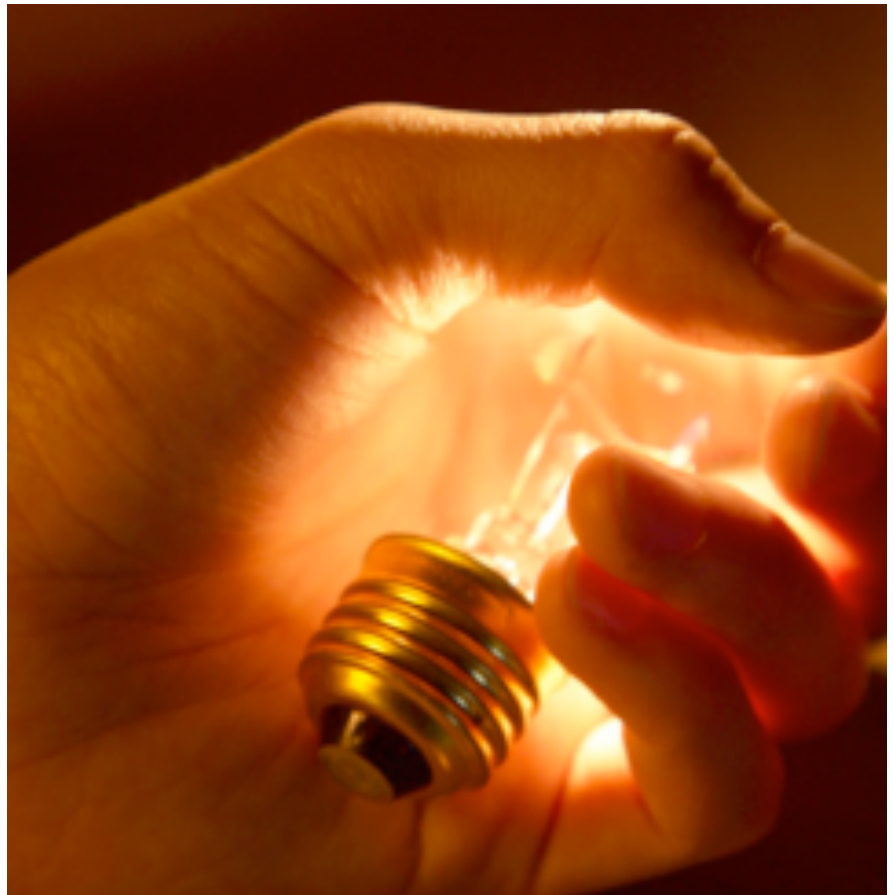




Broadband Strategies

Albemarle County

OCTOBER 2016



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Executive Summary

In the spring of 2016, Albemarle County was awarded a Virginia Telecommunications Planning Initiative (VATPI) grant through the Virginia Department of Housing and Community Development (DHCD) to develop a community-based telecommunication plan including:

- A demand aggregation study demonstrating a market
- Infrastructure/services inventory and gap analysis
- Identification of connectivity solutions
- Needs assessment
- Broadband education

Public action is needed to remove barriers, provide incentives, and enable competition for adequate and reliable high speed broadband service to be available throughout the County. The FCC recently redefined “broadband” to be 25 Megabits download speed and 3 megabits upload speed (25/3). In most rural areas of the county, the existing DSL services are unable to deliver even the older FCC broadband definition of 10 Megabits down, 1 Megabit up (10/1).

“Rather than wait for incumbent ISPs to build the network your cities want and need, you can take control of your own broadband futures. Rather than thinking of yourselves as taxers and regulators, which has been the traditional role, you can think of yourselves as facilitators of the kind of services you’ve been begging the incumbents to provide for years.” Gigi Sohn, FCC Chief Counsel

This report from the Broadband Management Team represents several months of effort by a diverse group of Albemarle County stakeholders and interested parties, including representatives from the Board of Supervisors, K12 schools, higher education, public safety and first responders, senior County staff, the Planning Commission, and regional economic developers.

The economic future in Albemarle depends upon the availability of affordable high speed broadband services at bandwidths needed to conduct business, both now and in the future. Businesses large and small are already heavy users of the Internet. Their bandwidth needs continue to increase. Over the past twenty years, typical bandwidth use has **doubled** every two years. The current patchwork approach of incremental network improvements being pursued by the incumbent telephone and cable companies will leave Albemarle businesses, students and residents further and further behind other Virginia communities in terms of broadband infrastructure. Improved broadband affordability and accessibility will:

- Bring qualitative and quantitative improvements to Albemarle in public safety,
- Enable new telemedicine and telehealth services that can lower health costs and improve outcomes,
- Provide equality of access to K12 and higher education, students, and
- Create increased opportunities for job creation and business attraction and retention.

Nationally, Gigabit fiber service is the standard “minimum” when talking about economic development, business and jobs attraction, and retention. While Gigabit fiber service is available in limited areas of Charlottesville and a few small pockets in the urban areas of the county, Albemarle as a whole is at an economic disadvantage with the current offerings.

Incumbent providers in Albemarle County have demonstrated a greater interest in increasing service to their existing customer base than in expanding to unserved areas. Continuing to rely on the “status quo” approach is not working, for our residents, our students, our workforce and our employers.

Fixed point broadband wireless will be an important technology to keep the rural areas of Albemarle viable from both quality of life and economic development perspectives. However, the “build plan” for Albemarle cannot be a “one size for everyone.” Approaches in the rural areas and the development areas will be different. The broadband build plan for Albemarle needs to consist of a set of strategies and initiatives that are tailored to fit the diverse geography, terrain, and population density. Consideration should be given to the following strategies:

1. **Establish goals:** In the rural parts of Albemarle, a reasonable near term goal is affordable access to a minimum of 10/1 service, with a long term goal of 25/3. These goals would guide the County’s initiatives to improve service. In the development areas, 25/3 is a reasonable near term goal, with a long term goal of widespread Gigabit fiber availability.
2. **Form public/private partnerships:** A key component to success is to create incentives for existing and new private sector providers to expand service availability and affordability, which will improve competition and pricing.
3. **Treat Broadband as a utility:** Given the importance of telecommunications for economic development, education and training, and personal access for social connection, data access, shopping, entertainment, and safety, broadband needs to be treated and managed as a utility and as essential infrastructure.
4. **Improve awareness/understanding of broadband challenges:** Create learning opportunities for leaders, residents and businesses to acquire a better understanding of the importance of improved broadband throughout Albemarle. Piedmont Virginia Community College would be a valuable resource in increase awareness of broadband.
5. **Identify broadband leadership:** Albemarle County could form its own Broadband Authority or join a regional Broadband Authority in collaboration with adjacent counties such as Augusta, Fluvanna, Greene, Buckingham, Louisa, Nelson, and Orange. An Authority will give Albemarle County the leadership needed to coordinate the numerous public and private entities that are making broadband investments and deployment decisions. The Authority will improve our ability to apply for and to obtain grant funding, and will simplify any regional efforts. Thomas Jefferson Planning District Commission would be an instrumental partner in this effort.
6. **Update the Tower Ordinance to help improve wireless:** The mountainous terrain and heavy tree cover in the County make it difficult for many properties in the rural areas to have adequate Line Of Sight (LOS) to towers where fixed point wireless services could be available. Allowing rural residents to erect 80’ wood utility poles by right would make wireless broadband more widely available.
7. **Improve access to tower space:** Strategically located towers with affordable access made available to WISPs (Wireless Internet Service Providers) would make significant

improvements in broadband availability and cost, reducing the challenges of the mountainous terrain in the county.

With the submission of this report, the Broadband Management Team for the Virginia Telecommunications Planning Initiative (VATPI) grant has completed its assignment, with this plan as the final deliverable. Any changes to policies, ordinances or the Comprehensive Plan would follow the County's standard processes and involve the Planning Commission. Future actions should continue to involve members of the VATPI Management Team to ensure that representatives are in place to speak for the public.

Why Broadband?

When local governments initiate a study of broadband infrastructure, a key question should be:

“What is the benefit if the community invests in broadband infrastructure?”

And the inverse question should also be asked:

“What happens if we don’t make strategic broadband investments?”

This report assesses and analyzes current conditions and future potential of broadband in Albemarle County. Broadband has become essential infrastructure for both business activities and personal activities. The very strong response to the business and residential surveys (more than 500 completed surveys) indicates that affordable, high performance broadband is seen as an important issue.

World class broadband infrastructure will be necessary to maintain the county’s attractiveness as a great place to live and to work. This can only be accomplished if the residents and businesses have the right telecommunications infrastructure that will support the needs of existing businesses and also attract new businesses.

Broadband is not a silver bullet for Albemarle. Broadband investments need to be tied to a wider set of community and economic development strategies that help make the area an engaging and interesting place to locate and run a business and a vibrant and interesting place to live. Communities that have made broadband investments without taking the time to identify a broader set of goals and expected outcomes have usually been disappointed when broadband investments have not had much of an impact. However, it is clear that broadband investments are critical for economic viability.

Community investments in infrastructure will accelerate the availability of broadband options within the community, especially in the business and retail sector. It is important to note that this report does NOT recommend that the County sell services like Internet, telephone, and TV to residents and businesses.

If the County chooses to make investments, the improvements should be at the basic infrastructure level (e.g. wireless towers, conduit, dark fiber) that can be leased to the private sector. Lease payments, over time, would be used to pay back the initial capital expense and to fund additional improvements as they are needed.

Private sector firms, including existing telecom providers, would use the new infrastructure to compete with each other. Service providers using the network would pay a small portion of revenue to the network for the use of the infrastructure.

Demographic and work changes must be considered as part of the decision-making process. The survey results show that well over 50% of respondents are trying to work from home part or full time. Broadband availability and affordability are affecting a wide variety of lifestyle and

economic decisions: Consider the following data from a Fiber To The Home Council report (March, 2013):

- ▶ Among young people under 35, 54% of males are “very interested” in advanced broadband services, and 44% of females are “very interested” in advanced broadband services. In this age group, over 65% are “very interested” in working from home.
- ▶ In the over 54 age group, one third of men and women are interested in advanced broadband services, and over half want to use HD video calls.
- ▶ 11% of fiber to the home users have a home-based business.
- ▶ Fiber service is ranked as the number one factor influencing a home purchase if the buyer already has fiber at their current residence. Fiber is ranked as the number two home buying factor if they do not have fiber service now.
- ▶ Fiber connected homes are perceived as being worth \$5,000 to \$6,000 more than an equivalent home without fiber.
- ▶ Because of the increase in home-based businesses due to fiber availability, fiber can create as much as \$1.1 million in new business revenue to the community for every 1,000 homes passed by fiber.

As the local schools continue to rely more heavily on Internet-based learning materials, usable and affordable Internet access in the home is becoming a critical part of the learning environment. Broadband in Albemarle must have the following characteristics to support economic development and business growth, and to support K12 education.

Accessible — Residents and businesses in the county need to have broadband available to them, preferably with a choice of providers, services, and pricing options.

Affordable — Broadband has to fit within the budgets of citizens and businesses in the county. Cellular data and satellite services may provide Internet access, but often at a very steep price.

Reliable — The aging copper cable plant in rural parts of the county limits the ability of DSL service to provide reliable broadband service. Complaints of service outages during periods of heavy rain are common.

Useful — Residents and businesses need enough bandwidth to meet business, personal, and educational needs.

The Role of Government

Successful improvements in broadband access, affordability, and reliability for Albemarle involves several decision points, as outlined in the illustration below. Government has several “first choice” options.

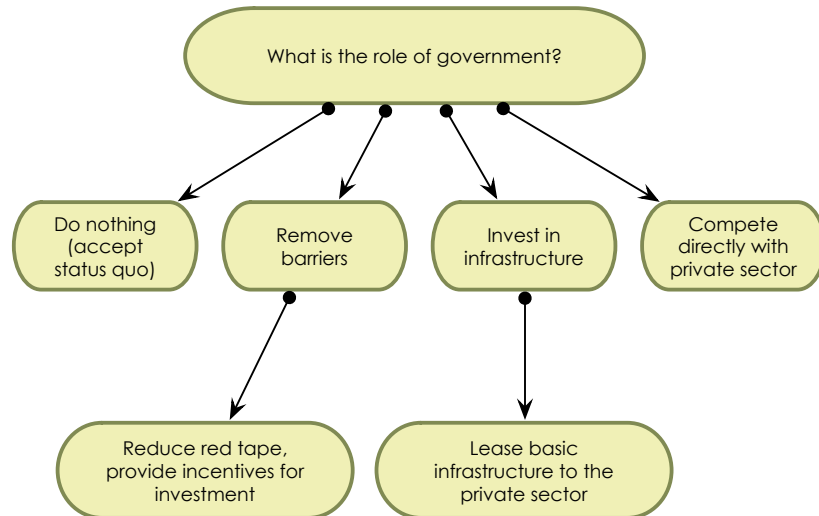
Do nothing is to accept that businesses and residents in the county will have to continue to use whatever is available, despite the cost and bandwidth limitations that limit what many are able to do online.

Government can *remove barriers* to private sector

investment. This can be an effective and low cost strategy. Possibilities include reducing permit fees for fiber construction and tower installation, incentives to developers to install conduit and meet-me boxes in new residential and commercial construction, simplified permit requirements for rural utility pole installation on private property, and identifying areas of residential and business demand and sharing that information with providers.

Albemarle County could choose to make *investments in basic infrastructure* and make that infrastructure available to the private sector via revenue-generating lease agreements.

As has been done in some other localities, the County could choose to *compete directly with the private sector* by offering retail Internet, phone, and TV services.



RECOMMENDATION

The County can both remove barriers and make targeted investments in infrastructure. These two activities can be executed in parallel, with infrastructure investments taking place as funding sources are identified. There are a variety of low cost and no cost efforts, mostly at the policy level, that both governments could do to encourage more private investment. As just one example, county planners could work with developers to help them realize that installing conduit and related infrastructure in new subdivisions is an inexpensive way to increase the potential sales price on the homes. No special funding is required of the County, but over time, if residential growth continues in Albemarle County, more homes and neighborhoods would improved broadband infrastructure. *Incentives for the private sector can include the initiation of public sector investment. In other localities, this has had an immediate and useful influence on private sector providers, including improved service and lower prices.*

Assessing Business Demand

A market research study was conducted to determine the market for improved broadband access and affordability. The study was an online and paper survey of residents and businesses in Albemarle County.

The surveying was primarily conducted through an online (Internet) survey. This method was chosen due to a number of advantages which include faster results, lower costs, and a shorter data collection period. Paper forms of the survey were also available to the community if individuals did not have access to a computer or Internet. Paper submissions were mailed back or dropped off at the Albemarle County Planning and Zoning Office. Both the online survey as well as the paper form were available to any business with no specific target group. Paper surveys were distributed at the library and in several other locations to help capture data from residents and businesses who may not have Internet access at home or the place of work.

The study was done to determine the following:

- Satisfaction with current Internet service
- Demographic information
- Types of Internet connections
- Current Internet usage and purpose
- Importance of Internet access
- Willingness to pay more for faster, higher quality Internet access
- Cost of services
- Current service providers for telephone, Internet/data and TV service
- Information about work from home requirements and needs

This market research can be very useful in setting priorities for next steps, and can be an important part of state and Federal funding and grant opportunities.

A total of 29 responses were collected. Not all responders answered every question.

Some of the key data points that resulted in the survey include:

- 85% of respondents are not satisfied with all their services.
- 96% of respondents answered that they needed better Internet/data service.
- 96% of respondents stated that they had an Internet connection.
- 69% of respondents use DSL while 8% use fiber or cellular wireless or satellite.

- 29% of respondents generally pay between \$61 to \$100 per month for Internet access. 21% spend between \$101-\$150 for Internet.
- 0% of respondents answered they were “very satisfied” with the current spend of their Internet service. 72% of respondents replied that they were “not at all satisfied” with the current speed of their Internet service.
- 84% of respondents indicated that they would be very willing or somewhat willing to pay more for faster, higher quality Internet access.
- 88% of respondents indicated that they found Internet technology to be a very important factor in the success of their company over the next five years.
- 68% of respondents answered that finding personnel with the needed computer, software, and Internet skills to be somewhat difficult or very difficult.
- 96% of respondents indicated that their organization would benefit from affordable broadband.
- 48% of respondents indicated they need nights and weekends access for company work. 76% are working at least part time from home either for another company or as self-employed.

CURRENT SATISFACTION OF EXISTING SERVICES

Overall, respondents felt a need for better landline telephone service, cellular telephone service, and Internet/data service. 95% of the respondents desired better cellular telephone service and Internet/data service. 85% of the respondents were not satisfied with all of their services. This data indicates that businesses generally are in need of better services that can offer reliability, speed, and a better price point.

ESTABLISHMENT INFORMATION & EMPLOYEE COMPUTER USAGE

96% of the businesses that responded to the survey indicated that an internet connection existed at the establishment. There are 520 employees that are employed by the 29 businesses that took the survey. There is an average of 21 employees per establishment that took the survey. Of the 520 employees, there are 213 computer users (41%) at these businesses. In addition, each establishment typically has an average of 9 employees who use computers.

A variety of establishments responded to the survey, which include professional, government, retail, medical, non-profit, educational and other. Other (52%) made up the majority of the establishments that responded followed by retail (24%) and professional (20%). “Other” establishments included construction, farm, manufacturing, industrial, winery, vineyard, and cidery.

EXISTING INTERNET CONNECTION TYPE, PRICE, AND SPEED

A DSL line provided Internet access to 69% of the respondents. Wireless Internet provided an Internet connection to 8% of the respondents. More than half of the respondents pay less than

or equal to \$150 for Internet access each month. The largest proportion of respondents paid generally \$61 to \$100 for Internet access each month. 4% of the respondents had Internet speeds between 56-256k, while 8% of the respondents had Internet speeds between 1.5-3Mb. In addition, 72% of the respondents were “not at all satisfied” with the current speed of their Internet service, while only 0% were “very satisfied” with their current speed.

USE OF THE INTERNET

Respondents were asked how they currently used the Internet to serve their needs at their respective establishments. The most common uses of the Internet included email, processing credit card / debit card transactions, ordering/managing inventory, maintaining a web presence with a blog or other site and receiving and processing online orders. 14% of the respondents used the Internet to maintain a web presence with a blog or other site.

WILLINGNESS TO PAY

While only 16% were “not at all willing” to pay for faster, higher quality Internet access. 24% were “somewhat willing” and 60% were “very willing” to pay.

IMPORTANCE OF INTERNET TECHNOLOGY & COMPUTER COMPETENCY

Respondents of the 29 business establishments overwhelmingly found Internet technology to be an important factor in the success of their company in the next five years. 0% found Internet technology to be “not important.” Furthermore, 23% of the respondents from business establishments found that it was “somewhat difficult” to find personnel with the needed computer, software, and Internet skills in the local area. 96% of the respondents indicated that their organization would benefit from an affordable broadband Internet connection, and only 4% indicated that an affordable broadband Internet connection would not be beneficial.

EXISTING SERVICE PROVIDERS

Phone: Verizon provided phone service (local and long distance) to 11% of the respondents and Century Link provided phone service (local and long distance) to 58% of respondents. Others service providers included AT&T, and Comcast. 25% of the responses included “Blank” and “None” for local dial tone and 36% of the responses included “Blank” and “N/A” for long-distance.

Internet: Century Link provided Internet access to the majority (68%) of the respondents with Internet. Other providers included Comcast, Hughes Net, SES, U.S. Cellular and Verizon. None of these providers had more than 4% of the respondents use their Internet services. 11% of respondents left the question blank.

Television: The largest provider of cable/satellite TV was Direct TV. Direct TV provided service to 14% of those with television service, while Dish Network provided service to 11% of the respondents. 29% of the respondents either indicated no TV, “None”, or “N/A”. 46% respondents left the question blank.

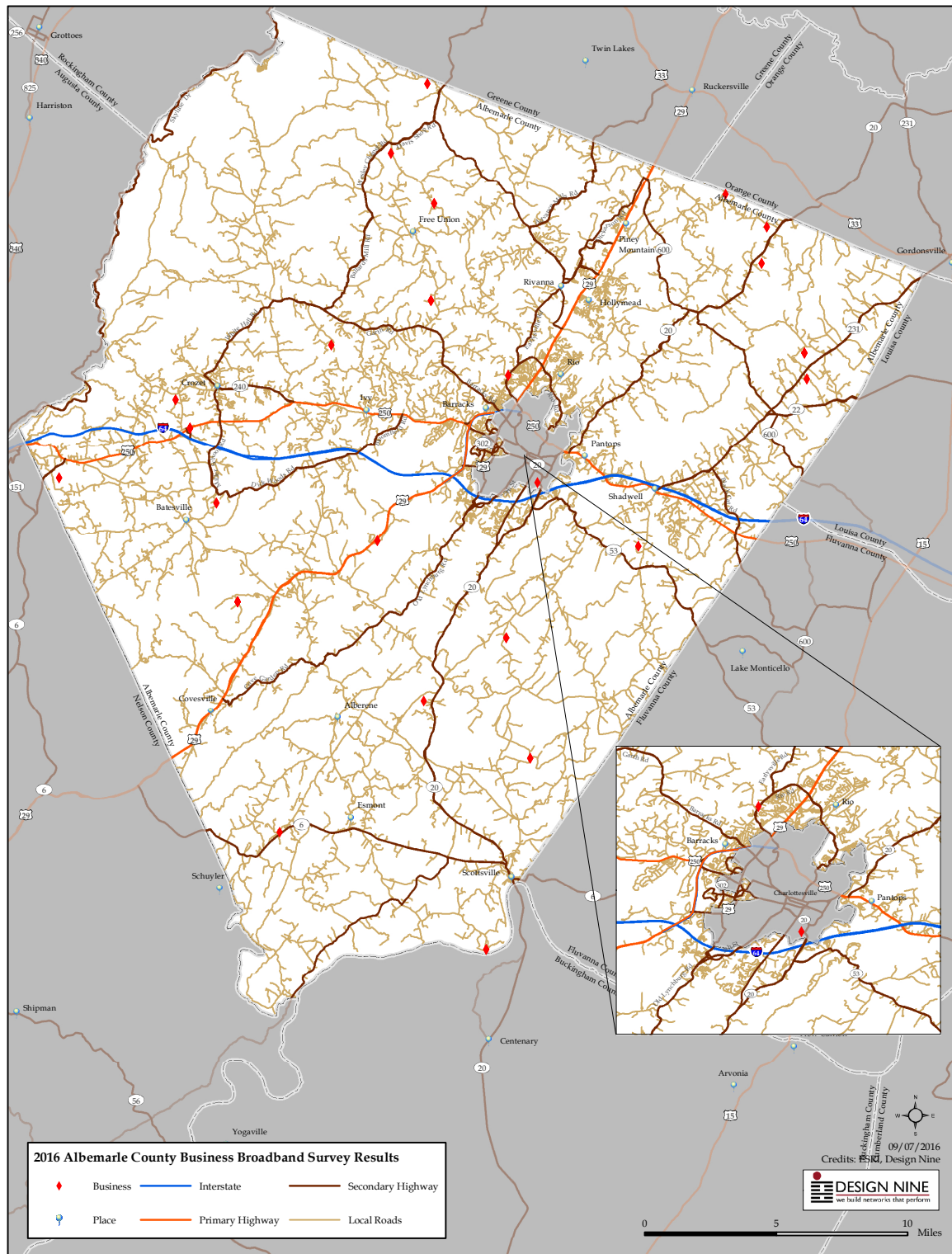
SERVICES DESIRED

Respondents were asked if there were other telecommunication needs that they desired that was not covered in the survey. This was an open ended question. Seven respondents desired better cellphone service. Two respondents said better Internet service would improve training for employees and several respondents said their business heavily relies on the Internet.

JOB CREATION AND TELEWORK

38% of the respondents said affordable broadband could allow them create new jobs at their establishments. The survey found that a portion of respondents generally work from home full time or part time. Only 24% of the respondents stated that they never work from home. 8% of the respondents stated that they are self employed and work part time from home. In addition, 16% of the respondents noted that they are self employed and hold full time positions at home.

The map on the next page shows the distribution of businesses that responded to the survey.



A total of 29 responses were collected. Not all responders answered every question.

Check the items you agree with below.

Question	Yes	No
I need better landline telephone service.	56%	44%
I need better cellular telephone service	95%	5%
I need better Internet/data service.	96%	4%
I need better cable/satellite TV service.	29%	71%
I am satisfied with all of my services.	15%	85%

Number of employees:

Total number of employees	520
Average number of employees per establishment	21

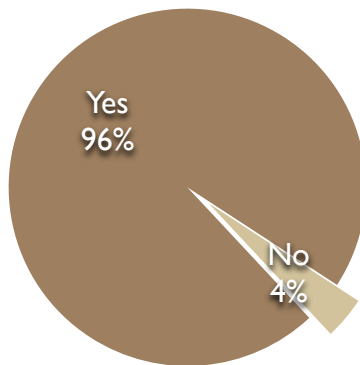
Number of computer users:

Total number of computer users	213
Average number of computer users per establishment	9

Types of organizational activities conducted at this facility:

Retail	24%
Professional	20%
Government	0%
Educational	4%
Medical	0%
Non Profit	0%
Other	52%

Does your organization have an Internet connection?



If yes, what type?

Dial-up	Cable Modem	Satellite	DSL Line	T1 Line	Don't know	Fiber	Cellular Wireless	Broadband WISP
0	1	2	18	0	1	2	2	0
0%	4%	8%	69%	0%	4%	8%	8%	0%

How much do you pay now for Internet access each month?

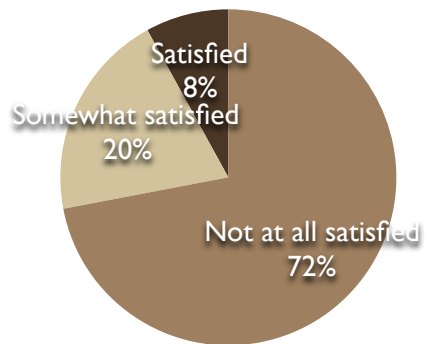
No Internet	\$0-20	\$21-40	\$41-60	\$61-100	\$101-150	\$151-300	\$301-500	\$501-1000	\$1001-\$5000	\$5000	I don't know
1	0	0	3	7	5	2	1	0	2	1	2
4%	0%	0%	13%	29%	21%	8%	4%	0%	8%	4%	8%

Speed of your Internet Connection?

No Internet	Dial up only	56-256k	256-512k	512-1Mb	1-3Mb	1.5-3Mb	3-10Mb	10-50Mb	50-100Mb	100+Mb	Gigabit	I don't Know
1	0	1	1	4	4	2	6	0	0	2	0	4
4%	0%	4%	4%	16%	16%	8%	24%	0%	0%	8%	0%	16%

How satisfied are you with the speed of your current Internet service?

Not at all Satisfied	Somewhat Satisfied	Satisfied	Very satisfied
18	5	2	0
72%	20%	8%	0%

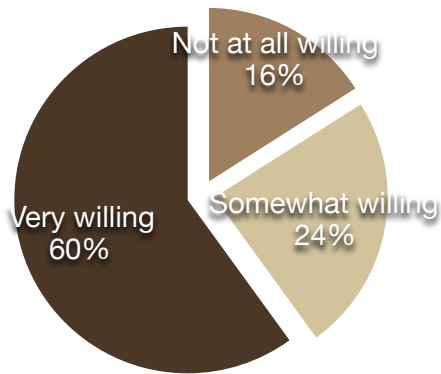


Check all the items you use the Internet for now:

Email	16%
Access news and current events	6%
Business videoconferencing	4%
connect to company VPN (Virtual Private Network)	4%
VoIP (Vonage, Skype, etc)	1%
Online Backup (files, photos, music)	5%
Transfer large files	5%
Monitor / control security, alarms, health, processes, etc.	2%
Telemedicine, telehealth	3%
Communication between headquarters and remote sites	10%
Processing credit card / debit card transactions	7%
Research	12%
Ordering/managing inventory	14%
Maintaining a web presence with a blog or other site	10%
Receiving and processing online orders	2%
Other	16%

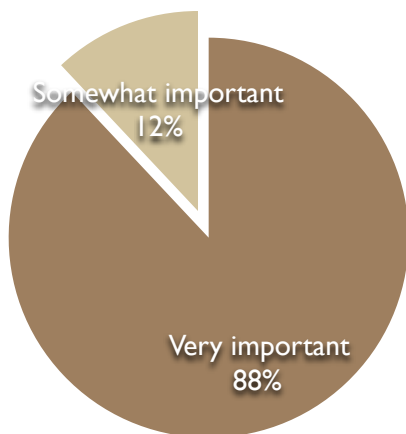
Would you be willing to pay more for faster, higher quality Internet access?

Not at all willing	Somewhat willing	Very willing	Not sure
4	6	15	0
16%	24%	60%	0%



How important do you think Internet technology will be for the success of your company over the next five years?

Very important	Somewhat important	Not important
23	3	0
88%	12%	0%



How difficult is it to find personnel with the needed computer, software, and Internet skills from the local area?

Very difficult	Somewhat difficult	Not difficult
2	5	15
9%	23%	68%

How difficult is it to find and provide the appropriate training for employees in computer, software and Internet applications?

Very difficult	Somewhat difficult	Not difficult
3	2	15
15%	10%	75%

Do you believe your organization would benefit from an affordable broadband Internet connection?

Yes	No
24	1
96%	4%

If yes, briefly state what is affordable and at what speed:

Responses
\$100 a month 100MB Symmetrical.
\$100 a month 20GB symmetrical
\$100 a month would be great
\$100 per mont 100MB symmetric
\$100 per month
\$100 to \$150 per month
\$150 is fine. DSL or faster would be preferred. Currently, emailing attachments involves lots of wasted time staring the the screen wait for uploads or downloads. I probably lose 45 mins a day because of the slow Internet.
\$40.00/month >5
\$50-\$100/month for at least 20Mbps
100 MB
300 for voice and broadband at minimum of 25 Mbps
A minimum of 5MB/s for around 60 dollars a month. Our ideal speed would be 10 MB/s or more
Currently paying \$3,500 per month from CenturyLink, would be very happy with a Gig connection at \$150-\$300 per month
Happy with existing speed. It's just that the land line reliability seems to be impacted by the DSL and we have no cellular service.
Higher speed with more people on at once would be great. We use Centurylink, which is limited. I don't know the numbers but speed is limited and so are the numbers of people that can be on at once. For what we pay, it seems we should be able to get more. It also goes down a lot, so we are in offline mode, which is scary.
Like what we have, do not want any changes
Satisfied with the current setup through CenturyLink - however the landline voice continues to be a challenge. Sometimes calls drop, etc. Would like that fixed.
Something around \$100 a month would be great. Comcast gave them a quote of \$367,000 to bring connectivity to them.
Symmetric 100MB in \$100 range would be great
We pay over \$100 a month for satalite Internet and according the speed test I just ran we have a download speed of .12mbps and there isn't a cloud in the sky today. Yes that is a decimal infront of the twelve, so we are willing to pay whatever it takes to get reliable moderately fast Internet.
Well different speeds different prices, and reliability counts too
Willing to pay whatever it takes to get good connectivity

Who is your Internet Service provider?

Blank	Century Link	Comcast	Hughes Net	Don't Know	SCS	U.S. Cellular	Verizon
3	19	1	1	1	1	1	1
11%	68%	4%	4%	4%	4%	4%	4%

Who is your cable/satellite TV provider?

Blank	Century Link	Direct TV	Dish Network	N/A	None
12	1	4	3	7	1
43%	4%	14%	11%	25%	4%

Who is your local dial-tone telephone service provider?

Blank	Century Link	Comcast	None	Verizon
5	20	1	1	1
18%	71%	4%	4%	4%

Who is your long-distance telephone service provider?

Blank	AT&T	Century Link	Comcast	N/A	Verizon
8	1	15	1	1	2
29%	4%	54%	4%	4%	7%

What other telecommunication needs do you have that were not covered in this survey?

Responses
ATT Cell
Cell Phone Coverage is inconsistent and for my job is needed when I'm on the road, at my place of business (home), and at many of my client's homes or places of business.
Cell phone-in Verizon
Cell reception in rural Virginia is spotty and inconsistent. Most of our guests do not have cell service when visiting us. Because of our slow Internet speed, we connect offer them consistent wifi either.
Cellular coverage is almost non existent in the area.
Emphasized need for better Wireless
Entire business dependent on Internet
Have 70 employees, 67 just have high school education. However their training is very specialized and could be improved greatly by a good broadband connection
Improved cellular service is critical to our business. We're at the end of a 2 mile gravel road. We're not far off Route 29 but today's customers panic when they lose cell service. To them it is a safety issue. They don't want to travel where they cannot see themselves on a map. We've have some customers leave an evening event and get lost and take two hours instead of ten minutes to get to route 29
Mobil service is absolutely critical. We could do everything over mobile if we had coverage
Most customers find us via the web and book their trips via the web after looking at river conditions. Currently Internet access is terrible
Online inservice trainings; college level course work
Worried that the random mountains in his area would pose a great problem for wireless. His area doesn't have long empty parallel valleys.

If more affordable broadband allowed your business to add new jobs, will the jobs to be filled require no more than a HS degree and no special skills required for employment? (unless training will be available from the company/business):

Yes--no more than high school degree, no special training	No--some college and/or special training required
8	13
38%	62%

Do you work from home?

I work part time at home for another company.	0%
I work full time at home for another company.	4%
I need nights and weekends access for company business.	48%
I am self employed and work part time from home.	8%
I am self employed and work full time from home.	16%
I never work from home.	24%

Gap Analysis and Current Conditions

BUSINESS BANDWIDTH NEEDS

The table below shows bandwidth consumption for several types of businesses and a projection of the bandwidth needed 5 and 10 years out. The cost of fuel is already affecting business travel decisions, and more and more businesses will invest in HD quality business videoconference systems to reduce the need for travel. These HD systems require substantial bandwidth; a two way HD video conference requires 20-25 megabits during the conference, and a three way conference requires 30-35 megabits during the conference. As more workers try to reduce the cost of driving to and from work by working part or full time from home, the business location must provide network access (Virtual Private Network, or VPN) to the employees working from home. These home-based workers will make extensive use of videoconferencing to attend routine office meetings remotely and to enhance communications with co-workers, including videoconferences with other home-based workers in the company. A VPN network providing remote access to just two or three home-based employees could require 50 megabits of bandwidth during normal work hours.

	Large Business		Small Business		Home Based Worker		Business From Home	
Description	A larger business with about 50 workstations.		A small business with 10 to 15 employees, and 7-10 workstations.		A single employee working at home for his/her company.		A home business with one or two employees working at home.	
	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps
Telephone	20	1.28	5	0.32	1	0.064	1	0.064
TV		0		0		0		0
HDTV		0		0		0		0
Credit Card Validation	4	4	1	1		0		0
Security System	1	0.25	1	0.25	1	0.25	1	0.25
Internet	20	30	7	10.5	1	1.5	1	1.5
VPN Connection	5	25		0	1	5		0
Data Backup	5	7.5	1	1.5	1	1.5	1	1.5
Web Hosting	1	2		0		0		0
Workforce Training (online classes)	2	20	1	10	0	0	1	10
HD Videoconferencing	10	100	2	20	1	10	1	10
Telecommuting workers	5	15	2	6	0	0	0	0
Totals		205.0		49.6		18.3		23.3
5 years from now (megabits)	615		149		55		70	
10 years from now (megabits)	1845		446		165		210	

RESIDENTIAL BANDWIDTH NEEDS

The table below depicts the bandwidth needed for typical residential services which are available now or will be available in the near future. In a next generation network all services will be delivered over a single network infrastructure which will require an access network that can support providing most services to most consumers simultaneously. Today's shared networks (cable and wireless in particular) rely on the "bursty" nature of traffic to provide services to end users. If all end users were consuming their "advertised" bandwidth today's cable and DSL networks would grind to a halt.

In fact, they already are; some cable providers have begun to receive heavy criticism for undocumented manipulation of data traffic. Existing cable modem network users are overwhelming the digital cable networks that were upgraded as little as three or four years ago, and the firms have had to artificially reduce the bandwidth available for certain kinds of high bandwidth services (e.g. peer to peer file sharing). Some cable providers have even run into capacity issues with the TV portion of their networks, and some consumers have observed that some HD TV channels have been so highly compressed that picture quality has been noticeably degraded when compared to the same channel delivered by satellite.

	Residential Daytime		Early Evening		Evening and Late Night		Snow Day	
Description	Intermittent Television and Internet use across a small percentage of households.		Increased video, voice and Internet use as children arrive home from school and employees from work.		Peak television and Internet use. Multiple TV's are on, phone and computer being used.		On top of typical daytime traffic children are home from school, and many employees are home working.	
	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps	Concurrent Use	Mbps
Telephone	1	0.064	1	0.064	1	0.064	1	0.064
Standard Definition TV	1	2.5	1	2.5	1	2.5	1	2.5
HD TV	1	4	2	8	2	8	3	12
Security System	1	0.25	1	0.25	1	0.25	1	0.25
Internet	1	1.5	1	1.5	2	3	3	4.5
Online Gaming		0.25		0.5		1		1
VPN Connection	0	0	1	2	1	2	2	4
Data Backup		0	1	5	1	5	1	0
Telehealth (subscriber)	1	4	1	4	1	4	0	0
Distance Learning / Workforce Training		0	1	10	1	10	2	20
HD Videoconferencing		0		0		0	1	14
Totals		12.6		33.8		35.8		58.3
5 years from now (megabits)	38		101		107		175	
10 years from now (megabits)	113		304		322		525	

LOCAL PRICING DATA

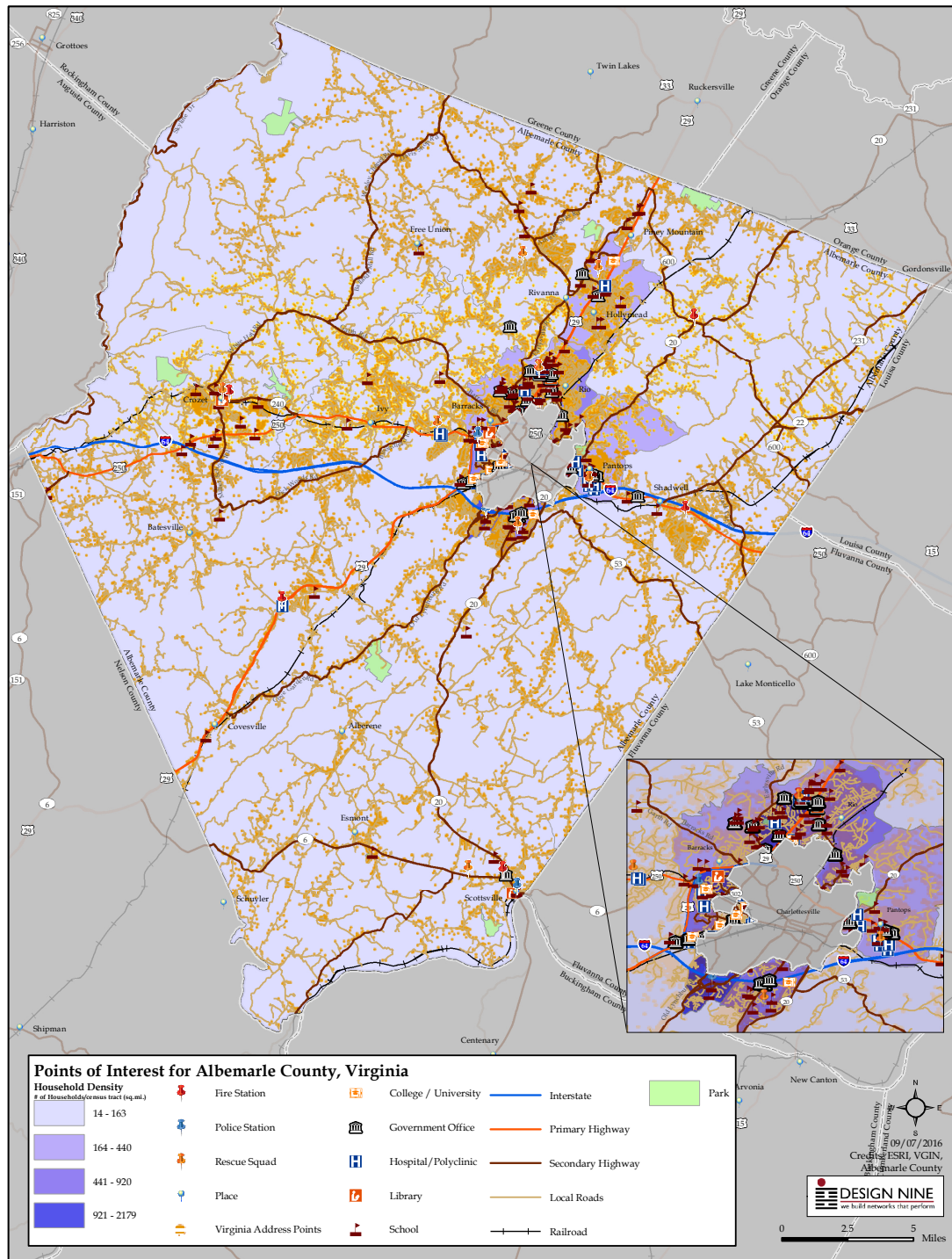
Century Link DSL
\$34.95/mo for 10 mbps 10 mbps ↓ and -- mbps ↑ w/ a 250 GB/mo data cap 1-year promo rate Contract Term: 1 year AutoPay enrollment and paperless billing required. Setup: \$0 (Free activation and modem shipping for self-installation option. Standard tech installation is \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99
\$44.95/mo for 25 mbps 25 mbps ↓ and -- mbps ↑ w/ a 250 GB/mo data cap 1-year promo rate. Contract Term: 1 year AutoPay enrollment and paperless billing required. Setup: \$0 (Free activation. Technician installation is \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99
Century Link Fiber Available for: Keswick and North Garden
\$29.95/mo for 40 mbps 40 mbps ↓ and -- mbps ↑ 1-year promo rate. Contract Term: 1 year Requires autopay and E-bill. Setup: \$0 (Free activation. Technician installation starts at \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99
\$69.95/mo for 100 mbps 100 mbps ↓ and -- mbps ↑ 1-year promo rate. Contract Term: 1 year Requires autopay and E-bill. Setup: \$0 (Free activation. Technician installation starts at \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99
\$69.95/mo for 100 mbps 100 mbps ↓ and -- mbps ↑ 1-year promo rate. Contract Term: 1 year Requires autopay and E-bill. Setup: \$0 (Free activation. Technician installation starts at \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99
\$109.95/mo for 1,000 mbps 1,000 mbps ↓ and -- mbps ↑ w/ no data cap. 1-year promo rate. Contract Term: 1 year Requires autopay and E-bill. Setup: \$0 (Free activation. Technician installation starts at \$59.99.) Modem w/ WiFi: \$9.99/mo or one-time \$99.99

Comcast Cable
\$49.95/mo for 10 mbps 10 mbps ↓ and 2.0 mbps ↑ w/ no data cap. Setup: \$15 (Includes standard shipping of self-install kit. Standard professional installation is \$59.99.) Modem: \$10/mo
\$39.99/mo for 25 mbps 25 mbps ↓ and 5.0 mbps ↑ w/ no data cap. 1-year promo rate. Regular rate is \$66.95. Setup: \$15 (Includes standard shipping of self-install kit. Standard professional installation is \$59.99.) Modem w/ WiFi: \$10/mo
\$82.95/mo for 150 mbps 150 mbps ↓ and 10 mbps ↑ w/ no data cap. Setup: \$15 (Includes standard shipping of self-install kit. Standard professional installation is \$59.99.) Modem w/ WiFi: \$10/mo
HughesNet Satellite Available for Earlysville, Keswick and Crozet
\$59.99/mo for 10 mbps 10 mbps ↓ and 1.0 mbps ↑ w/ a 10 GB/mo data cap Contract Term: 2 years with \$400 ETF Additional 50 GB from 2am - 8am Setup: \$0 (Free standard installation.) Modem: \$9.99/mo
\$129.99/mo for 15 mbps 15 mbps ↓ and 2.0 mbps ↑ w/ a 20 GB/mo data cap Contract Term: 2 years with \$400 ETF Additional 50 GB from 2am - 8am Setup: \$0 (Free standard installation.) Modem: \$9.99/mo
\$79.99/mo for 10 mbps 10 mbps ↓ and 1.0 mbps ↑ w/ a 30 GB/mo data cap Contract Term: 2 years Data Allowance: Business Period (8 a.m. – 6 p.m.) 20 GB, Anytime Allowance 10 GB Setup: \$0 (Free standard installation. Upfront fee is \$99.99.) Modem: \$19.99/mo
\$159.99/mo for 15 mbps 15 mbps ↓ and 2.0 mbps ↑ w/ a 60 GB/mo data cap Contract Term: 2 years Data Allowance: Business Period (8 a.m. – 6 p.m.) 50 GB, Anytime Allowance 10 GB Setup: \$0 (Free standard installation. Upfront fee is \$99.99.) Modem: \$19.99/mo

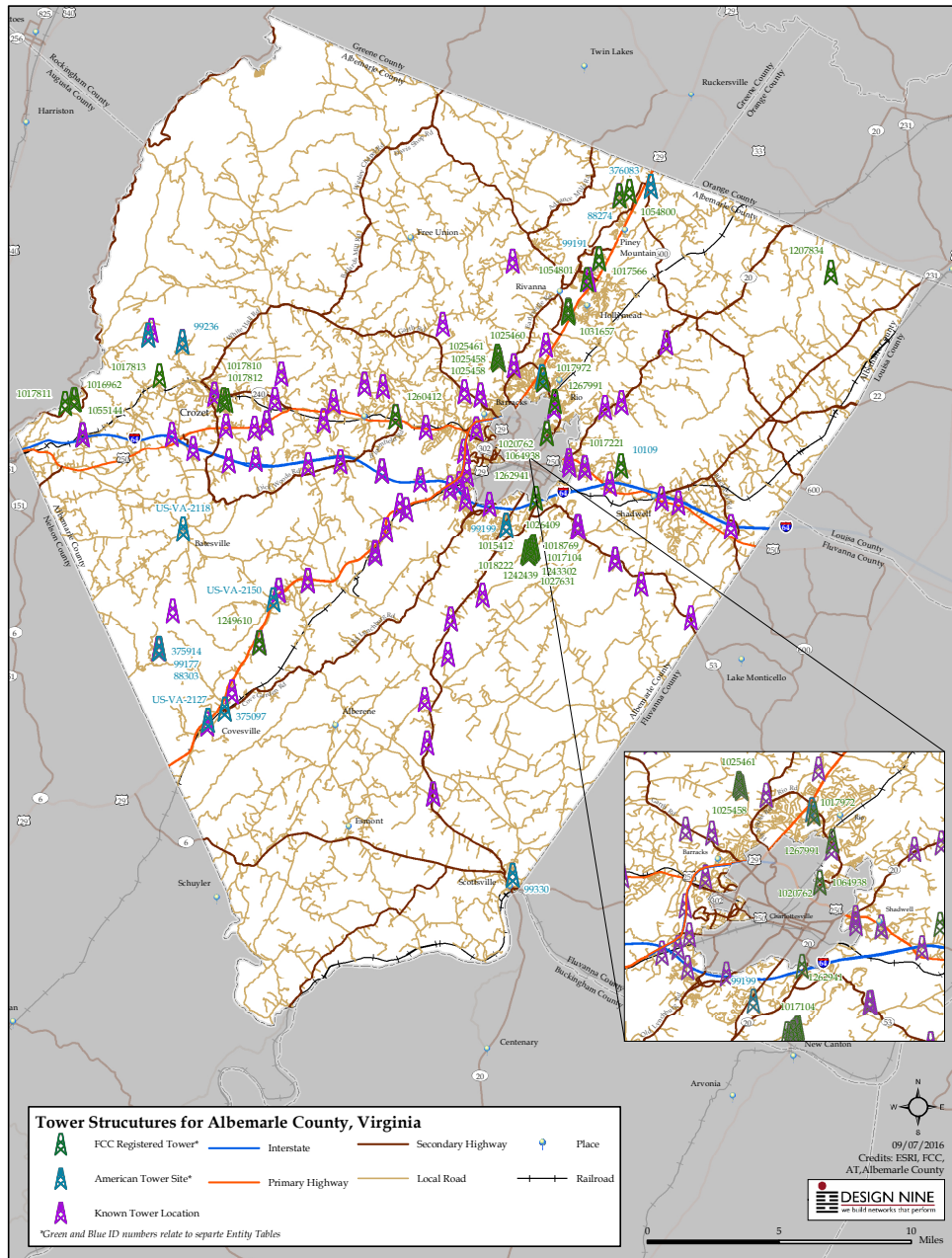
Exede Satellite
\$59.99/mo for 12 mbps 12 mbps ↓ and 3.0 mbps ↑ w/ a 10 GB/mo data cap 1-year promo rate. Contract Term: 2 years Up to 1-5 Mbps download speeds (morning/daytime) after Priority Data used. Setup: \$99.99 (Includes installation.) Modem: \$9.99/mo or one-time \$199.99
\$79.99/mo for 25 mbps 25 mbps ↓ and 3.0 mbps ↑ w/ a 12 GB/mo data cap Contract Term: 2 years Modem w/ WiFi included.
\$99.99/mo for 15 mbps 15 mbps ↓ and 4.0 mbps ↑ w/ a 20 GB/mo data cap Contract Term: 2 years Setup: \$299.99 (Includes standard installation.) Modem included.

EXISTING ASSETS AND DEMOGRAPHY

For large parts of Albemarle, household density is very low. This explains in part the reluctance of incumbent providers in upgrading their telecom facilities in rural parts of the county.



There are a large number of towers in Albemarle County. Most of them are privately owned cell towers clustered along primary and secondary roads. Large parts of the county have no towers or very limited tower access. This means many residents have poor or no cellular phone or data service. It also means that WISPs that want to provide wireless broadband access in rural parts of the county have few colocation opportunities (i.e. placing their radios on existing



towers). It is generally very difficult for a WISP to make a business case for a new tower because of the low margins on fixed broadband Internet services.

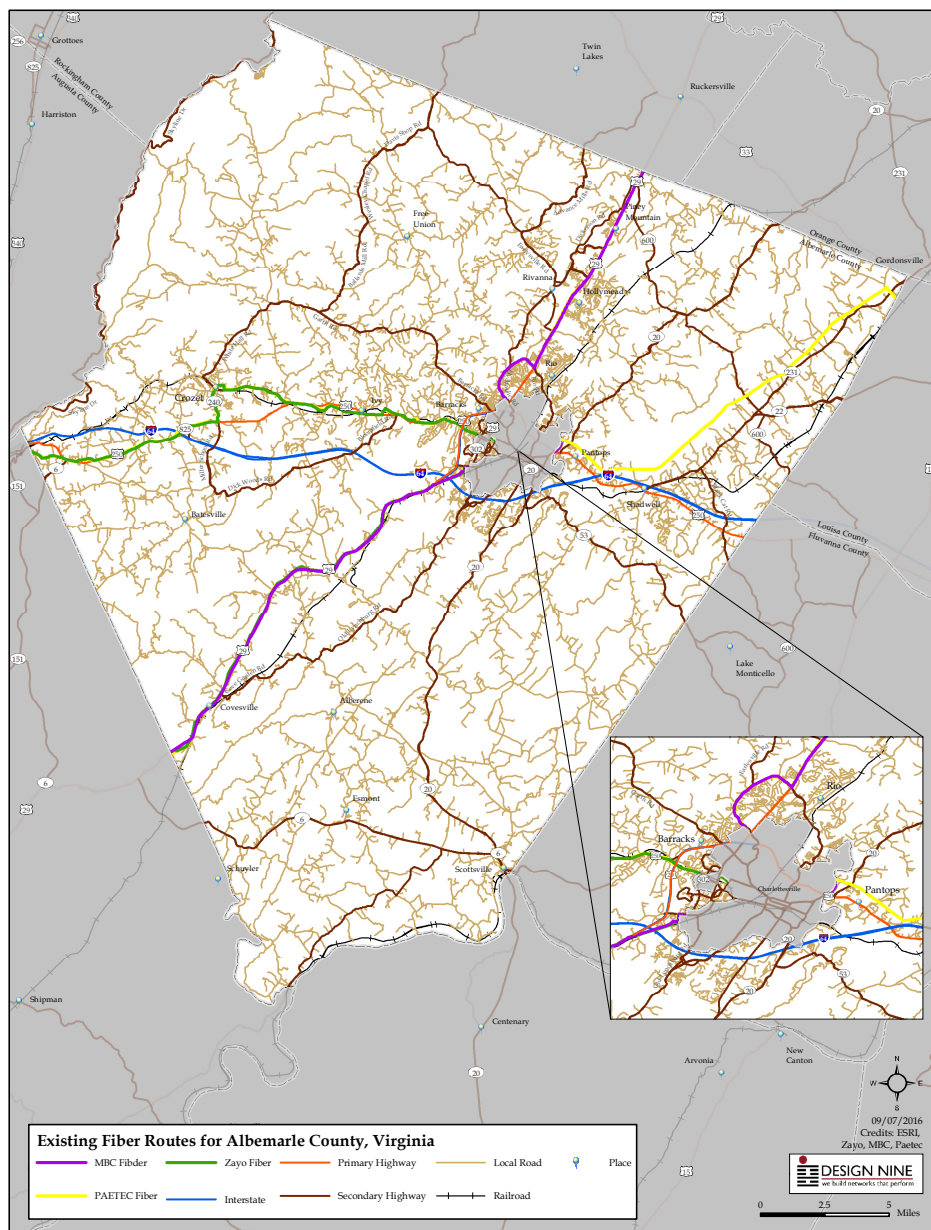
Tower owners include:

FCC Registration Number	Entity
1015412	American Towers, Inc.
1016962	Virginia Electric and Power Company
1017104	United States Cellular Corporation
1017217	Monticello Media, Llc
1017218	Monticello Media, Llc
1017219	Monticello Media, Llc
1017220	Monticello Media, Llc
1017221	American Towers, Inc.
1017566	Alltel Communications of Virginia, Inc.
1017810	Clark Broadcasting Company Db = WCYK Fm
1017811	Monticello Media LLC
1017812	Clark Broadcasting Company Db = WCYK Fm
1017813	Monticello Media LLC
1017972	Embarq
1018222	Central Virginia Educational Telecommunications Corp
1018769	Virginia Broadcasting Corp Db = WVIR Tv
1020688	Monticello Media, Llc
1020762	Charlottesville Broadcasting Corporation Db = WQMZ Fm
1023697	American Towers, Inc.
1025458	Saga Communications of Charlottesville, LLC
1025459	Saga Communications of Charlottesville, LLC
1025460	Saga Communications of Charlottesville, LLC
1025461	Saga Communications of Charlottesville, LLC
1026409	Pinnacle Towers LLC
1027631	Pinnacle Towers LLC
1031657	Alltel Communications of Virginia, Inc.
1054800	Crown Communication Inc.
1054801	Crown Communication Inc.
1055144	CFW Wireless, Inc. Db = Virginia RSA 6 Cellular Limited Partners
1064938	Eure Family LLC
1207834	United States Cellular Corporation
1242439	Albemarle, County Of
1243302	Virginia Broadcasting Corporation
1249610	SBA Towers II LLC
1260412	Alltel Communications of Virginia, Inc.
1262941	Alltel Communications of Virginia, Inc.
1267991	CitySwitch, LLC

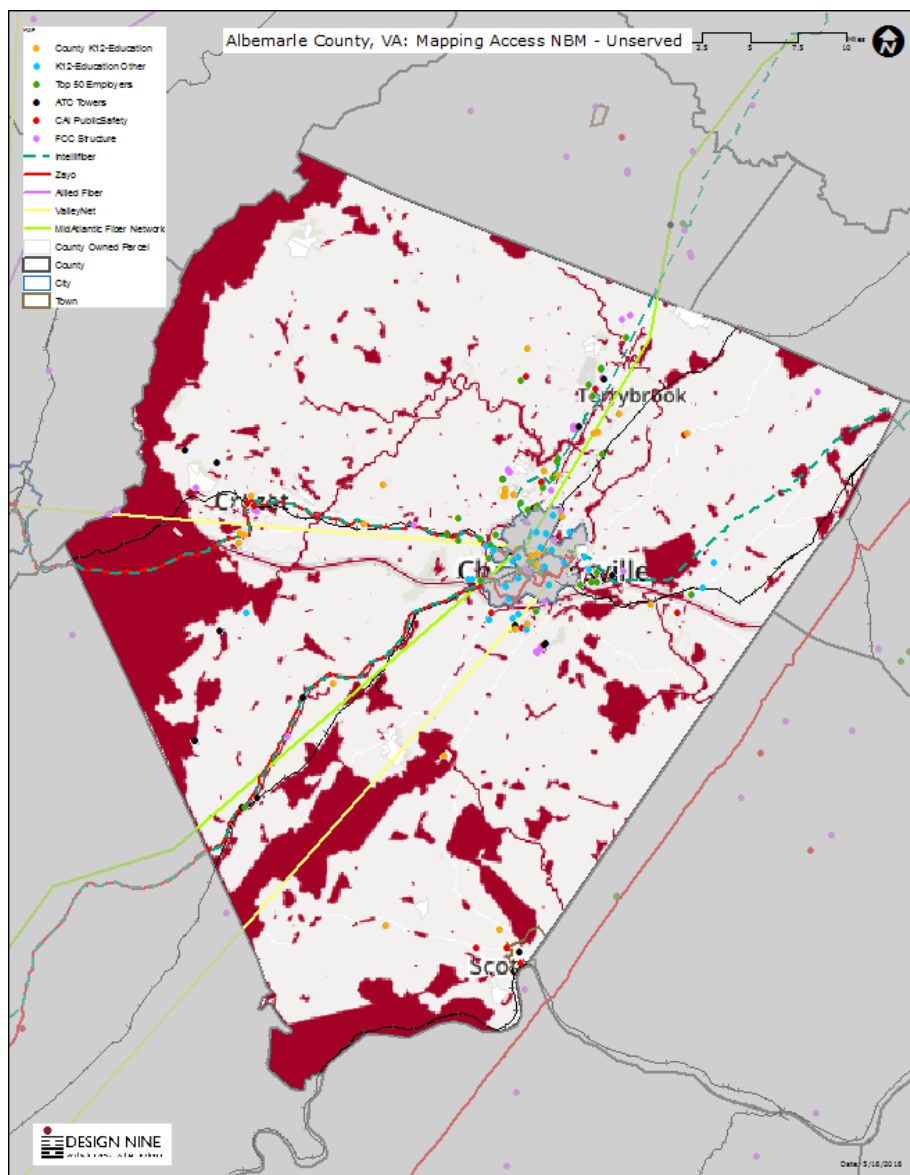
American Tower Sites

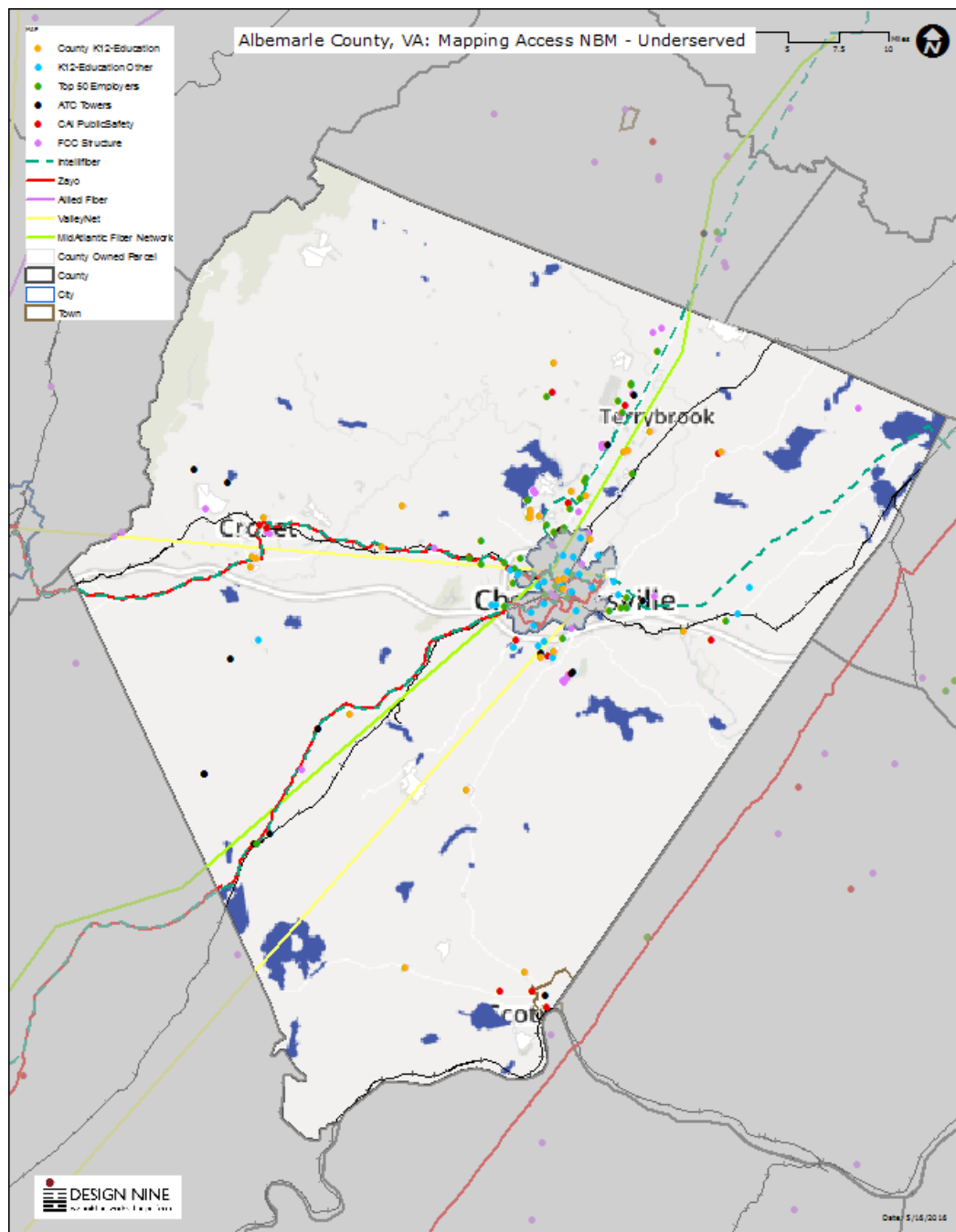
99173	Carrsbrook/WCHV Tower Farm
99177	Heards Mountain Va
88288	Bucks Elbow Va
88303	Heards Mountain Va
10109	Charlottesville (Shadwell)
99191	Airport (Central Va)
99199	Avon Va
99330	Scottsville Va
99236	Crozet
343660	Charlottesville Sq Ib Va
376083	Mt. Chapel Va
375914	Heards Mountain Va
375097	Covesville
US-VA-2150	North Garden Po Va
US-VA-2118	Batesville Po Va
US-VA-2127	Covesville Po Va
US-VA-2274	Charlottesville Sq Rt Va
88274	Advance Mills Va

Albemarle County has several long haul fiber providers, including Zayo (a major Tier One Internet provider); Paetec, another large fiber provider serving the Northeast and with connectivity out to Chicago; Lumos, with facilities throughout Virginia, Maryland, West Virginia, and western Pennsylvania; and MBC (Mid Atlantic Broadband Corporation), a Virginia long haul provider. These fiber resources pass through Charlottesville and provide centrally located businesses and institutions some fiber options if they are in proximity to the POPs (Point of Presence) of the providers. But the county has limited local fiber access. CenturyLink has provided fiber services in limited areas, including Scottsville. Inside the City of Charlottesville, Ting, a new fiber to the home provider, has been slowly building out service in some residential neighborhoods.

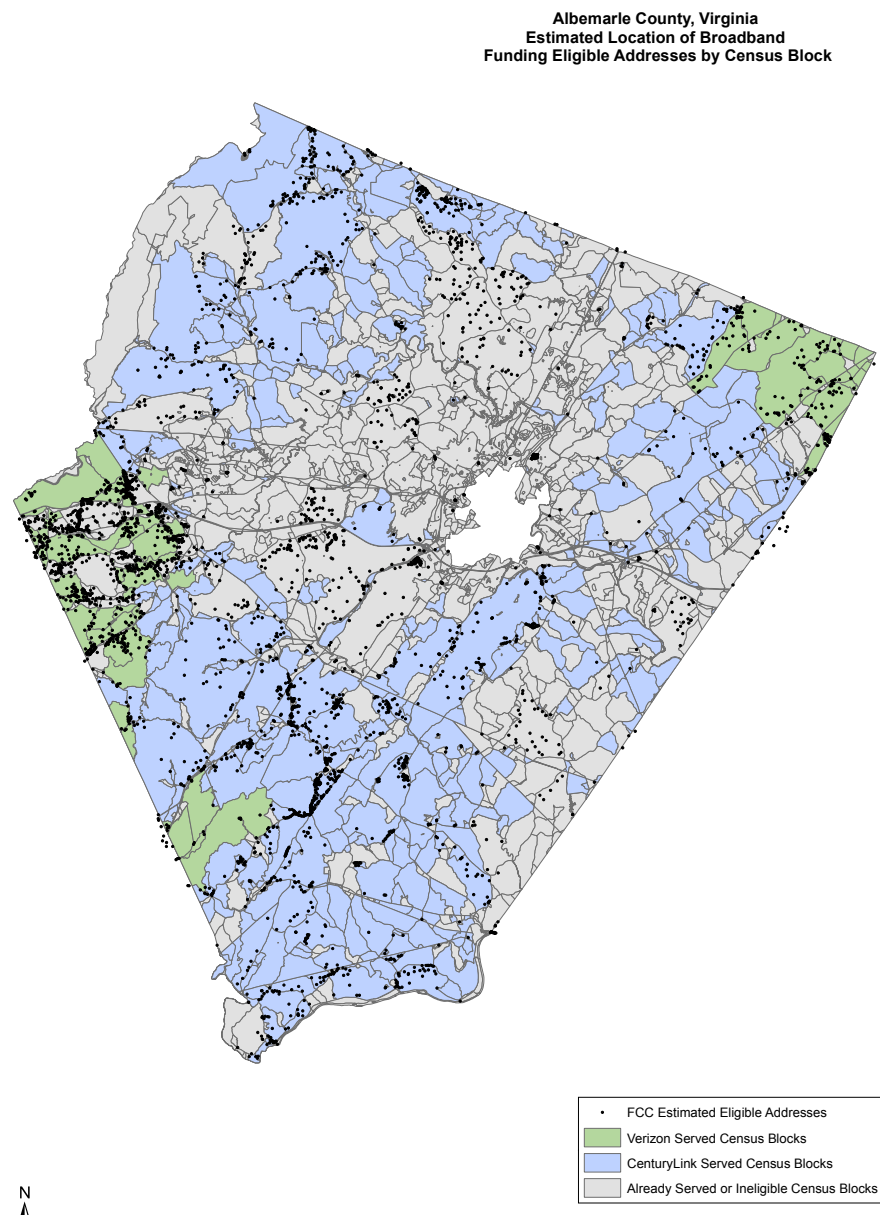


According to the National Broadband Map maintained by the U.S. Department of Commerce National Telecommunications and Information Administration (NTIA), large parts of Albemarle County are “unserved,” meaning those parts of the county have no access to broadband, or “underserved,” meaning Internet bandwidth is very limited. Broadband is defined as 4 Meg down and 1 Meg up for these maps, and the FCC is planning to expand that definition to 25 Meg down, 3 Meg up, which would then make much larger parts of the county unserved and underserved. These designations are important because they are used in some grant programs to determine eligibility (e.g. the USDA Community Connect program will only fund projects in unserved areas).

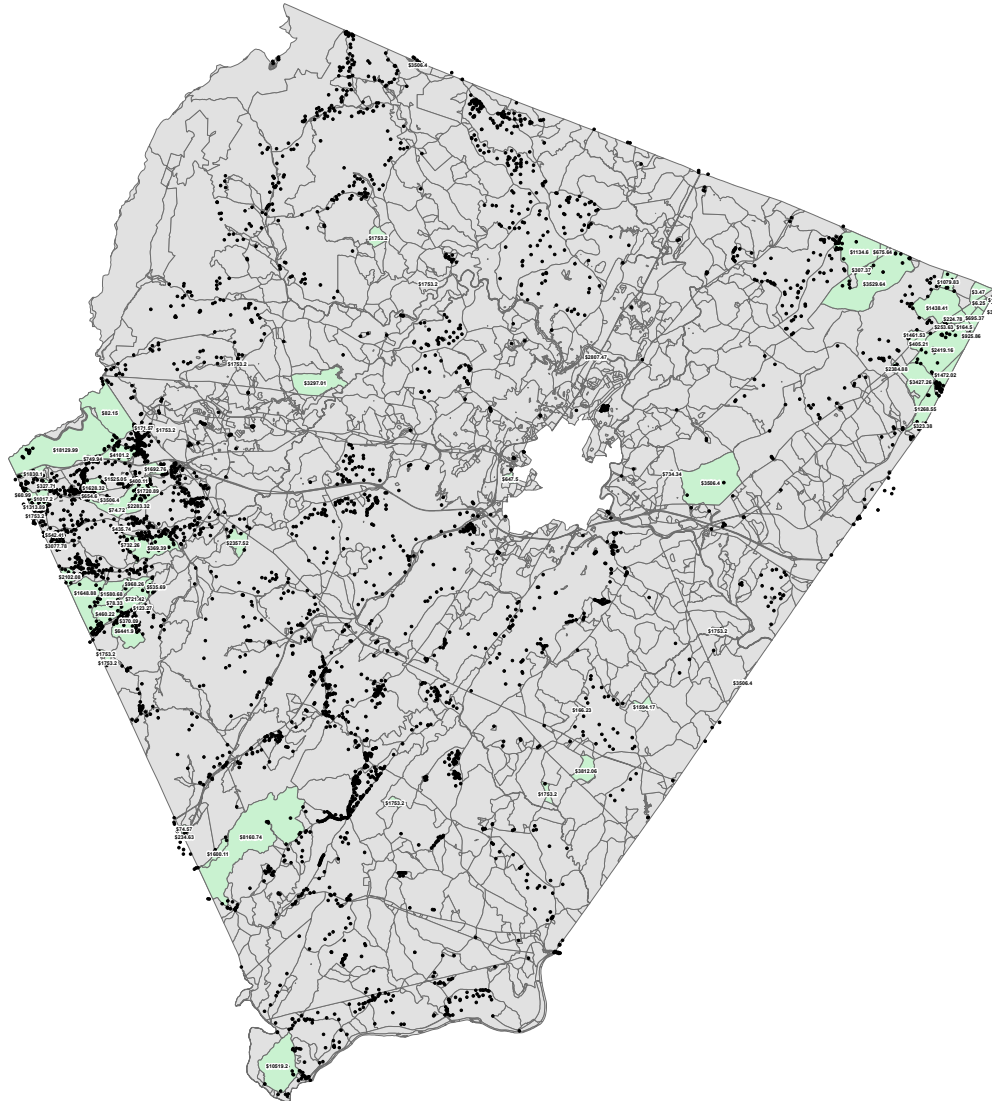




Connect America Fund (CAF) funding is distributed by census block, and incumbents have until November 1st (2016) to elect to accept CAF funds. The County has prepared the two maps that follow, showing eligible census blocks. Verizon has refused to accept CAF funds in Virginia in the past; if they refuse CAF2 funding, census blocks in the Verizon areas of the county will be subject to a reverse auction, allowing other providers to accept CAF funds for those areas. Previous CAF per subscriber funding has averaged about \$400, which will not fund new fiber build outs, but does support upgraded DSL. According to the FCC, nationally, about half of CAF eligible funding blocks will be capable of supporting the current broadband definition of 25 Meg down, 3 Meg up. About 37% will support 10 Meg down, 1 Meg up, and the balance (about 13%) will support only 4 Meg down, 1 Meg up.



Albemarle County, Virginia
Estimated Location of Broadband
Funding Eligible Addresses by Census Block

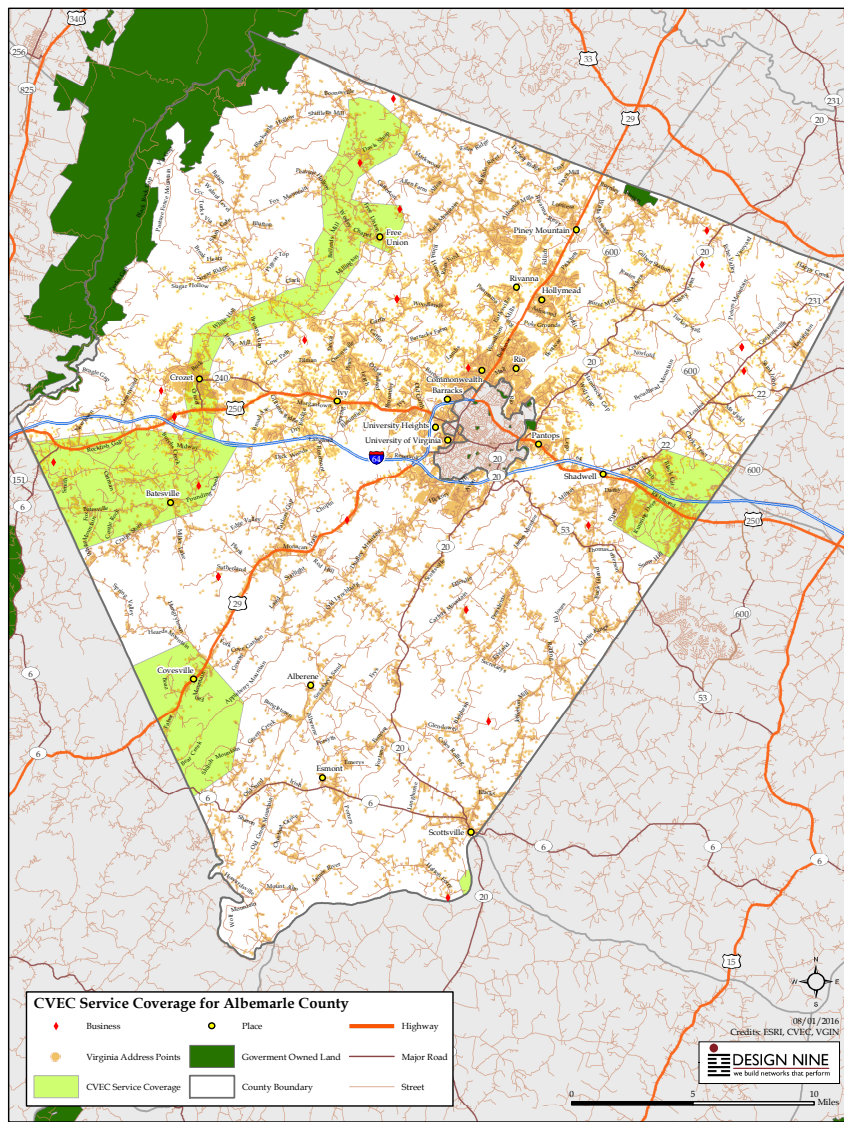


- FCC Estimated Eligible Addresses
- Preliminary Blocks 2017
- Already Served, Planned to be Served, or Ineligible Census Blocks

Age Group	Percentage
18-24	15%
25-34	25%
35-44	35%
45-54	45%
55-64	55%
65-74	65%
75-84	75%
85+	85%



CVEC (Central Virginia Electric Coop) recently announced a program of offering no-fee pole attachments to any entity that would provide fiber services within its territory. CVEC is still determining how it will administer the pole attachment awards. It is not clear at this point if only one company will be granted access for the entire CVEC service area or if CVEC will negotiate agreements with several entities, each deploying fiber in a different portion of the CVEC service area. The map below shows the CVEC services areas in Albemarle County. The County should maintain a conversation with CVEC as the coop develops its strategy. If CVEC elects to “sole source” its entire service area to a single entity, the build out could be several years. CVEC has 36,000+ customers, so a commitment to build throughout the entire area would require a financial commitment of well over \$100 million. Many CVEC poles are located on private property, and acquiring telecom easements from hundreds or thousands of property owners could negate much of the benefit of no-fee pole attachments.



Future Broadband Needs

NEXT GENERATION CONNECTIVITY

“Next generation” is the term used to describe future planning for the next step in network connectivity and infrastructure. There seems to be an emphasis on deploying fiber-to-the-home (FTTH). But why? By pulling fiber deeper into the neighborhood and providing greater access to connectivity, this allows the infrastructure to be in place to accommodate future communication needs, capacities, and innovations. Because of the U.S. demographic bulge that occurred during the baby boom after World War II caused exurban migration, the U.S. is currently the only country where fiber is being deployed in largely suburban areas with single family homes. In countries like Japan and Korea, fiber to the apartment is widely available, in part because the cost of delivering fiber to a high rise apartment building that might have 500 subscribers is much lower than the build cost of fiber to 500 single family homes in a subdivision.

Next generation broadband reaps substantial benefits. There are several key benefits of “Next-Generation Broadband”:

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

Clearly, consumers have a strong interest in a visual medium from when and wherever they are. YouTube is the second most popular search engine after Google, which demonstrates the need to support the infrastructure to transmit streaming video.

In addition to video streaming, true-real time collaboration also provides an effective way for people to interact from wherever they are. People can engage in a two-way, real-time collaboration, so that fruitful, visual conversations can be held between friends, family, business associates from the state, country, or internationally.

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

USE TRENDS

The county faces a challenge in economic development infrastructure with primarily “little broadband” (i.e. DSL, wireless, and cable services) when many communities, regions, and countries have already made the decision to focus resources on the development of “big broadband,” which is typically fiber with a minimum capacity of 100 megabits or Gigabit to the premises. Nationally, there are a number of trends that will affect or are already affecting land use, business location and relocation, and quality of life in Albemarle County.

- ▶ A third of IBM employees work from home at least part time, and the company has reported annual savings of \$110 million.
- ▶ FTTH users work more from home, reducing traffic congestion.
- ▶ In a 2013 report to the Fiber To The Home Council, Render Research and Consulting reported that fiber to the premises adds \$5000 to \$6000 to the sales price of the house.
- ▶ Fiber to the home users say they are able to work from home more often, averaging 7.3 workdays per month, reducing their carbon footprint and decreasing wear and tear (and maintenance) on roads.
- ▶ By late 2015, about 20% of homes in the U.S. had been passed by fiber, but incumbents like Verizon and AT&T have ceased deploying fiber in smaller and rural communities. Verizon FiOS is being deployed mostly in areas where the company has already built fiber, and Verizon has shown little interest in improving service in rural areas.
- ▶ 99% of home-based businesses report fiber is critical to success (the county has many home-based workers and businesses).
- ▶ Older users want telepresence and telemedicine services.
- ▶ Younger residents want collaboration tools and the ability to work from home.
- ▶ More than 20 million homes now have fiber passing them (about 30% take rate).
- ▶ 82% of home buyers who already have fiber will not buy a home without it.
- ▶ 68% of buyers who don't have fiber now want it (only 62% rate green space as most important).
- ▶ 49% would cancel fiber service last if forced to cut living costs.

FUTURE USE TRENDS

“U.S. homes now have more than half a billion devices connected to the Internet, according to a study by the NPD Group. Furthermore, the overall number of connected devices per household, according to a 2014 OECD study, is 10. This is more than three times the average number of people per household.”

The table below lists these and other services that all represent broadband-enabled applications and services that must be available in at least parts of the county if it is to remain economically viable.

Residential and Business	Videoconferencing
	IP TV (Internet Protocol TV)
	HD streaming video
	Ultra hi-def (BluRay) video streaming
	Video on demand (e.g. Netflix)
	Place-shifted video
	Cloud computing services
	Online and cloud-based gaming
	Smart homes, buildings, and appliances, including smart electric meters, AMR (automated meter reading), and AMI (advanced metering infrastructure)
	Remote computer aided design (CAD)
	Work from home jobs
	Business from home
	3D graphic rendering and CGI server farms
	Remote network management and managed services
	Virtual collaboration spaces (e.g. enhanced GoToMeeting, Webex style services)
Public Safety	Intelligent transportation applications (smart road systems)
	Public safety and first responder networks
	Emergency dispatch and coordination
	Webcast agency meetings (e.g. virtual meetings)
	Online training for first responders, fire, and rescue
Society	Broadcast of local sports events
	Videoconferencing of community and town hall meetings for wider participation
	Wider availability of nonprofit and community organization services

Health Care	Teleconsultations
	Telepathology
	Telesurgery
	Remote patient monitoring
	Remote diagnosis
	Remote medical imaging
	Grid computing for medical research
Education and Research	Distance education
	Virtual classrooms
	Remote instrumentation
	Multi-campus collaboration
	Digital content repositories and distribution (digital libraries)
	Data visualization
	Virtual laboratories
	Grid computing for academic research

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

This means that current DSL, wireless, and cable modem services are completely inadequate for future needs. Current DSL offerings are in the range of 1 megabit to 3 megabits for most residential users, 3 megabits to 5 megabits for business DSL users, and there are severe distance limitations on DSL. Higher bandwidth is possible, but as the DSL bandwidth goes up, the distance it can be delivered goes down.

Typical wireless broadband (i.e. not cellular data service) offerings are in the range of 1 megabit to 5 megabits. Some wireless providers are rolling out 10-15 megabit services, but wireless does not scale up well with respect to cost. As bandwidth increases, the cost of the equipment also increases, and even a 15 megabit service is well short of the FCC projections of the need for 50 megabits of bandwidth in the near term. Wireless performance and capacity is heavily dependent upon backhaul (the local connection to the provider’s core network); if this connection is also wireless, the bandwidth available at the access point is shared among all users, even if the rated capacity of an individual connection is 15 megabits. In other words, if the backhaul capacity is 100 megabits, and twenty local users are sharing that capacity, actual bandwidth available to any single user may be much lower than 15 megabits. If all the users are trying to watch video at the same time (not uncommon in early evening), performance can suffer drastically.

Across the U.S., current average bandwidth for cable modem services is typically 10 to 20 megabits, with cable companies promising “up to...” twenty or thirty megabits. It is important to note that cable providers make heavy use of the phrase “up to” in their advertising, and it is not unusual to see ads promoting cable modem speeds of “up to 30 megabits.” However, that amount of bandwidth is shared among many users (often 200 or more) in a neighborhood, which results in much lower average speeds, and during peak use times in residential areas, the actual bandwidth available to a single household may be less than one megabit.

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

Distance learning, entertainment, and video conferencing are three major applications of internet video. Distance learning from home with live video feeds will require high performance 2+ megabit connections in the near term (next 2-4 years), and over the next 4 to 7 years, there will be many distance learning courses that will incorporate live HD two-way video feeds, enabling students to participate in classroom discussions at a much higher quality level. Distance learning could be an important home-based application for workforce training and retraining. Some Idaho community colleges offer “hybrid courses” where a student attends several class sessions at the college and the remaining sessions online from their home, the library, or another location.

Massive Open Online Courses (MOOCs) are now being offered by many colleges and universities, and provide an important and affordable way to obtain certifications and/or college credit in virtually any topic. But many of these classes rely heavily on video to deliver course content, and so an excellent Internet connection is a requirement.

Entertainment will also drive bandwidth demand from the home, and the popularity of video sites like YouTube and Netflix provide a good indication of the long term demand for video in many forms, including:

- ▶ Live feeds (e.g. live TV shows, sports coverage, and live news reports).
- ▶ Video on demand (TV shows available for viewing at any time, rather than at scheduled times).
- ▶ Movies on demand (instead of going to the video store).
- ▶ Two way video conversations (family, friends).
- ▶ Video stored on home computers and distributed across the Internet (e.g. videos of grandchildren, family activities).
- ▶ Local video content streamed live or from a server (e.g. high school football games, other sporting events, council meetings, other civic activities).

Activities in Other Virginia Localities

DANVILLE, VIRGINIA

The City of Danville, Virginia is operating an open access, open services network (www.ndanville.net) focused on creating the right kind of economic development incentives and accompanying infrastructure that will help retain existing businesses and help attract new ones. Danville has a City-owned electric utility, and the growing fiber network is being managed as part of the electric utility operations.

Using a multi-phase approach, the City first hooked up government offices and local schools in 2004, and in 2006 began planning for extending the high performance all fiber network to local businesses and residents throughout the electric service area, which includes a large part of very rural Pittsylvania county. The first businesses began to get hooked up in late 2007, and Danville had fiber passing parcel in its business parks before the end of 2008. The City-County business incubator was one of the first locations to receive the fiber services.

The network has been operating in the black and has generated enough revenue to make an annual contribution to the City's General Fund, and a portion of the nDanville revenue is being used to expand the network. The City has completed the construction of Fiber To The Home (FTTH) to some of its residential neighborhoods (a total of about 1600 premises), and has been able to sign up an IP TV provider as well as Internet and telephone providers for the residential customers.

The City is not selling any services to businesses or residents; all services are offered by private sector service providers that use the network and pay the City for the use of the network via a revenue sharing agreement.

The availability of business class fiber has been a significant boost to the downtown area of Danville, and the City has counted at least 150 new jobs within walking distance of the Main Street commercial area of town.

Attribute	Description
Governance	nDanville is part of the City of Danville Utilities Department.
Funding	The City of Danville Utilities Department has used a combination of loans and revenue to fund the construction of the network. Revenue from key institutions like the City and County schools have been a significant factor in the development of the network.
Business Model	nDanville is an open access, open services network. All services provided to residents and businesses are offered by private sector providers.
Management	Network operations are managed by the City. Some outside plant maintenance is performed by City utility crews, and some work is outsourced to qualified private sector firms (e.g. splicing, some construction work).

Attribute	Description
Technology	nDanville is an active Ethernet fiber network, providing a 100 megabit symmetric connection as the standard service. Gigabit and 10Gigabit point to point connections are also available. nDanville has two colocation facilities available to businesses and providers, and the nDanville MSAP (Multimedia Services Access Point) provides access to more than twenty-five local, regional, and national service providers.

ROCKBRIDGE AREA NETWORK AUTHORITY

Rockbridge County, Virginia and the two independent cities of Lexington and Buena Vista (both within the borders of the county) formed a broadband authority in 2009 after completing an initial feasibility and market demand study. The authority consists of elected officials from each of the three localities, as well as representatives from the business community and Washington & Lee University. Rockbridge was able to build upon the study for the submission and successful award of a \$7 million grant.

The grant, which included \$7 million in ARRA Federal stimulus funding and \$3 million in local match, constructed 60 miles of backbone fiber and provide another 35 miles of Gigabit last mile connections to 53 community anchor institutions and 175 homes and businesses. The project includes a state of the art data center and also constructed 29 DSL cabinets throughout the county to help extend service into the underserved regions of Rockbridge County. Construction began in 2012 and the network's first customers were connected in the summer of 2013. The data center in Lexington is the most sophisticated facility of its kind in this part of Virginia. The 60 miles of fiber passes more than 11,000 homes and businesses and is "last mile ready," meaning businesses and residents can order and receive the standard Gigabit fiber connections quickly and easily.

Attribute	Description
Governance	The network and data center is owned and operated by the Rockbridge Area Network Authority (RANA).
Funding	Approximately \$500,000 in local match from the three local governments and \$2.5 million in funding from Washington & Lee University helped get the project started. These local funds were used as match to obtain \$7 million in Federal ARRA stimulus funds.
Business Model	Services are sold to business and residential customers by private sector service providers using the RANA network for transport
Management	The network began operating in the summer of 2013, and most operations and maintenance has been outsourced.
Technology	The network is an active Ethernet system with a standard Gigabit symmetric fiber connection. 10Gig connections are also available.

ACCOMACK/NORTHAMPTON BROADBAND

Accomack and Northampton counties, on the Eastern Shore of Virginia, have formed a broadband authority and completed construction of a 60 mile high performance fiber backbone that reaches from the northern border of Maryland and extends across the 17 mile Chesapeake Bay-Bridge Tunnel to meet other regional fiber networks in the Norfolk area.

The authority was formed in the spring of 2008, and construction on the fiber backbone was completed two years later. The region made the commitment to form the authority to provide fiber services to private sector firms that were demanding better connectivity to both the NASA Spaceport and Navy facilities in Chincoteague, Virginia and to provide higher performance and less expensive fiber routes off the Shore. The Authority is currently developing plans for the deployment of wireless and fiber services throughout the region. Construction of the northern and southern portions of the fiber backbone were completed in 2010, including a 17 mile link across the Chesapeake Bay Bridge-Tunnel to Norfolk, Virginia. The connection across the Chesapeake Bay gives users on the network access to a large number of commercial providers. On the northern end of the network, the ESVBA connects with fiber in Maryland, enabling a completely redundant fiber loop around the entire Chesapeake Bay. Businesses will be able to locate in the ESVBA service area and have carrier class network redundancy for essential business services. The network is in the black and returns modest funds to the two counties.

Attribute	Description
Governance	The Eastern Shore of Virginia Broadband Authority (ESVBA) is a regional authority owned by the counties of Accomack and Northampton. The Authority has an independent, five person board of directors.
Funding	The U.S. Navy and NASA both have large installations on the Eastern Shore, and both agencies provided some seed funds for construction of the backbone. The Commonwealth of Virginia also provided additional start-up funds.
Business Model	The network is being operated as an open access network with an initial focus on business and institutional customers. Private sector service providers will offer all services to residents and businesses. Long term plans include expanding fiber services into the many small towns in the two counties, and several towns have begun planning for the effort.
Management	The Authority has one full time project manager and two part time staff providing administrative and some technical support. Network operations and outside plant maintenance will be outsourced to qualified private sector firms.
Technology	The ESVBA network uses active Ethernet and will provide symmetric 100 megabit, Gigabit, 10Gigabit, and DWDM connections. The Authority is also actively working with some wireless broadband providers to get fiber to some tower locations to improve access to broadband wireless services in the region.

NELSON COUNTY BROADBAND AUTHORITY

The Nelson County Broadband Authority received a BTOP broadband stimulus grant and built 20 miles of fiber backbone on Route 29 in the county in 2012. It is a Gigabit fiber network with 200 customers in late 2016. The Authority received additional grant funds in 2015 and is completing construction of additional fiber segments in the western part of the county, which brings the total fiber route to 31 miles. Demand for the fiber connections has been brisk in 2016 and there is a backlog connection requests. There are three service providers on the network offering a variety of residential and business class services. County staff provide significant oversight and financial management of the effort, and private sector companies provide day to day network operations and outside plant repairs and maintenance.

The Authority is currently evaluating expanding access to county-owned towers to improve access to fixed wireless broadband for areas of the county that are not near the existing fiber backbone.

Attribute	Description
Governance	NCBA is a one county broadband authority.
Funding	A mix of local funding and grants have supported capital expenditures and operating subsidies.
Business Model	The network operates as an open access network, with private sector providers offering all retail services to residents and businesses.
Management	Day to day network monitoring and operations is provided under contract by a private sector firm. County staff provide fiscal management and some technical support.
Technology	The network includes both active Ethernet (Gigabit connections are standard) and GPON.

LOUISA COUNTY BROADBAND AUTHORITY

The Louisa County Broadband Authority was formed in 2014 as a single county broadband authority. The board is comprised of members that each represent one of the magisterial districts in the county. In 2015 the Board completed a feasibility study that recommended a countywide tower system to improve access to fixed broadband Internet. In late 2015, the Board of Supervisors allocated \$1 million to the Authority to construct between six and eight towers around the county. Tower space will be leased to private sector service providers, and the tower system will include a high performance wireless backhaul network between the towers to provide data transport redundancy to the K12 schools, for county use, and to reduce the number of backhaul radios that service providers would otherwise have to provision themselves (which reduces interference). Construction is expected to begin in late 2016, with the first towers available to service providers in the spring of 2017.

Attribute	Description
Governance	LCBBA is a one county broadband authority.
Funding	Allocations from the Board of Supervisors have supported planning work and capital expenditures.
Business Model	The primary service offered by the Authority will be tower space, with the between tower wireless backhaul as a secondary source of revenue.
Management	A modest management contract for operations has been awarded to a Virginia-based network operations firm.
Technology	The backhaul network will be a fully redundant ring IP-based ring architecture.

THE WIRED ROAD

The Wired Road is an open access, open service network jointly owned and managed by Carroll and Grayson counties and the City of Galax (Virginia). The three localities formed a regional broadband authority and began construction in September of 2007. The first institutional customers were added to the network (Carroll County Public Schools, Carroll County, Crossroads Institute) in March of 2008. The Wired Road is not selling any services to businesses or residents; all services are offered by private sector service providers that use the network and pay the Authority for the use of the network via a revenue sharing agreement. The three governments see the network investments as a way of differentiating the region and providing a valuable economic development marketing tool. The Wired Road is being designed as an integrated fiber and wireless network, with fiber in the three major towns and all business parks, and wireless services as the initial offering in under-served rural areas where many residents are still on dial up. The long term vision is to provide fiber to every home and business that requests it.

The Wired Road has installed fiber to 60 buildings in downtown Galax, which is the commercial and business hub for the region. Fiber availability and the open access business model have created a dramatic reduction in the cost of Internet and phone services for businesses using the Wired Road network--with the savings reaching 70% for some businesses. The Galax fiber was installed using City public works department staff and took only two weeks, including two days of training. City crews now routinely are able to extend fiber to additional buildings as needed, and 25 new jobs were brought to downtown just months after the fiber was installed. The new jobs were placed in a formerly empty building, and the jobs were moved there because of the fiber availability.

The project has attracted additional funding, and more than \$2 million of additional middle mile and last mile fiber was completed in 2014. This work installed fiber to all lots in all three regional business parks, new fiber in Hillsville and Independence downtowns, a fiber to the home project in Grant Virginia, and additional fiber in Galax.

Attribute	Description
Governance	The Wired Road Broadband Authority is a regional authority set up under Virginia law. It is owned by the counties of Grayson and Carroll and the City of Galax. It has a five member board of directors.
Funding	The first phase of The Wired Road (completed in 2008) was funded with a mix of local government funds, a grant from the Virginia Dept. of Housing and Community Development, and a substantial contribution from the Carroll County Public Schools. The Wired Road has since raised over \$300,000 locally and received a total of nearly \$4 million in state and Federal grants.
Business Model	The Wired Road uses an open access, open services model, with all services to homes and businesses provided by private sector providers. Two wholesale providers and three retail providers are currently competing for services.

Attribute	Description
Management	The Wired Road has one full time project manager, and the Authority has a contract with WideOpen Networks, which provides network operations and management of outside plant maintenance and repairs.
Technology	The Wired Road is the first fully integrated fiber and wireless open access, open services network in the U.S. Fiber is deployed in the downtown commercial areas of Galax, Hillsville, Independence, and Grant, and The Wired Road has twenty-six wireless access points that covers about a third of the 1,000 square miles of mountainous terrain that comprises the service area. The standard fiber connection is a symmetric Gigabit connection, and wireless services vary.

Choosing the Business Model

Governments build and manage roads, but don't own or manage the businesses that use those roads to deliver goods and services. The tremendous versatility of the Internet and the underlying technology bases now allows services that used to require their own, separate (analog) road system (voice telephony and TV services) to be delivered alongside other services like Internet access on a single, integrated digital road system.

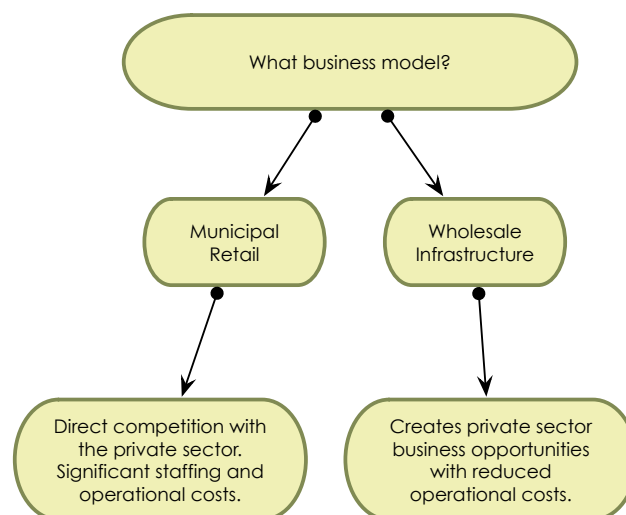


If we managed overnight package delivery the way we manage telecom, UPS and Fedex would only deliver packages to residences and businesses where each delivery firm had built a private road for their exclusive use. We recognize immediately the limitations of such a business model—few of us would have overnight package delivery to our homes because the small number of packages delivered would not justify the expense of building a private paved road.

Before the rise of the automobile, most roads were built largely by the private sector. After cars became important to commerce and economic development, communities began building and maintaining roads because it became an economic development imperative to have a modern transportation system in communities.

Before the rise of the Internet, digital networks were built largely by the private sector. As broadband has become critical to commerce and economic development, communities with digital roads are more competitive globally.

If the County decides to move forward with a broadband initiative, there are two business model options (which are determined in part by answering the previous question: “What is the role of government?”).



Features	Municipal Retail	Wholesale Infrastructure
Basic Concept	Typically just three services (voice, video, data) with little or no sharing of network capacity.	Improved efficiency because all providers share network capacity.
Government Involvement	Government competes directly with the private sector. Government decides what services are offered.	Government does not compete with private sector. Government provides high performance digital road system that benefits all public and private users. Buyers have rich set of choices.
Governance	Owned and operated by local government. Limited triple play services sold directly by local government.	May be owned by local government or by a community enterprise like a broadband authority or coop. Wide variety of services sold by private sector companies.
Competition	Government picks providers of each service. No incentive to lower prices.	Level playing field creates robust competition. Service providers drive down costs and provide great service to get customers.
Service Options	Limited. Government resells triple play services.	Determined by private sector service providers
Service Area Expansion	Limited by triple play approach, which keeps funds for expansion low.	Expansion developed organically based on funding and revenue from infrastructure leasing.
Risks	Government officials must predict business technology needs years in advance.	If limited to primarily passive infrastructure, operational costs and responsibilities are nominal. It is important to identify prospective service providers early in the process.

RECOMMENDATION

For Albemarle, the wholesale infrastructure business model is most appropriate. Albemarle County investments should be limited primarily to passive infrastructure (i.e. no network electronics, towers and tower space).

With respect to conduit and fiber, this is often called the “dark fiber” model, but passive infrastructure can and may include conduit, handholes, cabinets and shelters, and splice closures. This approach is an option that should be considered carefully, especially for smaller communities like Crozet, Rivanna and rural/residential neighborhood projects.

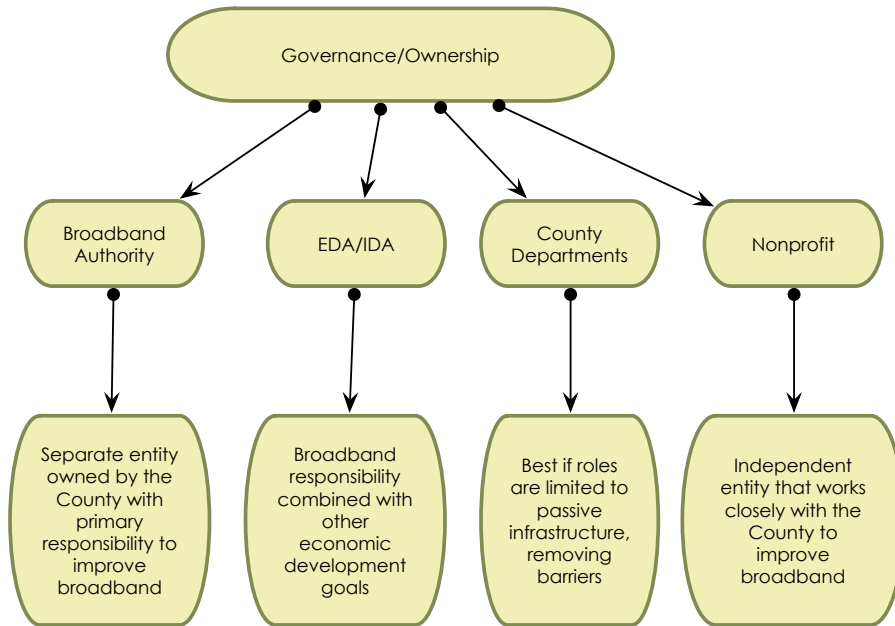
Space on new and existing towers would give rural residents an improved broadband option (fixed point wireless) offered by WISPs (Wireless ISPs). Adding four to six new towers in rural parts of the county would represent a relatively modest infrastructure cost (compared to deploying fiber widely).

Governance Options

For whatever infrastructure improvements Albemarle County may make, there will be a limited number of essential roles. If the improvements are limited largely to passive infrastructure, much of the routine responsibilities could be managed by County departments that might include IT, Public

Works, and Planning. If improvements include ownership of significant network equipment assets (e.g. network switches, wireless broadband radios, routers, etc.) an Authority structure may provide more flexibility than managing network assets inside

County government departments.



There are two (Municipal Department, Broadband Authority) that we recommend for consideration. Note that these two options are not necessarily mutually exclusive; some responsibilities and tasks may be performed best by existing County departments and staff, and an Authority may be better suited for other areas of focus.

- ▶ County Departments -- If County investments are limited to duct and dark fiber, the County could likely manage the infrastructure without significant new costs. Leasing tower space and leasing targeted duct/fiber infrastructure could create revenue streams that would have the potential to repay the County for any early capital costs and/or begin to contribute revenue for expansion over time. Projects like nDanville (City of Danville) and the Eastern Shore of Virginia Broadband Authority (Accomack, Northampton counties) are mature enough to cover their operating costs and make annual contributions to the city/counties general funds.
- ▶ Broadband Authority -- In Virginia, creating a Broadband Authority is a simple and straightforward process that can be done quickly. A broadband Authority must create a Board of Directors and develop a charter and set of bylaws. Broadband authorities are treated as a political subdivision, which has some benefits like bonding authority, although only one (the Roanoke Broadband Authority) has bonded for initial construction funds.

RECOMMENDATION

The size and scope of the challenges in meeting the near term and future needs of primarily rural residents and businesses in Albemarle suggests that an Albemarle Broadband Authority should be created and vested with the responsibility of improving broadband access in the County.

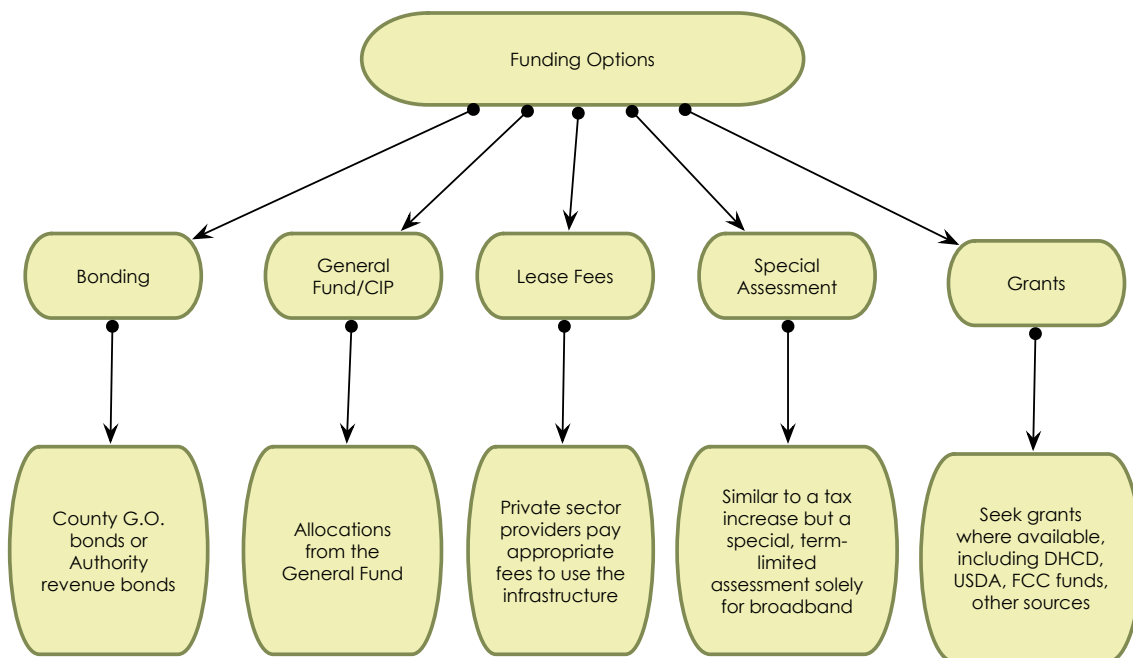
By creating an Authority, a single entity would could manage and coordinate a wide variety of activities effectively with less duplication of effort and overlap.

- Coordinate and manage grant funding opportunities, prepare grant applications, and manage grant funds.
- Coordinate expenditures of County CIP funds when available.
- Work directly with existing incumbent and competitive service providers to assist them in making service improvements, coordinating CAF2 expenditures (Connect America Fund round 2), and coordinating any joint funding opportunities (e.g. DHCD funds).
- Work closely with County departments (e.g. planning, IT, GIS, etc.) to remove barriers, simplify permitting, and track assets like towers and fiber/conduit.
- Collaborate with public safety initiatives, including shared space on existing towers and shared use of any new towers.

The Authority would have a volunteer board of directors, who would need business and management experience. The Authority would also need a budget appropriate to support at least one paid staff person and some additional funds to obtain technical expertise and assistance on an as needed basis. More information on forming an Authority is included in the Strategies section later in this report.

Funding Options

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



BONDING

Revenue bonds are repaid based on the expectation of receiving revenue from the network, and do not obligate the local government or taxpayers if financial targets are not met. In that respect, they are very different from general obligation bonds. Many kinds of regional projects (water, sewer, solid waste, etc.) are routinely financed with revenue bonds. We believe most community projects will finance a significant portion of the effort with revenue bonds. Obtaining funding using revenue bonds requires an excellent municipal credit rating and an investment quality financial plan for the operation and management of the network. In Virginia, broadband authorities can bond, and the Roanoke Valley Broadband Authority used the Virginia Resource Authority to assist with their bonding.

Revenue bonds must be used carefully, and a well-designed financial model is required to show investors that sufficient cash flow exists to pay back the loans.

General obligation bonds are routinely used by local governments to finance municipal projects of all kinds. G.O. bonds are guaranteed by the good faith and credit of the local government, and are not tied to revenue generated by the project being funded (i.e. revenue bonds). G.O. bonds obligate the issuing government and the taxpayers directly, and in some cases could lead to increased local taxes to cover the interest and principal payments. Some bond underwriters have indicated a willingness to include telecom funds as part of a larger bond initiative for other kinds of government infrastructure (e.g. adding \$1 million in telecom funds to a \$10 million bond initiative for other improvements).

GENERAL FUND/CAPITAL IMPROVEMENT PLAN

Some local governments are now routinely including a line item for telecom materials and expenditures in their Capital Improvement Plans (CIP). This creates a predictable, long term source of funding for broadband improvements over time. CIP funds might be used to maintain a modest County inventory of handholes and conduit that could be placed when other improvements are underway (e.g. sidewalk upgrades, street grinding and resurfacing, etc.).

LEASE FEES

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

SPECIAL ASSESSMENT

Communities like Bozeman, Montana and Leverett, Massachusetts have been funding broadband infrastructure improvements with special assessments (in Leverett, \$600/year for five years), and in Bozeman, TIF (Tax Increment Funding) is being used in some areas to add telecom conduit, handholes, and dark fiber.

GRANTS

Grant funding is limited and should be viewed as part of a larger basket of funding. Federal funds from sources like the USDA and the FCC are highly competitive and often come with substantial limitations on who can qualify and how the funds can be used. DHCD (VA Dept. of Housing and Community Development) provides some funding for planning, and they also administer CDBG (Community Development Block Grant) funds. CDBG funds can support telecom infrastructure construction but must be tied to job creation and/or job retention. In 2017, DHCD will have \$1.25 million in funds that can be requested by the county to give to service providers to support their improvements. Rules for how to apply for and spend those funds are still under development.

DHCD has \$2.5 million allocated (VATI, or Virginia Telecommunications Initiative) for community broadband improvements over the next two years (\$1.25 million per year). These funds were originally intended to be provided directly to localities that had completed early phase broadband planning studies (including the current Albemarle study), but the legislature

directed that the funds be channeled to service providers—with the collaboration of participating communities. There are likely to be several awards made, so the amount of the awards is likely to be modest. If six awards are made, the average award will only be about \$200,000. However, the private sector partner will also be expected to contribute funds, so the VATI award may be enough to enable the private sector partner to make an investment in an area that otherwise would not get upgrades.

At this time, the rules for distributing these funds have not been fully approved, but draft rules include the following guidelines:

- It will be a competitive process, and applications must be submitted by a unit of government (e.g. Albemarle County). At this time (early September, DHCD has indicated applications will be due in November, but this seems difficult given that rules are still in draft form).
- Funds must be requested for a well-defined “shovel ready” project.
- The funds must be used only for last mile service delivery in an unserved area (defined as less than 10 Meg down, 1 Meg up).
- A private sector applicant (e.g. an incumbent provider, a WISP, a competitive provider, etc.).
- Funding cannot be used in areas that qualify for CAF funding.

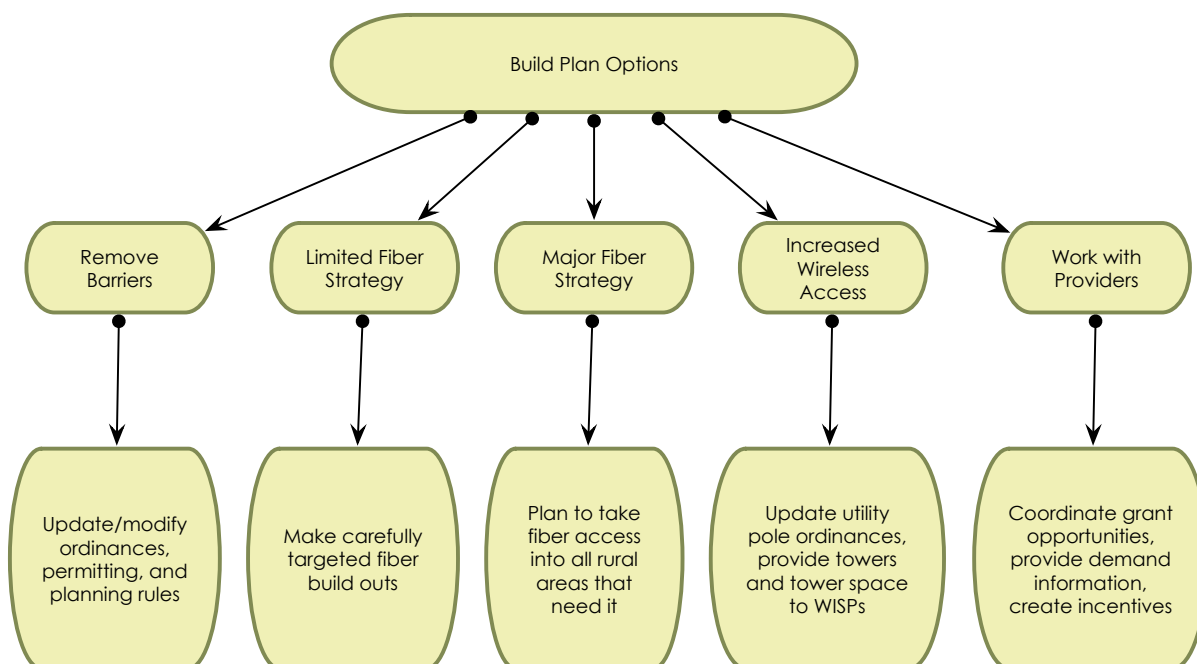
The impact of CAF 2 funding (Connect America Fund) on qualifying areas of Albemarle County is indeterminate. Based on past CenturyLink CAF awards, the company is likely to request and to receive CAF 2 funds, which would be used to upgrade existing DSL to provide better bandwidth. CenturyLink has provided only general targets and timelines for improvements in the county. The County should continue to meet with CenturyLink on a regular basis to provide the company with guidance on areas that are most in need of improved service.

RECOMMENDATION

Funding is going to be dependent upon the kinds of strategies the County and/or a new Broadband Authority want to pursue in partnership with the private sector. Grant funds are at best a supplement to local funds, and should not be viewed as a primary funding solution.

Competition for VATI funds is likely to be highly competitive, with numerous local governments submitting requests for a limited amount of funding. If Albemarle intends to pursue VATI funding, it will be necessary to initiate discussions with possible private sector partners early and to identify qualifying service areas and shovel ready projects.

Build Plan Options



It is not likely that there will be just one “build plan” for Albemarle County. Instead, the County is more likely to have to proceed in parallel with several initiatives.

As discussed previously, *removing barriers* can be an effective and early “win” at low cost. For example, providing “by right” ability of rural residents to place wood utility poles on their property (within specified guidelines) would make it easier for service providers to make a business case to offer improved access in rural areas of the county, as well as providing resident and rural businesses with an affordable solution.

A *limited fiber strategy* would identify certain smaller communities like Crozet and Rivanna as places where fiber infrastructure would encourage more growth in the Main Street areas of those places. Projects like this could attract CDBG grant funds and could be supplemented with modest County funds. Projects of this type would typically vary in cost from under \$500,000 to \$1 million.

A *major fiber strategy* would be to offer fiber to the home throughout rural areas of the county, using a demand-based strategy that only placed fiber in neighborhoods and down rural roads where residents agreed in advance to buy services. While the capital expenditure for such a venture would be substantial, this would generate a revenue stream over the long term that would pay back bonds or other funds used to support the build out. With an estimated 15,000 households and businesses in the rural/underserved areas of the county, this approach could cost \$50 million or more, spent over several years. It is worth noting that this could be funded by a “\$1/day” strategy: if each

household in an rural “fiber improvement zone” agreed to pay \$1/day for twelve years (about \$32/month), the entire capital cost of the effort would be fully funded.

Increased wireless access is an intermediate strategy that could produce improved access in a year or less, placing new towers in underserved and unserved areas of the County and leasing space to wireless providers. This would be most effective when coupled with ordinance changes that would give rural residents and businesses “by right” ability to place wood utility poles on their property.

In all cases, the County or the newly formed Broadband Authority will find it necessary and important to *work with providers*, especially providers that are open about their plans and demonstrate a willingness to be flexible in their approach to collaboration.

Broadband Strategies

Albemarle County is a diverse area with respect to broadband availability. Around the boundaries of the City of Charlottesville, residential suburbs and business/commercial areas have a choice of reasonably good DSL service or faster cable modem service. Fiber to the home has been rolled out by Ting, a newcomer, mostly inside the City limits. CenturyLink has made fiber service available in a limited area of Scottsville. But many areas of the county have poor DSL service, and some limited areas are listed as “unserved” on the U.S. Department of Commerce National Broadband Map.

With such sharp differences in connectivity in Albemarle County, there is no “one size fits all” solution that will meet every business, residential, and institutional need. The following pages provide a set of strategies: some can be applied to meet very specific needs in individual areas. Other strategies can be applied more broadly. These include:

Form a Broadband Authority — Albemarle County needs an organization with the primary responsibility of improving broadband access and affordability for rural businesses and residents.

Public/Private Partnerships — Any broadband improvements will require both public and private sector involvement.

County Tower Leasing — Where space is available on existing county-owned towers, make that space available to wireless providers. In rural areas where there are no towers, consider constructing new towers for fixed wireless broadband use.

Increased Wood Utility Pole Use — In rural areas of the county, given the difficult terrain (heavy tree cover, uneven topography), many rural residents may need a properly sited wood utility pole to “see” a broadband tower with wireless service. Provide incentives for increased use of these utility poles.

Conduit/Dark Fiber Strategy — A strategy of steady year by year development of telecom conduit placement in Designated Growth Areas could lead to increased availability of fiber services from private providers who would lease conduit. If the County also placed dark fiber in the conduit, additional revenue could be gained from the investments.

Meet-me Box and Fiber Drop Strategy — In both Designated Growth Areas and in some Urban Development Areas of the county, meet-me boxes and inexpensive fiber drops to nearby homes or business/retail locations could attract improved wireless services from service providers and/or promote increased competition.

Designated Growth Area Strategy — In some or all of the Designated Growth Areas, a combination of strategies (e.g. Conduit/Dark Fiber, Meet-me boxes) could increase competition, encourage better quality service from providers, increase bandwidth availability, and lower costs for Internet and other broadband services.

Cellular Tower Access — Some cell tower owners are beginning to recognize that there are advantages to allowing fixed wireless broadband providers to co-locate on their towers with their cellular customers. The County may be able to play a role in accelerating this process.

Demand Aggregation — A simple ongoing Web-based survey managed by the County that collects customer demand information (including location) could be distributed periodically to service providers.

Referendum — It may be useful to have a public vote on allocating funds for broadband improvements in the County.

FORM A BROADBAND AUTHORITY

In Virginia, broadband authorities are used for broadband network projects that require long term oversight. The Commonwealth of Virginia has created enabling legislation specifically for broadband authorities, and there about twenty that have been formed (about ten are active).

The Authority offers arms-length separation of routine decision-making from local government. A key benefit of an Authority is that it provides the oversight and management structure if participation from more than one local government entity is desirable. These regional agreements are widely used by local governments for the ownership and control of essential infrastructure that is better managed regionally.

The basic principle underlying this approach is to create an independent management and governance entity that operates on a non-profit/cost-plus basis and which is firmly vested in the community. Some of the advantages of this approach include:

- A single entity has the primary responsibility for improving broadband access and affordability in Albemarle County.
- Broadband authorities have revenue bonding authority, which provides a stable, long term financing solution. Revenue bond financing is particularly attractive as it does not affect the credit rating of the local governments involved and has little or no impact on local property tax rates.
- The enterprise is firmly vested in the community or region, as opposed to a private venture (e.g. a LLC or coop), and via the board of directors, the local governments can guide the long term goals and objectives of the organization.

OWNERSHIP AND GOVERNANCE

If a regional authority is planned, each participating local government must advertise and pass a resolution to join the authority. The minimum amount of time needed for this process is sixty to ninety days. Even if Albemarle County forms its own authority, a resolution and vote by the Board of Supervisors would still be required.

Broadband authorities are registered with the State Corporation Commission, which is a straightforward process with minimal paperwork. The authority has to have a charter document and a set of bylaws. The charter and bylaws could be drafted easily from the documents already developed by other Virginia broadband authorities.

A Board of Directors has to be appointed, with typically five to seven members. In a single county authority, there is often a board member for each magisterial district. In a multi-jurisdictional authority, each locality typically appoints one or two members. Board members should have substantial management and business experience. Not all members need to have a telecom background.

COST DISCUSSION

The direct cost of forming an authority is nominal. On an ongoing basis, an authority needs to have some funds available for a variety of projects if it is to be effective. Each participating locality should be prepared to provide a fair share of funding, with amounts based on mutually agreed upon projects and initiatives.

FUNDING OPTIONS

Authorities, as a political subdivision, are eligible to apply for many kinds of state and Federal funding. For large projects with an appropriately identified revenue stream, an authority can bond directly. The VRA (Virginia Resource Authority) is able to assist broadband authorities with revenue bond development.

OPERATION AND MANAGEMENT CONSIDERATIONS

An Authority can be started and managed without any paid staff, but that will depend on the level of support available from County departments and/or funding sources that the Authority can tap for support. The Authority is more likely to have a significant impact if it has at least one paid employee (which could be part time).

RECOMMENDATION

Rural businesses and residents in Albemarle need a strong advocate for broadband. Improvements to broadband access and affordability are more likely to be successful if there is a single entity in Albemarle County that has primary responsibility for those improvements. Current activities relating to broadband are spread across several County departments. The County Board of Supervisors should form an Authority and provide an appropriate level of initial funding.

FORMING AN AUTHORITY

The legal formation of the Authority is straightforward, with a simple registration form and fee submitted to the Virginia State Corporation Commission. Other steps prior to submitting the application should include:

- Resolution passed by the Board of Supervisors to create the Authority.
- Consensus among County leadership on whether or not to pursue a multi-jurisdictional Authority (e.g. with one or more adjacent counties, including Greene, Orange, Nelson, Augusta, Fluvanna, Rockingham, Buckingham, or Louisa). Note that Louisa and Nelson already have their own (one county) broadband authorities. If a multi-jurisdictional authority is deemed useful, each locality would have to pass its own resolution to join the regional authority.
- A charter for the authority has to be created. The charter is relatively short, and there are many samples available from existing authorities.
- A set of bylaws are required. As with the charter document, many examples are available from other authorities. Some of the bylaws governing seats on the authority board will

differ between an Albemarle-only authority and a regional authority. Single county authorities typically appoint board members by magisterial districts (e.g. each BoS member appoints a representative from their own district). Multi-jurisdictional authorities typically have one or two members from each participating locality. Authority boards meet monthly or quarterly depending on staffing, operational responsibilities, and funding.

- The Authority will require both initial funding and some ongoing financial support from the participating locality or localities. These funds may be relatively modest, but will be needed to support early costs (e.g. hiring a grant writer on an as-needed basis for grant opportunities, technical advice, and other start up expenses).
- For many Virginia broadband authorities, County staff often provide significant technical, financial, and administrative support. County staff who are going to be directed to provide support will need direction on amount of time to allocate to the Authority and the kind of support to provide. Some authorities have a part or full time staff member to provide leadership and to manage day to day interactions with service providers, incumbents, County staff, citizens, and other stakeholders (e.g. economic development entities, state agencies, etc.).

PUBLIC/PRIVATE PARTNERSHIPS

Because virtually any modern broadband network (and most older telecom networks) use public right of way for a large portion of network distribution, ALL efforts in Albemarle are going to be “public/private partnerships” at some level. The notion of the public/private partnership is exists along a continuum, with minimal public involvement on one end (i.e. only use of public right of way) to full public ownership on the other end.

SERVICE PROVIDERS

In Albemarle County, service providers are have to be part of the solution. No matter what investments the County chooses to make, service providers will have to use the new infrastructure to make the County investments successful. While in many respects telecom infrastructure investments share many similarities with other public utilities (e.g. roads, water, sewer) there is one fundamental difference. Other public utilities like water and sewer have a captive audience and the utility is able to operate as a monopoly—meaning the customer base can be taken for granted. Early discussions with service providers have been positive, with at least several providers expressing a readiness to offer services if the County makes new infrastructure (like tower access for WISPs) available at fair prices.

County telecom investments will be a public/private enterprise, and service providers are the primary customers of the County. Service providers cannot be taken for granted. Instead, a fair fee structure, high quality infrastructure, excellent maintenance and operations (where needed), and County flexibility on business agreements and pricing will be required to recruit and retain service providers.

Projects that are not successful in attracting service providers will fail. Affordable lease rates for tower space and/or fiber connections will attract service providers.

In 2017 and 2018, DHCD will be have \$1.25 million each year to award to localities, which in turn must work with local providers, who will be authorized to spend the funds for broadband improvements.

ALBEMARLE COUNTY PUBLIC SCHOOLS

The Albemarle County Public School system is moving ahead with an eRate-funded fiber network that will deploy as much as 100 miles of fiber to most schools in the county. Micro and macro cell radio systems are planned to extend wireless connectivity to homes near each school. The micro-cell radios have an effective range of 1.5 to 2 miles, and the larger macro cells have a range of up to 15 miles. Wireless connectivity will be limited to laptops and tablets provided to school children by ACPS. It is expected that as much as 95% of homes with school age children could have access to this free wireless coverage by 2019.

The County has the potential of partnering with the schools and install additional fiber for County, business, and residential use if the County agreed to cost-share the proposed construction costs (estimated at \$4.6 million).

TOWER SHARING

Existing and planned towers, especially those used or planned for expanded public safety, could be shared with wireless Internet Service Providers (WISPs). Most local government towers have spare vertical space could be upgraded to support wireless providers on those towers at relatively low cost. In unserved and underserved areas of the county where there are no County or public safety towers, new towers could be erected and offered to wireless service providers. Increased coordination among public safety uses, broadband use, and the planned expansion of towers on county school property could also reap benefits, with fewer towers providing better services for public safety, K12 broadband use, and general residential and business use. In particular, many of the existing public safety/first responder “dead zones” could be eliminated while simultaneously expanding rural broadband access.

The Albemarle County Public Schools (ACPS) have an initiative underway to place cell towers at K12 school locations, with one site approved recently by the Board of Supervisors. As part of the agreement with the cell tower owner, the schools will have free access a certain amount of tower space. ACPS plans to place their own radios in their allocated space to provide wireless broadband access to currently enrolled K12 students. It should be noted that the school service will be access controlled and only students with approved devices will be able to use the service. Other family members will not be able to use it. The County should explore working with the schools to negotiate free tower space both for K12 and for re-leasing by the County (or the Broadband Authority) to private sector service providers.

Any placement of new towers should be preceded by a careful viewshed analysis (how much area/users are likely to be able to receive service). Site acquisition and site preparation costs can affect the overall cost of such a project. Existing county properties (e.g. fire/rescue stations, county parks, dump transfer sites, etc.) may be candidates for towers.

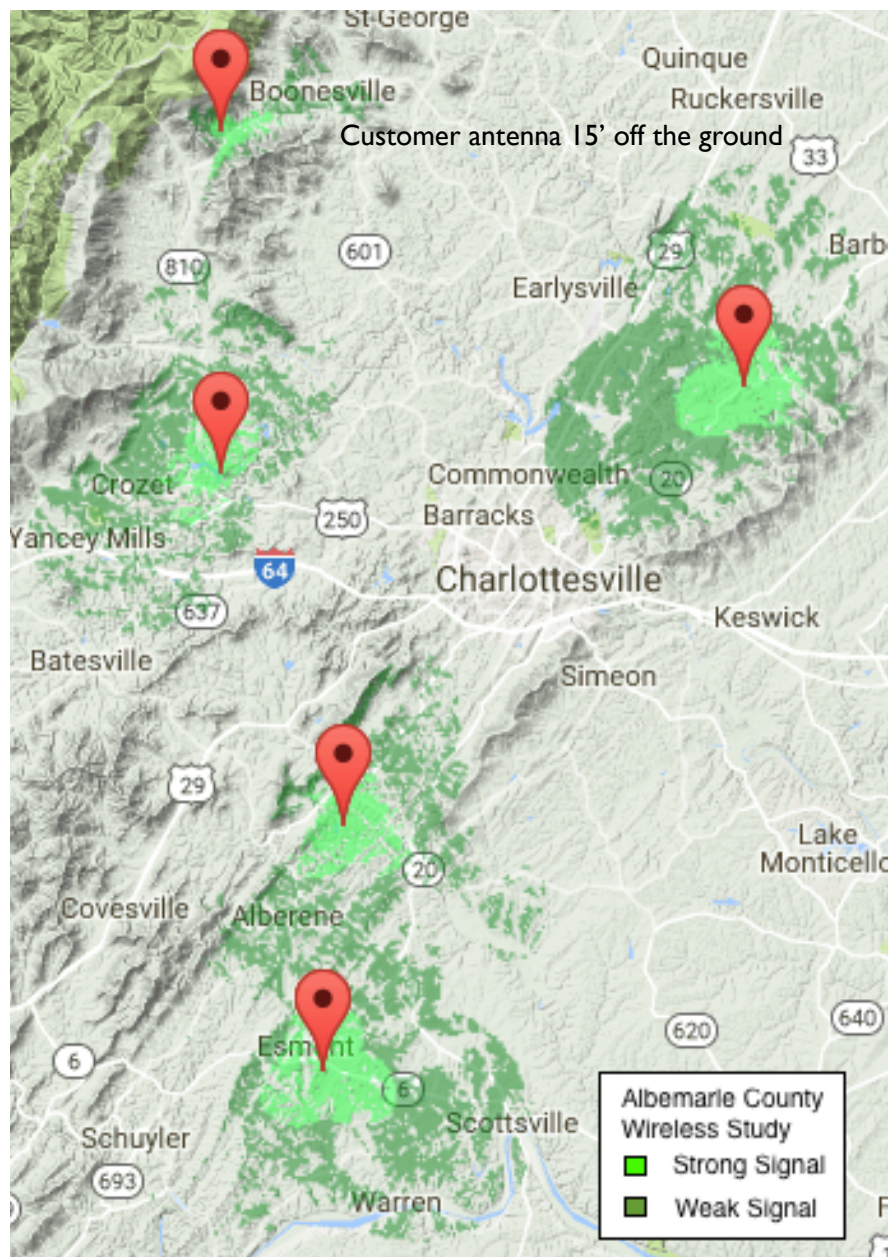
Tower space leased to wireless service providers (WISPs) can generate a small revenue stream, but the high cost of acquiring new wireless customers and the relatively low profit margins for in the wireless business will require only modest fees at best. The payback for the initial cost of a new tower could be fifteen years or more. At least one Virginia county is contemplating providing free or very low fee access to their towers with the goal of rapidly improving broadband access in their underserved areas.

The map on the next page shows what might be possible placing new towers on existing county-owned sites (fire/rescue locations and county parks). If some existing county towers have available space that could be made available to wireless providers, the number of new towers could be reduced.

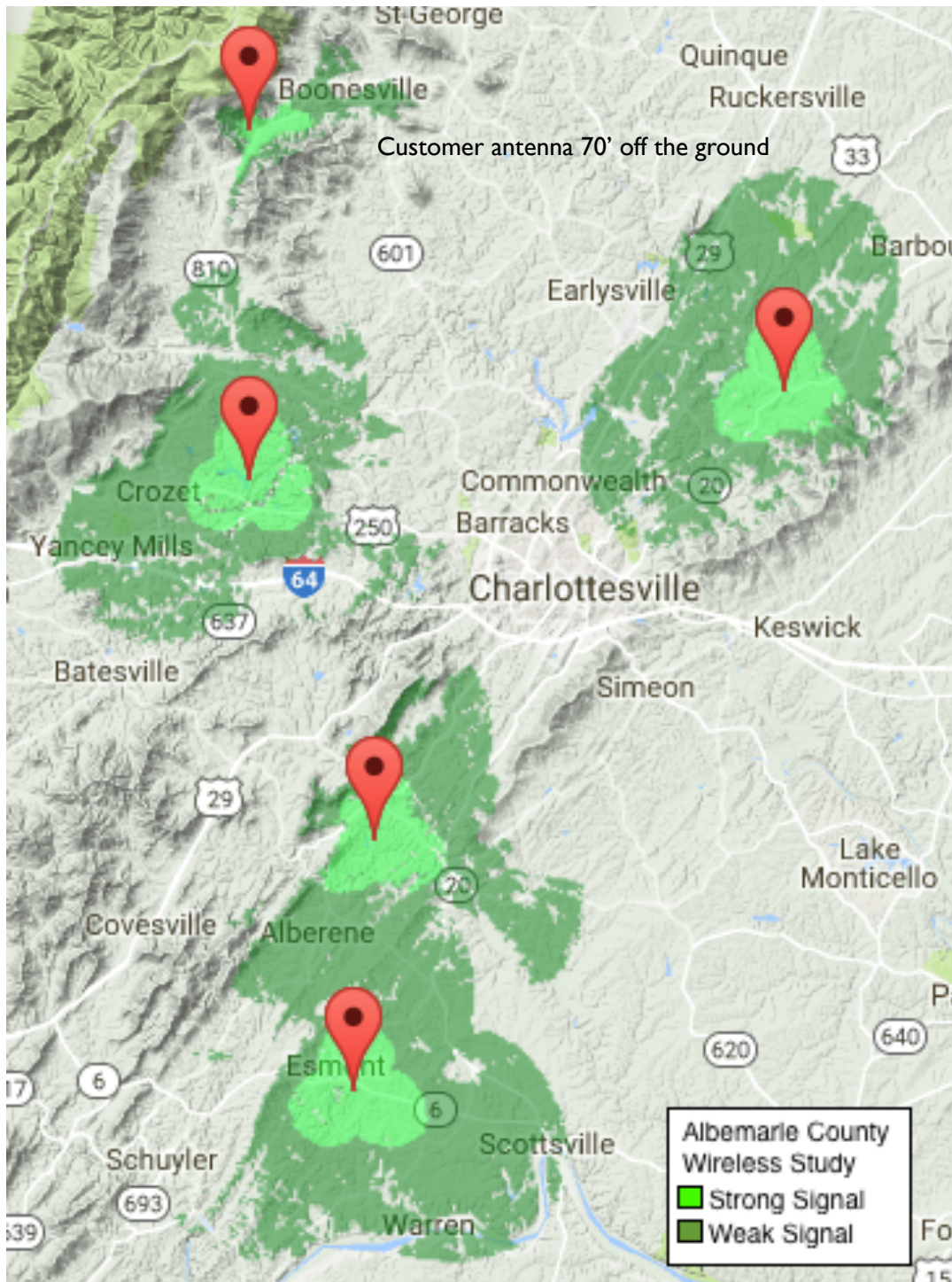
OWNERSHIP AND GOVERNANCE

New County or Authority owned towers would not require extensive day to day management. If generators are placed at tower sites (recommended), inexpensive monthly or quarterly generator maintenance is required.

The map below shows the potential coverage areas for 180 foot towers in the rural parts of the county when the customer receiving antenna is located 15 feet off the ground—typically fastened to the outside of the home or business. It is easy to see from the contour map how terrain and height of the receiving antenna affects areas of good coverage. It should be noted that current County tower ordinances should be reviewed to determine if changes are required. Height restrictions (e.g. a maximum of 120') may be viewed as advantageous from the perspective of maintaining the natural views of the county, it increases the total number of towers needed for both cellular and fixed broadband service coverage (and raises the overall cost of both of those services). There is also legislation pending at the state level that could remove much of the ability of localities to regulate wireless tower heights and locations.



The map below shows the potential coverage areas for 180 foot towers in the same locations as the previous map, but this study assumes that the customer receiving antenna is located 70 feet off the ground—attached to a wooden utility pole. The area covered by the towers is significantly increased when the receiving antenna can be located above existing tree cover.



COST DISCUSSION

Upgrades to existing towers typically may include adding or upgrading generators, additional cabinet or shelter space for service provider equipment, and sometime fencing and physical access changes.

TOWER UPGRADE COST TABLE

I	ITEM/PROJECT	UNITS	Estimated Cost (Conservative)	BEST ESTIMATE (WEIGHTED AVERAGE)
2	Small Telecom Cabinet	1	\$6,000	\$6,000
3	10kW Liquid Propane Generator	1	\$6,000	\$6,000
4	Cabinet Foundation and Installation	1	\$800	\$800
5	Spare Fuses	1	\$20	\$20
6	Power System Installation Materials	1	\$40	\$40
7	Samlex 1000W Inverter	1	\$450	\$450
8	Samlex SEC1230-UL Battery Charger	1	\$300	\$300
9	100ah 12v Non Spillable Backup Battery	1	\$350	\$350
10	DC Voltage Monitoring Device	1	\$60	\$60
11	Unmanaged Rack Mount PDU (6O)	1	\$45	\$45
12	Cabinet Installation Labor	1	\$1,000	\$1,000
13	Power System Installation Labor	1	\$500	\$500
14	Generator Installation Labor	1	\$1,700	\$1,700
15	Project Management		18%	\$3,108
16	Estimated Construction Cost			\$20,373

New towers have a range of configurations and cost options. If located on existing County property, the time needed to plan for construction can be shortened. If site acquisition or a site lease (of private property) is required, purchase or lease negotiations can add several months to the process.

NEW TOWER COST TABLE

I	ITEM/PROJECT	UNITS	COST(HIGH)	BEST ESTIMATE (WEIGHTED AVERAGE)
2	Small Telecom Cabinet	1	\$3,000.00	\$3,000
3	10kW Liquid Propane Generator	1	\$6,000.00	\$6,000
4	Cabinet Foundation and Installation	1	\$800.00	\$800
5	New Power Service / Installation	1	\$1,250.00	\$1,250
6	180' Self Supporting Tower Construction Materials	1	\$22,000.00	\$22,000
7	Spare Fuses	1	\$20.00	\$20
8	Power System Installation Materials	1	\$40.00	\$40
9	Samlex 1000W Inverter	1	\$450.00	\$450
10	Samlex SEC1230-UL Battery Charger	1	\$300.00	\$300
11	100ah 12v Non Spillable Backup Battery	1	\$350.00	\$350

12	DC Voltage Monitoring Device	I	\$60.00	\$60
13	Unmanaged Rack Mount PDU (60)	I	\$45.00	\$45
14	Tower Site Land Clearing and Site Development	I	\$12,500.00	\$12,500
15	180' guyed Tower Construction Labor	I	\$26,000.00	\$26,000
16	Cabinet Installation Labor	I	\$1,000.00	\$1,000
17	Power System Installation Labor	I	\$500.00	\$500
18	Generator Installation Labor	I	\$1,700.00	\$1,700
19	FCC License Coordination	I	\$1,500.00	\$1,500
20	Construction Total:			\$77,515
21	Project Management, Network Engineering, Testing			\$23,260
22	Site Engineering, Surveying, viewshed analysis Etc.			\$9,500
23	Misc Fees, Technical Services			\$7,500
24	Bookkeeping and Administration			\$5,000
25	Contingency			\$12,280
26	TOTAL:			\$135,055
27	Notes/Assumptions: Site work - Land acquisition and leases are not included in tower estimate. Site preparation is estimated and assumes a typical site with some small vegetation and work needed. If a site will require more extensive land clearing or road improvement work it should be estimated on a site by site basis. Generator - a small liquid propane generator is included in the estimate for this tower. The estimate does not include a tank and tank install because in our experience this cost is typically covered by the local gas company as long as there is a service contract. Cellular Carriers and Upgrades - Towers at this size must be specifically engineered for their location and equipment load. The pricing shown above is estimated at a size which will support WISP and Public Safety equipment. Designing to accommodate cellular providers should be expected to increase the cost by \$75,000 to \$150,000.			

FUNDING OPTIONS

The relatively low cost of tower upgrades and new tower construction suggests the most expedient funding is direct financial support from the County. If grant funds are needed (e.g. several new towers are proposed), working with public safety officials to combine public safety grant opportunities and public safety capital funds could be very beneficial.

OPERATION AND MANAGEMENT CONSIDERATIONS

Towers are passive infrastructure, and if properly designed and constructed, require minimal maintenance. Leasing space to the service providers, who will install their own radios, antennas, and electronics relieves the County of any responsibility for equipment management and configuration, and equipment repairs and replacement. Service providers will be required to do their own tower climbs and repairs to equipment on the tower; the County would not be responsible for any equipment placed on the tower itself.

RECOMMENDATION AND NEXT STEPS

An preliminary analysis of existing county towers and potential county-owned sites for new towers suggests that good coverage could be obtained with careful site analysis. If the County moves forward with this initiative, line of sight and viewshed studies are recommended for

existing towers and for any possible new sites. Discussions with wireless service providers to get their input on where they see benefits for improved tower access are also recommended.

Next steps would include securing funding, line of sight and viewshed analysis of existing sites, identification of county-owned property for new towers, line of sight and viewshed analysis of the new sites, determination of tower type for new towers (guyed or self supporting), and discussions with service providers. final identification of sites, complete detailed network engineering including site layouts and Line of Sight engineering, and work with local Service Providers.

NEW TOWER SITING CONSIDERATIONS

There are many factors in choosing sites to develop for towers. The cost of site prep in an area with unfavorable conditions can quickly outweigh the cost of the actual tower.

- Favorable site leasing or purchasing conditions such as County properties, infrastructure sites, industrial areas, or areas with other towers.
- The site must be useful to the network from the wireless engineering standpoint. Evaluate how the new site will fit into the wireless network and determine if it desirable early in the process.
- Proposed tower sites should be close to a road and accessible by truck. Improving access to a site and repairing damage caused by construction is expected, but constructing new roads on a site will increase costs dramatically.
- Proposed sites should be close to grid power. While evaluating a site locate the nearest utility poles or pedestals. If there is no transformer near the site, within 500 feet, there will likely be higher costs to bring power in.
- Mostly flat, or gently sloping sites cost less to develop than sites with steep terrain. When considering tower sites look for flat areas to place the tower and compound. It may be worth sacrificing some altitude or doing some additional clearing to avoid major ground disturbances and earth work.
- It is common to clear some trees and vegetation while developing a tower site, but excessive clearing requirements will raise costs. If sites are in a wooded area look for locations where vegetation is sparse and the tree growth is somewhat young (e.g., 8-10" in diameter). Large trees or very dense brush will be more expensive to clear.
- Look for secure sites with limited access. Sites are better off in an area that doesn't get frequent visitors.
- Look for tower sites with the potential to connect to fiber networks. Access to multiple fiber providers on a wireless network will be very important to potential tenants and the economic viability of the network.

Things to avoid:

- Avoid dense residential areas and retail areas when evaluating tower sites.
- Avoid parcels with creeks or other water features that could be an impediment to construction.
- Large concrete trucks will have to access the site while constructing the towers. During site evaluation consider the entire route that trucks will have to take.
- Avoid locating tower sites near areas where permitting could be an issue. Historic Districts, airports, scenic locations, and areas with strict zoning should be avoided.

TYPICAL CONSTRUCTION SCHEDULE

The timeline and activities describe the typical process for constructing a tower. Combining multiple sites into a single construction project will expand the timeline below but overall will save time and expense. Delays in the site identification and procurement stages of a project are the most common delays for counties and cities.

MONTH ONE

- ▶ Project kick-off
- ▶ Site identification
- ▶ Network design

MONTH TWO

- ▶ Pre-construction site planning
- ▶ Lease / MOU negotiation
- ▶ Procurement

MONTH THREE

- ▶ Site layout and planning
- ▶ Site clearing and preparation
- ▶ Tower materials shipping

MONTH FOUR

- ▶ Foundation construction
- ▶ Inspection
- ▶ Tower construction
- ▶ Construction wrap-up

MONTH FIVE

- ▶ Equipment installation and network testing
- ▶ Project close out

INCREASED WOOD UTILITY POLE USE

Albemarle County shares the same difficult terrain challenges that many other counties in western and central Virginia have: mountainous/rolling terrain and heavy tree cover. The tree cover is a constant problem for rural residents and businesses, as good line of site is required for fixed wireless Internet services. Even newer technologies like white space and LTE systems work better with clear line of sight to distant towers.

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



OWNERSHIP AND GOVERNANCE

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

COST DISCUSSION

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

FUNDING OPTIONS

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

OPERATION AND MANAGEMENT CONSIDERATIONS

The County would incur no ongoing operational or management costs.

RECOMMENDATION AND NEXT STEPS

Given that this strategy requires minimal financial support from the County and has the potential of improving broadband access in rural areas of the county quickly, the County should consider offering “by right” permitting of wood utility poles in rural parts of the county, including allowing a minimum of fifteen feet above existing tree cover and subject to a very limited set of restrictions (e.g. a minimum set back from public right of way).

County support for an awareness campaign developed with local wireless service providers would also be beneficial.

MEET-ME BOX AND FIBER DROP STRATEGY

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



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

OWNERSHIP AND GOVERNANCE

The meet-me boxes and related fiber, conduit, and handholes could be owned by the County or a broadband authority.

COST DISCUSSION

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

FUNDING OPTIONS

In some areas, where it can be shown that this infrastructure is going to keep existing jobs and/or add new jobs, CDBG funds may be available to support the initial capital costs. Some local match (e.g. 10% to 20%) may also be required.

Providers will pay monthly lease fees for the fiber strands they use to connect customers, and these fees will cover some or all of the ongoing operational costs. The greater the number of connected customers, the larger the revenue potential.

OPERATION AND MANAGEMENT CONSIDERATIONS

The cabinet requires electric power and has integrated heating and cooling. Service providers using the infrastructure would install their own equipment and be responsible for the maintenance and repairs of their own equipment.

For routine and emergency break-fix maintenance on the fiber or the cabinet HVAC, a small as-needed repair contract would be required with a firm qualified to make fiber splicing repairs and related service work.

Emergency repairs would be rare, and routine maintenance would also be very limited. It would be possible for the county IT and Public Works departments to support some of the routine management of this infrastructure. Monitoring and repair management could also be outsourced. If an Authority were formed, the Authority would probably choose to outsource all responsibilities except contract management (i.e. contracts with repair and monitoring firms).

RECOMMENDATION AND NEXT STEPS

Because this requires owning and managing infrastructure, the County will need to discuss how to handle the ownership of these assets and the ongoing operational responsibilities.

ECONOMIC/COMMUNITY DEVELOPMENT AREA IMPROVEMENTS

Dark fiber availability in smaller communities like Crozet and Rivanna , business parks, and industrial parks can increase property values, help attract businesses and jobs, and lower the cost of bandwidth. The Meet-Me Box strategy discussed previously is a specific instance of this more general strategy of identifying areas where improved telecom services are desirable to more effectively manage growth—improved telecom infrastructure can attract both businesses and residents to those areas where the improvements exist.

In new residential green field projects, developers should be encouraged through proffers and other planning tools to install the conduit, handholes, and drop conduit as part of their normal utility infrastructure improvements. Conduit would be routed back to a cabinet or small pre-fab shelter, where service providers could “meet” the sub-division customers.

These fiber-connected sub-divisions would become highly desirable places to live and to work. If developers install the infrastructure and turn it over to the County along with other infrastructure (e.g. water, sewer, sidewalks, roads, etc.), the County has little or no capital costs but gains improved property values. Homes with fiber are estimated to be worth \$5,000 to \$7,000 more than homes that lack fiber.

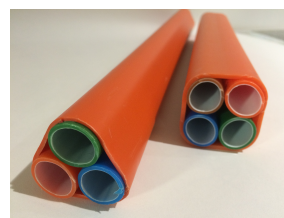


OWNERSHIP AND GOVERNANCE

The County could manage these investments directly, using existing IT and Public Works departments, or it could choose to form an Authority.

COST DISCUSSION

The cost of installing conduit and handholes can vary widely. Public Works departments can easily be trained to install the inexpensive plastic conduit (ranging in cost from under one dollar per foot to two or three dollars per foot depending on size and capacity). Similarly, handholes (pull boxes) are also easily installed with a minimum of training. This work can also be outsourced to qualified private sector firms.



One strategy to minimize the labor cost of installation would be to coordinate conduit installation with other projects like road remediation (install conduit before grinding and repaving), sidewalk and alley improvements, or other joint trenching/construction opportunities—only in previously identified areas where these improvements have been designated as important.

FUNDING OPTIONS

An annual budget allocation in the Capital Improvements Plan would allow Public Works to keep a small inventory of conduit and handholes on hand and to install them as needed in desirable areas. Over time, as shorter segments of conduit are connected together and become valuable to providers, the county could have fiber cable installed and make it available on a lease basis for providers.

OPERATION AND MANAGEMENT CONSIDERATIONS

Conduit and handholes require no routine maintenance. If dark fiber is installed, fiber break-fix repairs should be outsourced. A small as-needed repair contract would be required with a firm qualified to make fiber splicing repairs and related service work.

Emergency repairs would be rare. It would be possible for the county IT and Public Works departments to support some of the routine management of this infrastructure. Monitoring and repair management could also be outsourced. If an Authority were formed, the Authority would probably choose to outsource all responsibilities except contract management (i.e. contracts with repair and monitoring firms).

RECOMMENDATION AND NEXT STEPS

A successful implementation of this approach would require a multi-year commitment and annual funding allocations to support it. The County must decide on the management approach (e.g. managed via existing County staff and departments) or if it would prefer to form an Authority.

CELLULAR TOWER ACCESS

Some cellular tower owners are becoming more open to leasing tower space to wireless Internet Service Providers (WISPs) and/or local government. It may be possible for the county to negotiate a lease for vertical space on all towers belonging to one tower company, and then sub-leasing that space to local WISPs. The advantage to this approach is that service providers gain access to several towers at once with pre-negotiated space on each tower. This would make it easier for the providers to expand availability of their services in the county.

OWNERSHIP AND GOVERNANCE

The County would not have any asset management responsibilities. Service providers that took advantage of the bulk lease opportunity would be responsible for climbing the towers and maintaining their own network equipment and radios.

COST DISCUSSION

The cost of this opportunity would be determined by:

- The per tower cost of leasing space. Providers generally want a minimum of ten feet of vertical tower space.
- The number of towers deemed useful to expanding fixed point wireless service. Cell towers tend to be clustered along major roads and arteries (e.g. I-64, Route 29), so not all towers available from a single tower firm might be useful.



The cost would also be affected by the amount of space leased: a single ten foot segment of the tower, or two ten foot segments (thereby allowing two providers on the same tower).

Preliminary discussions about this approach with a major tower owner suggests that the County might have to subsidize a portion of the cost for some limited period of time while the WISP(s) build up the number of customers they have receiving access from that tower(s).

FUNDING OPTIONS

The County should charge the wireless providers at least some portion of the cost of maintaining the master lease. As providers develop the customer base from a tower or towers, a graduated fee scale could eventually phase out County subsidies.

OPERATION AND MANAGEMENT CONSIDERATIONS

No asset management required. The County would have to manage one or more master lease agreements with the tower companies, and a very small number of sub-lease agreements (probably no more than two) with WISPs.

RECOMMENDATION AND NEXT STEPS

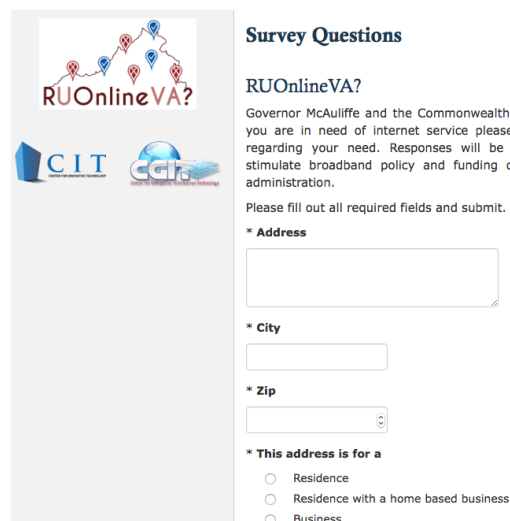
The County IT Department could initiate a pricing conversation with one or more companies that own towers in the county. American Tower has indicated a willingness to initiate a discussion, and the company owns eighteen towers in the county.

DEMAND AGGREGATION

A very brief survey that collects address information and bandwidth needs can collect valuable demand data that can be passed on to ISPs and/or help direct County infrastructure investments. For both wireline and wireless services, neighborhoods (often as few as a handful of homes) can aggregate their demand to attract improved service from ISPs.

The Commonwealth recently announced a broadband survey (RUOnline.virginia.gov) that collects similar information. If that data is available from the state or Virginia Tech (Tech is managing the survey site), there may not be a need to duplicate that survey at the county level.

This may be one of the least expensive and most effective strategies that the County and/or an Authority could pursue. While it could be argued (with some justification) that the incumbent providers like Comcast and CenturyLink should already be doing this, they are doing it only in a limited fashion or not at all (CenturyLink has begun to do some this). This is an excellent public/private partnership initiative that has the potential to improve broadband access in rural parts of the county by showing the incumbents that the demand for better service exists and identifying where it exists.



OWNERSHIP AND GOVERNANCE

No asset management is required. This effort could be managed by the County IT department. Some additional marketing and public awareness work would be needed to collect enough data from county residents and businesses to be useful.

COST DISCUSSION

A small amount of County staff time would be needed to support the data collection/distribution task and the public awareness effort.

FUNDING OPTIONS

No special funding required.

OPERATION AND MANAGEMENT CONSIDERATIONS

None.

RECOMMENDATION AND NEXT STEPS

Discussion by the Board of Supervisors.

REFERENDUM

It may be useful to have a public vote on allocating funds for broadband improvements in the County. Properly presented to the public, it could be an excellent opportunity to educate the public on the cost of demanding that local government “do something.” This approach could have two very different but positive outcomes.

- If the voters were asked to support a tax increase or special assessment to support improved broadband in rural areas of the county and they voted “no,” it could take some of the pressure off the Board of Supervisors to ‘do something.’
- If the voters agreed to support a tax increase or special assessment, then the Board of Supervisors would have a mandate to fund solutions.

COST DISCUSSION

County staff time would be needed to develop the cost proposition that would be placed on the ballot. Additional effort would be required to provide an appropriate public awareness campaign to educate the public on the meaning and purpose of the referendum.

FUNDING OPTIONS

No special funding required.

OPERATION AND MANAGEMENT CONSIDERATIONS

None.

RECOMMENDATION AND NEXT STEPS

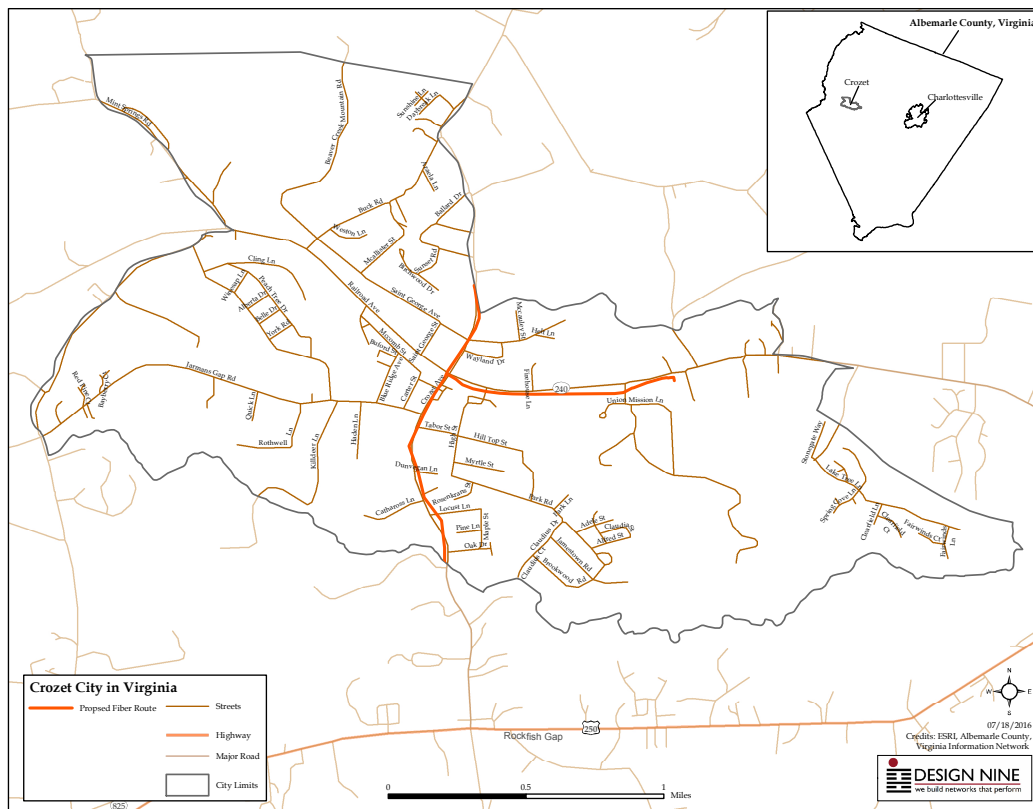
Discussion by the Board of Supervisors.

Fiber Deployment Cost Estimates

Preliminary cost estimates for deploying fiber infrastructure in Crozet and Rivanna are provided in this section. These estimates provide specific examples of the Meet-Me Box and Conduit/Dark Fiber strategies discussed previously.

CROZET

This estimate has been designed to provide dark fiber availability and a meet-me box in the core town area of Crozet. As seen in the Infrastructure Overview table on the next page, this includes about four miles of conduit and dark fiber, seventy handholes for customer drop cable access, and this could provide access to 100+ customers. The cost per building is relatively high because of the small number of buildings connected and the need for a relatively large amount of distribution conduit and fiber relative to the number of connected premises. If more buildings/customers were added incrementally once the initial “phase one” is complete, the cost per building would decline.



Infrastructure Analysis

1	ITEM/PROJECT	ESTIMATED
2	Total cost per mile	\$165,850.46
3	Distribution construction cost per mile	\$115,758.85
4	Distribution cost per mile (no drops)	\$95,082.16
5	Total Cost per building connected	\$6,617.43
6	Drop Costs per building connected	\$825.00

Crozet Infrastructure Overview

1	ITEM/PROJECT	VALUE
2	Miles of Fiber / Conduit Installed	3.99
3	Number of Handholes Installed	70
4	Splice Closures Installed	34
5	Cabinets Installed	1
6	Number of Customers Connected	100

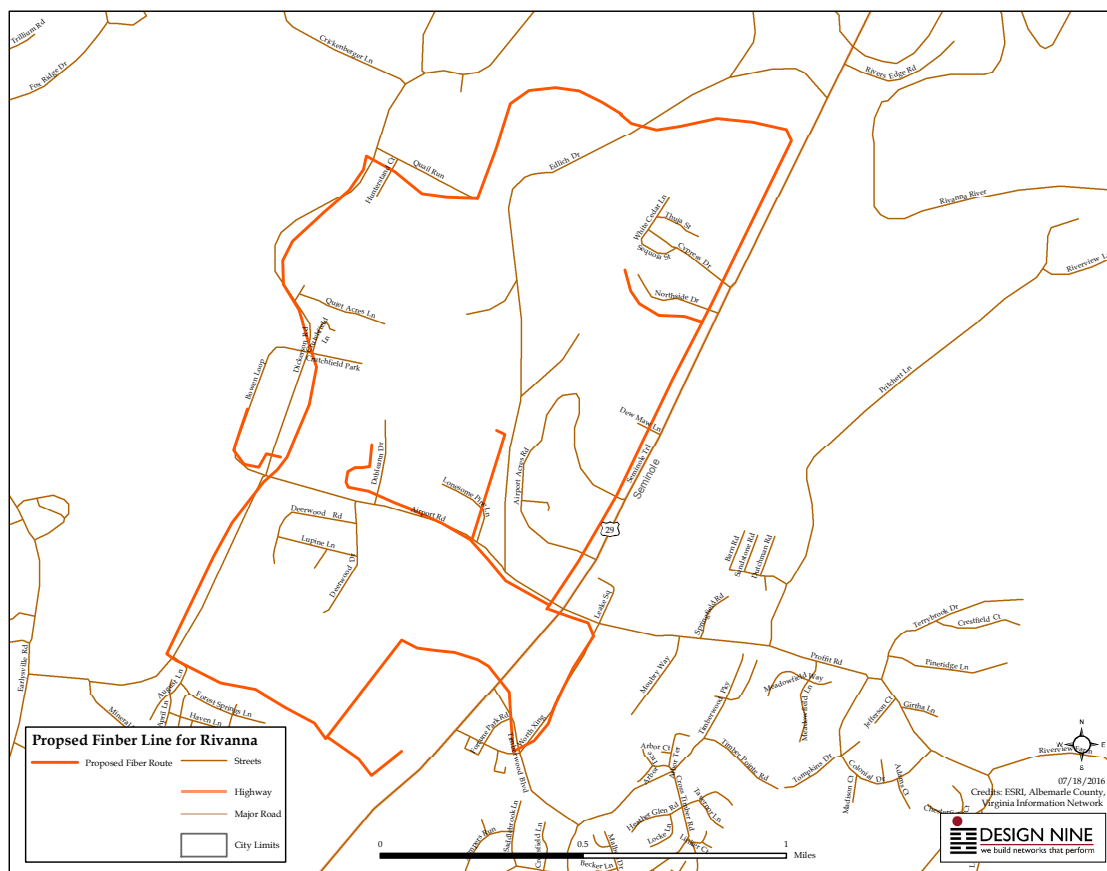
Crozet Summary of Costs

1	ITEM/PROJECT	ESTIMATED
2	Crozet Dark Fiber Construction Materials	\$148,792.01
3	Crozet Dark Fiber Distribution Labor	\$208,370.82
4	Crozet Dark Fiber Structures, Cabinets, and Equipment	\$22,215.00
5	Crozet Dark Fiber Drop Construction	\$82,500.00
6	Network Construction Subtotal	\$461,877.83
7	Project Management, Network Engineering, Integration, and Testing	\$55,425.34
8	Engineering, Permitting	\$69,281.67
9	Misc Fees, Advertising, Technical Services	\$10,000.00
10	Bookkeeping and Administration	\$5,000.00
11	Other Costs Subtotal	\$139,707.01
12	Project Total (No Contingency)	\$601,584.84
13	Contingency at 10%	\$60,158.48
14	Project Total (with contingency)	\$661,743.32

RIVANNA

This study includes more conduit/fiber route miles (7.5 miles) than the Crozet study and includes a complete loop, which can provide network redundancy—a highly desirable design element of fiber networks—a fiber cut on a redundant fiber loop will not cause loss of service.

This estimate also assumes a “first phase” connection to 100+ businesses and homes and a single meet-me cabinet where service providers would connect to the dark fiber network. The cost per building pass is high because of the larger amount of conduit/fiber routes miles, but like the Crozet analysis, adding more connected premises would bring that amount down.



Rivanna Infrastructure Overview

1	ITEM/PROJECT	VALUE
2	Miles of Fiber / Conduit Installed	7.52
3	Number of Handholes Installed	132.35
4	Splice Closures Installed	34
5	Cabinets Installed	1
6	Number of Customers Connected	100

Rivanna Infrastructure Analysis

1	ITEM/PROJECT	ESTIMATED
2	Total cost per mile	\$139,972.36
3	Distribution construction cost per mile	\$98,624.35
4	Distribution cost per mile (no drops)	\$87,653.60
5	Total Cost per building connected	\$10,525.92
6	Drop Costs per building connected	\$825.00

Rivanna Summary of Costs

1	ITEM/PROJECT	ESTIMATED
2	Rivanna Dark Fiber Construction Materials	\$273,770.35
3	Rivanna Dark Fiber Distribution Labor	\$363,169.75
4	Rivanna Dark Fiber Structures, Cabinets, and Equipment	\$22,215.00
5	Rivanna Dark Fiber Drop Construction	\$82,500.00
6	Network Construction Subtotal	\$741,655.10
7	Project Management, Network Engineering, Integration, and Testing	\$88,998.61
8	Engineering, Permitting	\$111,248.26
9	Misc Fees, Advertising, Technical Services	\$10,000.00
10	Bookkeeping and Administration	\$5,000.00
11	Other Costs Subtotal	\$215,246.88
12	Project Total (No Contingency)	\$956,901.97
13	Contingency at 10%	\$95,690.20
14	Project Total (with contingency)	\$1,052,592.17

Appendix A: Broadband Technologies

In Albemarle County, there is no one technology that is going to provide a “one size fits all” solution for homes, businesses and institutions. In some smaller communities and neighborhoods in the county, fiber build outs will be an important economic development and quality of life requirement.

In other parts of the county, improved DSL and one or more wireless technologies will continue to be important for some years. Over time, fiber connections will become more widely available, just as basic telephone and electric service became more widely available over a period of years in the early part of the twentieth century.

TELEPHONE/DSL

DSL (Digital Subscriber Loop) technology utilizes existing copper twisted pair telephone lines to provide broadband services. There are many variants of DSL, and the differences among them are primarily bandwidth and distance. Most DSL systems are limited to a maximum of 18,000 cable feet from a telephone switch or remote access module (DSLAM). Faster variants of DSL are limited to as little as a few thousand feet, making the service areas inconsistent from a subscriber perspective. A neighbor a few houses away from a home with DSL service may be told that no DSL service is available (because of the cable limitations). Current low cost DSL residential service offerings are priced competitively compared to cable modem service, but also tend to be much slower.

Because of the requirement to deploy DSL equipment close to subscribers, many areas of the country with older telephone copper-based local cable are at a distinct disadvantage for DSL. It is not uncommon in rural areas to have cable runs of many miles (from a telephone switch), making DSL impractical without substantial equipment upgrades. Even if a home or business is located within the prescribed distance to DSL equipment, older copper twisted pair cable may not be capable of handling the DSL signal properly. In some cases, speed of the service is degraded, and in other cases, DSL may not work at all.

The primary problem with DSL is the lack of capacity over the long term. In an optimum DSL situation, with high quality cable plant and subscribers close to DSL switches, the fastest DSL is limited to 15 to 20 megabits under these optimum conditions and short distances from network nodes or switches. Most homes will never be able to receive DSL services at those speeds because of sub-optimal service conditions, including old physical plant and distance. DSL cannot provide the capacity needed by businesses and residents in the near future.

From a local network investment standpoint DSL is a mediocre option at best given several limitations. In addition to the limitations above, DSL supports a single service (typically Internet) and a single Service Provider. While additional services may be provided “over-the-top” of the DSL Internet connection, those services are limited by the capacity of the primary service.

DSL CHARACTERISTICS

Bandwidth DSL is particularly plagued by line noise and distance limitations. As such the bandwidth in this table should be viewed as an "up to" limit and delivered bandwidth may be less.	DSL - 1.544Mbps (ITU-T G991.1) ADSL - 8 Mbps/640 Kbps (ANSI T1.413) ADSL2 - 12 Mbps/768 kbps (ITU-T G992.3) ADSL2+ - 24 Mbps/768 kbps (ITU-T G.992.5) VDSL - 52 Mbps/2.3 Mbps (ITU-T G993.1) VDSL2 - max sum in both directions 200 Mbps @ 1600' G.Fast - max sum in both directions 1 Gbps @ 328'
Line sharing	Individual subscribers do not share their upload/download speeds, but each cabinet will only support up to a maximum of what it is provisioned for. This is particularly important in rural networks where the cabinet are often provisioned with synchronous telecommunications services which are severely limited in bandwidth.
Latency	Latency is not an issue in DSL last mile connections, but due to bandwidth limitations at the cabinet, may be a factor due to queueing and competition for bandwidth at the middle mile. DSL with a fiber optic middle mile connection would reduce latency problems.
Symmetric/Asymmetric	DSL - Symmetric ADSL - Asymmetric ADSL+ - Highly Asymmetric ADSL2+ - Highly Asymmetric VDSL - variable and provisioned according to provider VDSL2 - variable and provisioned according to provider G.Fast - variable and provisioned according to provider
Effective Distance Distance in this table is cable distance and subject to the age and quality of the plant. The distances listed are for the bandwidth listed in the first row of this table.	DSL - 12,000' (2.3 miles) ADSL - 9000' (1.7 miles) ADSL2 - 5000' (0.95 miles) ADSL2+ - 2000' (0.38 miles) VDSL - 1600' (0.30 miles) VDSL2 - 1600' (0.30 miles) G.Fast - 328' (0.06 miles)
Services Support	Single Service, Single Provider
Typical per subscriber build cost	\$655 - \$1100 depending on site utilization

CABLE SYSTEMS

Cable systems that provide broadband in most U.S. communities use what is called HFC systems, or Hybrid Fiber Coaxial systems. Typically, fiber delivers television and broadband signals to equipment located in or near a neighborhood, and copper coaxial cable is used to connect the subscriber's home or business with the equipment fed by fiber. Cable systems have never been widely deployed outside community boundaries (residential neighborhoods and business districts) because of the high cost of placing equipment near subscribers. In this regard, cable systems have some of the same limitations as DSL, and rural communities are at a distinct disadvantage because of the lower density of homes and businesses.

Cable systems also cannot provide the future capacity that will be required by homes and businesses in the near future. Some cable companies have begun to announce pilot projects offering Internet access at speeds "up to 50 megabits." While this is an improvement over current offerings advertised typically at bandwidth "up to 6 megabits," this bandwidth is always shared among all users on a node. It is not unusual to have between 100 and 500 users (typically residential homes) on a single node. The advertised bandwidth (e.g. "up to 6 megabits") is shared among all users on a node, meaning that the usable per household bandwidth during peak use times like early evening is much lower.

Cable modem service typically has asymmetric bandwidth, meaning that the advertised bandwidth ("up to 6 megabits," or "up to 50 megabits") is only available on the downstream side coming into a home. The upstream bandwidth available to users to send data is often 1/10th of the downstream capacity. This makes most cable modem systems unsatisfactory for many kinds of work from home services and applications that require more balanced upstream and downstream bandwidth, like videoconferencing, which works best if the bandwidth is symmetric (the same capacity in both directions). This issue of symmetric bandwidth will become increasingly important as commuting patterns change and more people want to work from home part or full time.

CABLE MODEM SYSTEM CHARACTERISTICS	
Bandwidth	DOCSIS 1 - 42 Mbps/10 Mbps (shared), DOCSIS 2 - 42 Mbps/30 Mbps (shared) DOCSIS 3 - 171 Mbps/122 Mbps (shared, 4 bonded channels)
Line sharing	All subscribers on a given CMTS (Cable Modem Termination System) channel share both upstream and downstream capabilities.
Latency	Latency is not typically an issue with DOCSIS
Symmetric/ Asymmetric	All versions of DOCSIS are highly asymmetric
Effective Distance	The effective distance of DOCSIS can be up to 100 miles from the CMTS to the farthest cable modem.
Services Support	Single Service, Single Provider
Typical per subscriber build cost	\$2500 to \$3500

FIBER SYSTEMS

Fiber is a future proof investment. The upper limit of fiber capacity has not yet been found, and off the shelf hardware can handle thousands of times the needs of an average home or business well into the future. Fiber has a life expectancy of thirty to forty years, and may last much longer than that; every year, the number goes up as fiber systems installed in the 1970s continue to perform adequately. A single fiber can carry all the traffic and services needed by a home or business, including voice telephone service, television programming, live videoconferencing, and HD television.

Fiber's primary drawback is its apparent high cost compared to other systems. Fiber is often unfairly compared to wireless, with the misleading conclusion that wireless is much cheaper. Regrettably, most fiber versus wireless studies compare the start up costs for wireless to the thirty year life cycle costs of fiber infrastructure. During a thirty year period, fiber is installed just once, while wireless systems will have to be replaced entirely several times. Properly costed over a thirty year period, fiber is actually less expensive than wireless, with many times the capacity.

Metro Ethernet is a point-to-point service provided over fiber. Metro Ethernet networks can deliver service as far as 50 miles from network element locations and provide speeds up to 10 Gigabits per second (10GB Metro Ethernet circuits are now commonly available from some providers).

Carrier Ethernet is the term used to describe Active or Metro Ethernet deployed to the premises. Carrier Ethernet is available in 100 Mbps and 1 Gbps utilizing a pair or a single fiber strand and speeds of 10 Gbps over a pair of fiber optic strands. Carrier Ethernet can be deployed at distances of up to 50 miles (80km) from the central office.

A Passive Optical Network, or PON, is a fiber optic network based upon a splitter technology. A single PON port can support up to 64 customers utilizing either daisy chained splitters or a central splitter location. For service providers PON is cost effective as it allows the service providers to create "fiber light" networks and fewer network elements. However, PON has many drawbacks including bandwidth limitations due to the shared nature of the feeder fibers as all customers fed from a splitter share bandwidth over a single fiber (or single pair in some networks). A major drawback of PON, if field splitters are used, is the upgradeability of the network which usually requires additional feeder fiber to be deployed which is costly as it is considered a "forklift upgrade."

CARRIER FIBER (ACTIVE) ETHERNET CHARACTERISTICS

Bandwidth	1 Gbps standard
Line sharing	Each user has a dedicated 1Gbps between the premises and the core location.
Latency	Not latent
Symmetric/Asymmetric	Symmetric
Effective Distance	up to 50 miles (10km, 20km, 40km, and 80km optics available)
Services Support	Multiple services, multiple providers
Typical per subscriber build cost	\$3250 - \$3500

PON FIBER (PASSIVE) CHARACTERISTICS

Bandwidth	2.4 Gbps/1.24 Gbps (shared between users on a port). A few 10Gig PON systems are now being deployed because the older PON systems are running out of bandwidth.
Line sharing	Each port is shared by a power of 2 premises (2, 4, 8, 16, 32, or 64) depending on how the network is configured.
Latency	Minimal latency.
Symmetric/Asymmetric	Asymmetric
Effective Distance	up to 25 miles (40km)
Services Support	Multiple services, multiple providers
Typical per subscriber build cost	\$3250

We are now seeing even small and medium-sized businesses asking for fiber connections. Fiber is the only transmission system that will be able to deliver all the services businesses and residents will expect and demand in just a few years. Communities that choose to delay fiber infrastructure investments will be at a severe disadvantage in the next several years when trying to attract and retain businesses and workers.

In business areas of the county, fiber is an absolute requirement to retain existing businesses and to attract new ones. Many of subdivisions could have fiber within the neighborhood and wireless backhaul, and multiple services (e.g. video, Internet, voice, data backup) could be delivered within the neighborhood by fiber. In growth areas, retail and office space would become more valuable with high performance fiber availability.

FIXED POINT ACCESS WIRELESS

Fixed point wireless Internet access via private sector providers is already available in some areas of the county. This service introduces additional competition for Internet access customers, which can lower prices and create incentives to offer better customer service from the providers. Over time, most fixed point Internet users (five to seven years out) will want to migrate to fiber connections which will have the capacity to provide a much wider range of services, including HD TV, telemedicine, and tele-health, among other applications.

Fixed point wireless infrastructure investments (e.g. locations for towers, towers, fiber and duct backhaul connections) can be re-used over time to support mobile wireless services and long term public safety voice and data services.

The goal would be to identify existing tower sites that could be reached affordably with fiber. Fiber access to these towers will lower the cost of backhaul for local wireless broadband providers while simultaneously allowing them to increase bandwidth and overall performance.

Wireless broadband services will be important in rural parts of the county. And wireless is not going away; it will remain as an important component of a well-designed community broadband system--as a mobility solution. As we travel around the community, we want to be able to access the Web, check email, make phone calls, and do other sorts of things. Wireless services enable that, and in rural areas, wireless services are an important step up from dial-up.

WiMax and LTE capacities and distances are widely exaggerated. It is very common to see promises of “up to 80-100 megabits” of capacity and distances of “10 to 20 miles.” With respect to bandwidth, that 100 megabits of capacity will be shared among all connected users, so if 100 households are trying to access the network via a single WiMax access point, the usable bandwidth may be more like 2-4 megabits per household or per user. Distances are limited by line of sight.

Both WiFi and WiMax signals will work over many miles, but only with narrow angle antennas and clear line of sight. While WiFi can easily reach ten miles or more with clear line of sight, and WiMax can reach twenty miles with clear line of sight, in practice these optimum distances are rarely achieved; it is more realistic to consider WiFi usable over 2-4 miles and WiMax over 4-8 miles. Tree cover is particularly problematic, and it is often necessary to remove tree limbs, an entire tree, or to relocate the antenna in order to get a good signal.

LTE and television “white space” systems are emerging standards that can provide connectivity at much longer distances (five to ten miles is possible under ideal circumstances) and the radio frequencies used are better able to penetrate at least some foliage. Bandwidth of several megabits are possible, and compare very favorably with copper-based systems like DSL. But even these systems will have a limited ability to handle TV programming, interactive videoconferencing, and other business class services.

FIXED POINT WIRELESS CHARACTERISTICS

Bandwidth	5Mbps - 10Mbps on average for rural/residential service. Higher speeds available at higher cost.
Line sharing	In most Wireless ISP (WISP) architectures customers share a point to multi-point connection with an access point. Service can be affected when too many customers are on an access point.
Latency	Minimal latency issues
Symmetric/Asymmetric	Symmetric
Effective Distance	The effective range of an access point depends on the frequency chosen.
Services Support	Internet, VoIP, and streaming video can be supported by WISP architectures. A multi-provider environment can be configured on a WISP network, but is less commonly found compared to fiber networks.
Typical per subscriber build cost	\$370 to \$550, and costs could be much higher if a pole has to be installed (\$2000 to \$7000). High operating costs should be considered as a factor because of the high failure rate for wireless equipment.

CELLULAR DATA WIRELESS

Wireless access to the Internet and other mobile services like cellular telephone providers is a long term need that will not be replaced by fiber access. In fact, over the next five to seven years, the most common use for wireless Internet access will be for mobility--casual business, personal, and government access away from the home or office. In the Highlands, fixed point cellular data services (e.g. "air card") can provide substantial improvements over DSL, satellite, or dial up.

Mobile wireless access to voice and data services is already widely available from multiple providers in most of the U.S. Nationwide, Verizon, Sprint, and AT&T have already begun an aggressive expansion and upgrade to LTE (the so-called 4G/5G networks). However, the bandwidth caps and bandwidth overage charges make cellular data services too expensive as a primary residential or small business connection.

Perhaps more alarming, some telephone companies, including Verizon and AT&T, are abandoning their copper line plant in many rural areas of the country, and are only offering cellular-based dial tone for home and small business use.

Cellular data plans, because of the bandwidth caps and overcharges that are included with typical plans, can be a poor solution for rural residents who may be trying to use it for business purposes, for K12 school assignments, and/or personal use. Households with children report that it is very difficult (and/or expensive) to keep within data caps.

CELLULAR DATA SERVICE CHARACTERISTICS	
Bandwidth	2Mbps-12Mbps and up, but actual bandwidth can vary widely.
Line sharing	In a mobile wireless broadband network the access point is in a point to multi-point configuration, meaning access is shared.
Latency	Latency is generally not an issue
Symmetric/Asymmetric	Symmetric
Effective Distance	The effective range of an access point depends on the frequency chosen.
Services Support	Internet, VoIP, and streaming video can be supported but service may degrade at peak times.
Typical per subscriber build cost	\$80 and up, depending on data plan, bandwidth caps and overage charges.

EMERGING WIRELESS TECHNOLOGIES

MIMO WIRELESS

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

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

LTE/4G/5G

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

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

Appendix B: Glossary

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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