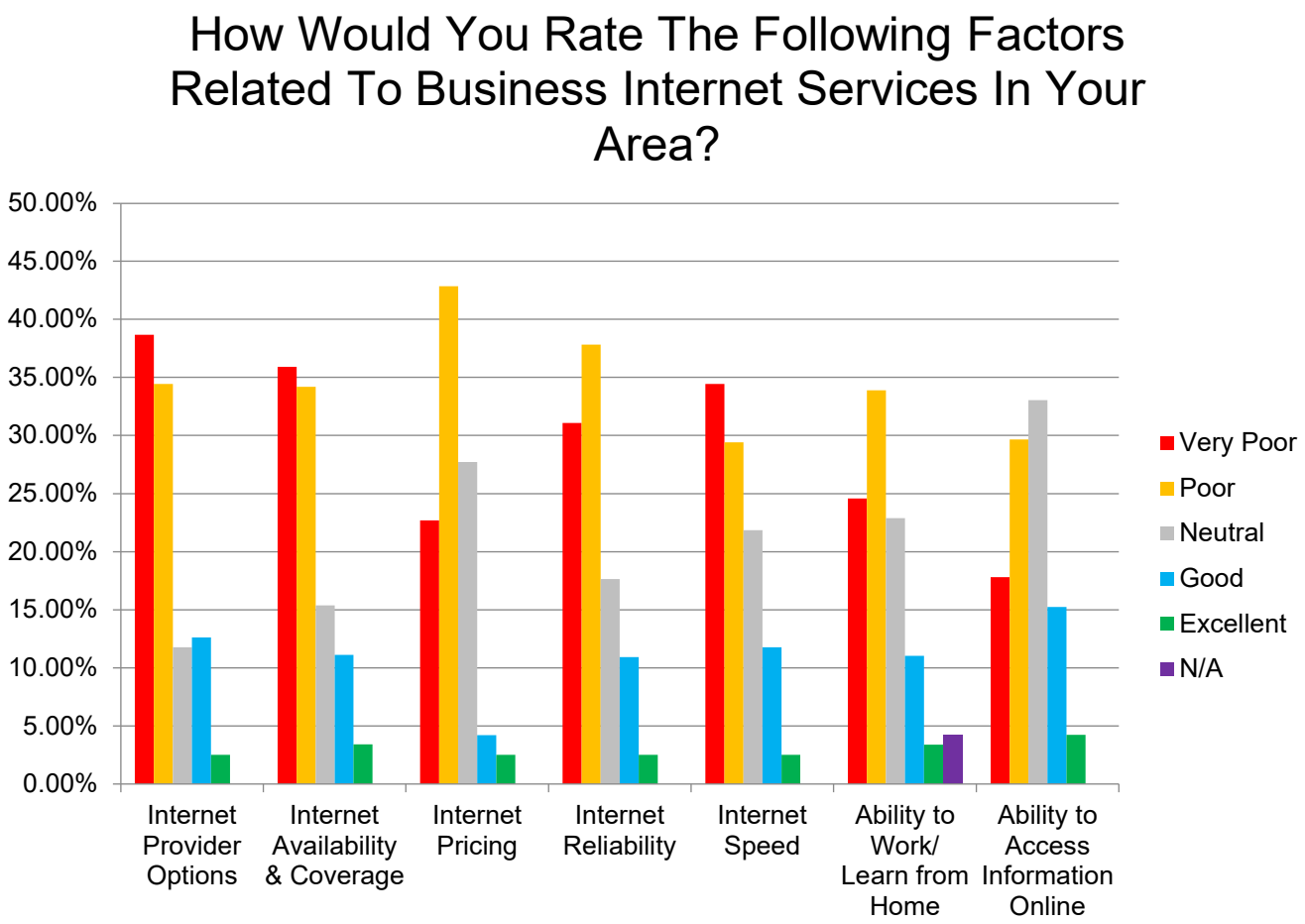

Figure 28: Survey Question - How Would You Rate The Following Factors Related To Business Internet Services In Your Area?

Table 6: Survey Score Based on Internet Connectivity Factors - Business Specific

Survey Score	
Internet Provider Options	-112
Internet Availability & Coverage	-103
Internet Pricing	-94
Internet Reliability	-100
Internet Speed	-97
Ability to Work/ Learn from Home	-77
Ability to Access Information Online	-49

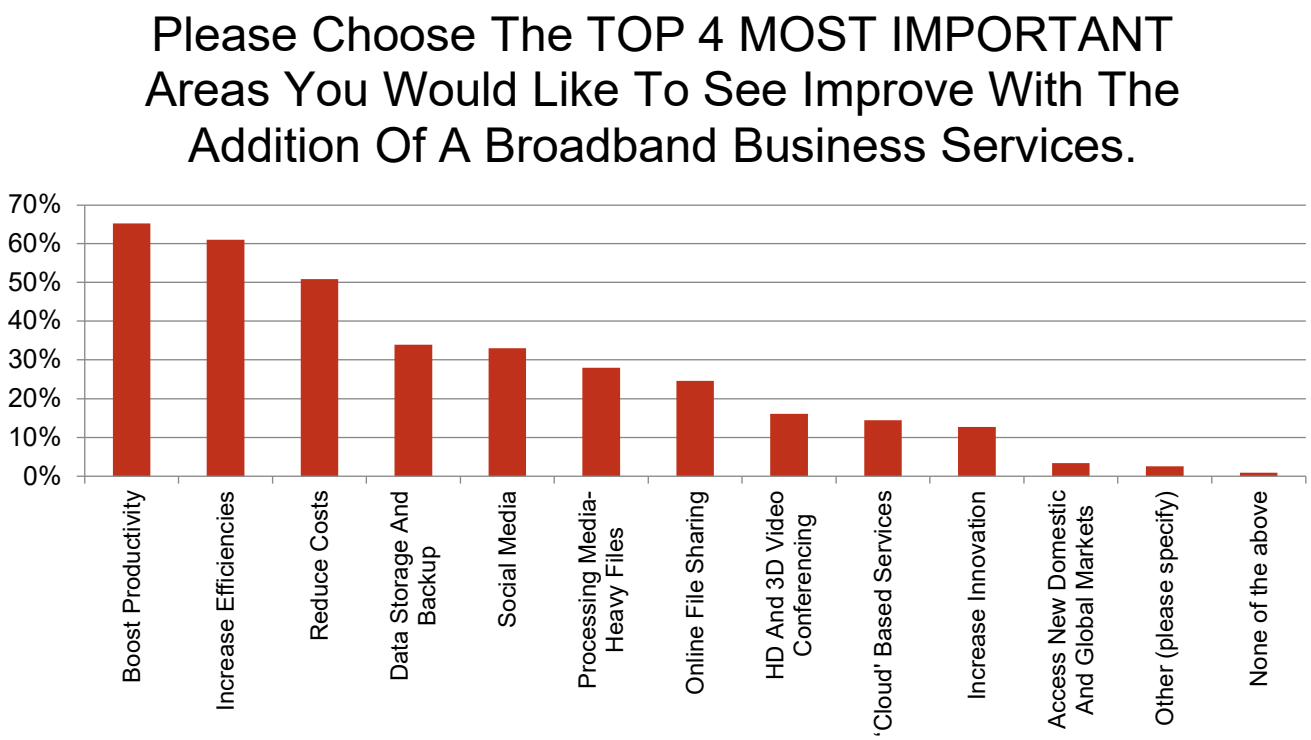

Figure 29: Survey Question - Please Choose The TOP 4 MOST IMPORTANT Areas You Would Like To See Improve With The Addition Of A Broadband Business Service.

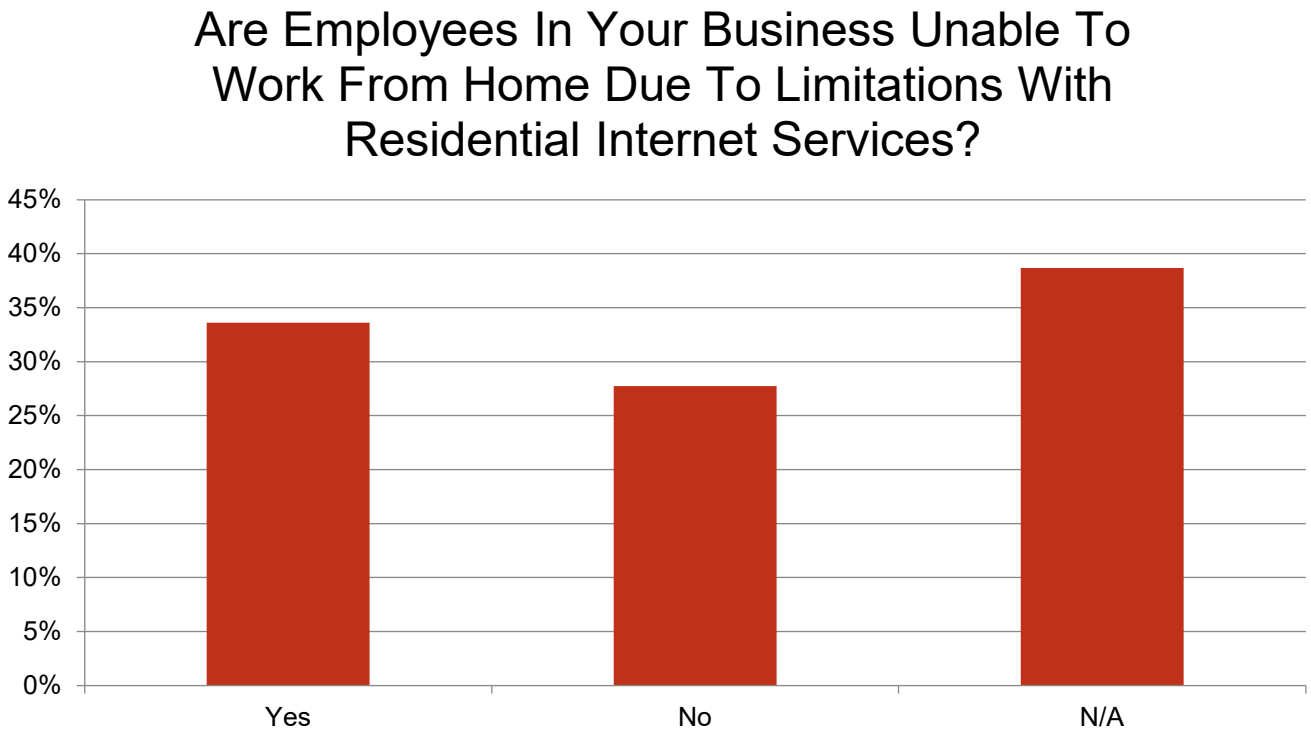

Figure 30: Survey Question - Are Employees In Your Business Unable To Work From Home Due To Limitations With Residential Internet Services?

7.2.2.1 Business Survey Analysis

Out of the 834 responses received overall by the survey, 149 of those (about 18%) answered on behalf of a business and its needs in Fort Bend County, TX. According to the US Census[13] data from 2018, which is the most recent that could be reviewed for this factor, there are about 13,982 total employer establishments within the County. Using that data, approximately 1% of businesses responded to this survey, and this should be made clear that this number of responses is not a valid representation of Fort Bend County businesses. However, while it may not be a complete depiction of needs for businesses, any data is valuable and will still be analyzed below.

The majority of responses to the business survey were similar to the residential survey in terms of where the survey was completed based on zip codes. These locations primarily include Fulshear, Weston Lakes, Needville, Pleak, Simonton, Richmond, and Rosenberg. Nearly all of these represented businesses that responded to the survey, the primary size of these businesses is relatively small with 1-5 employees (Figure 22).

About 58% of businesses do not use enterprise/ commercial internet services (Figure 24) and show a similar trend as residential respondents regarding where their internet comes from which is primarily cable but is surprisingly using nearly the same amount of fiber services as DSL, cellular, and satellite (Figure 25). The speed of these services is typically between 0-24Mbps or 25-99Mbps combining to about 62% total. For high-speed broadband of at least 100Mbps, 18% use 100-499Mbps, 4% use 500-999Mbps, and 18% use 1000Mbps or higher. While it is ideal to see almost 20% of businesses that responded using gig speed services, the majority amount of less than 100Mbps needs to be addressed.

In terms of challenges experienced and improvements requested, the speed and technologies are underperforming and customer services have become an issue (Figure 27) while businesses would like cheaper costs to help increase productivity, efficiency, and data storage while allowing the reducing overall costs (Figure 29).

Ultimately, the overall trends shown in Figure 14 and Table 4 of the residential responses nearly match a similar opinion for business services shown in Table 6 and Figure 28. all of the responses are overwhelmingly "Poor" at best, except for the ability to access information online also scoring relatively "Neutral" in this business case. The survey scoring all represents negative overall trends with the ability to access information online being the closest to neutral, although still negative. The provider options scored the worst for businesses, as opposed to pricing which scored the worst for residents.

Trends seen within both the business responses and the residential responses are quite similar and based on what has been reviewed about the infrastructure and services offered throughout this feasibility study, it is known that Fort Bend County does not have options for adequate service. It is not only a lack of adoption that is an issue for the County but just an overall lack of access or options for high-speed reliable broadband.

[13] QuickFacts. United States Census Bureau. https://www.census.gov/quickfacts/fortbendcountytexas. Published 2022. Accessed June 1, 2022.

7.2.3 Speed Test

In addition to the survey that was administered to the community of Fort Bend County, a speed test was also requested for residents to take so that real-world applications of the advertised speeds could be reviewed. The results gathered from the speed test are not invasive to where they can specify the physical addresses of those that took the speed test, if a VPN was used, or anything explicit about location data other than city, state, and general location. Because of that, some of the data gathered may include outliers that could not be filtered since there is no indication that external tests were completed that may affect the goal of collecting speeds from the primary internet source. Additionally, it should be noted that some factors can impact speed test results. Some of these factors include:

- Time of Day the Speed Test was Taken
  - Certain "peak hours" may result in slower speeds
- Location of Where the Speed Test was Taken
  - Having a line of sight to the router will indicate better results compared to on a second floor or in rooms further away from the router.
  - Certain construction materials in the home may cause dead spots for the Wi-Fi.
- Devices Connected to the Internet
  - Many devices in the background could be downloading or uploading data which may indicate a negatively impacted speed test
- Using a Virtual Private Network (VPN)
  - This typically throttles speeds since the internet is being routed through additional locations. Using a VPN would lower the values collected from a typical speed test.

With that in mind, all results are presented below apart from results that were gathered from tests taken outside of the state of Texas and outside of the general Fort Bend County area. The results of the speed test are as follows.

Note: This speed test was hosted on the internal servers of speedtest.net from Ookla.

Disclaimer: Survey results are representative of a sample of residents from across Fort Bend County who self-elected to take this survey. The results of the survey indicate speed levels recorded by participants in real-time; however, these results have not been verified by any providers.

Table 7, below, displays the upload and download speeds in terms of both median and average in Mbps as well as the average latency speeds recorded in ms. Since the use of median helps eliminate outlier answers compared to average it was necessary to include it in addition to average. Latency can sometimes be a more beneficial factor for internet speed experienced at the home or business as opposed to download or upload speeds.

Table 7: Speed Test Results - Average Speeds Recorded

Provider Name	Number of Speed Tests Recorded with This Provider	Average Download Speed (Mbps)	Average Upload Speed (Mbps)	Median Download Speed (Mbps)	Median Upload Speed (Mbps)	Average Latency (ms)
AT&T Enterprise	5	16	12	15	15	18
AT&T Internet	245	152	119	98	61	25
Comcast Business	3	186	176	255	261	7
Consolidated Communications	33	61	57	18	1	18
enTouch	1	307	39	307	39	18
Grande Communications	1	59	18	59	18	30
HughesNet	6	23	1	15	0	718
Lumen	1	510	41	510	41	19
Pure Speed Lightwave	1	95	94	95	94	4
Rise Broadband	19	45	6	46	6	24
SkyNet	7	13	4	15	6	27
SpaceX Starlink	7	30	4	17	4	100
T-Mobile	16	112	11	25	6	42
Verizon	16	27	6	31	6	46
Viasat	3	14	3	23	4	651
West Orange Wireless	1	19	3	19	3	41
Windstream	6	37	7	20	4	22
XFINITY (Comcast)	211	242	22	225	18	16

Table 8 below displays the maximum and minimum values recorded for both upload and download speeds. It should be noted that only responses from Table 8 that had at least 10 responses recorded from that provider are listed below. The maximum and minimum values with fewer responses would not provide additional context outside of the few responses recorded.

Table 8: Speed Test Results - Maximum and Minimum Speeds Recorded

Provider Name	Number of Speed Tests Recorded with This Provider	Maximum Download Speed (Mbps)	Minimum Download Speed (Mbps)	Maximum Upload Speed (Mbps)	Minimum Upload Speed (Mbps)
AT&T Internet	245	908	1	937	0
Consolidated Communications	33	948	1	936	0
Rise Broadband	19	76	14	17	2
T-Mobile	16	438	0	73	0
Verizon	16	46	1	13	0
XFINITY (Comcast)	211	716	3	43	1

7.2.3.1 Speed Test Result Analysis

Compared to the survey results only about 73% of respondents also completed a speed test (609 in total). A key point to highlight from the speed test results is that six out of the 18 recorded providers are either from cellular carrier sources or satellite services. With the exception of the T-Mobile responses, these speeds are near or under the Underserved definition of 25 Mbps/ 3 Mbps. Additionally, the latency for these services maxes out at nearly 3600% higher compared to the other recorded services.

For the remainder of the recorded responses, five services would be considered as having adequate levels of broadband by the NTIA funding requirements of at least 100 Mbps/ 20 Mbps, two of which are business-based services. These include Lumen (PS Lightwave), enTouch, XFINITY, Comcast Business, and AT&T Internet. For the residential services mentioned, enTouch has the highest download speeds but is not symmetrical while AT&T Internet was nearly symmetrical for 100+ Mbps. However, when reviewing median instead of average which helps removes outlier results, both XFINITY and AT&T Internet no longer meet that 100/20 threshold for speeds.

With all of those factors mentioned before that influence speed tests, it's interesting to see that two of the main ISPs recorded (456/ 582 or 78%) that there is a chance that neither are adequate for supplying future-proof high-speed broadband services. With minimal fiber present in Fort Bend County, but it is known that some of the present infrastructure belongs to Consolidated, it is worth noting that their average download and upload speeds are 61/ 57 Mbps, but shockingly their median download and upload speeds are 18/1. The disparity in results indicating such a big drop-off between average and median is not enticing for their services.

Finally, from Table 7 and Table 8, it is worth discussing the maximum and minimums recorded from the speed tests. While this could just be an outcome as a result of speed test flaws, it is concerning that nearly all of the shown minimums for download and upload speeds are nearly 0 Mbps. A Fort Bend County resident could be attempting to submit online homework or discussing treatment options for a medical condition through telehealth services when negative spikes like this occur. Rise Broadband, while only from 19 points of data, recorded the highest minimum speeds, the lack of symmetric results and actual values recorded are still not what is needed for future-proof demands. Otherwise, what is optimistic in general is that both AT&T Internet and Consolidated have proven that symmetrical speeds are possible for their services at nearly 1 Gbps. While these results are exceeding the minimum requirements for future proof standards, it is hopeful to see speeds present like this in Fort Bend County. The next step is making sure it reaches more residents and is affordable for adoption.

8 NEEDS AND GAP ANALYSIS

Section Highlights

- THE RURAL AND URBAN SEPARATION IS THE BIGGEST ISSUE LEADING TO LOW ADOPTION.
- REGIONAL AND LOCALIZED NEEDS ARE NOT BEING MET AND ARE IMPEDING SOCIO-ECONOMIC GROWTH.
- THE LACK OF PROVIDERS IN RURAL FORT BEND COUNTY NEEDS TO BE ADDRESSED.

Fort Bend County has a true blend of city life amenities as well as rural or small town lifestyles. These attributes are mirrored when it comes to broadband infrastructure, services, and network architecture. As shown in the upcoming figures, there is a clear line of where services are offered and where urban and rural homes are separated. Additionally, it is apparent that the individual cities within the County experience these broadband gaps as well. Residents, businesses, schools, and the local government require an affordable, capable, and reliable communications infrastructure to operate efficiently, which cannot be accomplished with patchwork coverage and non-competitive pricing tiers that are not valued-based on the quality of service (QoS) for the end customer. The concept and impact of the digital divide are finally under a national spotlight largely due to the COVID-19 pandemic and, more recently, Winter Storm Uri which crippled the state's electrical grid and localized utilities. Without a comprehensive understanding of the root causes of the lack of infrastructure in a particular region, a meaningful solution that is uniquely catered to address the broadband gap and the community's needs cannot be developed.

8.1 Understanding the Data and Sources

From a federal standpoint, the Broadband needs and gap analysis is extremely high level and trend-based at best. Until recently, the Federal Communication Commission (FCC) has been the single source of broadband coverage data, which is gathered primarily through FCC Form 477, which ISPs are required to submit twice a year. The primary issue with these forms is that they capture limited data at a census block granularity, ultimately providing an inaccurate analysis of broadband availability at the consumer level within that census block. If a fixed provider (provides services to fixed devices/locations, i.e., ethernet or Wi-Fi to fixed devices) offers service to a single household, the entire census block reflects this service regardless of whether any other household has broadband service from this provider.

As a result, in rural census blocks, the gap analysis is severely misrepresented. In addition, mobile providers (services to mobile devices, i.e., smartphones and tablets) only need to submit maps of their coverage area by broadband technology. Conclusively, the FCC's broadband coverage maps and data do not provide an adequate single source for determining broadband needs, which ultimately feed reports on qualifying metrics for state and/or federal funding and assistance. The FCC is aware of and has admitted the need for an overhaul of this data and has created a Broadband Data Task Force and various web-based tools and broadband experience repositories to capture data outside of the single source form. Updated FCC maps with more granular data based on parcel-specific services are expected to be released in the 3rd or 4th quarter of 2022.

In addition to the FCC, non-profit, state, and local entities have created working groups and committees that strive to collect better broadband data to help communities determine the needs, understand the cause, and consult on the development and implementation of applicable broadband solutions. One of these entities, ConnectedNation, relays resources aimed at closing the digital divide. ConnectedNation Texas is a statewide initiative funded by the Texas Rural Funders to support all Texans in leveraging broadband. ConnectedNation expands upon existing Form 477 data and aims to provide more localized and accurate reports of broadband coverage and technologies.

8.2 Identifying Lack of Adoption Areas

While the FCC data may be misleading when reviewed as a single, isolated source and in isolation, it does provide a sounding board to contrast with further research of the existing conditions and feedback through meaningful stakeholder engagement. The approach for this Broadband Improvement Study was to start by collecting the latest publicly available broadband data as a foundation, build in new layers that provide additional content for analysis, and overlay the proposed network footprint and service requirements. Many of the following figures and maps below may use ConnectedNation[14] resources and data which are ultimately derived from FCC Form 477[15] data which was most recently updated in December 2020. All of the collected information was used to help identify areas of need in Fort Bend County.

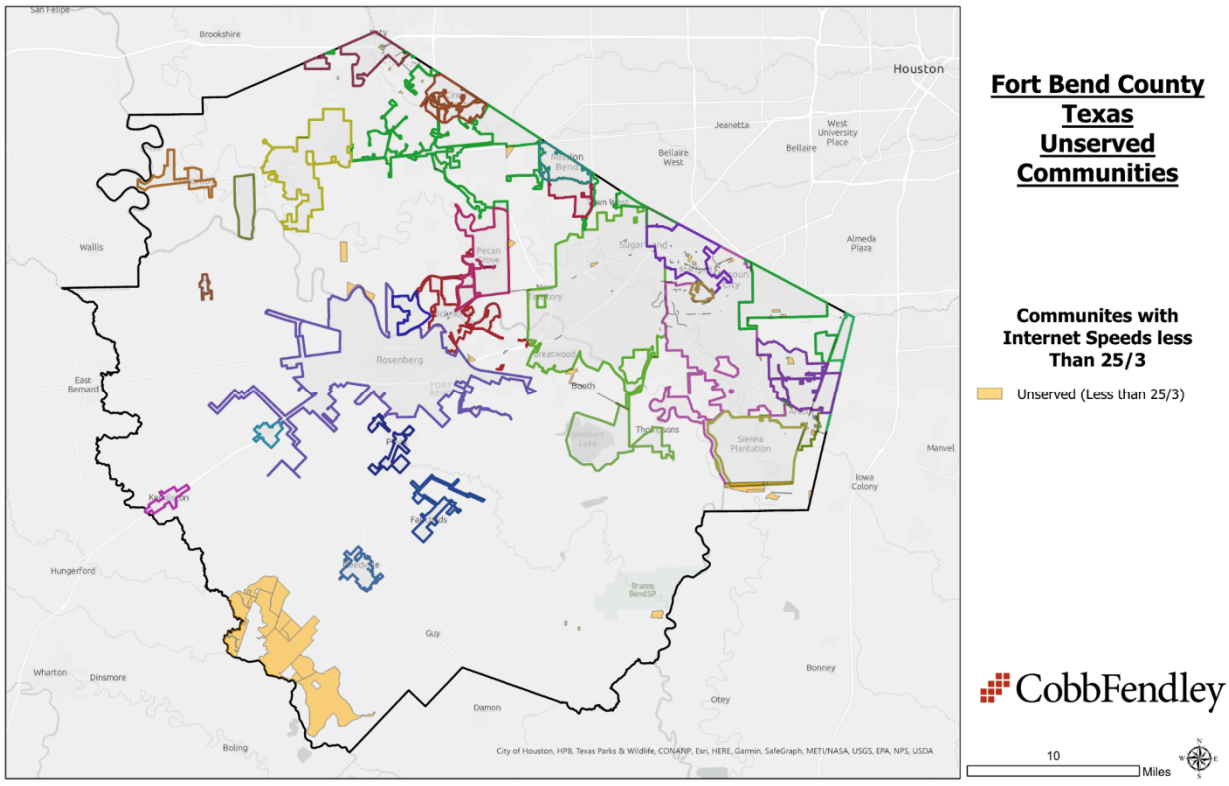

Figure 31: Unserved Communities in Fort Bend County (Lacking 25/3 Mbps)

[14] ArcGIS Web Application. Gis.connectednation.org. https://gis.connectednation.org/portal/apps/webappviewer/index.html?id=9e10c6120228435ca35c759fac3d805e. Published 2022. Accessed June 1, 2022.

[15] Form 477 Resources. Federal Communications Commision. https://www.fcc.gov/economics-analytics/industry-analysis-division/form-477-resources. Published 2022. Accessed June 1, 2022.

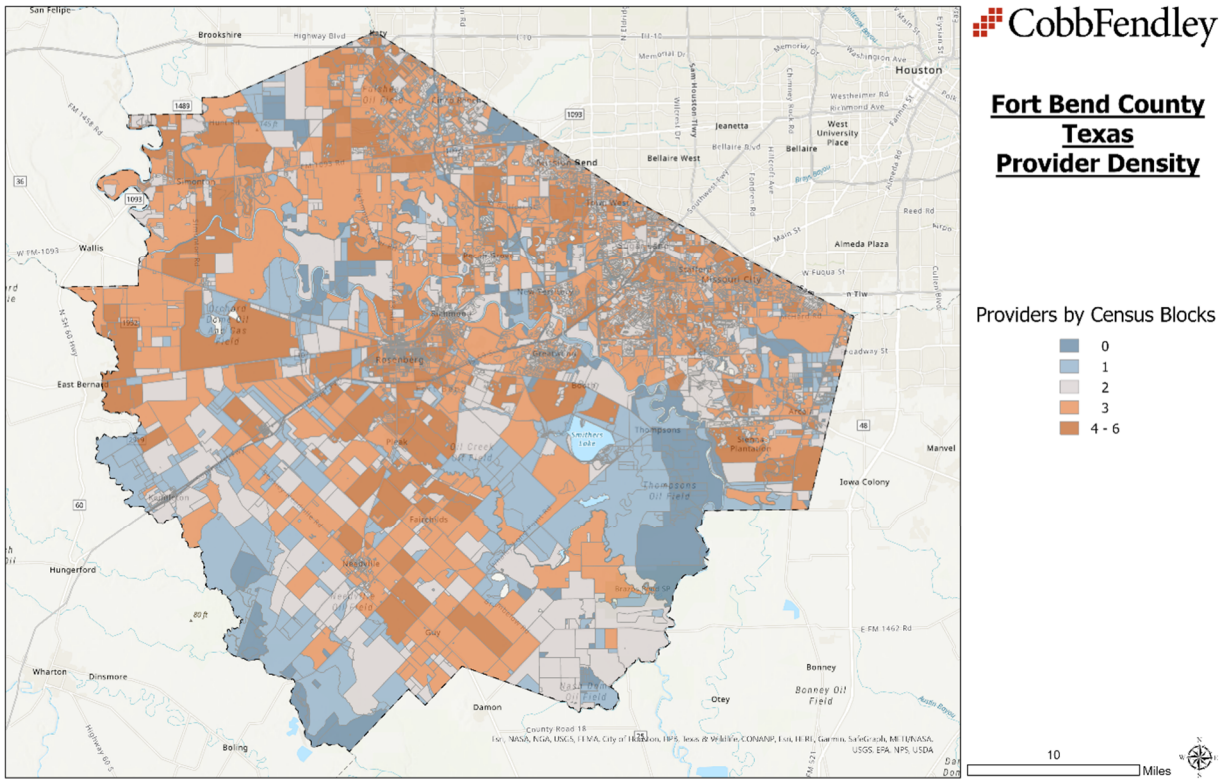

Figure 32: Broadband Provider Density

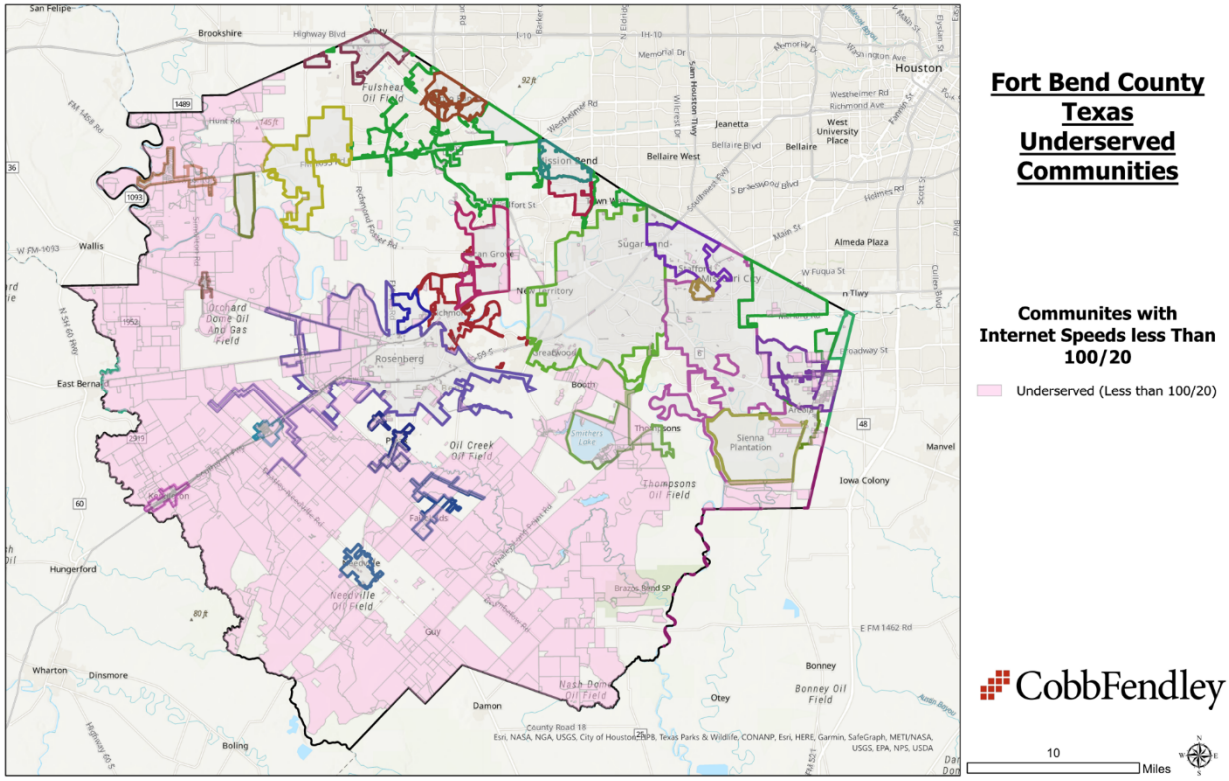

Figure 33: Underserved Areas in Fort Bend County (Lacking 100/20 Mbps)

Figure 31, as seen previously within this report, highlights the greatest need for broadband services by showing areas that do not currently have access to 25/3 Mbps services and are considered Unserved. The primary section of the County that is experiencing this lack of service is southwest of Needville, with other smaller sections sprinkled throughout the County. These areas are mostly just outside of city or town limits for many of these locations include Rosenberg, Pecan Grove, Mission Bend, Sienna, Arcola, and Booth. While some of these sites may not currently include residential homes, with the growth that Fort Bend County is experiencing it is important that all sections of the County are covered for future needs. When increasing the speed threshold to the Underserved criteria of 100/20 Mbps, nearly all of the southwestern half of the County is indicating a need for service. Most of this was covered extensively in earlier sections of the report, but 50% of households in the County don't have access to these fiber services at the home and some of these areas of need even extend north into Stafford and Missouri City. The County is expansive with multiple providers, but there are still too many gaps experienced even with the plethora of infrastructure.

When reviewing the provider density, shown in Figure 32, many parts of the County have access to only one provider. Within the cities, you see more saturation and variation, but as expressed before this is to be expected. These locations have the ideal 100Mbps download speed offerings and have broadband services from 5 or more providers, so with the population density experienced in those communities, the high take rate is more attractive to providers. However, in the southwestern half of the County, where the populations are sparser and more rural, the only opportunity for internet is from one provider. The lack of competition there can create additional problems, including high prices or subpar service, but ultimately can lead to a greater digital divide.

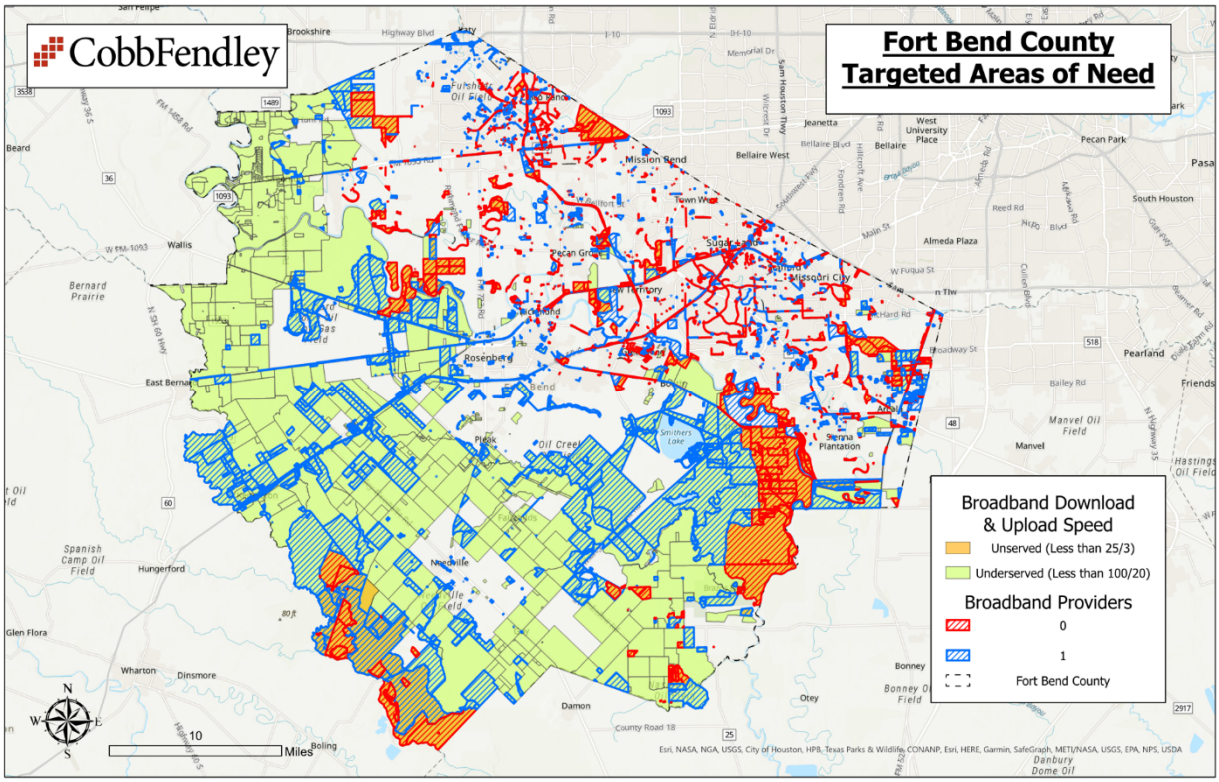

Figure 34: Targeted Areas of Need in Fort Bend County

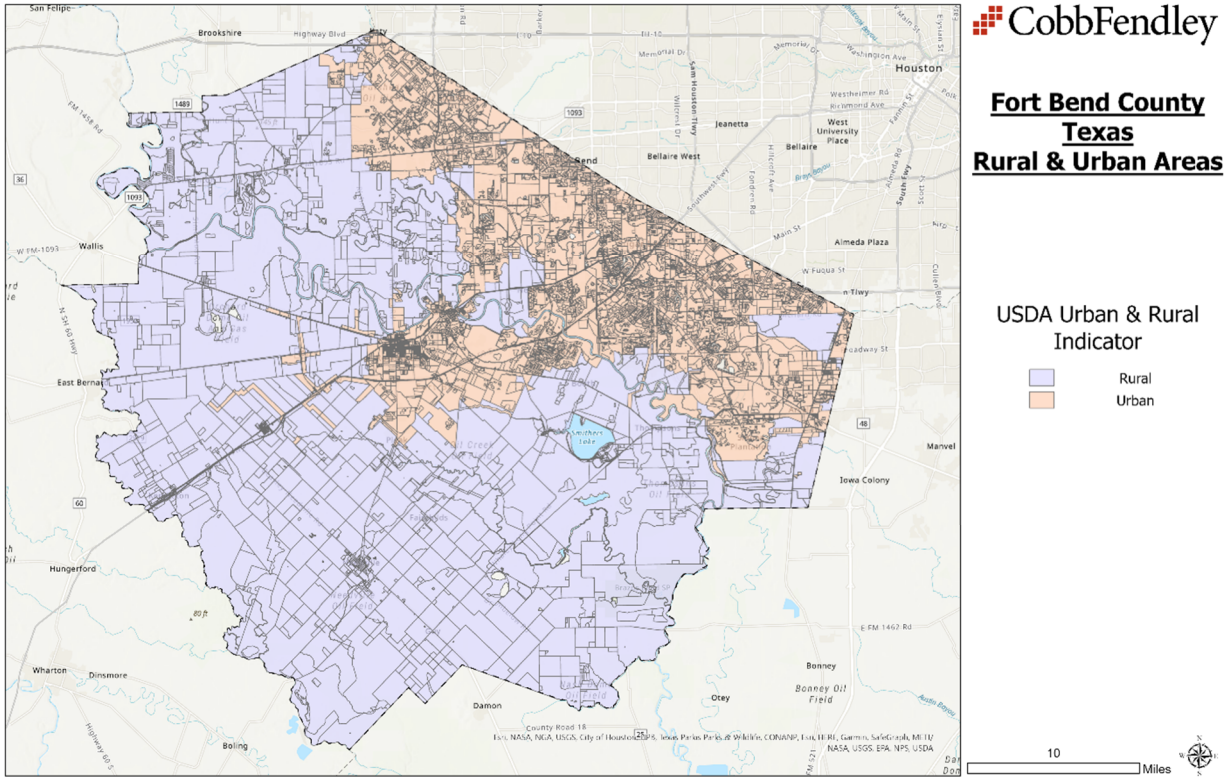

Figure 35: Rural & Urban Areas in Fort Bend County

In combining Figure 31, Figure 32, and Figure *33*, Figure 34 highlights all of these needs into one overlay map. The areas of the County analyzed above in the previous figures are all visible here with their needs showcased but with additional context of multiple factors playing into the potential gaps created by the digital divide. The areas that are experiencing the greatest impact from the combination of the infrastructure and providers present include Thompsons, Arcola, north of Mission Bend, north of Rosenberg, and south of Needville. Any highlighted area with Figure 34 needs to be addressed, but these overlayed areas of need just mentioned need to be a priority for the County when addressing gaps in adoption and coverage for high-speed broadband.

Figure 35, above, helps specify the differentiating areas of rural and urban Fort Bend County as officially designated by the United States Department of Agriculture (USDA). The interesting point of emphasis of this rural area of the County is that it is almost directly an inverse relationship of the provider density seen in Figure 32 and nearly matches that of the Underserved communities in Figure *33*. While mentioned previously that Fort Bend County is experiencing rapid population growth, that may be why the extent of broadband providers and 100/20 services extend passed the designated urban line, but the shape of spatial need is nearly identical which is mostly intend by design. To make business sense for a provider, the main factor is always going to be take rate and homes passed. However, with this federal and state funding that is about to source many broadband projects throughout the country, this is time to address the rural needs so that the digital divide cannot expand further.

Outside of a lack of infrastructure, the most common factors for lack of adoption typically include customer age, poor customer service, income and the cost of technologies, and digital literacy. The figures below help provide insight into some of the potential deeper ideas behind the lack of adoption in Fort Bend County.

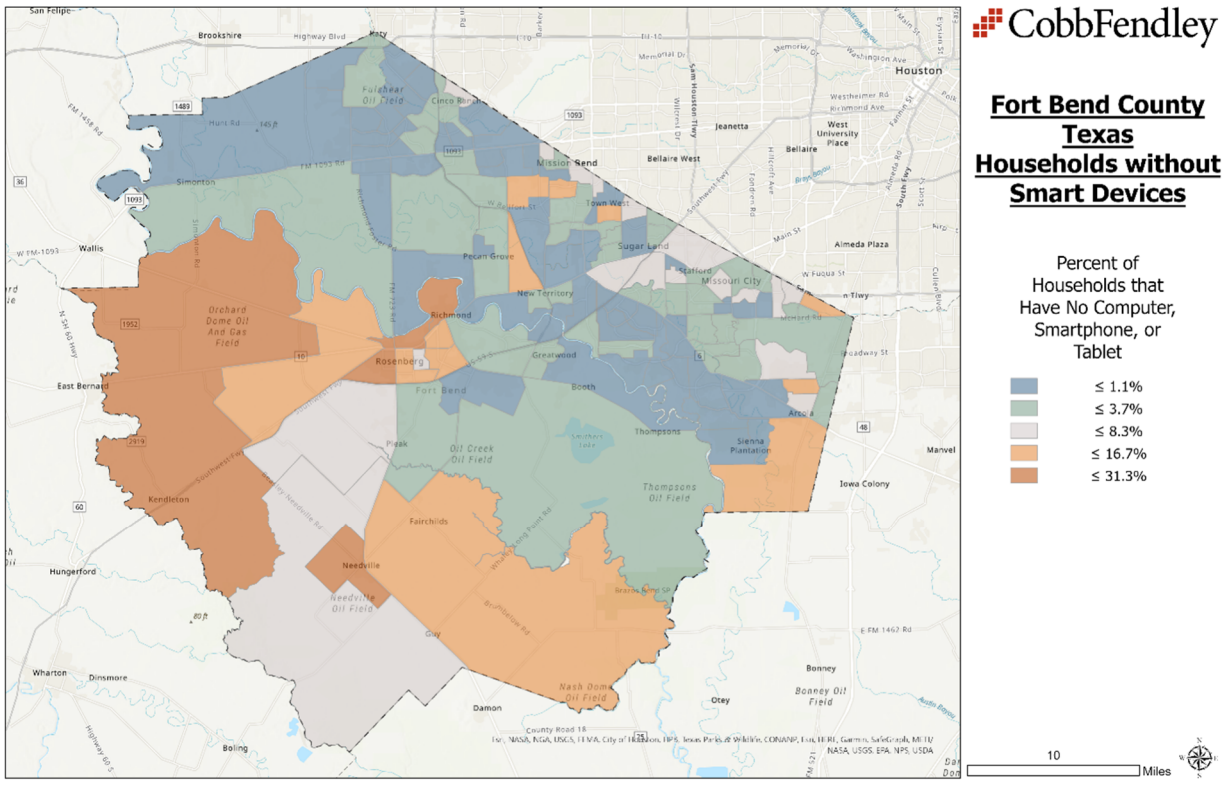

Figure 36: Households Without Smart Devices

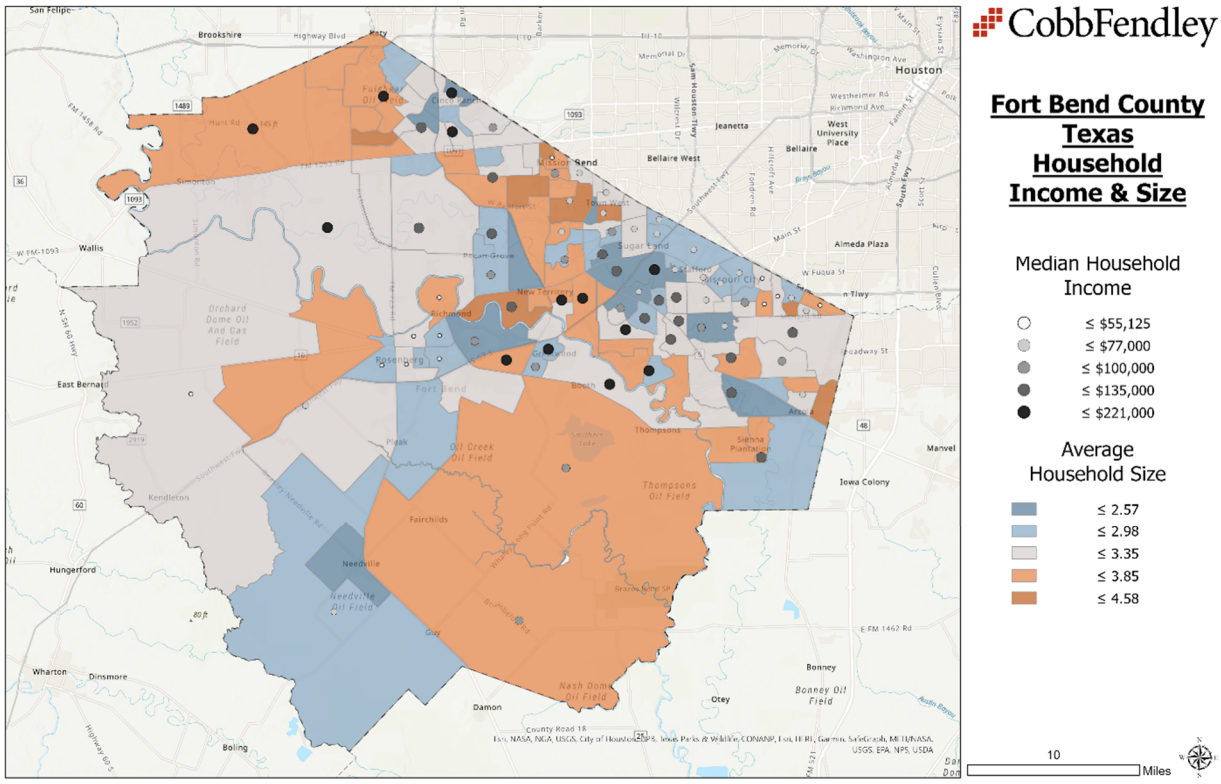

Figure 37: Average Household Size and Household Median Income Overlay

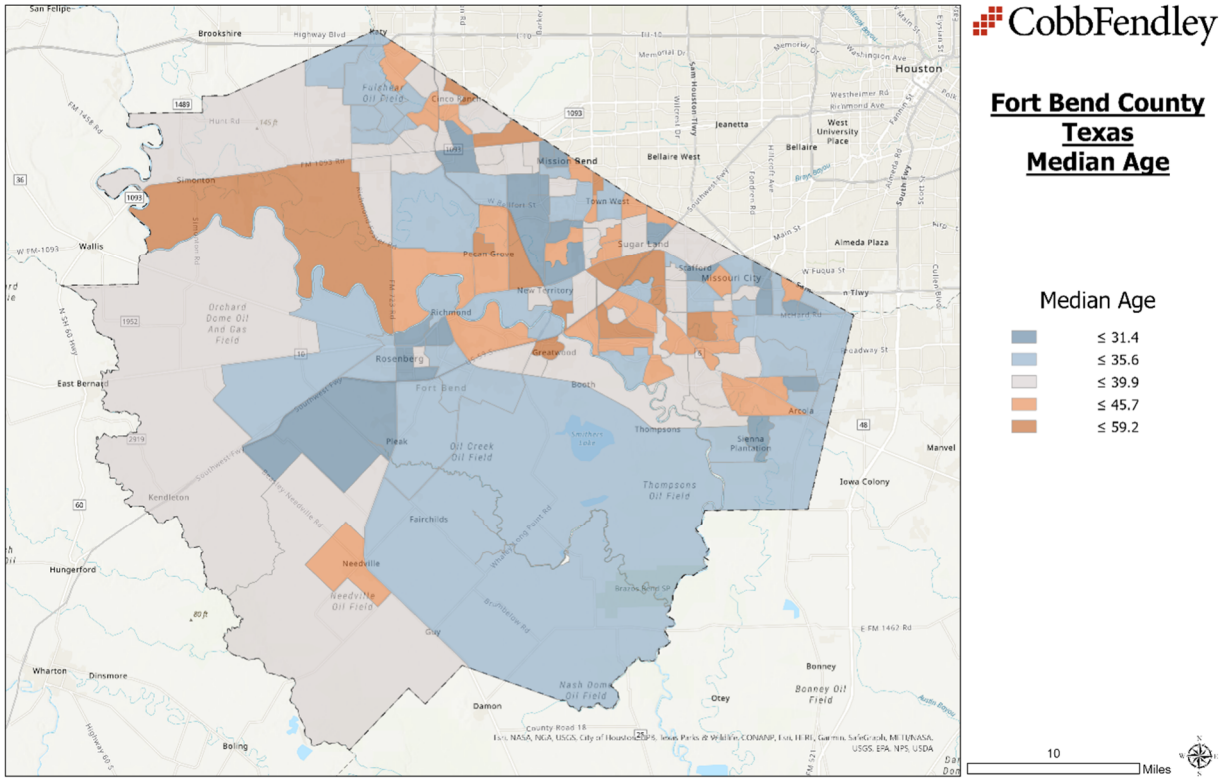

Figure 38: Median Age of Fort Bend County Residents

In Figure 36 the residents that do not have the necessary devices needed to adequately experience the full extent of broadband services, which includes a computer, smartphone, or tablet, can be analyzed. Out of the 104 tracts that make up Fort Bend County, 16% of these tracts result in a 10% or higher of households that do not have the appropriate devices. Some of which reach upwards of about 26% of households without appropriate devices (100% within the tract just northwest of Richmond, but this only contains 4 households). Many of these communities shown are those within rural Fort Bend County that do not contain adequate service. Whether it's income or knowledge of benefits that smart devices provide, these trends are what expand the digital divide and lead towards a digital illiteracy. As technology progresses, those within these areas will have a greater learning curve for understanding the way smart devices work and how to receive the largest impact out of them with upgraded infrastructure in the future.

Reviewing Figure 37 helps provide more information about the households in Fort Bend County. In general, one can assume that having a larger household size while also having a lower household income may result in less expendable income for an expense like sufficient broadband services. The public perception may be that broadband services are not considered essential, which may indicate that a lack of available quality services or application of these services is contributing to digital illiteracy. As seen in the figure, that trend of higher household size with lower household income is not typically seen in the rural areas of Fort Bend County, but it is seen in the areas that border Harris County, such as Mission Bend and Missouri City, in the Sugar Land area, and around Arcola. However, these areas typically do not see low adoption relative to what is seen in the rural areas. The tract near Mission Bend, north of the Sugar Land area, though does highlight a notable urban region of the County that is seeing lower broadband adoption compared to its neighboring areas. Many of the rural communities have smaller household sizes but also have lower household incomes. As seen in Figure 37 and Figure 38, these homes may represent a two-person household of an older than average age.

Finally, after reviewing Figure 38 and considering the average age for the tracts in Fort Bend County, the same trends that showed a lack of services and relative applications is reflected in the southern and western areas of the County. Again, Sugar Land appears to have an older average age as well, but considering the urban aspect of that area, it doesn't appear to be an issue for adoption here specifically. In the rural communities of the County though, especially in the western region of the County near Orchard and south of Fulshear and Simonton, the largest ages seen throughout the County are found there. In addition to the lack of services offered, the lack of infrastructure, household income, and now age, this is an additional region of the County that needs to be addressed for digital literacy and a priority for future implementation of broadband service and infrastructure.

8.3 Reasons for Lack of Broadband Adoption in Fort Bend County

Based on all of the figures above, the following adoption factors can be analyzed:

- Age
    - Age may be a factor in the lack of adoptions within the rural parts of Fort Bend County. The areas that have a higher average age line up with the areas that have no smart technology devices based on Figure 37 and Figure 38. Knowing this is the case for certain parts of the County, the digital literacy within rural Fort Bend County should be addressed. Within the urban parts of the County, there are no trends that suggest age is a factor in the lack of adoption.
- Lack Of Providers
    - The lack of ISPs in the County is the biggest cause of lack of adoption. As seen in Figure 32, the density heavily favors the bigger cities within the County, but elsewhere it is one or maybe two providers at most that meet the needs of residents. Thompsons does not have broadband services, according to this data. The lack of providers is a large concern that needs to be a focus in addressing broadband equity in Fort Bend County. When there are no providers offering adequate service, the need for smart technologies at high prices may not be seen as a priority for residents, and the digital divide continues to grow in these communities.
- Lower Income Households & Cost of Services and Devices
    - Upon further review of the data, it appears that cost could be a factor in some of the areas in the northeast and the eastern regions of the County where there is a lower household median income, specifically Mission Bend, Missouri City, and Arcola. There are tracts that show an estimate of about 15% of households have no

current internet access. In the rural parts of the County, specifically heading west along Highway 90 towards East Bernard, there are also areas in which income and cost could be a factor for broadband adoption.

- Digital Literacy
    - In areas and populations where there is a lack of access to modern networks and applications, knowledge gaps of emerging technologies can stunt adoption and disadvantage these populations. Broadband technologies are evolving and changing at rapid rates, and it's easy to feel left behind and individuals may be overwhelmed and so dissuaded from adopting. If an individual does not have access to broadband services, they are also likely to be unaware of the benefits of such a service. Overall, it can be assumed that a lack of experience ultimately leads to a lack of knowledge about the expansive features of broadband. There are trends seen within the data that suggest digital literacy could be a big factor within the rural parts of Fort Bend County.

Upon review, it appears that the Underserved areas of the County include anything west of Rosenberg, including Rosenberg, in the northeast of the County around Mission Bend along the Westpark Tollway, Thompsons, and the eastern area around Arcola. Most of this is due to a lack of existing infrastructure, and when new service eventually comes into these areas, subsidization for low-income families should be implemented.

8.4 Emergency Management, Education, and Additional Needs

Emergency management, especially as it relates to security functions and healthcare, typically requires secure and dedicated channels which do not share bandwidth within the network. Through this study various emergency management and healthcare facilities have been identified which will benefit from local connectivity while also ensuring the security and integrity of sensitive data that may stay local within the network or go into VPN-based (Virtual Private Network) cloud charting systems, patient databases, etc. Depending on how advanced a hospital and its specialty is, there can be a broad range of content of varying sizes from text charting to high-resolution scans and videos for surgical documentation. Healthcare facilities within this region need to have the network capacity to expand and take advantage of bandwidth-heavy applications to stay competitive and provide the best care for the local populace. Wireless facilities play a large role in connecting mobile devices for emergency services such as fire and police. These wireless facilities are more reliable when they have fiber backhaul connections to central facilities where they can manage connections to an array of applicable databases. Having interconnectivity between emergency service facilities would greatly increase the effectiveness of law enforcement and emergency response by consolidating network assets and removing costly leased lines.

The needs of the school districts in Fort Bend County are not on infrastructure or facility-based demand, but more so on the home life of the students. Through stakeholder engagement, Fort Bend County ISD and Lamar Consolidated ISD helped CobbFendley understand the more recent need brought about by the COVID-19 pandemic that forced remote learning on communities. The districts within the County made a tremendous effort to help bridge the digital divide with these students in need by providing hot spots and mobile Wi-Fi, but ultimately this need helps point to the fact that many of these families may be facing economic hardships, are experiencing issues with digital literacy, or just do not have the opportunity to subscribe to high-speed broadband for their homes. Broadband, and the devices required to access it, are not considered low among amenities, but there are current programs that help aid those in financial need, primarily the Affordable Connectivity Program (formerly the Emergency Broadband Benefit).

Addressing the Underserved and closing the digital divide is very important to Fort Bend County. The digital divide can be better defined as the "economic, educational, and social inequalities between those who have computers and online access and those who do not.[16]" The equity of digital wellbeing has been established lately as a necessary factor for successful health, education, and career, especially since the start of the COVID-19 Pandemic. Due to a lack of infrastructure, those who reside in rural areas, those who may be disabled, and racial and ethnic minorities are all disproportionally affected by the digital divide. Access to

[16] "Digital divide.". Merriam-Webster.com. https://www.merriam-webster.com/dictionary/digital%20divide. Published 2022. Accessed June 1, 2022.

technologies, such as computers and smartphones, can be a significant barrier to benefiting from broadband infrastructure and digital advancements due to their high price points for entry-level devices. Presently, bandwidth can now be added to the list of factors causing inequity of digital literacy, whether that's due to pricing, availability, coverage, etc.

The Digital Divide and Rural Broadband initiatives are not new, but the definitions and measurement criteria have evolved to be more comprehensive and applicable as the nation focuses in on infrastructure, with a specified focus on broadband. There have been many lessons learned over the past few years where the focus was on the rural and the Unserved populations as opposed to general adoption rates and a wide array of Underserved communities. Federal funding is a necessary component of the solution, but addressing the Underserved first requires understanding the Underserved, which is where municipalities outshine ISPs. Addressing the Underserved is complex and takes gathering all the facts and documentation that this study provides, but the real work which needs to be done is locally promoted engagement and facilitating responses and feedback from these communities. The County can address the Underserved by implementing incentives for development that will help upgrade the quality of life for residents in these communities so that all residents have the opportunities to flourish. Broadband has the potential to address these many of the needs in these areas and should not be excluded from any potential solutions employed by the County.

9 COMMUNITY IMPACT ASSESSMENT

Fort Bend is the fastest-growing County in the nation with exceptional schools and a highly talented workforce, it is also considered the most diverse County in the country. Understanding Fort Bend County's community benefits from the deployment of fiber requires a review of the roles broadband plays in long-term community success as it relates to both economic development and quality of life for residents. In this section, the reader will better understand:

- The key role of broadband as a digital transformation for local government
- The technical need for broadband to enable the implementation of technology now and in the future
- The potential qualitative and quantitative economic and community impacts specific to Fort Bend based on broadband deployment that enables multi-layered technology stacks

Section Highlights

- WITHOUT HIGH-SPEED, UBIQUITOUS BROADBAND, SMART TECHNOLOGIES CANNOT OPERATE PROPERLY.
- THE ECONOMY, QUALITY OF LIFE, AND MORE ARE ALL POSITIVELY IMPACTED.

9.1 Digital Transformation

Fort Bend County's leadership recognizes the opportunity to not only install a reliable and resilient communications network with a fiber backbone but also use this foundational technology as a powerful tool for economic development. More than ever, economic development is fueled by the ability to maintain or improve the quality of life for residents. Modern and future technologies available to the government improve efficiency, effectiveness, transparency, cost-effectiveness, resiliency, and safety, all of which improve life experiences in homes, places of work, and in the community. The ongoing application of these technologies to improve government performance is defined as digital transformation. According to Harvard Business Review[17]. digital transformation can be categorized into a few key components: technology, data, process, and organizational change capability. For the purposes of this analysis, technology, data, and process are considered the focus.

[17] The Essential Components of Digital Transformation. Harvard Business Review. https://hbr.org/2021/11/the-essential-components-of-digital-transformation. Published 2022. Accessed June 1, 2022.

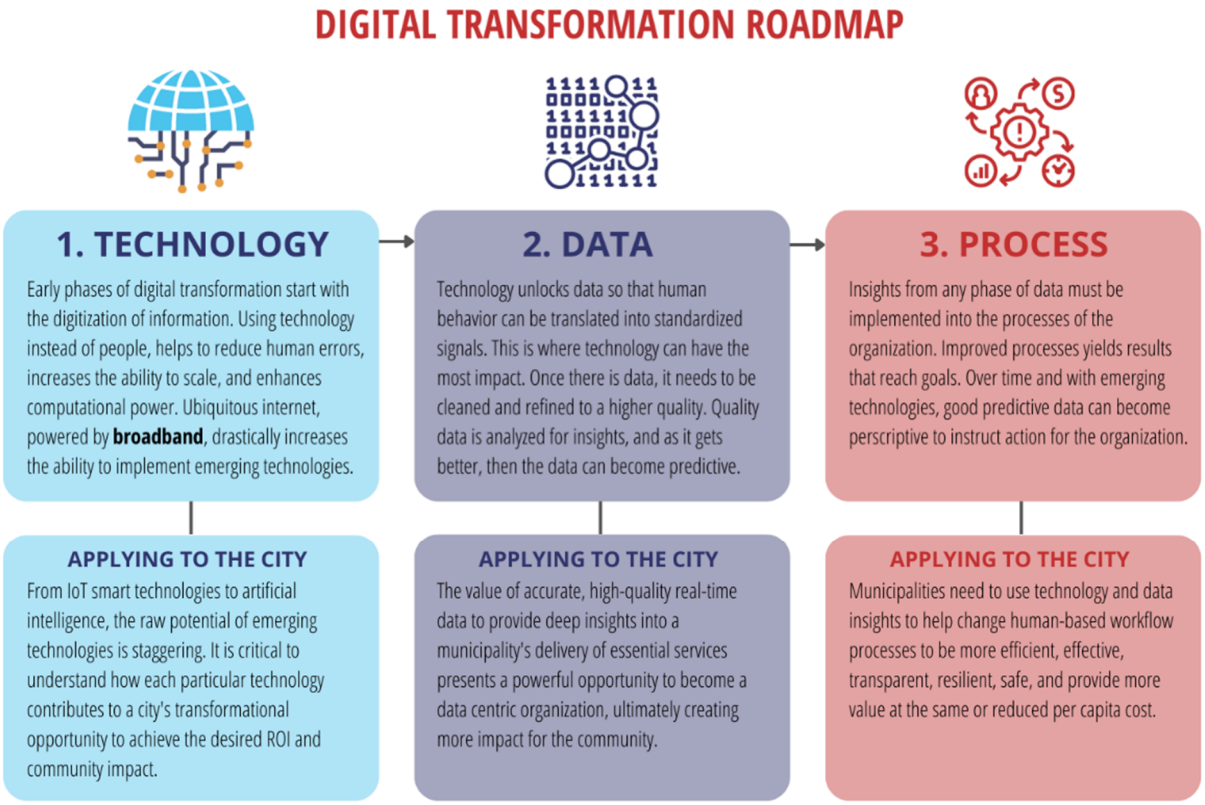

Figure 39: Digital Transformation Roadmap

For the County, digital transformation requires many different things to be successful. The initial step is for leadership to have the willingness, interest, and financial resources to match their digital transformation vision and goals. An essential component in the Technology phase of the journey to digital transformation is infrastructure, such as a fiber network, to enable high-speed, ubiquitous internet which serves as the foundation for all technology applications.

9.2 Broadband and Smart Technology Overview

Technology architecture is classified in layers, with infrastructure such as broadband at the foundation. Understanding how these layers are accretive and complementary demonstrates the necessity of broadband for innovation and future transformation. These layer-oriented categorizations are based on the component's critical architecture, functional impact, and/or complementary characteristics. The three layers are:

- **Foundational** - Essential technology that provides a dependent foundation for other technology applications to function
  - It should be noted that physical infrastructure (roads, streets, utility poles, etc.) can also be a foundational layer, although it may not be "technology"
  - The policy is also considered part of the foundation for operational compliance
- **Enabling** - Technology that provides specific functions
- **Impacting** - Technology that enhances or complements technology, usually at the enabling technology layer

Fiber infrastructure is in the **foundational layer** as a critical building block for other technology.

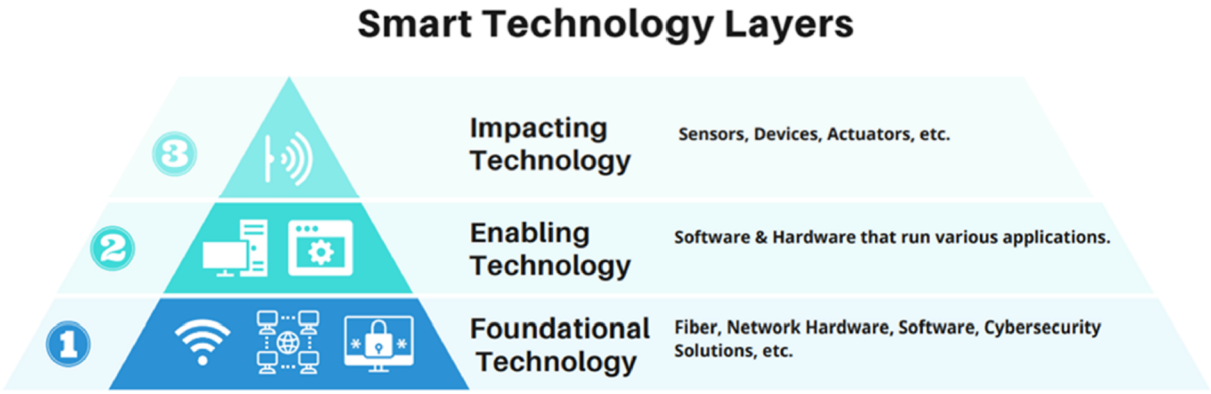

Figure 40: Technology Layers

It is also important to note that each layer enables the layer above it. Without high-speed, ubiquitous broadband, smart technologies cannot operate properly, and the desired outcome will not be achieved with the risk parameters.

Without high-speed, ubiquitous broadband, smart technologies cannot operate properly.

With broadband fiber availability, Fort Bend County will have an opportunity to enhance economic development initiatives by implementing various "smart" technologies on the path to digital transformation. Some examples of how these technologies could improve the quality of life, business attraction/retention, and the delivery of County services in Fort Bend are included below in Table 9. These technologies were specifically evaluated as potential examples that Fort Bend could implement based on the needs and goals of the community.

Table 9: Impact of Civic Technologies

Technology Example	Impact
Traffic Technologies (Intelligent Traffic Systems, Adaptive Traffic Signals, etc.)	With Fort Bend's high growth rate and major employers, technologies and infrastructure that support moving commercial and personally owned vehicles quickly makes a significant impact. Proven technologies that increase the flow of traffic will reduce commute time, improve EMS response times, and reduce CO2 emissions.
Public WiFi Connectivity (especially in Fort Bend's twelve parks, community centers, public gathering places like fairgrounds, and developing innovation hubs	Strategically placed public WiFi connectivity can bridge a gap (even temporarily) in underserved areas and expan the reach in rural coverage. While ubiquitous fiber is the goal, connectivity is where some of the impact occurs. Public WiFi not only connects residents in more ways but serves as a placemaking approach.
Transportation and Mobility Technologies (Micromobility, Autonomous Vehicles, Transit Options)	With Fort Bend's innovative culture and highly-educated workforce, innovative transportation options would enhance its comparative advantages. Autonomous microtransit corridors, only possible with reliable broadband, could provide additional options while preparing for the future.
Collect data derived from technologies across Fort Bend's digital infrastructure platform (such as optical sensors, origin-destination patterns, device connectivity patterns, etc.	Fort Bend is already a data-rich county that makes data-driven decisions. The data input can be greatly enhanced with technologies to gain real-time insights and diagnostics. Robust data enables information on how to manage growth, save money, improve system efficiency, and attract and retain employers and talent.

9.3 Broadband and Technology Impact

The community impact calculations in this section provide a closer, measurable look at the opportunities that digital transformation can play in unlocking the economic potential of a community when the transformation is properly planned, implemented, and maintained. These direct and indirect community impacts could be considered a return on investment (ROI). Another way to look at ROI from digital transformation is to measure it in terms of "customer experience", digital capability, and returns-on-innovation, all of which are drivers for economic development. This analysis does not reflect these additional estimates or opportunities for Fort Bend County. Instead, this snapshot is intended to provide a glimpse of the potential economic impact that is the result of enhanced technology, more robust data, and more efficient processes that Fort Bend could experience that ultimately lead to a higher quality of life for residents, businesses, and visitors. These efforts ultimately help to save money, enhance resident experiences, and provide a platform for future growth.

9.4 Methodology for the Impact Analysis

We have compiled economic impact areas using data from a wide variety of trusted sources*, and quantified them in specific terms, when able. A variety of models have been used to measure the impact of broadband on Fort Bend County's economy with different formulas and variables.

Some of these impact calculations provide specific ROIs, while others have ROI ranges. In some cases where quantitative

values were not relevant or able to be produced, we have provided quantitative commentary throughout to reflect the positive impact that broadband will have on Fort Bend County and the surrounding region.

Some of the economic benefits reflected in these calculations will require additional technologies to be installed on the broadband network, such as the ones discussed in the previous section. These "smart technologies" are in wide use throughout local governments and are not considered speculative or emerging. Other economic benefits are derived from the increase in network speed or internet access expansion to the Fort Bend County community**.

**The calculations used data from a variety of sources including: U.S. Census Bureau, Bureau of Labor and Statistics, datausa.io, Fort Bend Economic Development Council, Fort Bend County Texas website, Texas Department of Transportation, and U.S. Federal Reserve. Then additional information used from published research done by McKinsey Global Institute (MGI), Pew Research, Brookings Institute, FCC, and Deloitte.*

***Lack of broadband access disproportionately affects low- and moderate-income (LMI) communities. Households in the U.S. making $25,000 or less have a broadband adoption rate of 47 percent, while those making more than $100,000 have an adoption rate of 92 percent. For purposes of this analysis, these two groups are not differentiated.*

9.5 Examples of Overall Broadband Impact in Fort Bend County

- Fort Bend County has identified three innovation hubs that would benefit the entrepreneurial ecosystem. With the recent economic crisis caused by the global pandemic, entrepreneurship is a big part of the path to recovery. An extensive broadband network will only fuel this energy. Broadband communities experience higher rates of new business formation than communities without broadband access. This helps spur entrepreneurship and expand a home-based business and remote work productivity.
- Fort Bend ISD has been one of a few selected schools to participate in the Microsoft Showcase School program where a STEM Magnet school will be designed and built. The innovation in education and high technology emphasis will be supported by reliable broadband. A network tied and extended from the magnet school and other schools throughout the district will enhance Fort Bend ISD's ability to reach more students and provide a reliable online education platform to more students.
- Broadband connectivity enables more robust data collection and analysis, and with new technology, even prescriptive data. Departments such as Community Development which manages a Consolidated Plan for Community Development Block Grant (CDBG) and other grants from the United States Department of Housing and Urban Development (HUD) can greatly benefit from the enhanced data, aggregation from several entities, and analysis of that data.
- As new technology emerges, such as telemedicine, enhanced telecommuting (post-COVID), and enhanced remote learning (post-COVID), that requires Fort Bend to have high-speed, stable, state-of-the-art internet access, the community will be able to adopt these future technologies and receive the new benefits faster, with less cost and less disruption due to lack of installed base technology.
- New digital delivery of governmental services through automation, artificial intelligence, Internet of Things (IoT) technologies, and more improves efficiency and saves money.
- Given Fort Bend County's large employers, growing business parks, and award-winning master-planned communities that house talent, ubiquitous broadband will help Fort Bend County become a more competitive community relative to its neighboring peers with the attraction and retention of residents and employers alike.
    - Businesses will experience a reduction in operating costs through more e-commerce or advanced technologies being integrated into core operations
    - Continue to stay competitive in the "war on talent" as broadband increases the overall quality of life for residents (create a more digitally vibrant community)
- Broadband will increase access to information and services, especially for traditionally marginalized communities and rural areas.

9.6 The Economic Impact of Digital Transformation for Fort Bend County, Texas

In order to evaluate the full economic impact (or the return-on-investment) of a broadband network in Fort Bend County, it takes a multifaceted calculation. It involves easily quantified financial impact ROIs, along with the social impact areas, such as reducing the digital divide, enhancing social equity, improving social justice, etc. The social impact considerations on Fort Bend County's Underserved and Underutilized areas create the opportunity for big positive impacts.

The below calculations are primarily financial impacts, but to best understand the full impact, a holistic understanding should be used as each area that is improved affects another area of the community. Fort Bend's "product" is the total composite of the "live, work, and play" quality of life that people seek when they choose a community.
The following represents a list of potential, economic benefits. This list is not all-inclusive but does reflect specific calculations based on data for Fort Bend County, Texas.

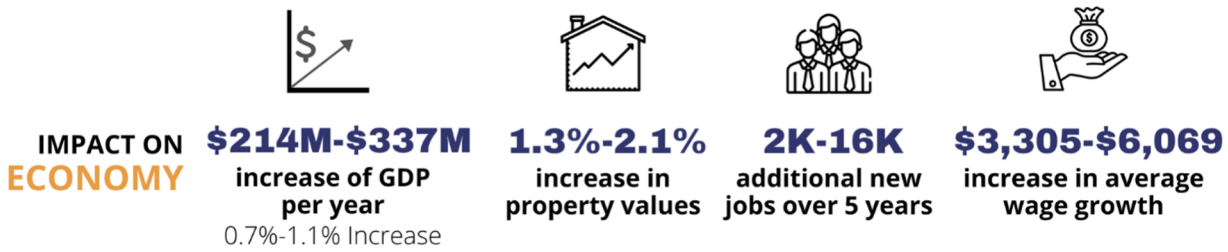

Figure 41: Broadband Impact on the Economy in Fort Bend County

9.6.1 Economy

Broadband-enabled communities experience higher economic growth rates and can achieve a higher quality of life.

- Potential to increase GDP by 0.7% to 1.1%. Estimated **GDP increase ranges from $214 million to $337 million per year**, based on multiple calculation methods and factors.
- Reduce the cost of living by 1% to 1.5%. Fort Bend County has a higher-than-average cost-of-living factor of 108.7. Note: This factor is made up of seven different factors, of which two (housing and transportation) are relatively much higher than the other factors. We project this could be a **reduced cost-of-living factor ranging from 107.6 to 107.0**, which makes Fort Bend County more affordable as a place to live, especially compared to neighboring Harris County which has a cost-of-living factor of 97.9.
    - This is especially important for economic growth considerations in order to attract and retain residents that are sought after by employers.
- Increase property value by 1.3% to 2.1%. This can create an **additional $4,002.70 to $6,158 of new household wealth** per homeowner based on an increase in home value using the median property tax growth rate.
- **Increase property tax revenues for Fort Bend County by approximately $26.7 million per year** (not adjusted for inflation). Recent property values have increased more than 10% annually (which is the maximum one-year property tax increase limit) but this growth rate may not be sustainable based on sheer supply and demand, and the increase in value produced by broadband may help maintain recent historical property valuations.
- Broadband would open up new remote work possibilities for its residents. Increase employment by 1.2% to 9% (relative to employment rates). This could **create an additional 2,255 to 16,916 new jobs over a 5-year time period.**
    - This would also help **reduce the current unemployment rate to the mid-3%** range from the current 4.0%.
- Increase the quality of jobs (higher wages for existing jobs). We project **average wage growth of approximately $3,034.74 to $6,069.48.** This means increased wages per person based on higher employer productivity gains.
- Communities with high-speed broadband have **lower rates of poverty** than those without it. Fort Bend County has a 13.41% rate of poverty, which is higher than the 11.4% national average.
    - Families that enroll in a government program that provides internet access at no cost, were 8% more likely to

be employed and experienced a $147 increase in annual income.

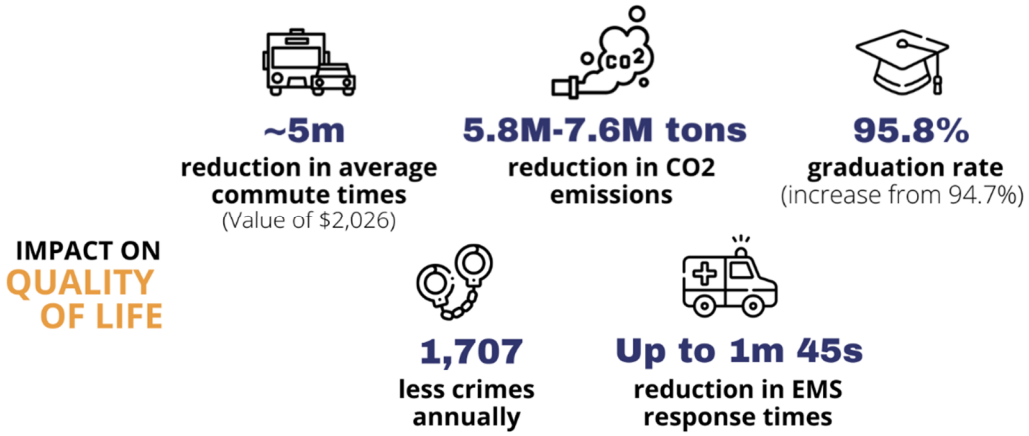

Figure 42: Broadband Impact on Quality of Life in Fort Bend County

9.6.2 Quality of Life

- Fort Bend County has a much higher than national average commute time of 33.3 minutes (compared to a national average of 26 minutes). **Commute times could drop by approximately 5 minutes** due to intelligent traffic systems, wayfinding, and other technologies that require connectivity. It is projected that a new average commute time of approximately 28 minutes 18 seconds could be achieved. This represents a reduction of approximately 2,500 minutes per year.
    - On average, the **value of this time savings is $2,026.25 per commuting household**.

9.6.3 Health

- Broadband communities experience a **45% to 65% reduction in time spent accessing healthcare**, due to increased customer satisfaction (experience) and elimination of commute time. This can make Fort Bend County a more attractive place to live and age and makes the medical staff more efficient at providing care throughout a patient's lifetime.
    - This is especially important for aging populations that are now using telehealth more extensively (pre-Covid versus post-Covid adoption). Fort Bend County has **99,589 seniors (over 65) who can benefit from telehealth** if mobility to healthcare becomes an issue.

9.6.4 Sustainability

- Fort Bend County has approximately 967,200 vehicles. Fort Bend County could **reduce its total CO_2 emissions by approximately 5.8 to 7.6 million tons per year**.

9.6.5 Education

- Fort Bend ISD has a 2021 reported high school graduation rate of 94.7%, which is well above the national average. Broadband access could increase this by approximately 1.25% (relative to a base graduation rate of 94.7%) and could **increase graduation rates to 95.8%** through additional remote learning options enabled by high-speed internet, ubiquitous connectivity, and improving the 93.91% of households with high-speed internet rate.
    - Fort Bend has identified 30,281 students (39.6%) considered at risk of dropping out of school. Providing high-speed internet access that is stable and ubiquitous, would provide an additional level of support to reduce the risk these students face.

9.6.6 Public Safety

- Broadband communities experience fewer crimes due to the related technologies that can be enabled. Fort Bend County could experience up to 30% fewer crimes annually, especially in violent crime and property crimes categories. This equates to **approximately 1,707 fewer crimes annually.**
- Due to advanced traffic technologies that require high-speed broadband and ubiquitous connectivity, broadband communities experience a 20%-28% reduction in EMS response times.
    - Fort Bend County could reduce its current response time of 6 minutes 16 seconds to as low as 4 minutes 31 seconds.

10 HIGH-LEVEL DESIGN

10.1 Map Development Approach

Section Highlights

- UNDERGROUND FIBER CONSTRUCTION IS THE PREFERED PLACEMENT METHOD BUT EXISTING AERIAL INFRASTRUCTURE SHOULD BE LEVERAGED WHERE APPLICABLE
- A CENTRALIZED CORE MIDDLE MILE NETWORK WILL EVENLY DISTRUBUTE ACCESS TO RURAL AND URBAN AREAS OF NEED.

The High-Level Design (HLD) serves as a visual representation of the necessary broadband infrastructure footprint required to address the needs and gaps as explored in prior sections. The development of this HLD requires first understanding factors which dictate network design criteria and bringing these in as visual overlays onto the map of Fort Bend County.

To define the space, boundaries for the County and Cities are brought in, followed by other jurisdictional boundaries and limits such as TxDOT control section maps, railroads, water authorities, state or federal lands, and any other reference that may dictate initiative and subsequent project limits. Next, maps from our Needs and Gap Analysis are overlayed to highlight identified demand points and determine areas of need. Through stakeholder engagement with public entities, facilities were identified as lacking the necessary broadband services to effectively serve their communities and these locations were added to the map. Market research layers, such as the maps which show the Unserved (25/3Mbps) and Underserved (100/20Mbps) were overlayed and contrasted with public and stakeholder feedback to develop a proposed coverage area for the initiative.

Finally, existing assets, such as private sector network fiber and towers, as well as any public network infrastructure, were overlayed as a reference prior to adding any proposed facilities as part of the HLD. Many other factors were researched, and reference layers were developed and reviewed that provided additional perspective as to the existing network landscape and geographical barriers, such as drainage channels and railroads. These reference layers help visualize cause and effect in terms of lack of connectivity in hard-to-reach areas, and shape routing design to minimize costly crucial crossings, while still providing Middle-Mile access. Having completed this background research, data accumulation, and overlay development set the stage for a considerate and deliberate HLD where all relevant factors are present and informing in design decisions.

10.2 Existing and Proposed Design Elements

The HLD, as represented in Figure 43, consists of many elements which are detailed below in a bulleted summary to break down the infrastructure components that together make up a Middle-Mile network throughout the County.

Orientation: The map extents include all of Fort Bend County, which is represented by the black line border, with a slight buffer to visualize adjacent counties. North is up and the map scale is set for ten miles. The legend on the right-hand side of the map includes the following elements:

Design Paths: These lines represent linear routing of proposed conduit and fiber paths within the network Middle-Mile, their function, and status.

- HWY 59 - 432 FO: This line (shown in blue) represents the primary backbone and backhaul route from East to West across Fort Bend County. As the major highway, bisecting the North and South areas of the County, this route along HWY 59 is ideal for transport networks to serve Broadband networks within Fort Bend County. The conduit and fiber along this route are upsized for 2-2" and 432F, respectively, to account for significant network traffic, allocating both physical space with spare conduit, and fiber allocations for various network components such as backhaul for Tier 1 transport, localized transport and backhaul, and the various fronthaul applications (FTTx).
- Regional Consideration – 288FO: These lines (shown in pink/magenta) represent the extensions of the Middle-Mile to account for regional connectivity, allowing for interconnects and convergence with other broadband networks for additional redundancy and resilience required for emergency services and extending access to adjacent municipalities and regional partners. Two 2" conduits are used for added capacity and maintenance, and a 288F cable is sized appropriately for necessary connections to proximal large demand points, such as provider Points of Presence (POPs),

network shelters/HUBs, and Edge Data Centers. From these demand points along the route, additional distribution cables would serve distribution HUBs and/or towers for Last-Mile connections.

- Unserved/Underserved Mille Mile – 288FO: These lines (shown in orange) represent the Middle-Mile to account for connectivity within those areas of the County designated as Unserved or Underserved by NTIA definitions, <25/3Mbps and <100/20Mbps, respectively. This Middle-Mile allows for localized interconnects between County and City facilities and facilitates further services to businesses and residents from connected distribution POPs and hubs. Two 2" conduits are used for added capacity and maintenance, and a 288F cable is sized appropriately for necessary connections to distribution POPs and hubs, in addition to proximal demand points requiring direct fiber connections to such as public facilities, anchor institutions, large business, and commercial properties. From these demand points along the route, additional distribution cables would serve distribution HUBs and/or towers for Last-Mile connections.
- Area with Existing Routes: These lines (shown as a black buffer) represent where market research has identified there to be existing fiber infrastructure that can be leveraged, through a partnership with private providers and operators, to reduce overbuild and overall costs of the Middle-Mile build. There is an 86% overlap, presenting much opportunity to leverage existing network infrastructure.

City Boundaries: City and community boundaries are shown in Figure 43, as a geographical reference. This regional Middle-Mile focuses on extending network access into Unserved and Underserved areas of the County and it should be noted that relative proximity to the Middle-Mile allows for lateral extension into any areas that are not directly along the proposed Middle-Mile route. In other words, this regional Middle-Mile accounts for further connectivity and there is no necessity to route fiber directly into every community within the County.

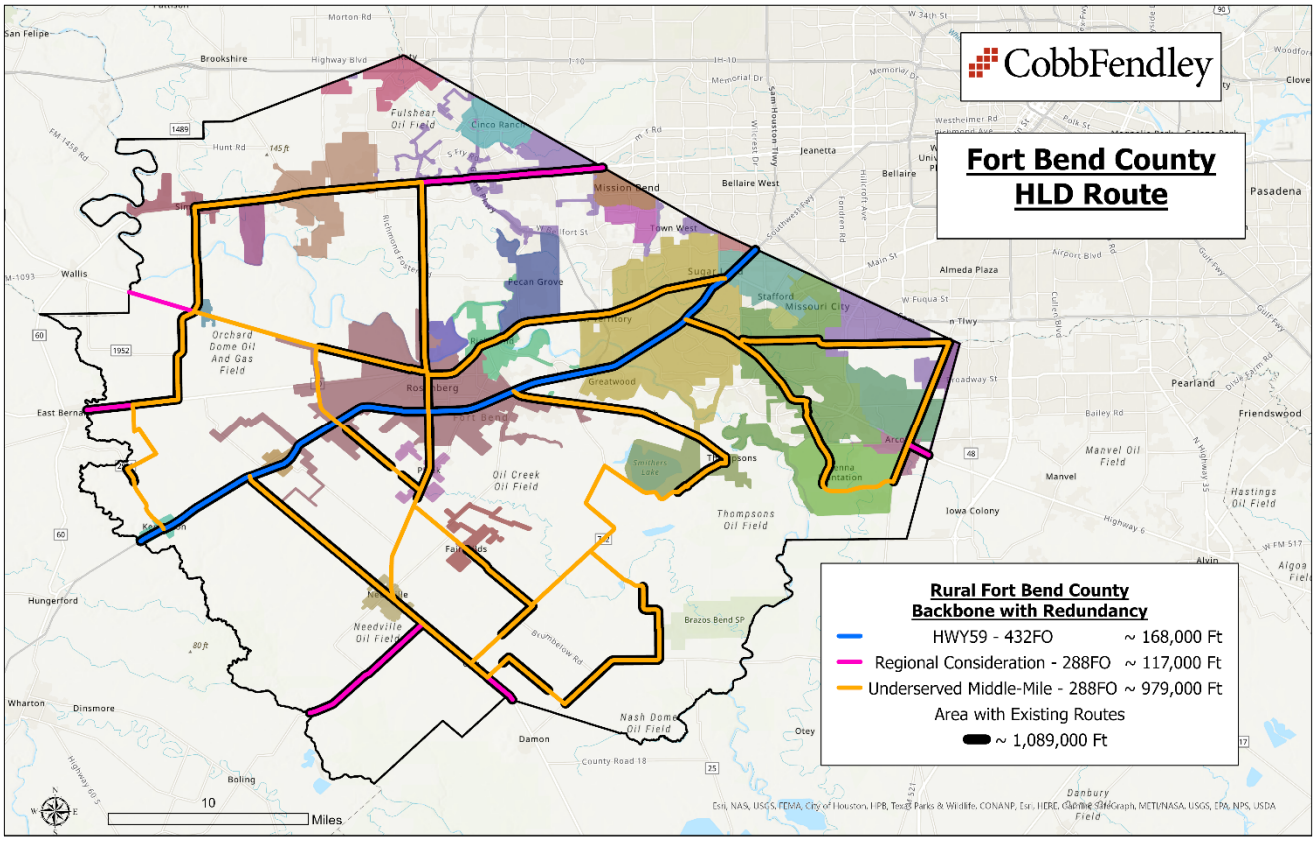

Figure 43: Proposed Fiber Network Plan

10.3 Methodology for Design

With the development of the map reference overlays and the proposed network design elements to be included in the Middle-Mile HLD, the design could commence. The first consideration is the desired overarching network architecture, or the types of networks, to be utilized. Ultimately, the decision was made to pursue a fiber-based, centralized core network, focused on supporting an access network for internet/data services. Foundationally, this allows for flexibility in access architectures that Last-Mile providers can implement and converge to meet the market needs. Both fiber wireline and wireless broadband solutions can facilitate the Last-Mile, while meeting the service level requirements recommended in this study and set by NTIA for funding eligibility.

In this HLD, the focus is primarily on the Middle-Mile infrastructure need, while suggesting the Last-Mile providers consider all manners of broadband technology solutions to meet the needs of the County, their constituents, and residents. As reviewed in the Asset Inventory, many existing tower locations will facilitate wireless solutions. While a pure fiber solution is ideal and provides the highest quality of service, it is not always cost-effective in all locations, even with subsidies. A converged wireline and wireless network extending fiber all the way to tower or small cell sites allows for a more reliable backhaul compared to Microwave/PTP/PTMP, and with this extension of Middle-Mile fiber, the potential for additional service laterals and densification is much more feasible. Fixed Wireless offers a solution that can meet and exceed federal guidelines, offers faster deployment, and can serve more residents in a more cost-effective way, in so, reducing the broadband service fees to encourage adoption. These two architectures can complement each other in that fiber provides the more reliable and low latency backhaul to towers or small cell nodes, towers or small cell nodes can be added onto the proposed fiber Middle-Mile for added coverage and redundancy. Essentially, this allows the network to grow in multiple ways. Given the favorable soil conditions for underground construction methods and density of population within areas of the County, FTTx solutions for Last-Mile provide the highest quality of service and potential for scalable applications and are recommended as the primary access network architecture where applicable.

Understanding the existing fiber infrastructure, geographical barriers, constructability, and logical distribution routes within the County, the proposed fiber routing focused on leveraging existing assets along TxDOT roadways and branch-off extensions into targeted areas of need (See Figure 44). TxDOT ROWs already contain most long-haul utilities and have utility pole infrastructure, green space for buried construction, and utility accommodation process in place to allow for simplified design, permitting, and construction measures. Geographical barriers, as explored in Section 10.2 and shown in Figure 43, appear to have played a role in restricting infrastructure development in cities such as Thompsons, where there are few bridges crossing the Brazos River, effectively creating both a physical and digital divide. While extending Middle-Mile broadband infrastructure into these areas does facilitate access to the internet, additional network topology components needed to be implemented into the design

which allows for a more comprehensively connected network. Network topology is the next step in shaping the HLD, allowing for connectivity with a specific or many purposes in mind.

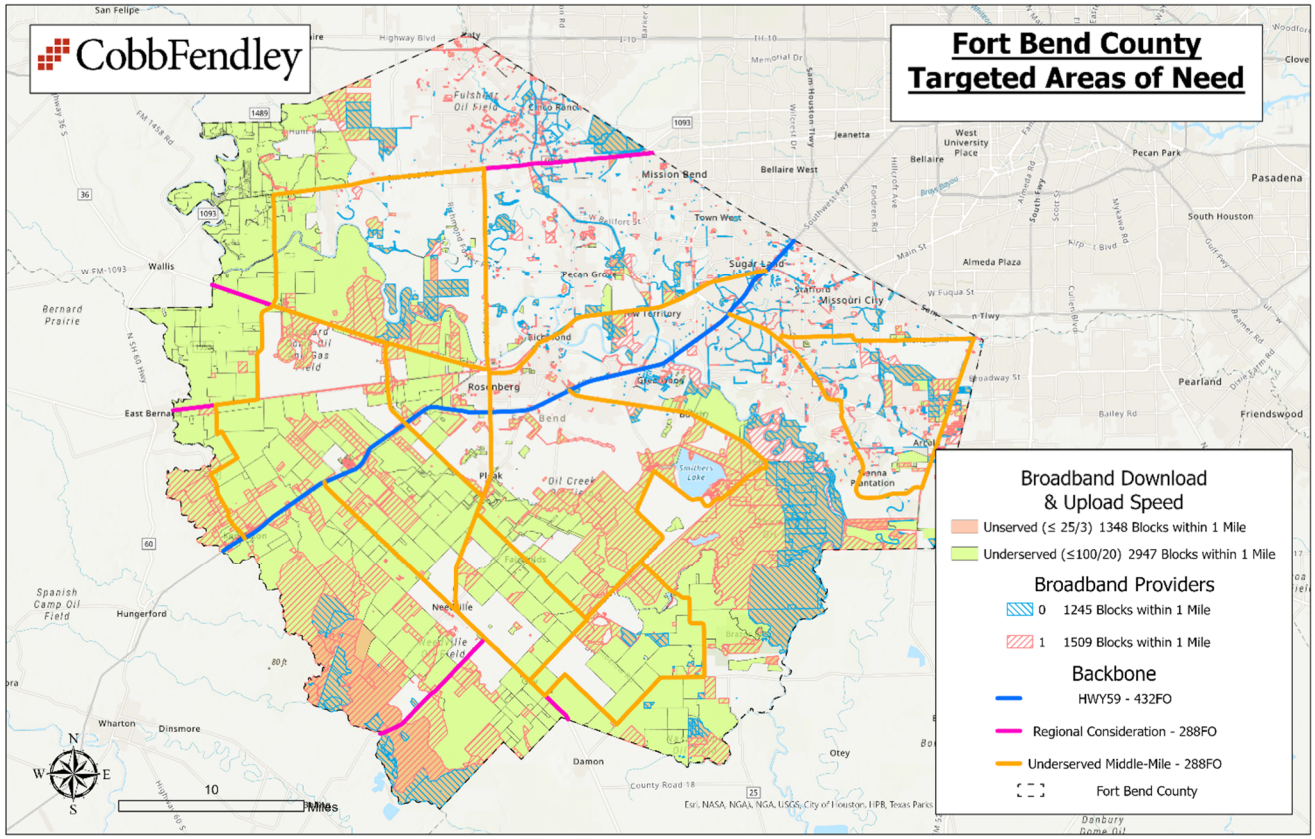

Figure 44: Targeted Areas of Need in Fort Bend County

10.3.1 Network Topology in a Mixed Rural-Urban Market

Another consideration in routing methodology pertains to making the case for rural connectivity. Although there continues to be significant growth, the south and west portions of the County are still considered rural by USDA standards and, as such, present specific challenges in network design. Unlike extremely rural counties, Fort Bend not only has a significant urban population but also has varying degrees of population sparsity across the urban communities as seen in Figure 45. As there are established broadband needs in both urban and rural areas, the Middle-Mile footprint needs to distribute out in all directions and to each corner of the County, so that each fiber cable, or spoke, can be centrally located in an effective serving area. In new fiber builds with no existing infrastructure, known in the industry as "greenfield," this approach is used to start with a centralized location in the middle of the marker, then start dividing that marking into quadrants, representing the sub-service areas that need to be served. By extending fiber from the centralized location across the middle of these quadrants, any demand points on either side of the fiber can be tied into the network without extensive laterals going from one end to the other. As shown in the Targeted Area of Need, Figure 34, this Middle-Mile leverages a couple of network topology elements to position the network to capture as many census blocks that meet broadband-needs criteria as possible. The network topology, or how the infrastructure is physically laid out, takes on a "Hub and Spoke" or "Star" topology in this way. Applying the greenfield approach to routing with a geographically appreciate centralized Hub, we applied this topology to the existing TxDOT roadways in building out evenly dispersed infrastructure across the County. These routes were further adjusted, and regional laterals were extended, to allow for connections in targeted areas as they bisected the various serving areas. Furthermore, ring topologies were introduced which, when paired with a "Hub and Spoke," allows for redundant connections to demand points by connecting back to adjacent spokes. Many business and commercial properties require this kind of connection as it eliminates or at least reduces any

downtime for network maintenance or damages. With the proposed topologies applied to the routing and considering more immediate access within a one-mile buffer, the proposed Middle-Mile serves 1348 Unserved blocks, 2947 Underserved blocks, 1245 blocks with no listed providers, and 1509 blocks with only one listed provider. Finally, it is important to reiterate that although the Middle-Mile does not route directly through each and every community, additional laterals and Last-Mile services to all other targeted areas can now be connected to this network, given the established proximity and improved feasibility through this effort. Another consideration when reviewing the targeted areas and the population dispersion is that many areas census blocks identified with needs are representative of uninhabited areas such as much of the Thompsons and Oil Creek Oil Fields and even George Bush Park up near Mission Bend.

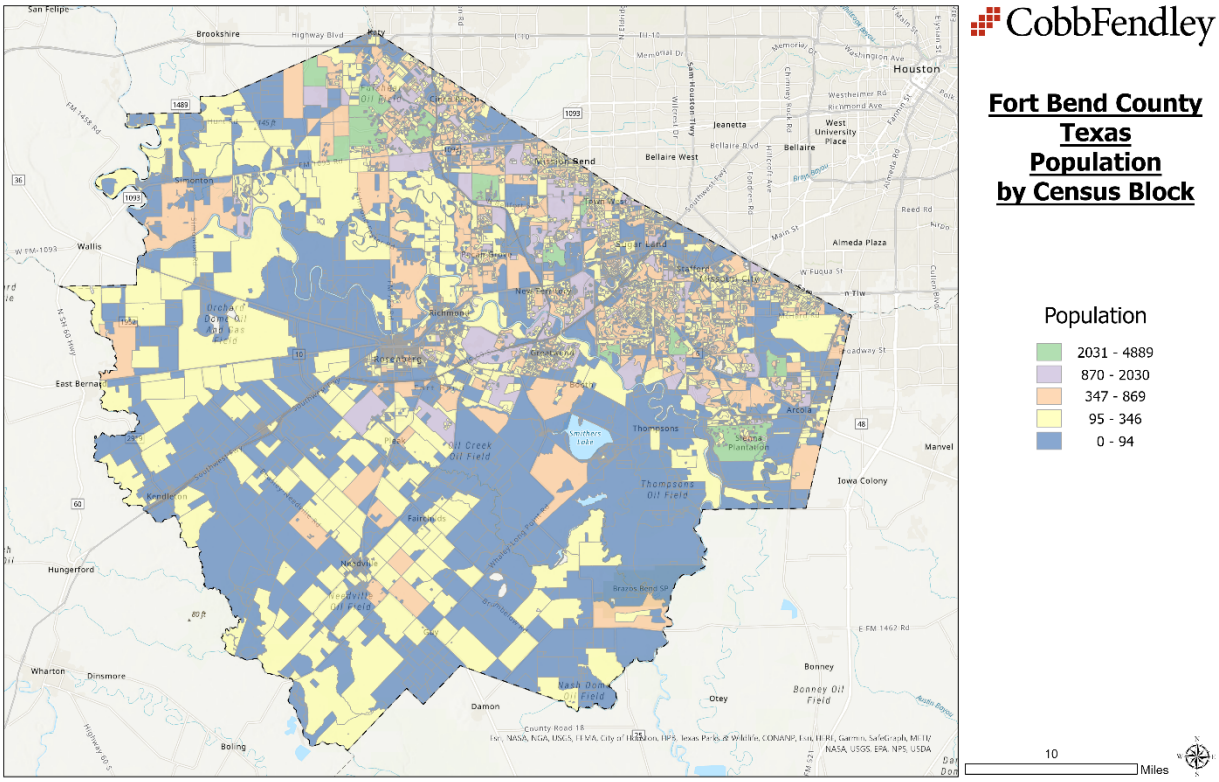

Figure 45: Fort Bend County Population

It should be noted that routing for a HLD does not include detailed alignments at the street level, with considerations for the right of way, easements, existing utilities, permitting design requirements, or final construction methodology. Routing at the High Level does allow for providing an overall order or magnitude and is the foundation for a successful Low-Level Design and engineering. To round out the HLD and analysis, further consideration for aerial or buried construction, material, and capacity is discussed in the following subsections.

10.3.2 Aerial Attachment Considerations

The necessity of accessing existing pole infrastructure needs to be included in the HLD, understanding the positives and negatives of a purely underground solution, one of them being the potential impact on construction costs and timelines. In areas with harder soil conditions, boring and trenching can be incredibly expensive and may delay project timelines. Where the hard soil conditions overlap with existing utility pole infrastructure, pole attachment for an aerial route is recommended. While Fort Bend County soils are favorable towards buried construction, the availability of pole infrastructure should be considered to reduce additional disturbance of the ROW and can be leveraged to mitigate maintenance issues associated with flood-prone

areas. Buried fiber is generally more protected, as it is less exposed to wind events or damages from traffic accidents or vandalism, Aerial attachments of the fiber-optic cable include the following conditional benefits:

- The cost to attach to poles is generally cheaper than burying underground, especially within hard rock conditions, although some pole owners may have increased pricing due to terrain demands.
- The time to completion for this method of fiber routing is typically faster compared to underground trenching or boring, even though pole analysis for each pole needs to be conducted prior to attachment.
- Construction of aerial attachments are less likely to damage existing utilities within the ROW given the visibility of existing attachers and power conductors. SUE or utility locates are required to avoid conflict with existing buried facilities which are not visible to the contractor.
- When repairs are needed to fiber attached to a pole, the procedures and timing are more efficient which greatly reduces downtime.

10.3.3 Material and Capacity Considerations

As previously discussed throughout this study, existing broadband infrastructure is present throughout much of the County and so the potential for overbuilding is a factor Fort Bend County should consider given the eligibility requirements for NTIA grant funding. As such, it is even more important to leverage these existing assets to reduce the overall build costs and minimize overbuild. Fiber, conduit, handholes, facilities with space for collocated equipment, poles, and tower structures should be considered when exploring partnerships. Compatibility with the proposed infrastructure is especially important as existing assets may not have the required capacity from a physical space perspective in conduit and innerducts or available dark fiber in existing cables. When sizing for capacity, both physical and network aspects are considered.

The proposed conduit system would consist of 2-2" HDPE pipes, allowing space for overpulling additional fibers, maintenance, and potentially leasing. Fiber cables would be upsized to allow for growth in the Middle-Mile and any distribution directly off the cable to demand points along the route. The additional capacity in the 432F and 288F fiber cables promotes growth, redundancy, and a potential source of revenue via dark fiber leasing. Both the spokes and ring routed design help carry the bulk of the network across the County, and they facilitate fiber lateral construction to help expand the network to various locations that could be considered Last-Mile, which includes any stakeholder-provided demand points or tower locations. Sizes of the fiber laterals off these components can be decreased based on the capacity needs of the demand points or Last-Mile wireless serving areas. For the transition from outside plant to inside plant, whether at tower locations, demand points, or anywhere else, adequate fiber sizing and allocations ensure proper connectivity in case of emergency and additionally will promote growth for nearby future projects.

For the capacity of the network, the most crucial factor to consider is scalability. The capacity of a County sized network will not experience the same demand today that it does 10 to 20 years from now. As the surge capacities for each identified demand point and future demand points are unknown, a lower capacity is manageable and could potentially increase as the network traffic is monitored and analyzed. This is the most economical and responsible method to scale the network capacity. While this does not necessarily impact the routing, it is important to consider in terms of the inside plant facilities the relative space needed for equipment and associated costs. Network technologies have allowed for existing infrastructure to yield more capacity than when originally placed by smarter network routing and multiplexing.

The HLD as presented in this section represents the collective understanding of the existing conditions, needs and gap analysis, stakeholder/partner capabilities and assets, broadband network design criteria, and with consideration for scalability, future-proofing, economic growth, and regional connectivity.

11 BROADBAND NETWORK IMPLEMENTATION CONSIDERATIONS

Section Highlights

- STANDARDS FOR CONSTRUCTION AND NETWORK ACCESS NEED TO BE ESTABLISHED FOR CORRECT IMPLEMENTATION
- PROCUREMENT OF MATERIAL AND LABOR MAY BE ONE OF THE BIGGEST BARRIERS AND COST DRIVERS

Network implementation is one of the most complex and challenging portions of establishing a broadband network. Feasibility studies are a crucial component as this effort establishes the needs, proposes applications, and presents options, all of which ultimately determine the various network architectures involved. Preliminary engineering was conducted as a necessary part of this study to determine capacity requirements and network footprint. The capacity assessment is necessary for the determination and incorporation of network equipment into the cost estimate and overall order of magnitude. Network equipment and network footprint are interdependent considerations in the HLD, which is necessary for the quantification of distribution assets and translation into relative costs for construction, maintenance, and operations. Other considerations include efforts to ensure modularity and future-proofing of the network and external environmental constraints in constructability and sustainability.

11.1 Outside Plant Implementation

Outside plant (OSP) is the physical manifestation of a fiber-optic network within the public Right of Way (ROW) as it is the most visible and easily conceptual component of the network. OSP includes the civil engineering and construction to design and install underground conduits, fiber optic cables, handholes, and splicing cases among various other components. The outside plant is designed, constructed, and implemented in accordance with both jurisdictional and owner standards. In this case, there are a multitude of jurisdictional standards to be met regarding applicable clearances from existing utilities, placement in the ROW in accordance with required typical cross-section alignments, and other specified design and construction standards. Owner standards for this network will ultimately depend on the business model selected, whether the operator has established OSP standards and specifications or if these will need to be developed through a collaborative effort in future preliminary engineering phases. Determining OSP standards is critical in ensuring the quality and consistency of near-term and future design and construction of the network. These standards would be summarized and implemented into participating entity design manuals and ordinances to streamline broadband development in conjunction with community growth and expansion. Future-proofing of the network in OSP is accomplished by overbuilding physical infrastructure to allow for future growth of the region network in conduit space, distribution fiber availability, and slack storage capacity.

11.1.1 Fixed Wireless Network

With the increased available spectrums and technologies such as Citizens Broadband Radio Service (CBRS) and private Long-Term Evolution (LTE), broadband networks commonly converge traditional wireline fiber networks with fixed wireless networks. Fixed wireless is an ideal broadband solution for areas that may struggle to place fiber underground or in areas that may need more cost-effective measures. Geography typically dictates the necessity and effectiveness of fixed wireless implementation. Terrain with considerable elevation fluctuation makes for extremely difficult underground construction of fiber networks and even placement or attachment to aerial pole lines can be a challenge. Coupled with difficult digging conditions in hard soils and dense vegetation, the case for fixed wireless becomes more appealing to many operators and providers. Fixed wireless broadband uses antennas, which are mounted on towers, building roofs, poles, etc., that use specific frequency bands to reach an antenna located at a user's house or place of business to provide internet access to the user. It is important to note that fixed wireless is different from mobile broadband, which is catered towards data services for mobile devices, whereas fixed wireless focuses on internet services for stationary locations and devices such as residences and computers.

When considering fixed wireless as a solution there are two scenarios to take into consideration: New Tower Build or Co-location build. Both scenarios come with specific processes and requirements.

For a Co-Located tower application, we must consider multiple factors such as the height and type of the existing tower. Surveys would be conducted to determine if there is space to accommodate a new sector of antennas on the tower and new base station equipment on the ground. Accessibility to sufficient power sources and the relative proximity to the location of the new equipment needs to be considered. A structural analysis will be required to prove that the existing structure can handle the weight of the new sector being added. Lease negotiations with the current tower owner will have to be in place before any new construction can be done. Once the existing site survey and evaluation is conducted, detailed planning and design of the build can occur. Design considerations include the number of antennas needed and the type of antenna mounts that will be used, which is normally based on the type of existing structure, whether it is a monopole or self-support tower. Installation of the base station equipment on can be located on a new or existing platform, or in a new tower shelter. All new equipment installed requires the proper power and grounding to run properly. Material and construction prices will be based on the equipment specifications and labor requirements for installation.

There are quite a few more considerations for New Tower Builds. First, the location will need to be confirmed and lease negotiations will need to take place. The location must be secured with the property owner before proceeding with the next steps. An environmental study will be required to make sure the tower is not being placed in protected wetlands, tribal area, or migratory bird pattern. There are also federal regulations to consider as the tower must also be FCC compliant. This consists full NEPA, SHPO, Tribal, 1A/2C documents and any other FCC requirements for a new tower, such as proper lighting. Once the prerequisite actions have been completed, tower and equipment specifications and design can commence. There are options for monopole, self-supporting, or guyed towers, depending on the available space and topography. The height of the tower, the number of antennas to be installed, and the type of ground equipment will need to be determined. New power to the location will need to be confirmed and secured with the local utility company. Much like Co-Located Towers, the cost of materials and construction will vary depending on what is being installed. Simply put, the taller the tower and the more equipment installed, then the higher the price will be. The structural analysis will be provided by the tower manufacturer and will have details of all the equipment and heights that will be installed. Both scenarios have their pros and cons and will be dependent on what is needed in the coverage area. Co-locations will be cheaper and easier to build. Where New Tower Builds have the potential for ROI because tower and ground space can be leased out to other carriers or customers in the area.

Depending on the desired level of service and coverage area, the design will need to evaluate spectrum and license availability, required power, fiber backhaul capacity, tower height, and equipment requirements to develop an applicable solution. Economies of scale come into play when considering tower placement and propagation. Higher frequency spectrums do not travel as far and so require denser tower placement and have more extensive power requirements. Newer technologies have emerged which utilize spectrum and equipment which can range many miles, making the case for rural fixed wireless much more feasible.

11.2 Inside Plant Implementation

Inside plant (ISP) refers to the network build which connects to core network facilities such as data centers, distribution points of presence (POPs), customer premises, and other network assets outside of the public ROW. Like OSP, this component includes the civil engineering and construction to design and install drops, or connections, from a meet-me location in the public ROW and routed inside the building to the designated demarcation where the fiber is taken into facility telecommunication rooms. In this case, jurisdictional requirements are replaced by property management requirements in the penetration of exterior walls and routing through ceiling racks across the building. Owner requirements and specifications will need to be established for uniformity, in the same manner, they are needed for OSP. Future-proofing of the network in the ISP space still involves designing for additional conduit space and providing for the growth of the facility or customer premise network needs. ISP can also refer to the network equipment space which will be reviewed after considering the capacity requirements and method of implementation.

11.3 Capacity Requirements and Implementation

The capacity requirements of a network are dependent on the scale and complexity of the needs and applications that need to be addressed and supported. Network architectures represent the various solutions needed to accomplish this and provide adequate capacity within their specific function and to the identified customers. When reviewing network capacity, it is important to understand that there is traffic that stays within the network to communicate within and between the connected facilities, and there is also traffic that needs to leave the network and connect to a larger access network such as the internet. Traffic that leaves the network requires transport circuits, the capacity of which is dependent upon the scale and consistency of the traffic. When determining the transport capacity, it is important to consider that this is easily scalable and does not need to immediately be sized to the future anticipated growth of the network. From a cost-savings perspective, transport capacity should be estimated to meet the immediate needs, monitored, and increased as the network grows. This concept not only applies to the transport, but also to all network links or connections. Through the course of this Feasibility Study, the determined estimated capacity requirements for demand points based on their function or as recommended by the stakeholders can be seen below in Table 10.

Table 10: Proposed Capacity Based Upon Location Type

Location Type	Proposed Capacity per Location (GB)
AIRPORT	1-3
LOCAL GOV. FACILITIES	1
FIRE	1
MEDICAL	1-3
OTHER	1
POLICE/SHERIFF	1-3
SCHOOL	5-10

Another key concept when considering capacity is bandwidth management, which consists of understanding that advanced fiber networks can control traffic in ways that individual links are making efficient use of bandwidth through techniques such as multiplexing. What this translates to is that individual capacity estimates for customers represent the absolute maximum capacity needs which will rarely, if ever, be required at a given time. These links share bandwidth where applicable and so the determination of the network capacity is not simply a summation of all estimated maximum capacities. Instead, it is based on an estimation of the surge capacities. For example, if there are ten 10GB links in a network and the average surge capacity for these links is only around 200Mb at a given time. The network size does not need to support 100GB as 2GB would handle the network surge. As the surge capacities for each identified demand point and future demand points are unknown, it is logical to begin with a lower capacity that is manageable and increases as the network traffic is monitored and analyzed. This is the most economical and responsible method to scale the network capacity. It is also the reason that future proofing and modularity of network components are critical as they need to have the ability to scale with the network from both a distribution and capacity standpoint.

With the understanding of the concepts above and capacity estimates for all demand points, it was determined that a good starting point for the network would be two 40GB transport circuits for redundant connections to the access network. The backhaul links should be 100GB between network data centers and distribution POPs. Individual demand points in the Middle-Mile will have anywhere from 100Mb-10GB links depending on their classification and anticipated needs.

11.4 Future-Proofing and Modularity

The important consideration here is the fiber distribution network in the OSP is not modular in the same way as the ISP and network equipment. Components can be added or swapped out to support greater link capacities, and larger transport services can be secured very easily and quickly, whereas building additional conduits and pulling new fiber in the OSP is costly and time-consuming. So, while one may start small and build in the ISP, it is not economical to take the same approach in the OSP.

Network architectures such as Gigabit Passive Optical Networks (GPON) share capacity among multiple customers and are typically seen in fiber-to-the-home network builds. The latest variant of this architecture is XGS-PON (or 10 Gigabit Symmetrical PON) which takes the same concept but is not limited to 1GB connections and can support variable optics up to 10GB which can be used to service thirty-two or more large customers requiring up to 10GB services on the same active link. Fixed wireless Last-Mile solutions also provide an opportunity to share capacity between multiple customers, with the advantage of reducing the wireline fiber built into the customer premise while also providing high-quality wireless connections required in an advanced broadband network. While GPON and XGS-PON are more efficient from a distribution fiber standpoint, fixed wireless solutions provide the necessary flexibility in Last-Mile connections. These proposed network infrastructures must be able to support these architectures and so building a robust core network in the OSP with scalable capacity equipment is crucial.

11.5 Data Center and POP Considerations

To effectively implement a network, the equipment and facility component of the ISP must be a concurrent effort with the OSP network infrastructure. The physical plant must correlate with and complement the network equipment that will ultimately facilitate and manage the network connection. Data Centers and distribution Points of Presence (POPs) are where the distribution and core networks converge and connect to transport networks through centralized network equipment such as core/edge routers, optical line terminals, or distribution switches, OSP patch panels, and supporting power management and security systems. Data Centers are the primary facilities that transport connections and house the core/edge routers which manage the network. These locations can be centralized or diversified on opposite ends of the network to provide physical separation for ISP connections. Robust power supply, storage, and management are required at these locations to condition or rectify power and allow the network to operate reliably. Placement of these facilities is dependent on network topology and suitability criteria such as flood adverse locations, security, access to sustainable power sources, and necessary space to accommodate equipment and network staff. POPs differ from Data Centers in that they contain mainly distribution equipment and do not typically receive the ISP transport connection and core/edge routing equipment. Distribution POPs are placed centrally, along the backhaul, in customer-heavy areas where the distribution OSP can be condensed and so reduced in terms of physical plant to individual customers. The network topology utilized in most distribution POPs is the Star or Hub & Spoke because it caters to a centralized point of distribution. POPs can be as small as a handhole in the public Right of Way where the network can tie into other networks and leased lines or as large as a Data Center depending on the required function. Very dense locations may have thousands of customers and require significant power and rack space to accommodate the distribution. In this case, POP locations would serve as access and distribution points for the expansion of these spokes. Depending on the capacity needs of the area the POP will distribute into, the required space will likely be no larger than a large storage closet or small room to house distribution switches, patch panels, power supply, and cooling systems. Data Centers and POP facilities, like the equipment they contain, need to be scalable and should consider the feasibility of future expansion in considering suitable locations.

11.6 External Environmental Factors

The final factors that go into network implementation are environmental externalities, constructability, and sustainability. These factors are usually an afterthought in network engineering, but they are essential as they challenge the network build with real concerns and constraints, whereas design can be completed in a vacuum. External environmental factors include regulatory and jurisdictional constraints, industry trends and competition, and socio-political conditions. These factors have the potential to disrupt the network build and so should be anticipated and contingencies should be formulated to control risk. Regulatory and jurisdictional entities introduce constraints such as the engineering design and construction requirements of the OSP, as previously mentioned, and these constraints may further impact the build in the form of a permitting process. While this is a necessary process, the timeline and fees involved should be considered as they impact the budget and schedule of the build. Design engineering firms will need to have the knowledge and experience of working with these entities to ensure that the permitting schedule does not delay and fragment the construction efforts.

11.7 Local Public Policy

Broadband technologies are ever evolving and so the municipalities and jurisdictions should have a clear understanding of the proposed infrastructure components and impact on the ROW. Ordinances, design manuals, and permitting requirements should be updated and clarified to protect the ROW, but also streamline processes for partners of this initiative, as well as other broadband expansion projects. In many instances, broadband facilities have been subject to the same requirements as public utilities in lieu of having specific requirements which are more applicable and reasonable. A couple of examples would be requiring the same horizontal and vertical clearances of 2" HDPE conduit as for large diameter water lines or requiring small cell poles or attachments to go through the same processes as monopole or lattice macro towers. Another strongly recommended policy would be to update residential subdivision ordinances so that developers consider broadband facilities for fiber to the home (FTTH), or potential small cell fixed wireless solutions. For existing subdivisions, section typicals should have space for broadband facilities to reduce service utility strikes and damages during installation. Having a clear-cut process is an enticement for broadband providers as this reduces costly delays and frustration for all parties. Municipal Engineering and Public Works should have a defined role and involvement in all proposed municipal broadband projects, for both visibility and to strengthen relationships with local providers. Fort Bend County does not currently have any specific design requirements or ordinances regarding broadband infrastructure deployment.

For an example of a detailed set of standards, it is recommended to implement what TxDOT uses for its fiber and broadband processes. TxDOT has decades of experience, and its standards evolve to reflect the necessary changes that come with recent technologies. For this initiative specifically, much of the fiber is expected to be placed within TxDOT ROW, and similar, if not exact, requirements would help expedite the permitting and procedural aspect later down the timeline. In the links below, you may explore the requirements set by TxDOT in the TxDOT Manual and the Utility Accommodation Rules (UAR).

TxDOT UAR:
http://onlinemanuals.txdot.gov/txdotmanuals/utl/compliance_with_the_uar.htm

TxDOT Manual:
http://onlinemanuals.txdot.gov/txdotmanuals/utl/introduction.htm

11.8 Design and Construction Implementation

The network and civil engineering designs must complement each other to meet the needs of the network operation and the construction of network infrastructure. Civil engineering design considers constructability to develop both an economical design, on behalf of the client, and a feasible design, to ensure the contractor is set up for success. Constructability considerations include understanding soil conditions and the method of construction that is most conducive, whether that is aerial construction, directional drilling, plowing, or trenching. Critical crossings, such as drainage canals, floodways, freeway underpasses, and railroads, must be evaluated from both a permitting and constructability perspective as crossing these locations can be costly and time-consuming. For example, the perpendicular crossing of a depressed section of the freeway would require an extremely deep and expensive wireline bore up to one hundred or more feet deep. At this depth, the contractor cannot accurately locate the bore and so the risk of hitting an obstruction in the bore increases. Engineering design would need to evaluate alternatives such as bridge attachments, aerial attachment to existing poles, installing new poles, or even rerouting to cross at a shallower depth. Successful implementation of the fiber network requires that the preliminary and detailed design engineering work be thoughtful and comprehensive to support the subsequent construction effort, without delay and need for change orders.

11.9 Procurement & Equipment

Another critical component of the implementation is continued refinement of the network build Order of Magnitude (OOM) into detailed bill of materials (BOM), cost estimates, and schedules. Even from a preliminary engineering standpoint, quantifying the OSP and ISP is essential in understanding the procurement needs and timeline feasibility. Our Cost Estimate section is based upon this preliminary quantification and assumed network OSP materials and ISP equipment. The OOM serves as a project charter document that guides the client in the procurement process, especially considering the global shortages and increasing

price tag of essential network materials such as HDPE and fiber cable. Given the state of the industry when it comes to the supply chain, it is essential that the OOM is flexible and adaptive to quickly swap out various materials and equipment to provide insight on the updated costs and ensure compatibilities. Changes in equipment and materials during the procurement process may have impacts on the OSP design and ISP equipment may lose functionality that provides for future-proofing, modularity, and sustainability of the network. Therefore, it is essential to implementation that the services and materials procurement effort is collaborative and deliberate so that these impacts are discussed and weighed before making final decisions so that there is no excessive redesign of the network through a continually varying BOM. When considering procurement as a municipality or consortium, state purchasing cooperatives offer an advantage in the current environment in terms of cost regulation and supplier/manufacturer relationships. The telecommunications market is incredibly competitive and with the influx of broadband funding at the federal and state levels, there are new ISPs, infrastructure companies, and municipalities competing in this space. Compounded with the global supply issues, materials and services are increasingly difficult to attain at competitive prices and within a reasonable timeline. Common components such as HDPE and splice closures are experiencing more than 26-week lead times and quotes are only held for weeks to months at best as demand surges. Due to these external factors, direct sales with individual suppliers, or including material procurement into the construction vendor contract through generalized specifications, may result in significantly limited options and risk of inferior quality materials being used in the build. Partnering with well-established operators in the telecommunications space or contracting purchasing cooperative services presents the most favorable options for procurement, which is key in enabling implementation of the broadband network build.

As reviewed in the section above, there are a multitude of components involved in the implementation of the network and internal and external factors that impact the effectiveness of the implementation. Understanding the relationship of these components, and the applicable considerations, is crucial in the follow through of the implementation methodology. The feasibility study, preliminary and detailed engineering of the OSP and ISP, procurement, and construction all play into the overall network implementation. The final steps of implementation involve securing transport and transit services, installation, registration, and licensure of equipment, and establishing network management policies. Once the business model and network ownership has been determined, the final steps of implementation can be determined and carried out by the appropriate parties.

11.10 Innovative Solutions for Cost Savings

- Co-locate POPs in existing public facilities that meet the suitability criteria.
- Utilize spare duct and available fiber capacity in an existing fiber network by a third-party provider.
- Utilize wholesale pricing for material procurement with regional approach.
- Utilize plough construction in TXDOT ROW rural segments.
- Modularize the ISP – “Buy as You Go” Model.
- Bulk Procurement and Construction of OSP for better pricing/schedule in a competitive environment.

11.11 Operations And Maintenance

To ensure the proper performance of this potential broadband plan, regular maintenance will need to occur to repair any problems with the fiber network. One benefit of a fiber network is the low amount of maintenance needed to keep the system up and running. The system should work properly unless there is specific damage that occurs somewhere in the network. The maintenance will stem from breaks that occur in the fiber due to damage to infrastructure like conduit, or any damage to the end equipment, such as a splice cabinet knockdown or a patch panel disconnection. It is recommended that to reduce the risk of damage to fiber infrastructure the contractor should install tracer wire with the conduit. The current outlook for maintenance responsibilities is that the partnership collaboration will lead to hiring an operator who would perform all maintenance.

During the build phase of the route, the contractor is responsible for the build until it is completed. Therefore, the costs are covered by the builder for any issues that occur during the build phase such as cracked handholes. As the equipment ages, the maintenance needs will grow, especially in more rural areas. It is important to understand that maintenance costs will not be consistent from month to month, especially in the early years of the equipment. In the present day, the current digital dependence and lifestyle make the operation costs invaluable. The operator will ensure that the connectivity to users and business is uninterrupted should any major or minor disaster occur again and would ensure that connectivity is always a priority.

To ensure proper performance of the fiber network, some level of permanent staff will likely be needed to monitor the system and perform regular preventative and reactive maintenance. Since the operator will be planning on leasing fiber strands out to commercial clients for internet access on behalf of the municipality, the operator will need staff in place to manage all billings for commercial client use of the network.

With the further development and implementation of the fiber network, there will be an increase in possible locations that have issues. Maintenance for the end equipment for each run of fiber located at the network hubs will need to be routinely checked and maintained by qualified IT staff with the municipality. There are a few options for maintenance on the equipment located in the field, such as the fiber-optic cables and splice cabinets.

As part of this analysis, we have checked with other cities/counties regarding their operations budgets to provide a high-level estimate of the costs of operating a fiber network based on the reference design the project team proposed.

Costs for replacement are expected to be low for the first twenty years following construction. However, since all circumstances are unknown initially, the municipality should consider allocating a portion of funding for a replacement fund. These funds would be utilized in the event of a catastrophic failure where entire portions of infrastructure would be required to be replaced. This would also include end equipment such as switches or routers, which may have expired warranties after 3-5 years. The County may also consider earmarking revenue generated by the system, via commercial clients, for a replacement fund. This revenue, and revenue created via Last-Mile networking, could also help pay for any maintenance costs over time.

In summary, the implementation of our recommended plan consists of further engagement with ISPs promoting a PPP that is specifically catered toward building a network that addresses the needs of the Underserved and incentivizes business development. Criteria for the selection of an operator will include their ability to secure grants and funding opportunities geared towards digital equity and economic development.

If the County wishes to expand the fiber network in the future, the budget will need to expand to help pay for this growth. This could come from money raised by commercial client leasing of fiber. Any expansion costs will vary based on the scale and nature of the expansion but using revenue from commercial clients will be the easiest source of funding for an expansion after initial funding incentives are utilized for the build-out with the goal of developing a sustainable operation.

12 COST ESTIMATES

12.1 High-Level Infrastructure Costs for Middle-Mile Labor and Materials

Section Highlights

- THE COMPREHENSIVE MIDDLE-MILE PLAN IS EXPECTED TO COST $36M+
- POTENTIAL PARTNERSHIP AND FUNDING OPPORTUNITIES ALLOW FOR COST SAVINGS FOR THE COUNTY
- SUPPLY CHAIN ISSUES AND MATERIAL SHORTAGES MAY IMPACT THESE PRICES WHEN IMPLEMENTATION BEGINS

Table 11: Labor and Materials Cost Estimate, Infrastructure Only

Cost Estimate (Construction Phase)	
Materials	$ 11,481,000
Labor	$ 25,278,000
SUM	**$ 36,759,000**

Table 11, as seen above, represents the total construction cost for the Fort Bend County broadband network update as if the County were to take on this project on their own with no partners, consisting of the infrastructure needed based on the HLD, and buried underground. The cost for this broadband network can be broken down into two main categories for this project i.e., Materials and Labor. Both of which come with specific assumptions and unit costs and can each be split into various subcategories. The materials included are using recent prices from a local vendor, but with the current material shortages and supply chain issues in many fields, it is recommended to use these values as an estimate. For that reason, Table 12 below has a lower and higher range associated with various costs.

Table 12: Cost Estimate Ranges

Type of Cost	Lower Range	Upper Range
Underground Labor	$ 19,336,000	$ 29,004,000
Underground Materials	$ 9,051,000	$ 13,576,000
Splice Labor	$ 673,000	$ 1,009,000
Splice Materials	$ 32,000	$ 48,000
ISP Labor	$ 214,000	$ 321,000
ISP Materials	$ 102,000	$ 153,000

The fiber and conduit sizes were determined based on current and future demands, promotes redundancy, and allows for expansion or leasing options, should the County be interested in that. To do that, fiber sizes of 12FO minimum and 288FO maximum were picked, where the larger size is to accommodate the Middle-Mile infrastructure and the smaller size is for Last-Mile connectivity purposes, also built to include redundancy. To accommodate for redundancy or any future needs, it was also decided to include 2 – 2" HDPE conduits for fiber placement underground. There are natural water bodies and railroads that will need crossings, and including more ducts helps aid future adaptations to this fiber build by minimizing construction and labor costs. This size and quantity of conduit will also help promote safety within the network by having those spare ducts available.

Both rural and urban-specific handholes were included in this estimate. The rural-based handholes are typically placed approximately every 7,500 linear feet of fiber and were considered primarily along the HWY 59 route. The urban-specific handholes are estimated to be placed every 500' and at every demand point or fiber conduit intersection. The number of handholes included in this project takes these fiber lengths and sizes into account to determine the estimated total amount of handholes. Based on the fiber size and the natural conditions, the sizes for handholes include 36" x 60" x 24" for rural needs and 17" x 30" x 24" for urban needs.

Additionally, both splicing and the transition from OSP to ISP were considered. The assumptions for these conditions include splice closures based on sizing, fusion splicing ribbon or loose tube, splitters, and more. For plant transition, the assumptions include 1.25" Plenum innerducts, Hoffman boxes, building entrances, core drilling, 4" EMT, drop cable, and approximately 250' of 12FO cable per demand point. Both splicing and OSP to ISP costs are based on the number of expected demand points, towers, handholes, and expected footages.

The material prices are then determined to be based on the linear footage for each project, the size of fiber, and more. The breakdown of these linear footage values can be seen below in Table 13:

Table 13: Material Quantities

Fiber Size	Linear Footage
432F	168,000
288F	1,096,000
12F	5,000
Estimated Slack	225,267
Conduit Size	**Linear Footage**
2-2"	1,264,000
Handhole	**Quantity**
17" x 30" x 24"	2,230
36" x 60" x 24"	23

Additional considerations for labor consists of bore crews, fiber crews, splicing crews estimated efficiencies as well as estimated additional costs for traffic control, mobilization, engineering, administration, and contingency. The construction estimates were derived from local vendors, and the remaining costs were based on federal communications studies for fiber optic construction. Construction Engineering pertains to inspection, oversight, and field engineering (not detailed design). These assumptions may not reflect the current landscape which includes inflation, supply chain issues, and material shortages, but estimates can be seen below in Table 14.

In the tables below the assumptions are detailed for each labor cost.

Table 14: Additional Cost Estimate Assumptions

Bore Crews	Excluding Weekends, 2,000LF/Day, 3-Person Crew
Fiber Crews	Excluding Weekends, 6,500LF/ Day, 3-Person Crew
Splicing Crews	Excluding Weekends, 400 Splices/ Day 3-Person Crew
Traffic Control	7% of Total Labor Cost
Mobilization	9% of Total Labor Cost
Construction Engineering	10% of Total Labor Cost
Administration	7% of Total Labor Cost
Contingency	20% of Total Labor Cost

To assume the estimated timeline using these considered crews, Table 15 below highlights the expected time per 1 crew for each boring, fiber, and splicing based on the number of weeks. To decrease the time to completion, more crews could be hired at additional costs.

Table 15: Estimated Work Crew Durations

Crew Type	Number of Weeks
Bore Crew Days	127
Fiber Crew Days	53
Splicing Crew Days	17

As detailed in additional sections, the expected Operations and Maintenance cost estimate can be seen below. Depending on the business model chosen by Fort Bend County, this may not need to be paid by the County.

Table 16: Operations and Maintenance Estimate

Network Details		
Approximate Mileage	Network Cost	Capacity
240	~$37,000,000	100GB 10GB
Maintenance Details		
Maint. Terms	Monthly Maint. Cost	Maint. Cost Estimate
20 Years	~$37,000	0.1% Network Cost
Operations Details		
Managed Service Terms	Monthly Service Cost	Operations Cost Estimate
7 Year	~$14,800	0.04% Network Cost

12.2 Additional Costs Considerations for Data Center, POP Locations, and Towers

Data Center and POP Location construction and upgrades were not included in the materials and labor aspect of the design but should still be considered. With the variability of factors relating to these locations that will be further discussed below, specific cost values cannot be calculated at this time.

The proposed solution would require at least one Data Center (a large room with specific HVAC and electrical needs), one large Pop Location (located within a spare room/ closet), and a smaller POP location (an external large handhole). Depending on the business model chosen by Fort Bend County, these may be managed by a potential partner. Materials needed for these locations would include port line cards, breakout cables, aggregation cards, transceivers, chassis shelves, distributed denial-of-service (DDoS) appliances, distribution switches, firewalls, patch panels, servers, and batteries, rectifier systems, generators, mounting hardware, and other various building upgrades. Data Centers and POPs are available to collocate with established County owned buildings and would therefore not require the purchase of new facilities. A passive infrastructure model would be the most cost-effective way for the County to include these locations.

Similar to the Data Center and POP location considerations, the same thoughts need to apply to that of towers for fixed wireless solutions as well. Whether the plan is to collocate on existing towers or propose new towers, different factors apply to either situation. When considering the colocation process for towers, through a rough estimate it can be assumed that collocation itself will range from $30-75k. The price is determined by the number of antennas or radios currently installed on the tower as well as what would be on the ground. For ground equipment, factors that can impact pricing would be determining the number of cabinets required, is there need for a generator to be installed, what is the current situation of sending power to the tower from the local energy provider and is it easy to access at the tower, and more. If proposing a new tower is a viable option, then costs for this situation will vary based on the height of the tower with costs ranging from $100-200k should be expected. For adequate consideration of locations, the ground conditions for foundations, tower ancillaries, and ground equipment are required. If the tower height needs to be higher than anticipated, then the amount and types of equipment will need to be updated to reflect those changes which will also impact costs. Furthermore, outside of material and labor costs, additional considerations for towers will include various regulatory requirements. Each tower proposed will need several environmental studies completed that range from geotechnical soil analysis, to bird flight path migratory patterns, and even protected wetland or tribal area evaluation. The FCC has regulatory compliance documents that will need to be completed which include NEPA, SHPO, Tribal, 1A/2C, and more. All of these considerations, and more, can be further detailed in supplementary developments.

13 BUSINESS MODEL OPTIONS

There are multiple, applicable business models to consider for municipal broadband projects with Middle-Mile, Last-Mile, and digital equity components. These models are determined and shaped based on available funding opportunities, potential partner capabilities and levels of investment, community and public utility stakeholder input, actual demand and anticipated take rates, forecasted economic output, and regulatory framework and a regional and national level. Fortunately, there are many diverse funding opportunities and a tiered range of options to build catered versions of these models as no municipalities and broadband infrastructure needs scenarios are the same. The models listed below should be considered base ownership and operation models and will be further developed and defined through subsequent phases which may include a request for information, qualifications, or proposals from interested parties.

Section Highlights

- THERE ARE VARIOUS LEVELS OF INVOLVEMENT FORT BEND COUNTY CAN ASSUME IN A PPP CONTRACT
- CONSIDERING THE FINANCIAL INCENTIVES AVAILABLE IT IS IMPORTANT TO NOTE THAT INVESTMENT DOES NOT NECESSARILY ASSUME UNIQUE OWNERSHIP

13.1 Considerations For Business Model Selection & Partnership

Prior to evaluating and planning for the appropriate business model, there are some base considerations that will conceptualize the necessity, values, and risks of municipal broadband networks in any form. The first and most apparent consideration is the necessity of municipal involvement further than the promotion of the issues and driving initiatives to improve broadband access and adoption. This study presents findings and data which can help inform this consideration. In many cases, the study and initiative itself drive private sector action and spur modernization of incumbent networks and draw attention to new providers to saturate the market. While there may be some private sector movement, there is no guarantee that it will be to the extent that the municipality envisions and there are still additional incentives for the municipality to play a role in broadband development. Municipalities can benefit from improved broadband network infrastructure in their own network operations and applications across departments and public service components, such as Supervisory Control and Data Acquisition (SCADA) and Automatic Meter Reading system (AMR) for public utilities. Cities and counties are often considered a tier one commercial account for providers and so they are a potential benefactor in the initiative and an attraction for partners to provide commercial services. Local governments can influence how broadband deployments are implemented through public policy, which can serve as both an incentive in a partnership and to manage the public ROW and protect community interests. Regardless of the selected model, or variant of, it is imperative that those municipalities and jurisdictions involved in the initiative have considered their standards when it comes to new broadband infrastructure. Refer to Section 11.7 on Public Policy. Local governments can introduce further financial incentives in the form of subsidies or tax credits, incentivizing providers and adoption. Municipal infrastructure can be leveraged as broadband assets and reduce costs or provide revenue generation. This concept applies to existing assets such as water towers and properties for collocated ISP facilities in addition to any broadband-specific assets the municipality may own as a part of a proposed network. In exploring these models, the municipality and partners must consider shared risks and incentives, areas of expertise and resourcing, and take measures to ensure a healthy competitive market.

13.2 Ownership & Operations Models

There are three primary models based on the level of involvement of municipalities and private partners, across three network service components: Infrastructure, Access, and Service. The infrastructure component consists of civic components such as conduits, poles, dark fiber, and handholes. The access component comprises of electronics and services to “power” the network and connect it to transport networks. The service component covers providing the actual commercial and residential services to the end customers. The three models reflect the inclusion of one or more of these components, starting with the least involvement in the infrastructure component, adding access, and then finally service. Respectively, these models are: Passive Infrastructure or Infrastructure Only, Wholesale or Operator Owned, and Fully Integrated or Full-Retail Service. We have provided multiple common terminologies as these vary across municipal broadband model studies.

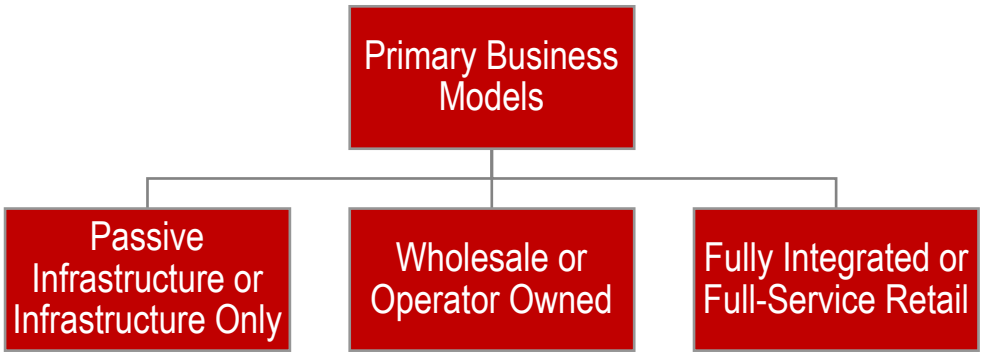

Figure 46: Primary Business Models

It is important to note that there are accessory models within these base models such as Open Access, Public Policy Only, Public Services, Commercial Only, and Residential Only. These accessory models focus on specific needs within the base structure, for example, a municipality may want to pursue a Wholesale model where they provide both infrastructure and access components, but only for target commercial customers (Commercial Only) or local government facilities (Public Services). The Open Access model is inherent in both the Passive Infrastructure and Wholesale models where there is a neutral operator and can be used to promote healthy competition of providers at the access and service levels. Depending on the range of scope for the municipal broadband initiative, there may be multiple models and accessory models to serve different purposes.

13.2.1 Passive Infrastructure | Infrastructure - Only

In this model, the municipality's involvement is limited to facilitating some or all the passive infrastructure needed for the broadband network. Passive infrastructure only includes the labor and network materials at the physical layer, such as conduit, dark fiber (fiber not being actively used), utility poles, towers, buildings, and properties for Data Centers and POPs. This infrastructure is usually the most costly and essential to support the network but does not include the necessary transport equipment and connections for access or equipment and provisioning for internet services. A private sector provider or operator would manage the access and service components. The municipality has the option to own and lease or sell some or all their infrastructure to broadband service providers or operators. This model allows for full open access at both the access and service levels given the municipality enters an agreement with a neutral operator where the network infrastructure is available to both access providers and service providers. Typically, the passive infrastructure does not include residential development as this is often costly and there are many implications in the access and service levels that need to be considered in the design and implementation. This model is effective to incentivize operators and providers to serve areas of need that were otherwise cost-prohibitive. If the municipality retains ownership of the infrastructure and opts for the leasing option, there needs to be a clear delineation in the agreement with the operator or provider as to maintenance. Ownership of the infrastructure may be beneficial to the municipality given fixed costs, indefinite use, ability to influence the cost to consumers, ensure equal access across the communities, and can be leveraged for public services and applications. These benefits of ownership need to be weighed with the cost and resources required for maintenance, competitive rates for lease while ensuring ROI, and the potential for the open access components to dissuade providers from entering the market.

13.2.1.1 Lease and Selling Options

The following are options the municipality would have in terms of the sale or lease of infrastructure assets:

1. Purchase Agreement: Municipality would be paid upfront or through annual payments and transfer titles
2. Indefeasible Right of Use: Municipality would be paid upfront with annual maintenance payments for a certain capacity of their fiber for ~10-20 years

3. Lease: Municipality would be paid monthly for use of infrastructure assets for ~3-5 years
4. Asset Swap: Municipality could exchange assets and would transfer titles accordingly

These options also apply from the opposite perspective, should the municipality look to purchase or lease infrastructure from operators or providers.

13.2.2 Wholesale | Operator Owned

The Wholesale model increases the involvement of the Passive Infrastructure Model to include the municipality facilitating the access component, including all necessary equipment and transport services to activate the network. In this scenario, the municipality could be the neutral operator, responsible for providing wholesale broadband access to private operators or providers. The municipality may still opt to engage a private operator as they typically prefer to own the access component and sell to providers. This is often a large step toward a full-blown Fully Integrated model and requires increased staffing and expertise. For this reason, Public Private Partnerships are often a more viable solution for municipalities considering this option. From an open access perspective, there is still full competition from service providers as the access component is now the responsibility of the municipality. When a municipality owns the access component and does not contract an operator, there is typically more hesitation from private providers to use the municipal network given the relative experience the municipality has in managing wholesale services and the risk associated. Benefits include more control over the selection of quality service providers and revenue options in wholesale broadband access to operators and providers. As with the previous model, maintenance and operations costs will increase and consideration should be taken in that broadband technologies are constantly evolving and require more frequent investment than other utilities.

13.2.3 Fully Integrated | Full-Service Retail

With the addition of the service components, the Fully Integrated Model requires comprehensive involvement from the municipality as a broadband service provider. Municipalities can provide Middle-Mile and Last-Mile services to residential and commercial customers services from end to end. The municipality owns the network and can often converge this with other public utilities for billing simplicity and other verticals. The municipality is responsible for operations, management, construction, maintenance, network monitoring, billing, marketing, retail offerings, troubleshooting, and customer service. While this model can create significant value, it also assumes the most risk and should only be considered when there are no willing and capable private sector providers willing to enter the market or provide the level of services required to meet the needs of the communities. This Full-Service Retail model looks attractive and garners public attention when implemented as there have been remarkable success stories, such as the City of Mont Belvieu, TX's "MBLink," there have also been many failures that can put a municipality in financial hardship and the burden falls to taxpayers. Another consideration of this model is that it eliminates the open access concept as the new municipal ISP would be considered a competitor with private sector providers at all levels. There is space within this model to still allow for healthy competition when the municipal ISP only serves Unserved or Underserved markets that the private sector has not elected to serve. While a Municipal ISP does need to consider ROI and healthy financial operations, the goals of the Municipality for their ISP often focus on other factors such as promoting local competition to bolster the local economy and target areas that require subsidy or at-cost services to promote adoption. Successful municipal ISPs using this model often have advanced economies which can steady concerns over the financial risks in taking on such an initiative. Any municipality considering this model should strongly evaluate its expertise, capabilities, resources, and the overall necessity of this make-or-break model.

13.3 Accessory Business Models

The base models above are not rigid and can be catered to the unique needs and capabilities of the municipality to assume different levels of responsibility and investment. Accessory models accentuate or serve as sub-models to represent some of the more common options associated. As mentioned previously, different models can serve various project scopes as a part of the broadband initiative and so there is no need to resort to one model-fits-all mentality.

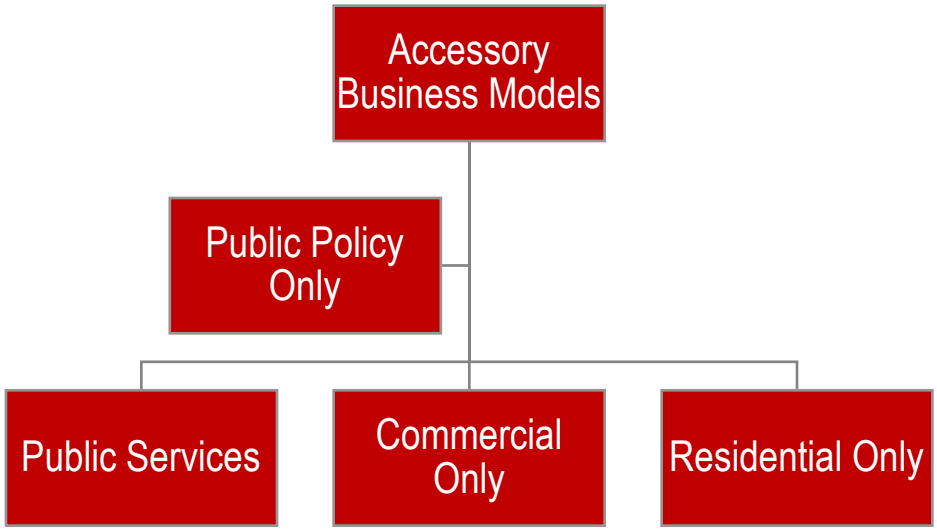

Figure 47: Accessory Business Models

13.3.1 Public Policy Only

In a Public Policy Only model, the municipality can still play a role in promoting broadband expansion through the available policy tools at their disposal, and without having to invest in any of the infrastructure, access, and service components. Consider this model at the lowest end of the risk spectrum, where the municipality and local government entities facilitate private sector investment through streamlining jurisdictional processes and red tape that might otherwise delay or deter broadband expansion efforts. Through public policy, municipalities can promote an "ISP Friendly" market and may influence the improvement of services or expansion into areas of need, but it is unlikely that this level of investment will incentivize private providers where they cannot profit.

13.3.2 Public Services

The Public Services model relies on municipality and local public entity support to address broadband needs solely for municipal and public entity facilities and relative applications. Oftentimes, municipalities look to improve their internal services in conjunction with broadband initiatives focused on residential and commercial services. Public sector IT groups typically look to reduce operational and service costs associated with leased lines and Multiprotocol Label Switching (MPLS) networks by building their own dark fiber and providing data services to other public organizations. This model can be considered in isolation, focused on building municipal interconnects between ISDs, public utilities buildings, governmental buildings, Emergency Operations Centers (EOCs), and public safety assets. There are many benefits to this which indirectly improve the quality of life for communities that rely on these public services and facilities. Municipalities may also leverage private sector competition to provide these services to incentivize private investment in the residential and commercial areas of need. All three base models can be catered towards strictly public services, where the municipality can determine its level of involvement.

13.3.3 Commercial Only

Similar to Public Services, The Commercial Only model can utilize one of the three base models to focus strictly on providing commercial services to businesses and commercial properties. The availability of capable commercial services is a huge economic growth driving by attracting businesses to the market and retaining those already currently in place. Most modern, large companies require multiple, redundant connections from tier one providers and so attracting multiple capable providers to the market in the Middle-Mile space can be very impactful. Municipalities can directly offer these services through the Fully Integrated base model but should consider if their presence in the commercial service space would deter the necessary private sector saturation. As commercial customers are often in the Middle-Mile space, open access is a possibility here where there is a known necessity for multiple providers to provide these multiple, redundant services. Commercial Only can be implemented as a separate scope or part of a larger initiative including public and residential services.

13.3.4 Residential Only

Residential Only is a sub-model to the three base models in which the municipality would focus solely on involvement in providing residential services. As this is one of the more costly and complex targeted services, in most cases, private providers have the expertise to deploy and operate in residential markets. The risk and investment associated with providing residential services are higher than that of commercial and public services, and regarding digital equity, the greatest needs are often with residents in the Unserved and Underserved communities, and this is where municipal influence can make a significant impact. A Passive Infrastructure model, catered towards residential only would be a logical, catered model for a municipality looking to incentivize private provider saturation. However, open access potential would be limited as residential customers do not require redundant service connections and private providers will likely avoid using infrastructure owned by a municipality in this space. Residential Only can be implemented as a separate scope or as part of a larger initiative including public and residential services.

13.4 Business Model Funding

Another layer to the business model determination is the funding aspect, representing tangible investment and risk assumed by the parties involved. Funding a component of a broadband network does not necessarily translate to unique ownership of specific assets as there is a need to ensure that the right party focuses on their area of expertise. For example, while a municipality may elect to cover the costs of the access components to spur the development of a network, they may have no intention of handling the installation, operations, or maintenance of this component as they do not have the resources nor expertise to manage. As touched on in the business model outlined above, there are benefits to the municipality in ownership such as being able to promote open access, lease, and generally have more control over the network. On the other hand, there is an increased risk of crowding out the private sector or discouraging their investment, the learning curve in obtaining the expertise and training to manage and operate, and costs of maintenance and frequent technology upgrades. Weighing all these considerations in mind, a municipality must determine the feasibility and necessity of public funding or public-private partnership funding. In isolation, a municipal broadband network can be funded entirely through public sector means such as bonding, grants, loans, and Community Reinvestment Act (CRA) or Public Welfare Investments (PWI). Other than grants requiring no match, the municipality has all the financial burden and would not offset costs through private sector investment. As the private sector is constantly looking for where to expand and invest to grow their business, a public-private partnership leverages this pending investment and reduces municipal risk.

13.5 Public Private Partnerships (PPPs)

Public-Private Partnerships take the best of both worlds where all parties focus on their areas of expertise and share the risks and benefits associated with the network development. PPPs can allow municipalities to attract private capital when it would not be feasible otherwise[18]. Collectively, the partnership compartmentalizes and accommodates all aspects of the network, leveraging assets from both the private and public sectors for mutual benefit. The initial infrastructure investment, operational and maintenance costs, and revenue sharing are all considered in the following PPP contracts.

Table 17: Various Forms of Broadband Public Private Partnerships

Contract	Network Funding	Network Operations	Subscription Fees Collected By	Revenue Share To
Third Party Run	Municipality	Private Operator	Municipality	Private Operator
Lease	Municipality	Private Operator	Private Operator	Municipality
Special Purpose Vehicle	Both	Both	Both	Both
Build Operate Transfer	Private Operator	Private Operator	Municipality	Private Operator
Concession	Private Operator	Private Operator	Private Operator	Municipality

13.5.1 Municipality-Funded PPP Networks

In a Third Party Run Service Contract, the network is funded and built by the municipality, but the connectivity and end-user services are provided by a private operator. Subscription fees are collected by the municipality, possibly through existing utility billing services. The municipality then transfers a share of the revenue to private operator to cover costs of operations, maintenance, and quality of service (QOS) expenditures. Allows for a return on capital.

In a Lease Contract, the network is funded and built by the municipality and then leased by the private operator, who in turn provides connectivity and services. Subscription fees are collected by private operator and a portion of the revenue is transferred to the municipality to cover the network rental fees.

In a Special Purpose Vehicle Contract, the network is co-financed, built, and operated by the municipality and private operator, who both share in the return on investment.

13.5.2 Private Sector-Funded PPP Networks

In a Build Operate Transfer (BOT) Contract, the municipality facilitates private investment through a "tender," such as a Request for Information (RFI), Request for Qualifications (RFQ), or Request for Proposals (RFP) to a private operator to fund, build, and operate the network. Subscription fees are collected by the municipality, possibly through existing utility billing services. The municipality then transfers a share of revenue to the private operator to cover operations, maintenance, and QOS expenditures. Allows for a return on Capital

[18] Municipal Broadband Networks—Opportunities, Business Models, Challenge. Ifc.org. https://www.ifc.org/wps/wcm/connect/publications_ext_content/ifc_external_publication_site/publications_listing_page/municipal+broadband+networks. Published 2022. Accessed June 1, 2022.

In a Concession Contract, the network is funded, built, and operated by a private operator. Subscription fees are collected by the private operator as well. This contract requires that the Municipality allows the private operator access to municipal resources or assets such as utility poles and ducts. Concession fees are paid to the municipality for use of their assets.[19]

13.6 Managed Services

Partnerships are not limited to private operators or providers but can also include broadband services companies that do not necessarily own or provide direct internet services. These companies can support the municipality and their partners in the service activation and service assurance aspects of the network. As previously mentioned, broadband networks are dynamic and complex in comparison to traditional utilities and require substantial expertise, in which the municipality, and sometimes even the operator or internet service provider, needs external resources. Managed services are typically catered, modular solutions which fill in the implementation and operational components of the network to include monitoring, troubleshooting, performance analysis, inventory management, cybersecurity, and much more. For a municipality considering more extensive involvement and ownership, or in a partnership with smaller private operators, managed services companies can assist in standing up the network and making necessary connections to operations and business support systems (OSS/BSS), including municipal billing and notification systems. Managed services should be considered early in the broadband network development and not as an afterthought when operations suffer or there are delays due to unforeseen complications. Under a Full Retail Service Model, managed services can be essential to round out the municipality-team, providing necessary resources and even training leading towards a potential transfer to a municipally run or sponsored ISP.

[19] Municipal Broadband Networks—Opportunities, Business Models, Challenge. Ifc.org. https://www.ifc.org/wps/wcm/connect/publications_ext_content/ifc_external_publication_site/publications_listing_page/municipal+broadband+networks. Published 2022. Accessed June 1, 2022.

14 FUNDING ANALYSIS

As outlined and reenforced throughout this study, broadband is a necessary component to everyday life across the globe. Federal sources state that 30 million Americans do not have access to at least minimally acceptable internet speeds and according to the Economic Co-operation and Development (OECD), among 35 countries studied, the United States has the second highest broadband costs. Recognizing these facts, Congress, through the Bipartisan Infrastructure Deal identified broadband as a high priority from the initial drafting of the Infrastructure Investment and Jobs Act (IIJA). The final bill allocated $65 billion (out of $1.2 trillion) to several federal agencies with the goal of ensuring every American has access to reliable high-speed internet.[20]

To achieve this goal, 4 key initiatives were identified:

1) Deploy future-proof connectivity to all Americans.
2) Provide broadband subsidies for low-income users.
3) Provide funding to accelerate the Country's progress toward addressing both broadband access and adoption challenges.
4) Provide funding to address digital literacy and digital equity.

Section Highlights

- $65 BILLION IN FUNDING ALLOCATED FOR BROADBAND CONNECTIVITY PROGRAMS
- LEVERAGING THESE FUNDING SOURCES WITH PRIVATE/LOCAL MATCH THROUGH PPP WILL INCREASE OVERALL IMPACT
- FORT BEND COUNTY HOUSEHOLDS SHOULD GO TO GETINTERNET.GOV TO SEE IF THEY QUALIFY AND APPLY FOR THE AFFORDABLE CONNECTIVITY PROGRAM

14.1 State Broadband Development Office

One of the key components of the IIJA was the decision to place a majority of the funding in the Broadband Equity, Access and Deployment program (BEAD), with the responsibility for administering these funds falling to each state government and US territories' representatives. Each entity is required to develop a state-wide plan for how they will administer the funds to new infrastructure projects at the local level and in order to do so, had to establish a State Broadband Deployment Office (BDO). Some states already had offices overseeing broadband policy and deployment while others have had to form one at the direction of the funding guidelines. In Texas, the State BDO is overseen by the Comptroller of Public Accounts office.[21] The Texas BDO office's mission is to:

- Create an accurate broadband map of eligible vs. ineligible areas for financial assistance. The map will have a challenging process to dispute any perceived inaccuracies.
- Establish a long-term, statewide plan that addresses strategies and goals for expanding access to and further adoption of broadband service.
- Award grants or other financial instruments to meet the goals of the plan.
- Set the effective threshold speed for broadband service (25 Mbps download/3 Mbps upload).
- Engage in outreach to communities regarding the expansion.
- Address barriers for future expansion efforts.

In its development, the BDO created a 10-member Board of Advisors to provide guidance regarding the expansion, adoption, affordability, and use of broadband service and the programs administered by the office. The Board is chaired by the Texas Comptroller and includes a representative of the BDO as a non-voting member. The other appointees come from the Offices of the Texas Governor, Texas Lieutenant Governor, and the Speaker of the House. At the time of this study, the Chair and non-gubernatorial appointees are as follows:

- Glenn Hegar, Chair
- Representative Trent Ashby, Board Member

[20] Fact Sheet: The Bipartisan Infrastructure Deal | The White House. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2021/11/06/fact-sheet-the-bipartisan-infrastructure-deal/. Published 2022. Accessed June 1, 2022.
[21] Mission. Comptroller.texas.gov. https://comptroller.texas.gov/programs/broadband/leadership/%23mission. Published 2022. Accessed June 1, 2022.

- Sergio Contreras, Board Member
- Adriana Cruz, Board Member
- Robert F. McGee, Board Member
- Dr. Scott Muri, Board Member
- Mari Robinson, Board Member

As a part of the BDO's mission to create a statewide plan in relation to the BEAD funding, the Comptroller held 12 regional listening tours in communities across Texas to gain insights about internet access and collect input for the plan.[22] The BDO office is working on a Toolkit that will assist local communities, service providers, and stakeholders with information and resources for identifying community needs and gaps, developing effective leadership strategies for implementation, and analyzing funding opportunities.[23] The State is currently working to develop the State Plan for the BEAD funding and the information gathered and analyzed as a part of this study will be presented to the Texas BDO for review and inclusion in the state planning efforts.

The Texas BDO developed the following chart to display the current known funding allocations to Texas for broadband initiatives. The $100 million per state listed under BEAD includes an initial $5 million in planning funds for each state to develop its five-year plan which is in development. As the State develops the plan, Fort Bend County will be well positioned to submit its project for consideration with this study and future partnerships for implementation.

[22] Texas Broadband Listening Tour. Comptroller.texas.gov. https://comptroller.texas.gov/programs/broadband/communities/tour.php. Published 2022. Accessed June 1, 2022.
[23] Texas Broadband Development Office. Comptroller.texas.gov. https://comptroller.texas.gov/programs/broadband/toolkit/. Published 2022. Accessed June 1, 2022.

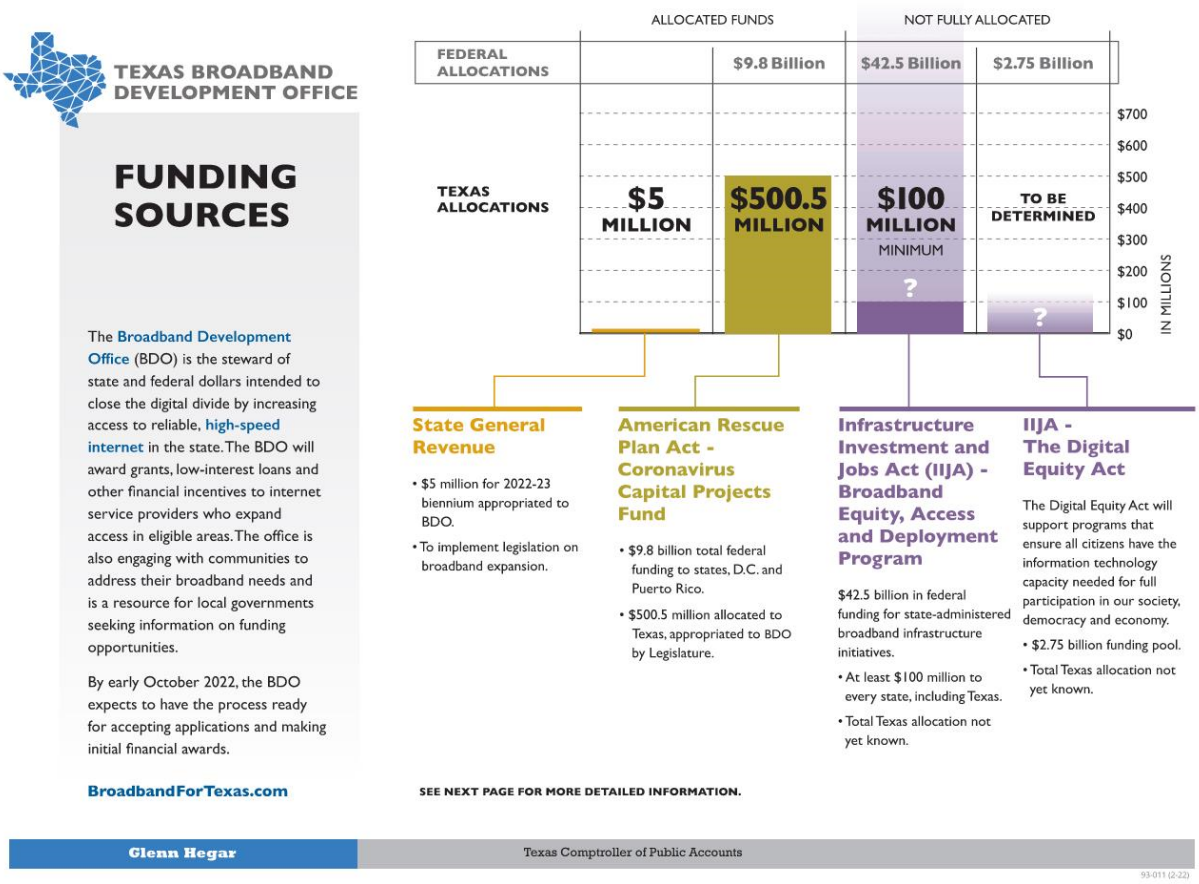

Figure 48: Breakdown of IIJA Funding to Texas BDO

14.1.1 Affordable Connectivity Program

Under the terms of the Affordable Connectivity Program (ACP), an eligible household that signs up for the program will receive a discount of up to $30/month on any internet service plan a participating provider offers. The ACP is the largest high-speed internet affordability program in our nation's history. Under the terms of the ACP, an eligible household that signs up for the program will receive a discount of up to $30/month on any internet service plan a participating provider offers. It is estimated that 48 million households—or nearly 40% of households in the country—qualify for the ACP based on the following eligibility criteria:

- Supplemental Nutrition Assistance Program (SNAP), formerly known as Food Stamps
- Medicaid
- Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)
- Supplemental Security Income (SSI)
- Federal Public Housing Assistance (FPHA)
- Veterans Pension and Survivors Benefit
- Free and Reduced-Price School Lunch Program or School Breakfast Program, including at U.S. Department of Agriculture (USDA) Community Eligibility Provision schools
- Federal Pell Grant (received in the current award year)
- Lifeline

- Certain Tribal assistance programs, including Bureau of Indian Affairs General Assistance, Head Start (only households meeting the income qualifying standard), Tribal Temporary Assistance for Needy Families (Tribal TANF), and Food Distribution Program on Indian Reservations
- Meets the eligibility criteria for a participating broadband provider's existing low-income internet program.

Each of the following companies committed to offering all ACP-eligible families at least one high-speed plan for $30/month or less, with no additional fees and no data caps.[24]

- Allo Communications
- AltaFiber (and Hawaiian Telecom)
- Altice USA (Optimum and Suddenlink)
- Astound
- AT&T
- Breezeline
- Comcast
- Comporium
- Frontier
- IdeaTek
- Cox Communications
- Jackson Energy Authority
- Mediacom
- MLGC
- Spectrum (Charter Communications
- Starry
- Verizon (Fios only)
- Vermont Telephone Company
- Vexus Fiber
- Wow! Internet, Cable, and TV

[24] FACT SHEET: President Biden and Vice President Harris Reduce High-Speed Internet Costs for Millions of Americans | The White House. The White House. https://www.whitehouse.gov/briefing-room/statements-releases/2022/05/09/fact-sheet-president-biden-and-vice-president-harris-reduce-high-speed-internet-costs-for-millions-of-americans/. Published 2022. Accessed June 1, 2022.

14.2 Key Programs for Fort Bend County Consideration

Three key programs for Fort Bend County to consider being an applicant or partner on applying include the following programs. There are various factors for consideration, including match requirements, levels of service, partnership agreements and other factors, that would impact which funding source(s) should be applied to and leveraged collectively to try and bring as much funding to the County as possible.

Table 18: Fort Bend County Specific Funding Opportunities

Grant Program	Funding Agency	Description	Timeline	Total Allocation
Middle-Mile Grant Program[25]	National Telecommunications and Information Administration (NTIA)	National awards will be issued on a technology-neutral, competitive basis to eligible entities for the construction, improvement, or acquisition of Middle-Mile infrastructure.	Sept. 30, 2022	$1 Billion (Nationally Competitive)
Capital Projects Fund[26]	American Rescue Plan Act (ARPA)	For payments to states, territories and tribal governments to complete capital projects directly enabling work, education and health monitoring, including remote options, in response to the public health emergency	Sept. 24, 2022 (State to submit plan)	$10 Billion, ($500 Million to Texas)
Broadband Equity, Access, And Deployment (BEAD) Program[27]	National Telecommunications and Information Administration (NTIA)	Through state allocation and planning, this program intends to expand high-speed internet access by funding planning, infrastructure deployment and adoption programs.	Spring 2023 (State submitting plan by July 18, 2022)	$42.5 Billion ($100 million initial to Texas)

[25] Enabling Middle Mile Broadband Infrastructure Program | Internet for All. Internetforall.gov. https://www.internetforall.gov/program/enabling-middle-mile-broadband-infrastructure-program. Published 2022. Accessed June 1, 2022.
[26] Capital Projects Fund. U.S. DEPARTMENT OF THE TREASURY. https://home.treasury.gov/policy-issues/coronavirus/assistance-for-state-local-and-tribal-governments/capital-projects-fund#:~:text=The%20American%20Rescue%20Plan%20provides,to%20the%20public%20health%20emergency. Published 2022. Accessed June 1, 2022.
[27] Broadband Equity, Access,and Deployment (BEAD) Program | Internet for All. Internetforall.gov. https://www.internetforall.gov/program/broadband-equity-access-and-deployment-bead-program. Published 2022. Accessed June 1, 2022.

15 SUMMARY

The need for modernized and resilient broadband networks has been highlighted in recent weather and health events, such as the Winter storm Uri and the Coronavirus Pandemic, respectively, which have demonstrated a clear societal dependency on communication networks for emergency response, communal interaction, and access to remote services like; telehealth, remote learning and telework. Broadband network access and connectivity should be viewed as a commodity in improving the overall quality of life. Given the varying accessibility and rates of adoption of broadband networks around the country, there are now historic-level funding opportunities from the Federal and State levels to achieve digital equity. Based on funding eligibility, several key grants the County's project could be funded through include; the Middle-Mile Grant Program, Capital Projects Fund, Broadband Equity, access and Deployment (BEAD) Program, and the Digital Equity (DE) Program.

As a qualifying metric for grant funding, the National Telecommunications and Information Administration (NTIA) set minimum speed thresholds to create standards for adequate access to high-speed broadband. These primary standards are divided into the following two categories: Underserved areas which consist of speeds below 100 Mbps download and 20 Mbps upload and Unserved areas with speeds below 25 Mbps download and 3 Mbps upload. Many census blocks within Fort Bend County have been designated as Unserved and Underserved by these standards, and the funding opportunities provide an opportunity to fill the existing broadband gaps identified in this study.

CobbFendley's base recommendation for this Broadband Improvement Initiative is a network solution that meets or exceeds a minimum of 100Mbps symmetrical (100 /100Mbps) speed for residential service which would provide levels of service above the minimum standards set by NTIA and provide high-speed reliable internet for the future needs of Fort Bend County residents. A greenfield based Middle Mile High-Level Design was developed as a part of this study, to understand the full capacity of Middle Mile need to have sufficient capacity for last mile connection. Leveraging the various funding sources, in partnership with private providers, can help implement the High Level Design and incentivize the last mile deployment with the ultimate goal of closing the digital divide in Fort Bend County.

The positive impact to Fort Bend County from investing in this infrastructure, can have both short-term and long-term benefits. The building, operation, and maintenance of the network expansion will create immediate job opportunities within the market. Reliable, high-speed internet can enhance economic development by creating robust communication connections, remote job opportunities, access to telehealth services, ability to utilize innovative technologies, facilitating faster response times for day-to-day activities and many other aspects of quality of life. Fort Bend County's investment in this infrastructure is essential to expand its digital transformation footprint, foster countywide growth, and ensure residents and constituents have the fundamental access they need to thrive in their everyday lives.

16 APPENDIX

16.1 Acronyms

ACRONYM	MEANING
ACP	Affordable Connectivity Program
ADSL	Asymmetric Digital Subscriber Line
AMR	Automatic Meter Reading System
BOM	Bill Of Materials
BDC	Broadband Data Collection
BDO	Broadband Deployment Office
BEAD	Broadband Equity, Access, And Deployment
BOT	Build Operate Transfer
CAPCOG	Capital Area Council Of Governments
CTEC	Central Texas Electric Cooperative
CBRS	Citizens Broadband Radio Service
CRA	Community Reinvestment Act
CAF	Connect America Funds
COG	Council Of Governments
DDoS	Distributed Denial-Of-Service
OECD	Economic Co-Operation And Development
ESC	Education Service Center
EBB	Emergency Broadband Benefit Program
EMS	Emergency Medical Services
EOC	Emergency Operations Centers
FCC	Federal Communications Commission
FPHA	Federal Public Housing Assistance
FTTH	Fiber To The Home
FTTP	Fiber To The Premise
GLO	General Land Office
GIS	Geographic Information Systems
Gb	Gigabit
GPON	Gigabit Passive Optical Networks
Gbps	Gigabits Per Second
GDP	Gross Domestic Product
HDPE	High Density Polyethylene
HLD	High Level Design
ISD	Independent School District
IT	Information And Technology
IIJA	Infrastructure Investment And Jobs Act
ISP	Inside Plan Implementation
ISP	Internet Service Providers

KMZ	Keyhole Markup Language
LEA	Local Education Agency
LTE	Long-Term Evolution
LMI	Low- And Moderate-Income
LCRA	Lower Colorado River Authority
MGI	Mckinsey Global Institute
Mb	Megabit
Mbps	Megabits Per Second
MPLS	Multi-Protocol Label Switching
NTIA	National Telecommunications And Information Administration
NG911	Next Generation 911
OSS/BSS	Operations And Business Support Systems
OOM	Order Of Magnitude
OSP	Outside Plant Implementation
POP	Points Of Presence
PALs	Priority Access Licenses
PWI	Public Welfare Investments
PPP	Public-Private Partnerships
PSAP	Public-Safety Answering Point
QoS	Quality Of Service
RFI	Request For Information
RFP	Request For Proposals
RFQ	Request For Qualifications
ROI	Return On Investment
ROW	Right Of Way
RDOF	Rural Digital Opportunity Fund
SHR	Self-Healing Ring
SNAP	Supplemental Nutrition Assistance Program
SSI	Supplemental Security Income
TxDOT	Texas Department Of Transportation
Tribal TANF	Tribal Temporary Assistance For Needy Families
USDA	United States Department Of Agriculture
USAC	Universal Service Administrative Company
UAR	Utility Accommodation Rules
VPN	Virtual Private Network
WISP	Wireless Internet Service Providers
WIC	Women, Infants, And Children

16.2 Glossary of Terms (from Broadband.Money[28] and NTIA[29])

0-9	
3G	The term for the 3rd generation wireless telecommunications standards usually with network speeds of less than 1 Mbps
4G	The term for 4th generation wireless telecommunications standards usually with network speeds greater than 1 Mbps.
5G	The term for emerging 5th generation wireless telecommunications standards usually associated with network speeds of up to 1 Gbps or more
63-20 Financing	In Revenue Ruling 63-20 the IRS ruled that, in certain circumstances, bonds issued by a nonprofit corporation (the "Nonprofit") will be considered issued on behalf of a Governmental Unit – thus allowing the interest on such bonds to be eligible for tax-exempt treatment. A 63-20 financing may help avoid certain political and legal hurdles that otherwise might be present if the Governmental Unit were to issue the bonds directly.
A	
Aerial Installation	A type of fiber optic cable that is usually used for outside installation on poles. Due to its installation environment, the design of aerial fiber optic cable must consider how to protect it from destruction by nature or man-made damage.
Affidavit	A written declaration or statement that is sworn or affirmed before a person who has authority to administer an oath. Affidavits verify the legitimacy of a claim and are used in conjunction with witness statements or other related evidence in a dispute or a criminal matter. The person who signs the affidavit must be personally aware of the facts contained within, and he or she must swear that the affidavit is 100% true.
Affordable Connectivity Program (ACP)	Under the Infrastructure Investment and Jobs Act, the previous Emergency Broadband Benefit Program has been renamed the Affordable Connectivity Program. Although the program's benefit has been lowered from $50/month to $30/month, the definitions and operative terms of the program remain intact. Under those definitions, an Affordable Connectivity offer is one that is affordable for four-person household that includes two dependents under age 18 and has an income 136% of poverty line. IIJA Section 60502, "Broadband Affordability". For white-labeled, turnkey ACP automation, please contact Ready.
Asymmetric	When the upload and download speeds do not match. A rate of 10 Mbps down/1 Mbps up would be asymmetric.
Asymmetrical Digital Subscriber Line (ADSL)	A form of Internet service communications technology that delivers constantly accessible data transmissions over copper telephone lines. ADSL is a common brand of DSL and has download speeds between 2 and 6 Mbps and upload speeds reaching 512 Kbps.

[28] Glossary of Broadband Grant Terms. Broadband.money. https://broadband.money/broadband-grant-terms. Published 2022. Accessed June 1, 2022.
[29] Broadband Glossary. Broadbandusa.ntia.doc.gov. https://broadbandusa.ntia.doc.gov/sites/default/files/publication-pdfs/bbusa_broadband_glossary.pdf. Published 2022. Accessed June 1, 2022.

Asynchronous Transfer Mode (ATM)	A transmission method where information is re-structured into cells. It is asynchronous due to the fact that the recurrence of cells from an individual user is not necessarily periodic.
Attestation	The process for scrutinizing the authenticity of a document by corroborating every detail given on it and then manifesting it authentic with the sign and stamp of verifying personnel on it.
Average Revenue Per User (ARPU)	The term is used by companies that offer subscription services to clients. It is a measure of the revenue generated by one subscriber per unit time, typically per year or month. It is a particularly useful measurement for companies in the telecommunications industry, which relies on subscribers or users.
B	
BEAD Timelines	Eligible entities decide whether to participate in the BEAD program, which will provide ~$42B for infrastructure planning and implementation. If they choose to, they need to submit a letter of intent to NTIA by the deadline. To read in more details about the multitude of deadlines for the BEAD program, as well as any newly established deadlines from the National Telecommunications and Information Administration themselves, refer to our Timeline of Key Milestones and Grant Application Deadlines.
Backbone	The Internet is really a network of networks, and the large trunk lines that connect them are referred to as the “backbone.” It can also be thought of as being like the highway system: the interstate highways are the backbones that connect regions that have highway networks of their own.
Bandwidth	In the world of Internet service, bandwidth has come to mean the speed of Internet service, measured in bits per second. Not to be confused with bandwidth referring to a range of radio wave frequencies, which may be used in more technical discussions about how data is transferred.
Bank Loan	An amount of money loaned at interest by a bank to a borrower, usually on collateral security, for a certain period of time.
Bit	A bit is the basic unit of information in computing. The name comes from “binary digit,” and each bit has one value, either 1 or 0, or on and off. It usually takes eight bits to represent one character of text; a group of eight bits makes a byte. Data file sizes are measured in bytes while data speed is measured in bits.
Broadband	Shorthand term for any high-speed Internet access that is faster than dial-up and, unlike dial-up, is always on. Over the years, as what we use the Internet for has demanded a larger capacity for moving data, different entities have set speed definitions for broadband, implying that an Internet-access service shouldn’t be called “broadband” or “high-speed” unless it meets a certain speed level.
Broadband Deployment Accuracy And Technological Availability (DATA) Act	Passed on March 10, 2020, just prior to the significant shutdown occasioned by the coronavirus pandemic, the Broadband Deployment Accuracy and Technological Availability (DATA) Act established new guidelines and rules for the Federal Communications Commission's production of broadband availability and deployment maps. The rules effectively require an address-by-address inventory of broadband. These requirements are codified at 47 U.S.C. Section 642.
Broadband Deployment Accuracy And Technological Availability (DATA) Act Maps	Under the Infrastructure Investment and Jobs Act, funding eligibility for areas that are "Unserved" and "Underserved" will be determined by

	reference to the Broadband DATA Maps created under the Broadband DATA Act. IIJA, Section 60103.
Broadband Equity, Access And Deployment Program (BEAD) Program	A $42.45B formula grant program directed towards states and territories with the objective of closing the availability gap, as Congress finds that "access to affordable, reliable, high-speed broadband is essential to full participation in modern life in the United States."
Broadband Initiatives Program (BIP)	The Broadband Infrastructure Program is a $288 million broadband deployment program directed to partnerships between a state, or one or more political subdivisions of a state, and providers of fixed broadband service to support broadband infrastructure deployment to areas lacking broadband, especially rural areas.
Broadband Technology Opportunities Program (BTOP)	The Broadband Technology Opportunities Program (BTOP) is an approximately $4 billion grant program administered by NTIA to help bridge the technological divide; create jobs; and improve education, health care, and public safety in communities across the country. Funded by the American Recovery and Reinvestment Act of 2009, BTOP projects are deploying broadband Internet infrastructure, enhancing and expanding public computer centers, and encouraging the sustainable adoption of broadband service.
Buried Fiber Deployment	Buried fiber deployments are buried below the layer where the soil freezes so they are immune to wind and ice damage. This means that underground deployments are often more reliable than aerial routes, especially where poor weather is common.
Burstable	Authorizes a connection to exceed its specified speed, normally up to a set maximum capacity for a period of time.
Burst Speed	A method which momentarily allots additional bandwidth to consumer's services for short periods of time.
Byte	A unit of digital information that most commonly consists of eight bits. Historically, the byte was the number of bits used to encode a single character of text in a computer and for this reason it is the smallest addressable unit of memory in many computer architectures.
C	
Cable	A category of broadband Internet access that uses the infrastructure of cable TV network to provide Internet services. Cable Internet provides connectivity from the Internet service provider (ISP) to the end users in a similar manner as digital subscriber line (DSL) and fiber-to-the-home (FTTH).
Capital Expenditures (Capex)	A category of broadband Internet access that uses the infrastructure of cable TV network to provide Internet services. Cable Internet provides connectivity from the Internet service provider (ISP) to the end users in a similar manner as digital subscriber line (DSL) and fiber-to-the-home (FTTH).
Capital Structure	Also Known As: Capital Structure - The structure of all capital that is invested into a company. At a high level, this means that the capital stack includes both the equity and the debt invested to date. More specifically, though, this means all types of both equity and debt. That means both common and preferred equity, and both junior and senior debt. These categories can be further split. You can have different types of preferred equity, for example.

Census Block	The smallest geographic area for which the Bureau of the Census collects and tabulates decennial census data. Generally small in area. In a city, a census block looks like a city block bounded on all sides by streets. Census blocks in suburban and rural areas may be large, irregular, and bounded by a variety of features, such as roads, streams, and transmission lines. In remote areas, census blocks may encompass hundreds of square miles. Census blocks are grouped into block groups, which are grouped into census tracts.
Challenge Process	The process of grant applicants engaging communities they intend to serve, and the right of refusal held by communities for broadband grant applications. Each Eligible Entity shall develop and describe in the Initial Proposal, a transparent, evidence-based, fair, and expeditious challenge process under which a unit of local government, nonprofit organization, or broadband service provider can challenge a determination made by the Eligible Entity in the Initial Proposal as to whether a particular location or community anchor institution within the jurisdiction of the Eligible Entity is eligible for grant funds.
Churn	Churn rate, sometimes known as attrition rate, is the rate at which customers stop doing business with a company over a given period of time. Churn may also apply to the number of subscribers who cancel or don't renew a subscription. The higher your churn rate, the more customers stop buying from your business.
Coax	A type of cable used to transmit data, the internet, video and voice communications. A coax cable is made up of an aluminum and copper shield with an outer plastic jacket with the dielectric insulator helping to minimize signal loss.
Common Equity	The amount that all common shareholders have invested in a company. Most importantly, this includes the value of the common shares themselves. However, it also includes retained earnings and additional paid-in capital.
Communications Act Of 1934	Signed into law by Franklin D. Roosevelt, the Communications Act of 1934 created a unified regulatory system for communications. Among other things, it created the Federal Communications Commission, which replaced the Federal Radio Commission, and took over the regulation of interstate telephone services from the Interstate Commerce Commission. The central principle of the act was that a comprehensive nationwide communications system "with adequate facilities at reasonable charges" was good for the country.
Community Anchor Institution (CAI)	An entity such as a school, library, health clinic, health center, hospital or other medical provider, public safety entity, institution of higher education, public housing organization, or community support organization that facilitates greater use of broadband service by vulnerable populations, including, but not limited to, low-income individuals, unemployed individuals, children, the incarcerated, and aged individuals.
Conduit Financing	A means for private companies, nonprofit organizations (NPO), and public entities to raise capital via tax-exempt municipal bonds to fund large-scale projects that typically benefit the general public. Such projects can include

	hospitals, airports, industrial and housing projects, public facilities, and schools.
Connect America Fund (CAF)	The Connect America Fund was unveiled in 2011 as part of the Universal Service Fund, redesigned to help fund Internet infrastructure in the nation's high-cost areas. CAF put a new emphasis on Internet service.
Connecting Minority Communities Pilot Program (CMC) Pilot Program	The Connecting Minority Communities Pilot Program is a $268 million NTIA grant program to Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Minority-Serving Institutions (MSIs) for the purchase of broadband internet access service and eligible equipment or to hire and train information technology personnel. The CMC grant program was established by the Consolidated Appropriations Act of 2021 to support MSIs and their surrounding communities.
Consolidated Appropriations Act Of 2021	The Consolidated Appropriations Act of 2021 created the $980 million program to provide grants to expand regular and remote broadband access and adoption by Tribal entities, the $268 million Connecting Minority Communities Pilot Program, and the Emergency Broadband Benefit.
Content Provider	A website or organization that handles the distribution of online content such as blogs, videos, music or files.
Co-Op	Also Known As: Co-Op - An autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly-owned enterprise. Cooperatives are democratically owned by their members, with each member having one vote in electing the board of directors.
Customer Premises Equipment (CPE)	Refers to any piece of connected equipment that is used for accessing the Internet or generally accessing services on a provider network, whether directly or indirectly connected to that network. CPE can be provided by the telecommunications provider, such as a cable operator, telephone company or satellite provider. These companies either rent this equipment to the customer, provide it at no charge as part of the service, or allow a customer to purchase and provide their own equipment.
D	
Dark Fiber	Fiber that is in place but not being used for broadband services. ("non-lit" fiber, also see "Lit Fiber").
Data Packet	Data is sent over the Internet as packets. One file is divided into many packets when it is sent, then reassembled into one file again at its destination. Using packets allows data to travel much faster since the individual packets are smaller than the original file and can travel separately over different routes before reassembling.
Debt	Debt is an obligation that requires one party, the debtor, to pay money or other agreed-upon value to another party, the creditor. Debt is a deferred payment, or series of payments, which differentiates it from an immediate purchase.
Debt/EBITDA	A ratio measuring the amount of income generated and available to pay down debt before covering interest, taxes, depreciation, and amortization expenses. Debt/EBITDA measures a company's ability to pay off its incurred debt.

Demand Point Passed (DPP)	Total number of active and potential subscribers that an ISP's network could service.
Digital Divide	The Digital Divide, or Digital Canyon, is the gap between people who have access to affordable, reliable Internet service (and the skills and gadgets necessary to take advantage of that access) and those who lack it.
Digital Equity	Recognizes that digital access and skills are now required for full participation in many aspects of society and the economy. Digital Equity links Digital Inclusion to social justice and highlights that a lack of access and/or skills can further isolate individuals and communities from a broad range of opportunities.
Digital Inclusion	Implies that individuals and communities have access to robust broadband connections; Internet enabled devices that meet their needs; and the skills to explore, create and collaborate in the digital world.
Digital Literacy	The ability to leverage current technologies, such as smartphones and laptops, and Internet access to perform research, create content and interact with the world.
Digital Skills	Any skills related to operating digital devices or taking advantage of digital resources.
Digital Subscriber Line (DSL)	A group of technologies used to transmit data over telephone lines. DSL made high-speed Internet access possible for ordinary consumers without having to do a great deal of rewiring. "ADSL" stands for asymmetric digital subscriber line, meaning the data travels downstream and upstream at different rates.
Data Over Cable System Interface Specification (DOCSIS)	The international telecommunications standard for cable signaling data and spectrum sharing.
E	
Earnings Before Interest Taxes Depreciation And Amortization (EBITDA)	A company or project's earnings before interest, taxes, depreciation, and amortization is a measure of a company's profitability of the operating business only, thus before any effects of indebtedness, state-mandated payments, and costs required to maintain its asset base.
Economic Development Incentive	An array of benefits designed to promote new business activity or to encourage business or job retention. These benefits principally encompass tax and economic incentives provided by federal, state, or local governmental bodies. Other entities, such as utilities and non-profits, can also make incentives available for these purposes. They accord the recipient, in some manner, a monetary benefit (i.e., tax incentives) or an in-kind benefit (e.g., state regulatory releases of environmental liability, municipal infrastructure improvements).
Eligible Community Anchor Institution	A Community Anchor Institution that lacks access to gigabit-level broadband service. IIJA, Section 60102.
Eligible Entity	Under the Infrastructure, Investment and Jobs Act, an "eligible entity" is a state, a territory, the District of Columbia, or an eligible Tribal entity. IIJA, Section 60102.
Enterprise Value (EV)	A measure of a company's total value. It is a combination of the value of common stock, preferred stock, cash, and debt. Determining the value of public companies is much easier than private companies which don't make their financials available to the public. You can use the comparable company analysis approach, which involves looking for similar public companies. Using findings from a private company's closest public

	competitors, you can determine its value by using the EBITDA or enterprise value multiple.
Equity	The value that would be returned to a company's shareholders if all of the assets were liquidated and all of the company's debts were paid off. Equity financing involves selling a stake in your company or project in return for a cash investment. Unlike a loan, equity finance doesn't carry a repayment obligation. Instead, investors buy shares in the company in order to make money through dividends (a share of the profits) or by eventually selling their shares.
F	
FCC Registration Number (FRN)	The FCC Registration Number (FRN) is a 10-digit unique identifying number that is assigned to entities doing business with the Federal Communications Commission. The FRN is obtained through the Commission Registration System (CORES).
Feasibility Study	An analysis that considers all of a project's relevant factors—including economic, technical, legal, and scheduling considerations—to ascertain the likelihood of completing the project successfully.
Federal Communications Commission (FCC)	The FCC was created by the Communications Act of 1934 and today regulates "interstate communications by radio, television, wire, satellite, and cable in all 50 states, the District of Columbia and U.S. territories."
Fiber	A fiber optic cable is made up of bundles of hair-thin strands of very pure glass or plastic. Data passes over them in the form of light pulses created by lasers. Because of the purity of the glass or plastic, data can travel much farther and faster on fiber than on copper wires with much less loss of data.
Fiber-To-The-Curb (FTTC)	The installation and use of optical fiber cable directly to curbs near homes or businesses. Coaxial cable or another medium carries signals the short distance from the curb to the home or business. As such, this system is inexpensive to employ. The basic idea of fiber to curb technology is that suitable wires can carry high-speed signals at short distances. The twisted wire pairs or coaxial cables have acceptable bandwidth loss while sending signals only a few hundred feet. Also known as integrated fiber in the loop (IFITL).
Fiber-To-The-Home (FTTH)	Equipment used in fiber access deployments where fibers extend all the way to the end-user premises and the equipment is designed and optimized for use in residential applications.
Fiber-To-The-Node (FTTN)	Equipment used in fiber access deployments where fibers extend to the network connection point/box/node in a neighborhood and no farther.
Fiber-To-The-Premises (FTTP)	The installation and use of optical fiber from a central point directly to individual buildings such as residences, apartment buildings and businesses to provide high-speed internet access.
Fixed Wireless Broadband Access	The use of wireless devices/systems in connecting two fixed locations, such as offices or homes. The connections occur through the air, rather than through fiber, resulting in a less expensive alternative to a fiber connection.
Formula Grant	A United States federal grant specifying a precise formula in the legislation creating the program. Formula grants include quantifiable elements, such as population, amount of tax effort, proportion of

	population unemployed or below poverty level, density of housing, or rate of infant mortality.
G	
General Obligation (GO) Bond	A municipal bond backed solely by the credit and taxing power of the issuing jurisdiction rather than the revenue from a given project. General obligation bonds are issued with the belief that a municipality will be able to repay its debt obligation through taxation or revenue from projects. No assets are used as collateral.
Grant Adjusted Yield On Cost (YOC)	The percentage an unlevered broadband project pays out per year in EBITDA based on the initial cost of the project but the grant is subtracted from total project cost.
Grant Anticipation Note (GAN)	Short-term municipal financing issued in anticipation of receiving a grant from the federal government or one of its agencies.
Gross Profit Margin	Is net sales less the cost of goods sold (COGS). In other words, it's the amount of money a company retains after incurring the direct costs associated with producing the goods it sells and the services it provides. The higher the gross margin, the more capital a company retains, which it can then use to pay other costs or satisfy debt obligations. Companies use gross margin, gross profit, and gross profit margin to measure how their production costs relate to their revenues. For example, if a company's gross margin is falling, it may strive to slash labor costs or source cheaper suppliers of materials. Alternatively, it may decide to increase prices, as a revenue-increasing measure. Gross profit margins can also be used to measure company efficiency or to compare two companies of different market capitalizations.
Guaranteed Bank Loan	A guaranteed loan is backed by a third party, and if the borrower defaults, the third party repays the loan.
H	
High Cost Area	A "high-cost area" is an Unserved area in which the head of the National Telecommunications and Information Administration determines that the cost of deploying broadband service is higher than the average cost of deploying broadband service to other Unserved areas. The head of NTIA has flexibility in making the determination, also considering: -the remote location of the area -the population density of the area -the unique topography of the area -a high rate of poverty -any other factor that contributes to the cost of deploying broadband service IIJA, Section 60102.
I	
Incumbent And Competitive Local Exchange Carriers (ILEC)	Before the Telecommunications Act of 1996, telephone companies operated as legal monopolies in defined territories of service, called exchanges. After the 1996 act and its emphasis on competition, these carriers became incumbent local exchange carriers in their operating territories. At the same time competing local exchange carriers were

	allowed to enter any territory, build their own infrastructure, and offer services.
Indefeasible Right Of Use (IRU)	The effective long-term lease (temporary ownership) of a portion of the capacity of an international cable. IRUs are specified in terms of a certain number of channels of a given bandwidth. IRU is granted by the company or consortium of companies that built the (usually optical fiber) cable. Some IRU legal agreements forbid resale of the capacity ownership. For at least one major international cable owner, an IRU ownership period is granted for 25 years. An IRU gives a large-scale Internet service provider (ISP) the ability to assure its own customers of international service on a long-term basis.
Industrial Development Bond (IRB)	Municipal debt securities issued by a government agency on behalf of a private sector company and intended to build or acquire factories or other heavy equipment and tools.
Infrastructure Investment & Jobs Act	Passed by the Senate on August 10, 2021, by the House of Representatives on November 5, 2021, and is expected to be signed into law by President Joe Biden on November 15, 2021, the Infrastructure Investment and Jobs Act (IIJA) is a landmark bipartisan bill providing $65 billion in funding for broadband infrastructure and deployment.
Inside Plant (ISP)	All cabling and equipment installed in a telecommunications facility.
Interconnection	The linking of numerous telecommunications networks to exchange user traffic.
Internet Protocol	The computer language that allows all the above-mentioned technologies to speak to each other. Before the invention of Internet protocol (IP), telephone networks could only transfer data on other telephone networks, cable networks on other cable networks and so on. IP makes the transfer of data technology-neutral, allowing networks everywhere to transfer data anywhere.
Internet Service Provider (ISP)	An organization that provides services for accessing, using, or participating in the Internet. Internet service providers can be organized in various forms, such as commercial, community-owned, non-profit, or otherwise privately owned.
L	
Last-Mile	The term that describes the last link connecting the provider's network to the customer's premises, either a house or a business. The Last-Mile is the most expensive part of the network to build or upgrade because of the number of units involved. One fiber cable may be trenched down a street, but there may be twenty houses on the street that need to be connected. Upgrading the copper cable connection between each house and the fiber in the street would be the Last-Mile. This last link can also be the reason customers often don't receive the level of Internet speed advertised by their provider. Since data travels more slowly on copper compared to fiber, when the data hits the copper, it slows down.
Latency/ Ping	The reaction time of your connection. How quickly your device gets a response after you've sent out a request. A low latency (fast ping) means a more responsive connection. Latency is measured in milliseconds (ms).

Letter Of Credit (LOC)	A letter from a bank guaranteeing that a buyer's payment to a seller will be received on time and for the correct amount. In the event that the buyer is unable to make a payment on the purchase, the bank will be required to cover the full or remaining amount of the purchase.
Limited-Tax General Obligation Pledge	Asks the issuing local government to raise property taxes if necessary to meet existing debt service obligations. However, this increase is bound by a statutory limit. With limited-tax general obligation pledges, governments can still use a part of already-levied property taxes, use another stream of income, or raise property taxes to an amount equating to existing debt service payments to answer its debt obligations.
Lit Fiber	An active fiber optic cable capable of transmitting data.
Loan	A type of credit vehicle in which a sum of money is lent to another party in exchange for future repayment of the value or principal amount. In many cases, the lender also adds interest and/or finance charges to the principal value which the borrower must repay in addition to the principal balance.
Local Area Network (LAN)	A group of network devices that are on a high-speed connection and typically within the same building or location.
Local Coordination	The process of grant applicants engaging communities they intend to serve, and the right of refusal among communities held by communities for broadband. Language in the local coordination component is going to drive community
Local Multipoint Distribution Service (LMDS)	A wireless broadband service that uses microwave signals to render communications service – voice, data, Internet – to customers within the Last-Mile.
Low-Cost Broadband Service Option	Under the Infrastructure, Investment and Jobs Act, each state will submit to NTIA its own definition of a "low-cost broadband service option." Each state's definition shall apply to the award recipients that receive funds from the state in question. "Nothing in this title may be construed to authorize the Assistant Secretary or the National Telecommunications and Information Administration to regulate the rates charged for broadband service." IIJA Section 60102, subsection (h)(5)(D).
Long Term Evolution (LTE)	A 4G wireless broadband technology that provides speeds up to 100 Mbps download and 30 Mbps upload.
M	
Make Ready Work	Before an Internet Service Provider (or any company) can add a new attachment or line to a utility pole, the existing attachments may need to be moved around so that the pole can be made ready to handle a new attachment or line. This is known as 'Make Ready Work.' The reason Make Ready Work is necessary is that, under Federal Law, to prevent the risk of outages or other issues, lines on utility poles must be spaced a certain distance apart from each other based on how many lines are on the pole. Under federal guidelines, Make Ready Work must occur sequentially, meaning that attachments can only be moved in the order with which they were originally placed on the line. This process can create massive delays, as well as other large disruptions in high traffic areas, such as alongside major roadways. In addition, the make ready work can take months, or even years, to complete as every company involved must send out their own approved contractor to move only their respective

	attachment. Each contractor must also schedule their work to not conflict with other contractors performing Make Ready Work, as well as taking into account other local factors, such as weather, traffic, and maintenance work (such as road paving). These factors must be considered as the United States primarily uses aerial work platforms to perform Make Ready Work.
Match Funding	The portion of the project or program costs that are not paid by the funding agency. If the award is federal, only non-federal expenses qualify as cost sharing. Most broadband grant programs require between 25% to 50% matching capital. Common private match capital sources include equity, debt, and forward-receivables purchases. For more information about match capital including capital providers, see the Match Capital channel. Notes - Sub-grantees are required to provide a contribution of at least 25% derived from non-Federal funds (or funds from a Federal regional commission or authority), except in high-cost areas. Waivers to match can be granted at the discretion of NTIA. Eligible Sources - While most applicants will get their match capital from their own balance sheet, or through a combination of equity and / or debt investors, the match may also be provided by the State, a unit of local government, a utility company, a cooperative, a nonprofit organization, a for-profit company, regional planning or governmental organization, a Federal regional commission or authority, or an combination thereof. May include in-kind contributions and may include funds that were provided to an Eligible Entity or sub-grantee under: -Families First Coronavirus Response Act -The CARES Act -Consolidated Appropriations Act 2021 -The American Rescue Plan Act of 2021 -Any amendment made by an Act described above For definition, Federal regional commission or authority means: -Appalachian Regional Commission -Delta Regional Authority -Denali Commission -Northern Border Regional Commission
Mezzanine Debt	Any subordinated debt or preferred equity instrument that represents a claim on a company's assets which is senior only to that of the common shares. Mezzanine financings can be structured either as debt or preferred stock. Mezzanine debt bridges the gap between debt and equity financing and is one of the highest-risk forms of debt—being subordinate to pure debt but senior to pure equity.
Middle-Mile/ Backhaul	The section of the network that connects the Last-Mile portion of the network to the service provider's core network, where the services such as broadband, TV, and phone service originate from. More specifically, any broadband infrastructure that does not connect directly to an end-user location, including an anchor institution; and includes leased dark fiber, interoffice transport, backhaul, carrier-neutral internet exchange facilities, carrier-neutral submarine cable landing stations, undersea cables, transport connectivity to data centers, special access transport, and other similar services; and wired or private wireless broadband infrastructure,

	including microwave capacity, radio tower access, and other services or infrastructure for a private wireless broadband network, such as towers, fiber, and microwave links.
Millimeter Wave	Millimeter waves are also known as extremely high frequency (EHF). It's a radio frequency that would allow transmission frequencies between 30 GHz and 300 GHz, compared to 5 GHz frequencies used by previous mobile devices. It also has wavelengths between 1 mm and 10 mm, compared to the several-dozen centimeter wavelengths possessed by smartphones' current radio waves. At this point in time, millimeter waves are only used by radar systems like satellites. But mobile network providers have already started utilizing EHF in various ways, making it a new and promising approach. There are two ways to increase the speed of wireless data transmission. The first is increasing spectrum utilization. The second is increasing the spectrum bandwidth, often seen as a more simple and direct approach. That is the approach that millimeter waves would provide for 5G to increase transmission speeds.
Mobile	Mobile wireless Internet, accessed via smartphones. Data is transferred between cell phone towers, which are connected to the service provider by fiber.
Multiple Dwelling Unit	Residential duplexes, triplexes, fourplexes, apartment buildings, condominiums, mobile home parks, trailer courts, or similar types of multiple dwelling unit arrangements on one parcel of land.
Municipal Bond	A debt security issued by a state, municipality, or County to finance its capital expenditures, including the construction of highways, bridges, or schools. They can be thought of as loans that investors make to local governments. Municipal bonds are often exempt from federal taxes and most state and local taxes (for residents), making them especially attractive to people in higher income tax brackets.
N	
National Telecommunications And Information Administration (NTIA)	The National Telecommunications and Information Administration is an agency of the U.S. Department of Commerce. The NTIA resides within the Executive Branch of the federal government, and is the president's principle advisor of telecommunications matters. By contrast, the Federal Communications Commission - the other agency with significant telecommunications- and broadband-related responsibilities - is an independent agency outside of the official purview of the White House. NTIA has existed since 1978 and has numerous communications responsibilities. It is the principal federal agency responsible for administering grants and funding under the Infrastructure Investment and Jobs Act.
Network Node	A connection point in a communications network. Each node is an endpoint for data transmissions or redistribution. Nodes have either a programmed or engineered capability to recognize, process and forward transmissions to other network nodes.
Nielsen's Law Of Internet Bandwidth	A high-end user's connection speed grows by 50% per year.

Notice Of Funding Opportunities (NOFO)	Notice of Funding Opportunities (NOFO) describe the requirements under which a federal agency will award grants for funding as instructed by a specific law. In this case, it's the Infrastructure, Investment, and Jobs Act, Public Law 117-58, November 15th. 2021. The Infrastructure, Investment, and Jobs Act, provides new federal funding for the Assistant Secretary to make grants on a competitive basis for the deployment of broadband infrastructure. It also provides funding for Middle-Mile projects, tribal broadband funding and digital inclusion and digital equity activities
O	
Open Access Network	Networks that offer wholesale access to network infrastructure or services provided on fair and reasonable terms with some degree of transparency and nondiscrimination.
Operating Margin (EBITDA Margin)	A measure of a company's operating profit as a percentage of its revenue. Knowing the EBITDA margin allows for a comparison of one company's real performance to others in its industry. EBITDA margin is calculated by dividing EBITDA by revenue.
Optical Line Terminal (OLT)	The device that serves as your ISPs endpoint of the passive optical network (PON). The OLT also provides the interface between a PON and your ISP's core network. Simply put, an OLT is ISP equipment. The OLT is the device that exists at your ISPs central hub. An OLT has a few purposes: -Control the information flowing upstream and downstream. -Convert the standard signals used by fiber optic service to the frequency and framing used by a PON system. -Coordinate the multiple analog or digital signals that are combined into one signal (called multiplexing) that happens between the ONT conversion devices. The upstream channel transmits different types of data and voice traffic from users to the ISP. The downstream channel is what receives data, voice and video traffic and sends it to all ONT devices on your network.
Optical Network Terminal (ONT)	The device that serves as the telecommunication chain's endpoint of the PON on your end. Another abbreviation to know is an ONU, which stands for Optical Network Unit. ONU and ONT are often used interchangeably. More or less, they are the same. Simply put, an ONT/ONU refer to the user side equipment. The ONT/ONU is the device that exists at your home or office. The ONT acts as an optical modem and communicates with your ISP through a fiber optical cable. The ONT sends user data upstream to the OLT and receives data on the downstream channel. ONT and OLT are essential devices in a PON network system.
Outside Plant	In civilian telecommunications, outside plant refers to all of the physical cabling and supporting infrastructure (such as conduit, cabinets, tower or poles), and any associated hardware (such as repeaters) located between a demarcation point in a switching facility and a demarcation point in another switching center or customer premises.
P	

Packet Loss	Occurs when a packet of data being sent over the internet is not received or is incomplete. This is described in percentage of packets lost compared to packets sent. Packet loss in most cases is a result of poor signal/line quality.
Peering And Transit Agreements	Agreements that govern moving one entity's data traffic over another entity's network. With peering agreements, network owners allow each others' traffic to move over their networks at no cost or in some kind of cost-sharing arrangement. With transit agreements, the entity that wants to move the data (it may be an ISP or a content provider like Netflix) must pay the network owner to use their network. If a provider moves its own customers' data on its own network (e.g., sending an email to someone served by the same provider), there are no fees. If two entities don't have an agreement, the data may have to travel farther around on networks they do have agreements with, which can also slow traffic down.
Point of Presence	The particular place or facility where local Internet service providers connect to other networks. Distance from the Point of Presence can affect service availability and pricing.
Point To Point	A Point to Point Connection is a private data connection securely connecting two or more locations for private data services. A point to point connection is a closed network data transport service which does not traverse the public Internet and is inherently secure with no data encryption needed. Point to Point connections are available in a range of bandwidth speeds including point to point T1, point to point Ethernet or point to point DS3. A point to point connection provides unparalleled quality of service (QoS) as it is not a shared service (a private line) and follows the same direct network path every time. Point to Point links are used by businesses to provide reliable, secure point to point network data service for applications including credit card processing, file sharing, data backup, point to point VOIP, and video conferencing. A point to point network can also be configured to carry voice, video, Internet, and data services together over the same point to point connection. Point to Point circuits are also known as a Point to Point Link, Private Line, Leased Line, or Data Line.
Preferred Equity	A type of shareholder class. When a company files for bankruptcy, equity and debt holders are paid in a specific order that is dependent on the type of financing they are holding (also called the capital stack): 1. Bondholders (debt) 2. Preferred equity 3. Common stock
Project Finance	Project finance is the funding (financing) of long-term infrastructure using a non-recourse or limited recourse financial structure. The debt and equity used to finance the project are paid back from the cash flow generated by the project.
Public-Private Partnership	Arrangements in which a governmental unit engages a private party to deliver an integrated solution for the design, construction, financing, operation and/or management of new or existing government-owned infrastructure projects.
Public Utility Company	An organization that maintains the infrastructure for a public service (often also providing a service using that infrastructure). Public utilities are subject to forms of public control and regulation ranging from local community-based groups to statewide government monopolies. Public utilities are meant to supply goods/services that are considered essential;

	water, gas, electricity, telephone, and other communication systems represent much of the public utility market.
R	
Revenue Bond	A category of municipal bond supported by the revenue from a specific project, such as a toll bridge, highway, or local stadium. Revenue bonds that finance income-producing projects are thus secured by a specified revenue source. Typically, revenue bonds can be issued by any government agency or fund that is managed in the manner of a business, such as entities having both operating revenues and expenses.
Revolving Credit Line	A type of financing that allows a borrower to maintain an open credit line up to a specified limit and make minimum monthly payments based on the balance and interest rate per the credit agreement. A revolving credit line typically comes with a variable interest rate set by a bank, meaning it can fluctuate with market conditions.
Rights-of-Way (ROW)	ROW are legal rights to pass through property owned by another. ROW are frequently used to secure access to land for digging trenches, deploying fiber, constructing towers and deploying equipment on existing towers and utility poles.
Rural Digital Opportunity Fund (RDOF)	The RDOF is the latest iteration of the FCC's universal service fund (USF), more recently referred to as the Connect America Fund (CAF). This program was developed decades ago to fund the construction and operation of telecommunications networks, and later, broadband networks. The goal of the program was to ensure comparable telecommunications services at affordable costs to rural Americans, to be on par with their urban counterparts. The initial focus of the USF was telephone service, but it has shifted focus in recent years to broadband service through the CAF. The RDOF is an extension of the CAF and will provide $20.4 billion in funding over a ten-year period to support broadband networks in rural communities across the country. The funding roots of RDOF come from traditional high-cost universal service funding previously earmarked for territories served by large "price cap" telecom carriers such as CenturyLink, Frontier, AT&T, and Verizon. Historically, the FCC provided this funding directly to these legacy telecom carriers to support broadband service in the rural communities served by them. But RDOF changed this process significantly.
Rural Electrical Cooperatives (RECs)	Electric cooperatives play a vital role in transforming communities. They are energy providers that act as engines of economic development in rural areas, responsible for 42% of U.S. electric distribution lines. These local energy and technology providers are shaped by the specific needs of the communities they serve, powering over 20 million businesses, homes, farms, and schools in 48 states. RECs are eligible to apply for and win IIJA broadband funding.

Rural Utility Service	A division of the U.S. Department of Agriculture, Rural Utility Service grew out of the Depression-era Rural Electrification Administration. Its mission is to help provide public utilities—water and sewer, electrification, and telecommunications—to rural areas through public-private partnerships providing loans and grants. RUS is one of three agencies that make up USDA Rural Development (including Rural Business-Cooperative Service and Rural Housing Service).
S	
Satellite Internet	Internet service provided via satellite. Satellite can be the only option for remote residents, but it is generally considered slow, less reliable, and more expensive than other options if and when they are available.
Secured Debt	Debt that is backed by property, like a car or a house. Should you default on the repayment of the loan or debt, the creditor can take the collateral instead of opening a debt collection on your record or suing you for payments.
Security	A certificate or other financial instrument that has monetary value and can be traded. Securities are generally classified as either equity securities, such as stocks and debt securities, such as bonds and debentures.
Senior Debt	Borrowed money that a company must repay first if it goes out of business.
Simple Agreement For Future Equity (SAFE)	An agreement between an investor and a company that provides rights to the investor for future equity in the company similar to a warrant, except without determining a specific price per share at the time of the initial investment.
Spectrum	A conceptual tool used to organize and map the physical phenomena of electromagnetic waves. These waves propagate through space at different radio frequencies, and the set of all possible frequencies is called the electromagnetic spectrum.
Subgrantee	The government or other legal entity to which a subgrant is awarded and which is accountable to the grantee for the use of the funds provided. Under the Infrastructure, Investment and Jobs Act, the grantee must be an eligible entity.
Subordinated Debenture	An unsecured loan or bond that ranks below other, more senior loans or securities with respect to claims on assets or earnings. In the case of borrower default, creditors who own subordinated debt will not be paid out until after senior bondholders are paid in full.
Subsidiarity	Subsidiarity is a principle of social organization that holds that social and political issues should be dealt with at the most immediate (or local) level that is consistent with their resolution.
Symmetric	When the upload and download speeds match. A rate of 10 Mbps down/10 Mbps up would be symmetric.
T	
Take Rate	The percentage of potential subscribers who are offered the service that actually do subscribe. Within the context of information infrastructure investment, take rate has become a byword for network viability and success, making it a key economic driver of the investment.
Tax-Exempt Debt	An investment in which the income produced is free from federal, state, and/or local taxes. Most tax-exempt securities come in the form of municipal bonds, which represent obligations of a state, territory or

	municipality. For some investors, U.S. Savings Bond interest may also be free from federal income taxes.
Taxable Debt	A debt security whose return to the investor is subject to taxes at the local, state, or federal level, or some combination thereof. An investor trying to decide whether to invest in a taxable bond or tax-exempt bond should consider what they will have left in income after taxes are taken.
Telecommunications Act Of 1996	The Telecommunications Act of 1996 was the first significant overhaul of United States telecommunications law in more than sixty years, amending the Communications Act of 1934. The Act, signed by President Bill Clinton, represented a major change in American telecommunication law, since it was the first time that the Internet was included in broadcasting and spectrum allotment. According to the Federal Communications Commission (FCC), the goal of the law was to "let anyone enter any communications business – to let any communications business compete in any market against any other." The legislation's primary goal was deregulation of the converging broadcasting and telecommunications markets.
Telemedicine	The use of high-speed, high-capacity Internet to support long-distance healthcare services, patient and provider education and enhanced healthcare administration.
Tier 1, 2, 3	Classification indicating the size of a service provider. Tier 1 providers are the largest, such as AT&T, CenturyLink, Zayo, and Verizon, with network systems that span the globe. They can generally send data anywhere without having to pay transit fees, either because they own the network or they have peering agreements with other networks. A Tier 2 network "peers" with many networks, but also has to pay some transit fees. A Tier 3 service provider must pay transit fees to access the Internet.
Tribal Broadband Connectivity Program	The Tribal Broadband Connectivity Program is a $980 million program directed to tribal governments to be used for broadband deployment on tribal lands, as well as for telehealth, distance learning, broadband affordability, and digital inclusion. NTIA is continuing to review the more than 280 applications received during the application window, which closed on Sept. 1, 2021. The Tribal Broadband Connectivity Program will announce additional awards on a rolling basis as they go through NTIA's review process.
U	
Underserved	A location that, as determined in accordance with the broadband DATA maps, is (1) Not an Unserved location, and (2) Lacks access to reliable broadband service with a speed of not less than 100 megabits per second for downloads, 20 megabits per second for uploads, and a latency sufficient to support real-time, interactive applications.
Underserved Service Project	According to the BEAD Program, a project in which not less than 80% of broadband-serviceable locations served by the project are Unserved locations or Underserved locations.

Universal Service Fund	A central principle of the Communications Act of 1934 was that all Americans should have access to a basic level of telecommunications service—universal service—and many policies were enacted to carryout that goal. The Telecommunications Act of 1996 created the Universal Service Fund, a pool of money collected from telecommunications companies and used for building and maintaining telecommunications infrastructure and services in high-cost areas. Four programs are supported by the Fund: the High-Cost Program, Lifeline Program, Rural Health Care Program, and Schools and Libraries Program. Telecommunications companies may charge a Universal Service Fund fee back to customers to help recover some of their contribution to the program.
Unlevered Returns	The implied rate of return a company expects to earn without the effect of debt.
Unlimited-Tax General Obligation Pledge	Is similar to the limited-tax pledge. The only difference is that the local government is asked to increase property tax rates to necessary levels — up to a maximum of 100% — to cover delinquencies from taxpayers. Residents must first agree to increase property taxes to the necessary amounts required for the bonds.
Unsecured Debt	Debt that is not backed by an asset pledged as collateral.
Unserved	A broadband-serviceable location, as determined in accordance with the broadband DATA maps, that has no access to broadband service or lacks access to reliable broadband service with a speed of not less than 25 megabits per second for downloads, 3 megabits per second for uploads, and a latency sufficient to support real-time, interactive applications.
Unserved Service Project	According to the BEAD Program, a project in which not less than 80% of broadband-serviceable locations served by the project are Unserved locations.
Upload And Download	The direction of the data between the end user and the service provider. Something moving “upstream” or “uploading” is moving from the end user’s computer or device to the service provider, while data moving “downstream” or “downloading” is moving from the service provider to the end user. When referring to speed, “10 down” means data is moving downstream to the end user at a rate of 10 megabits per second or Mbps, while “1 up” means data is moving at a rate of 1 Mbps up from the end user. Downstream is important in applications like streaming video, while upstream is important for end users who need to send large files somewhere, for instance, to a customer or to a hospital.
W	
Wi-Fi	A technology that produces a wireless local area network allowing a computer or other device to connect to the Internet wirelessly. Equipment in the device communicates with the Wi-Fi router, which is connected to the network with some type of physical cable or wire. Depending on the system’s power, the area can be as small as a room or cover several square miles. Examples include the Wi-Fi router in a home, a hotspot at a coffee shop, or citywide Wi-Fi networks. Wi-Fi is a trademark of the Wi-Fi Alliance, an organization that certifies equipment for interoperability. A generic term is “wireless local area network.”

Wireless	A short name for fixed wireless (as opposed to mobile wireless). Fixed wireless technology transmits data between two fixed antennas using radio waves, including microwaves. Unlike Wi-Fi, the radio beams are often kept narrow to keep up the strength of the signal. Antennas are preferably set up high on buildings since line of sight is necessary.
WISP	An ISP that provides service through a wireless network.
Working Capital/ Net Working Capital	The difference between a company's current assets—such as cash, accounts receivable/customers' unpaid bills, and inventories of raw materials and finished goods—and its current liabilities, such as accounts payable and debts. A measure of a company's liquidity and short-term financial health.
Y	
Yield On Cost (YOC)	The percentage an unlevered broadband project pays out per year in EBITDA based on the initial cost of the project. This metric is useful to compare the potential return to investors across multiple geographic regions when all project assumptions are held constant.