ctc technology & energy

engineering & business consulting

Broadband Strategic Plan

Prepared for Harford County, Maryland
April 2020

Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

Contents

Figures

Tables

1 Executive Summary

Harford County, Maryland, has undertaken a multi-year strategic planning effort to investigate the potential for expanding broadband—in partnership with the private sector—to those areas of north Harford County where inadequate internet service exists. Through this process, the County has undertaken strategic pilot programs to determine the viability of broadband expansion in a way that would be financially feasible and not burdensome to Harford County taxpayers.

This report was prepared by CTC Technology and Energy (CTC) in March 2020 to summarize the County's efforts to date, marshal the data developed thus far, and lay out a strategic roadmap for next steps. The opportunity is timely given that, for the first time in more than a decade, federal grant support is available that might enable this effort—and the state of Maryland has also created a very usable and well-designed grant program to support counties like Harford that have unserved rural areas.

That said, we note that the broadband challenge—in Harford County and throughout the country—is enormous and will be very costly to fully address. Even in this time of increased rural broadband grant opportunities, the competition is enormous for a limited pot of grant funding – and the federal funding for rural broadband amounts to a small fraction of what it will take to fill all rural broadband gaps in the U.S. For that reason, we commend the County on its strong, proactive efforts to date and encourage the County to see this effort as a long-term challenge that will require both federal and state partners—as well as motivated private partners—to fully resolve.

1.1 Project Background

CTC performed the following tasks at the County's direction:

- Identified, at a high level, the areas of the County that are unserved by wireline broadband infrastructure, based on statistically valid residential survey results, desk and field surveys, and additional data sets
- Met with representatives of internet service providers (ISP) operating in the County (or with potential interest to operate in the County) to learn what market forces, grants, or County support might lead them to invest in the County
- Evaluated a high-level design and cost estimate for a fiber optic network deployment to fill the identified broadband gaps in the County

- Prepared a high-level design and cost estimate for a fixed wireless network deployment that might help fill broadband gaps in the County
- Analyzed a range of federal and state funding opportunities to identify potential sources of grants or loans (to the County or to ISPs) that might support the expansion of broadband services in unserved areas
- Developed a series of potential strategies the County could pursue to leverage federal and state funding—in partnership with the private sector—to meet the County's broadband goals

1.2 Project Findings

Most residents of Harford County have access to a variety of internet services, but many locations do not have robust wireline *broadband*[1] services. For example, while Armstrong, Comcast, and Verizon provide residential wired broadband service in the County's denser neighborhoods, none of these companies provides service that meets the definition of broadband in most sparsely populated areas. Based on a wide range of data, the County already knew it has a substantial number of unserved households; this project confirmed that understanding, and that the County's North End is particularly affected.

Because of the challenging economics of broadband deployment in rural areas, private ISPs likely will not invest in ubiquitous wireline broadband infrastructure in currently unserved parts of the County absent some sort of financial support. State and federal funding programs may present the County and its potential partners with incremental opportunities to fill some broadband gaps, but there exists far more need for such funds nationally than current funding can address. Given the gap between the need and the available funding, developing a solution for the unserved areas of Harford County may require a period of years.

1.2.1 The County has more than 2,500 homes and businesses unserved by broadband in scattered locations, predominantly in the North End

For purposes of this report, we identified as "unserved" any parts of the County not passed[2] by infrastructure capable of delivering internet service with speeds of at least 10 Mbps download

[1] Defined by the Federal Communications Commission as an internet service delivering speeds of 25 Mbps download/3 Mbps upload. ("2018 Broadband Deployment Report," FCC, Feb. 2, 2018, https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report.) This is also the definition adopted by the state of Maryland.

[2] A "passing" is the infrastructure that "passes" a home or business along the public rights-of-way, but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business (i.e., fiber or cable in the right-of-way adjacent to the property) is the universally understood definition of what is served, both within the industry and among the state and federal government entities that fund broadband expansion[2] and regulate communications services.

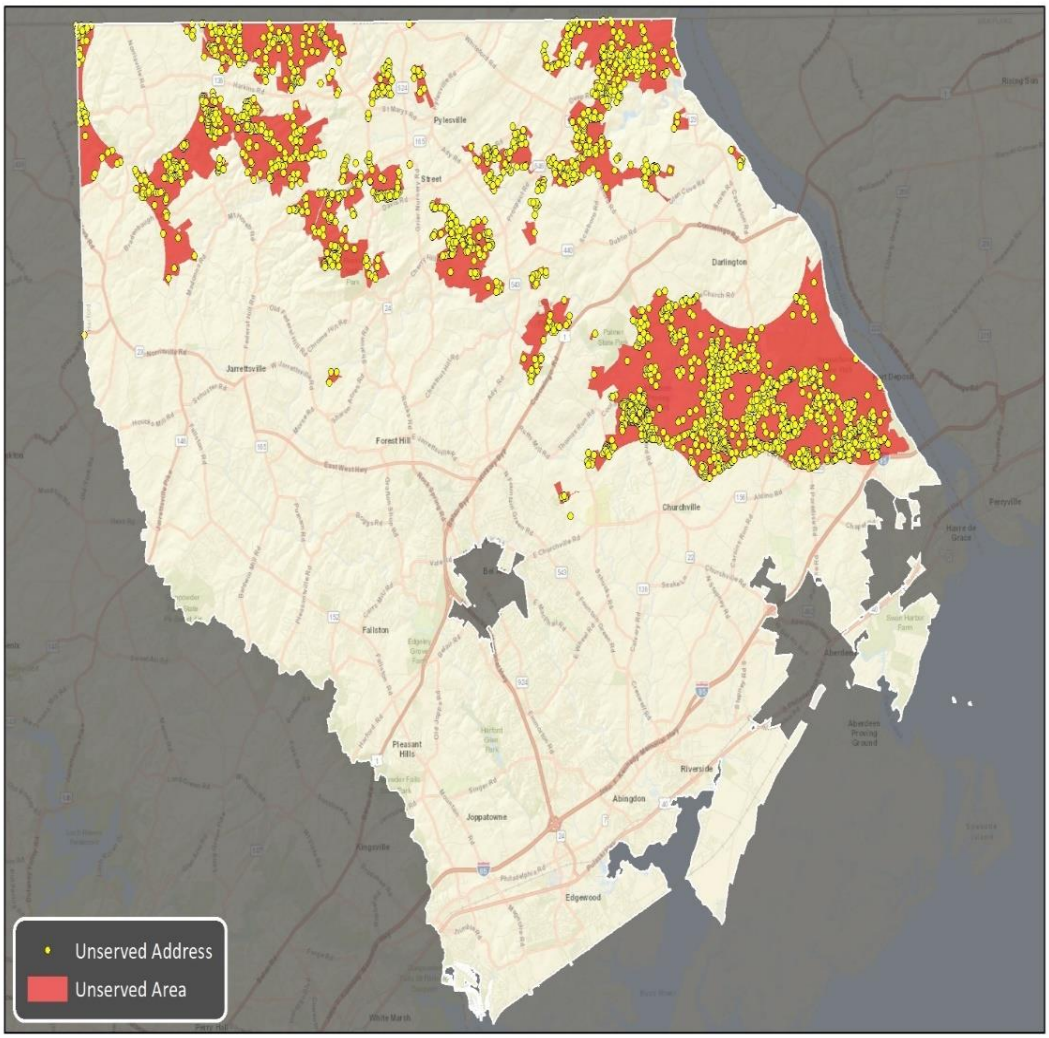
and 1 Mbps upload (i.e., 10/1)—the eligibility threshold for grant applications to the federal ReConnect program.[3]

Our development of the analysis of unserved areas for ReConnect purposes included three key steps: An evaluation of FCC Form 477 data, an analysis of the results of a statistically valid survey of County residents conducted in 2019 (and refined with datasets and field studies), and field surveys.

Based on this research and analysis, we determined that the County has approximately 2,500 addresses that are unserved with 10/1 internet, as illustrated in Figure 1. (The state's grant program may allow funding for a broader area, as described elsewhere in the report.)

[3] We chose this definition in consultation with the County because, at the time of our analysis, the ReConnect program was the County's primary focus. Armstrong Cable had committed to filing a ReConnect grant application to serve the County (a commitment it later withdrew), so we took a conservative approach to defining unserved status in line with ReConnect eligibility—to maximize the chances of an award under the ReConnect program's requirements. Because we followed ReConnect guidelines, we also refer to these unserved areas with the nomenclature used for ReConnect grant applications: proposed funded service area (PFSA). The PFSA we developed represents a subset of areas unserved at the federal definition of broadband (i.e., 25/3, which is also the threshold for the FCC's Rural Digital Opportunity Fund, as discussed in Section 3.3). The County's objective was to define a conservative PFSA that admittedly might exclude certain residents and businesses that would be considered unserved for purposes of the Rural Digital Opportunity Fund, but that would avoid conflicts with the USDA's ReConnect eligibility requirements.

Figure 1: Unserved Areas and Addresses Eligible for ReConnect Funding



1.2.2 Federal and state broadband funding could enable incremental wireline broadband deployment

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that a number of programs—including Maryland's rural broadband grant program and the federal ReConnect program—could assist the County's efforts to reduce the number of unserved homes and businesses.[4]

[4] First, we note that USDA's ReConnect program (which was the County's focus as this report was being developed) represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009. The initial $550 million allocated for 2020 was expanded by an additional $100 million in the CARES Act, which Congress passed in response to the coronavirus crisis); the program will likely see annual future appropriations. The program awards loans, grants, or a combination of the two for last-mile connections in rural

We encourage the County to view these programs as helping to gradually address the unserved areas of the County. A comprehensive solution is likely to require multiple years, including multiple rounds of applications to these and future federal and state funding programs.

Section 3 describes each of these opportunities in detail and presents strategic recommendations on how to approach the applications—and with what type of potential partner. Armstrong Cable had committed to working with the County to develop a ReConnect grant application, but withdrew that commitment at the last minute, after the County had invested time and resources in supporting that application. The County has also developed alternative options and is positioned, based on the extensive work done to date, to partner with another entity to secure both state and federal funds. For example, a competitive operator, ThinkBig, has expressed strong interest in engaging with the County on a ReConnect application in the next round of funding. We also recommend that the County use a Request for Information or similar vehicle to seek the interest of other potential partners.

1.2.3 The economics of rural broadband—and the nature of federal funding opportunities—mean that no silver bullet exists to solve the broadband problem in the County

Despite the existence of these programs, the aggregated total of state and federal funding is not sufficient to address the problem at either the national or state level.

Further, there does not exist a purely private sector investment strategy that will support the investment needed to create infrastructure parity in the most rural areas of the County, especially the North End. For the private sector, large parts of the area are too costly to build on a per-customer basis (given the low population density) to merit extensive investment in the types of broadband available in the central parts of the County.

1.2.4 Sparsely populated areas like the North End do not offer ISPs enough customers to justify ubiquitous fiber or coax deployment

Northern Harford County faces similar challenges to those of other rural communities in terms of attracting broadband infrastructure investment. Even in the most affluent rural and semi-rural

areas; it favors applicants that demonstrate both experience in network operations and strong support from the local government in the area to be served. The current round of grant applications was scheduled to close March 16, 2020 but was extended to mid-April due to the coronavirus crisis. Second, the FCC's Rural Digital Opportunity Fund is an auction process, scheduled to begin on October 22, 2020, that will award $20.4 billion over the next decade to support the buildout of high-speed broadband networks in unserved areas of the country. Third, Maryland's Office of Rural Broadband manages a broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that could enable an entity partnering with the County to use the state's funding as a match for a federal ReConnect grant application. The state will award grants of $1 million to $3 million from a total funding budget of at least $9 million. Applications for the first round of funding were due in February; we anticipate future rounds of funding to be announced by the state.

areas—from the horse farms around Lexington, Kentucky, to the ski communities outside of Aspen and Telluride, Colorado, to the resort areas on Maryland's Eastern Shore—the economics simply do not exist for rural broadband deployment absent substantial government funding. The private sector will not build costly wireline infrastructure to reach all homes and businesses in rural areas simply because the potential return on investment is insufficient to justify the investment.

The same dynamics apply to virtually all areas of rural infrastructure development. In the case of broadband, the issues are starker because broadband is traditionally thought of as an area of private investment, rather than public investment. And yet the economics do not exist for private investment. The challenging economics result from the lack of density of homes—and, in many cases, the fact that homes are located on large parcels of land; long driveways or setbacks from the road greatly increase the cost to deploy wired infrastructure to those homes.

1.2.5 Federal funding programs have significant flaws that challenge the potential to quickly solve the broadband problems in the North End

For many of the unserved areas of the North End, there exists the potential—but considerable challenge—to secure federal funding to address the broadband gap. USDA's ReConnect grant program in particular presents a fruitful roadmap for extending infrastructure from served areas to unserved pockets, and we are optimistic that the County will be positioned to support a private partner application for this program in future rounds of funding as it had planned for the current round until Armstrong's untimely departure from its partnership with the County.

The FCC's Rural Digital Opportunity Fund program also offers an opportunity for securing federal funding to improve the economics of broadband in the rural parts of the North End, but the FCC persists in relying on deeply flawed data, self-reported by internet service providers, to determine what is served and unserved. The FCC's problematic methodology treats a single serviceable address in a census block as a determination that the entire census block is served and therefor ineligible for the Rural Digital Opportunity Fund. This means that many thousands of largely-unserved census blocks across the country are considered by the FCC to be served even if only one location in that census block could actually get service.

1.2.6 Armstrong's departure from a partnership with the County—as well as their challenge to the FCC—had an impact on the County's broadband strategy

Because of its existing infrastructure, Armstrong was a natural partner to extend its infrastructure to the unserved parts of the North End.[5] By withdrawing from the partnership shortly before the

[5] As the incumbent cable company, Armstrong has physical infrastructure in most regions of the County, including in distributed locations in the North End. Our mapping with Armstrong's active participation demonstrated that it is currently the only provider in that position capable of delivering broadband speeds. This means Armstrong has

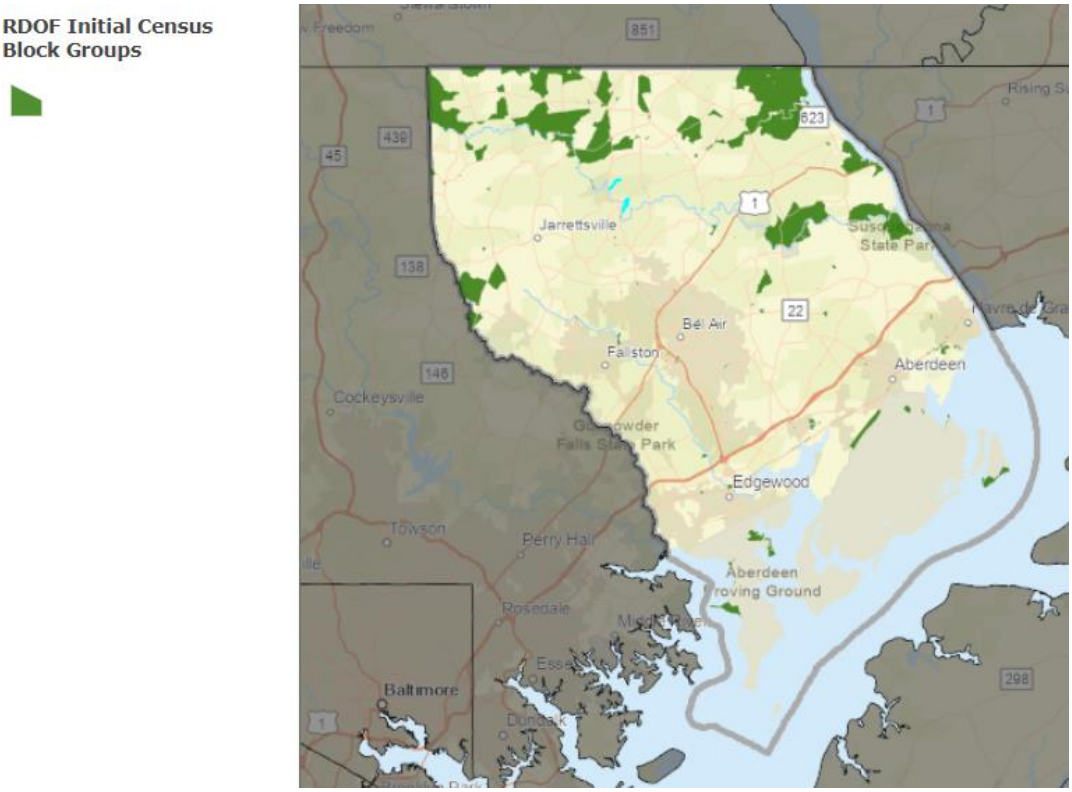
ReConnect applications were due, Armstrong left the County with no time to seek an alternative partner. Given that Armstrong has now demonstrated that it is uninterested in partnering with the County, an alternative private partner will need to be identified who is nimble and enterprising enough to use a very different model of building a network in rural areas. The broadband strategy will therefore need to center much more around facilitating such a provider with getting access to targeted areas in the North End through its own extensive fiber optic network and working with other regional networks to get to those areas.

Armstrong's challenge to the FCC also has an effect on the County's strategy. By way of background, when the FCC released its initially eligible areas for the Rural Digital Opportunity Fund on March 17, 2020, it also allowed a "limited challenge" period for providers to challenge these areas up until April 10.[6] The FCC made no provisions for other entities to contest such challenges on merit.

infrastructure relatively close by that can be extended to new areas; in contrast, a new entrant to that part of the County would need to secure a brand-new wireline backbone to reach onto the unserved areas and then also build an entire distribution network from scratch. Relative to other potential partners, the economics favors Armstrong in this regard. In addition, to the regular network expansion grant from the State, Armstrong is also eligible to apply to the State for the smaller line extension grant that explicitly targets providers who can reach smaller, disaggregated pockets of unserved areas.

[6] Providers could challenge their own areas in three different categories. They could challenge census blocks they had extended into since their last required FCC filing on June 30, 2019, which was the basis for the Rural Digital Opportunity Fund eligible areas. They could challenge areas for which they had secured federal or state grant funding and therefore should be excluded from Rural Digital Opportunity Fund grant eligibility. Or they could challenge areas they had previously filed as served in error and required correction so they could be made eligible for Rural Digital Opportunity Fund funding. A valid challenge was required to fall into one of the above three categories and to be filed before the deadline.

Figure 2: Initially Eligible Areas for Rural Digital Opportunity Fund



The County was not aware of any major expansion undertaken by Armstrong in the previous eight months—during much of which it had worked closely with Armstrong to prepare to apply for federal funding. It therefore did not expect any significant challenges by Armstrong. However, on April 10, Armstrong filed a challenge with the FCC in which it claimed:

> *AUI has deployed service, including voice and broadband service above the RDOF's [Rural Digital Opportunity Fund's] 25/3 Mbps service threshold, to additional census blocks since it's June 30, 2019 [form] 477 filing. The census blocks listed in Attachment A indicate those which were included in AUI's most recent Form 477 filing for its served locations through December 31, 2019 and those that have been served to the date of this letter. Therefore, AUI requests that these census blocks should be deemed served by the FCC and not included as areas eligible for RDOF Phase I support going forward*. [all grammatical errors in the original]

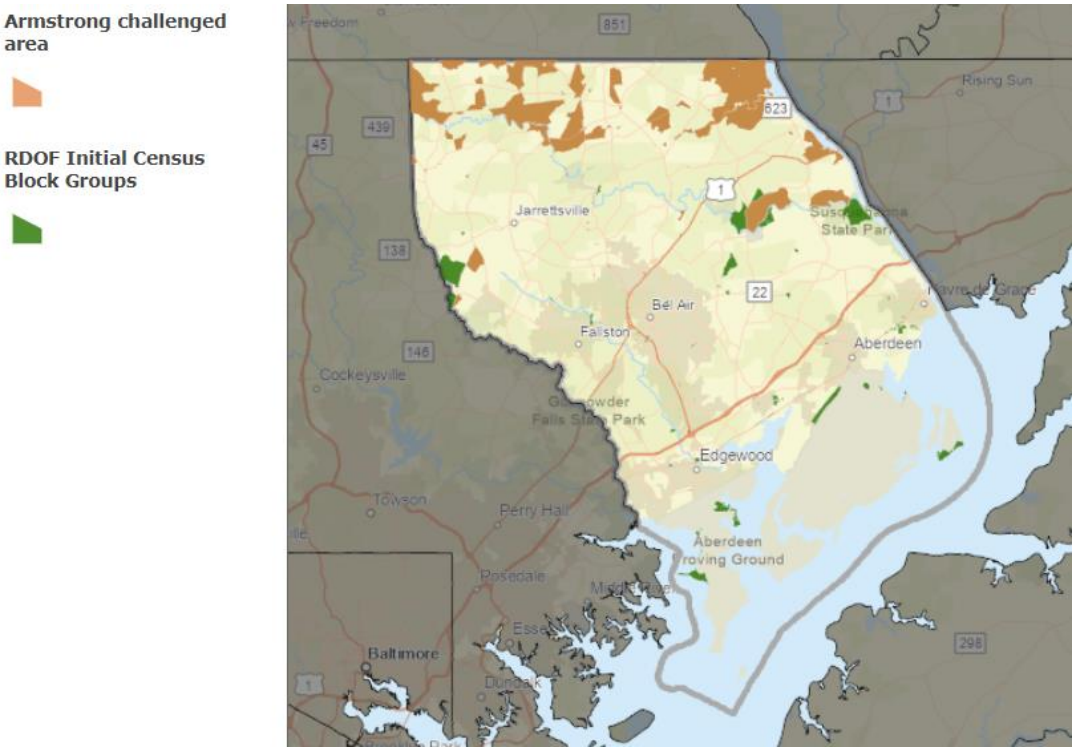
The referenced Attachment A purported to list census blocks but actually lists census block groups, a much larger geographic area. We do not know if Armstrong intentionally listed census block groups which would imply a larger area of impact, or intended to list census blocks, but

forgot to append the three-digit census block identifiers to the 12-digit census group code to get the full 15-digit census block code.

This development could present a disincentive for an alternative partner to pursue the Rural Digital Opportunity Fund in particular. The FCC could of course reject the challenge from Armstrong either on the grounds that the vast amount of sudden construction in the span of only eight months is not realistic, or that it failed to list the required impacted census block codes. Or it could alternatively seek clarification from Armstrong and allow it to file a corrected challenge—although there does not seem to be any provisions in the published FCC rules around the Rural Digital Opportunity Fund that allows for this process. It is also possible that Armstrong did indeed have infrastructure to a few premises crossing into those areas but was lax in its previous filings. While the filing might still be rendered invalid, the extent of that infrastructure would be important to understand for the viability of a partner to take advantage of the Rural Digital Opportunity Fund.

With a few reasonable assumptions, it is, however, possible to draw a picture of worst-case impact on this round of the Rural Digital Opportunity Fund at least. If we interpret the codes Armstrong listed as the Census Block Group codes they seem to be, we can assess worst case impact at the Census Block Group level. The GIS layers FCC provides are drawn at the Census Block Level as well—both for visual reasons and because bidding in the Rural Digital Opportunity Fund will actually be at the Group level rather than at the level of the specific eligible census blocks. The map below shows the overlay of the Census Block groups listed in Appendix A on top of the Rural Digital Opportunity Fund areas. Unfortunately, it is almost a complete overlay in the areas the County is most focused on to redress the broadband gap:

Figure 3: Armstrong's Challenge Areas – Worst-Case Impact



Actual impact can only be assessed when Armstrong clarifies its real service coverage, and when the FCC releases the final eligible areas within the next couple of months.

1.2.7 Given the extensive work the County has done, it is well-positioned to pursue other grants with private partners

The rigorous approach the County and CTC adopted to drawing PFSAs will serve the County well, as ReConnect and state of Maryland grants depend on actual service areas and not on the FCC's overstate map based on census blocks. We expect future rounds of both. And even for the Rural Digital Opportunity Fund, the FCC has promised that the next round will adopt more granular data to determining area eligibility and incorporate a process for local stakeholders—such as the County itself—to challenge exaggerated claims by providers.

The economics of rural deployment requires public support of private enterprises even under the best conditions, and it is not a cheap problem to fix. Forging creative partnership and support systems will likely require incremental efforts over several years, and will gain new urgency given that Covid-19 has proved in many ways how critical high-speed, quality broadband truly is.

The County has spent significant time and effort in robust data collection and analysis that prepares it extremely well for future grant opportunities. The County is an eager partner in encouraging private enterprise to participate jointly in addressing community needs. The County

also provides an attractive and growing market for potential partners to reach, and the County may be able to leverage its own prior investments in fiber optic infrastructure to facilitate partners' efforts to reach unserved areas.

1.2.8 A fiber-to-the-premises cost estimate illustrates a baseline level of funding needed by the County or a partner

For purposes of understanding the level of federal funding a partner or the County might require to serve the County's PFSA, we note that a detailed fiber-to-the-premises design for serving the County's PFSA shows that deploying such a network would require an estimated $12.4 million capital investment. This is a baseline, order-of-magnitude number that could increase significantly depending on a range of variables and assumptions.

By comparison to the limited cost estimate developed for serving the PFSA, a CTC study completed for the County in 2016 (in an earlier phase of the County's long-running efforts to solve its digital divide) depicted a scalable FTTP network for the North End encompassing a much larger scope than the ReConnect-grant-driven PFSA.

That network, which would have served 13,000 premises (and included some overlap with existing cable service areas), had a projected capital cost of $58 million to $78 million, including service drops and customer premises equipment—and, like the baseline estimate described above, based on a range of variables and assumptions.

1.2.9 A fixed wireless network could also serve unserved premises, but with higher ongoing operating costs and significant technical limitations compared to fiber

As an alternative to deploying fiber-to-the-premises, the County could consider a fixed-wireless network to deliver broadband services to unserved areas. At the County's request—so leaders would be able to make informed decisions—CTC's engineers developed a candidate model to assess the viability and cost of a candidate fixed wireless network.

Our analysis found that a fixed wireless network could be used to serve a portion of the County's unserved homes and businesses—but it would have a capital cost similar to a fiber-to-the-premises network, and would also have clear technical limitations relative to a fiber optic network, would not reach all unserved premises, and would be significantly more expensive *to* operate than a fiber network.

A fixed wireless network could cover more than 2,000 addresses (or approximately 90 percent of the homes in the PFSA) at an estimated cost of $12.4 million. The network would leverage existing telecommunications towers where available and build new support structures where needed. It would extend existing fiber for backhaul connectivity where feasible and use point-to-point wireless connections where fiber is not available.

1.3 Recommendations

The following are our recommendations for steps the County can take, in light of what we have learned in conducting this study, to begin to remedy the broadband challenges identified. Our recommendations lay out a strategy and timeline beginning in 2020, with the understanding that there likely will be state and federal broadband funding in 2021 and beyond—and it may take years to access sufficient grant funds to address the entirety of the County's unserved areas.

1.3.1 Begin partnership discussions with private sector providers

Our primary recommendation is that the County identify another private partner with fiber-to-the-premises experience and capabilities with which to apply for federal and state broadband grants, given Armstrong Cable's withdrawal from partnering on a ReConnect application. To do this, the County could undertake a formal procurement process or could undertake informal conversations with interested parties.

For example, ThinkBig Networks, one of the companies with which we consulted in preparing this report, has demonstrated significant interest in collaborating with the County—and is a highly qualified potential partner. ThinkBig is a Maryland company that is operating fiber-to-the-premises in Kent County and parts of Baltimore. ThinkBig appears willing and engaged in preliminary discussions with the County—and could be a viable partner for state and federal grant applications to construct fiber to serve the County's unserved areas.

We recommend that the County seek potential partners and begin discussions with a range of companies that may have the potential to lead to a partnership to address the County's unserved areas. Fully addressing these challenges is likely to be a multiyear effort, but first steps can certainly be taken in 2020.

In any potential partnership, the County's role would be to provide strong letters and other indications of support, as well as to facilitate and support the development of the grant applications. The County's private partner would file the federal grant applications and potentially bid in the FCC's Rural Digital Opportunity Fund auction later this year. As is discussed above, we fully anticipate that both the state of Maryland and the federal government will continue current rural broadband grant programs in coming years.

All of these programs are highly competitive. Many very deserving grant applications will not be funded simply because there are insufficient funds appropriated to meet the demand. So the County's partner's applications may not succeed at first, but this is one of the reasons we recommend a multiyear strategy and a persistence in applying to these grant programs over time.

1.3.1.1 Work with a private partner to develop an appropriate grant strategy

For all of the grant programs identified here—most notably, the state of Maryland's funding and the federal ReConnect and Rural Digital Opportunity Fund programs—we recommend the County and its private partner collaborate on a grant strategy. This will encompass a prioritization of grants that the partner will pursue, a timeline for preparing and submitting the applications, and a defined set of responsibilities and financial commitments to be made by the County and its partner.

Importantly, the development of a grant strategy with a private partner will require the refining of the unserved areas identified in this report. The state's grants and the ReConnect program depend on the applicant demonstrating unserved areas. This study has defined the County's unserved areas in terms of ReConnect parameters. The state's program allows more eligibility than ReConnect (because it encompasses lack of 25/3 service rather than 10/1 and does not have some of the exclusions of the federal program). The Rural Digital Opportunity Fund's eligible areas are different from the PFSA defined in this report (and the unserved areas that will be eligible for the state's program), because the areas are predefined by the FCC—based on provider-claimed coverage in census blocks.

In terms of the Rural Digital Opportunity Fund, the County should engage in discussions with its partner about timeline considerations. The FCC has not yet announced when the short form application is due, but—given the announced October auction deadline—the County and a potential partner should anticipate that the application will be due mid-summer. This preparatory work will likely require defining the service area, developing the engineering to reach those areas (e.g., designing a fiber network map), and developing financials. The County would also need to determine what, if any, financial support it will offer—and, if necessary, engage with the state to solicit any available state funding.

Because the Rural Digital Opportunity Fund puts a higher emphasis on securing capital up front (because the subsidy support is delivered in the form of recurring monthly payments throughout a 10- year period), the greater an applicant's affordable leased access or in-kind contribution of fiber backhaul, the lower the need for a large amount of capital funding needed in the early years to deploy the network. In that light, the County could consider—if feasible—enabling its partner to develop a better business case by making HMAN fiber backhaul available as part of the partnership. (The process of identifying potential HMAN access will also enable the County's partner to identify the most cost-efficient areas to serve from those backbones; that coverage approach can be incorporated into the joint grant strategy that the County and its partner will adopt.) [7] Similarly, the County could engage with other ICBN jurisdictions and Maryland

[7] The legal and operational limitations of the use of HMAN by a private partner would need to be evaluated before any proposal could be considered.

Department of IT to help its partner secure additional middle-mile connectivity to its network point of presence in Baltimore as necessary.

1.3.1.2 The County should negotiate with its private partner to mitigate the County's partnership risk

If the County does move forward with a partnership, we recommend additional elements in the partnership between the County and its partner that will serve to further mitigate the County's risk.

First, we recommend that the private partner be the grant applicant and the owner of the infrastructure built with grant funds. Private ownership and grant obligations remove those areas of risk, including construction risk and market risk, from the County—placing the risk squarely with the private partner. Second, we recommend a negotiation between the County and its partner that will, in consideration of the County's efforts and potential financial contribution, give the County options in the event of failure of execution by the private entity, even if that represents an unlikely scenario. These options would allow the County to select another partner and proceed with the initiative without having to return to square one.

At the same time, we note that the County's risk is further reduced by the strategy of leveraging state and federal funding. One significant benefit of state and federal grants is that those expert agencies bear the cost and the effort of evaluating the grant application—and will not only vet the applicant, but also administer and enforce the funding program requirements. This state and federal effort will reduce the County's risk and ongoing burden when it comes to the partner's performance.

1.3.2 Continue the robust data collection approach

To take advantage of creative partnerships with the private sector and future cycles of broadband grant funding, the County should continue collecting data at periodic intervals on citizen access to broadband. The data the County has collected to-date has allowed for a more efficient and comprehensive approach to mapping existing infrastructure for PFSAs. The County also maintains excellent documentation of its own infrastructure that it can leverage to facilitate creative partnerships with private sector partners.

We also recommend that the County monitor FCC coverage claims by broadband providers such as Armstrong and verify them through its data collection, citizen reports, and construction permit data when practicable. Given the persistent problem with FCC maps that overstate the availability of broadband, the County should be active in challenging erroneous or exaggerated provider claims to the FCC even when a formal process is not well defined, to establish a record.

1.3.3 Consider fixed wireless as an alternative plan—but only if a fiber partnership does not work out

As we note above, the County could consider a fixed-wireless network as an alternative to deploying fiber-to-the-premises to deliver broadband services to unserved members of the community. However, because a fixed wireless solution would have clear technical limitations relative to a fiber optic network—with a similar capital cost and higher ongoing operating costs than a more robust fiber network—the fixed wireless solution should be a last resort for the County.

Although a limited wireless deployment would offer a relatively low-cost way to serve a significant number of residents, this scenario has obvious drawbacks: It would not be ubiquitously available, it would not deliver "broadband," and it would not be easily scalable. A fixed wireless network is likely to deliver only mediocre DSL-like service levels for most of the coverage area; speeds of 25/3 Mbps or greater would not be the norm.

2 The County Has Homes and Businesses Unserved by Broadband Infrastructure in Scattered Areas, Predominantly in the North End

For purposes of this report, we identified as "unserved" any parts of the County not passed[8] by infrastructure capable of delivering internet service with speeds of at least 10 Mbps download and 1 Mbps upload (i.e., 10/1)—the eligibility threshold for grant applications to the federal ReConnect program.

We chose this definition in consultation with the County because, at the time of our analysis, the ReConnect program was the County's primary focus. Armstrong Cable had committed to filing a ReConnect grant application to serve the County (a commitment it later withdrew), so we took a conservative approach to defining unserved status in line with ReConnect eligibility—to maximize the chances of an award under the ReConnect program's requirements. Because we followed ReConnect guidelines, we also refer to these unserved areas with the nomenclature used for ReConnect grant applications: proposed funded service area (PFSA).

The PFSA we developed represents a subset of areas unserved at the federal definition of broadband (i.e., 25/3, which is also the threshold for the FCC's Rural Digital Opportunity Fund, as discussed in Section 3.3). The County's objective was to define a conservative PFSA that admittedly might exclude certain residents and businesses that would be considered unserved for purposes of the Rural Digital Opportunity Fund, but that would avoid conflicts with the USDA's ReConnect eligibility requirements.

Our development of the County's PFSA for ReConnect purposes included three key steps: An evaluation of FCC Form 477 data, an analysis of the results of a statistically valid survey of County residents conducted in 2019 (and refined with additional datasets and field studies), and field surveys.

2.1 Form 477 data indicate widespread service availability—but overstate actual service

We used FCC Form 477 data as a starting point for our analysis of the County's unserved areas, because those are the fundamental broadband availability data reported by the federal government and used for a variety of federal programs. We recognize, however, that these forms are notorious for overstating actual service availability. They not only rely on data self-reported by internet service providers, but also allow a provider to claim an entire census block is served

[8] A "passing" is the infrastructure that "passes" a home or business along the public rights-of-way, but it does not include the "service drop"—the portion of the network that connects from the road to the home or business itself. The availability of a passing to a home or business (i.e., fiber or cable in the right-of-way adjacent to the property) is the universally understood definition of what is served, both within the industry and among the state and federal government entities that fund broadband expansion[8] and regulate communications services.

if that provider could serve even a single address in the block. (The provider does not have to actually serve that address.)

According to Form 477 data, Harford County is almost completely served—not only from the perspective of the outdated 10/1 minimum speed benchmark used by the ReConnect program (which, as we note above, was to be the basis for our definition of the County's PFSA), but also the higher federal broadband benchmark of at least 25/3 speeds. Nevertheless, the Form 477 data provide a useful starting point as they indicate which general areas would have different transmission technologies and speeds.

Figure 4 illustrates the Form 477-documented service in the County for the 10/1 anticipated threshold of eligibility for future ReConnect funding. Figure 5 illustrates the Form 477-documented service in the County for the higher 25/3 threshold of eligibility for state awards (as discussed in Section 3).

Figure 4: FCC Form 477 Data Depicting Served and Unserved Census Blocks (at least 10/1)

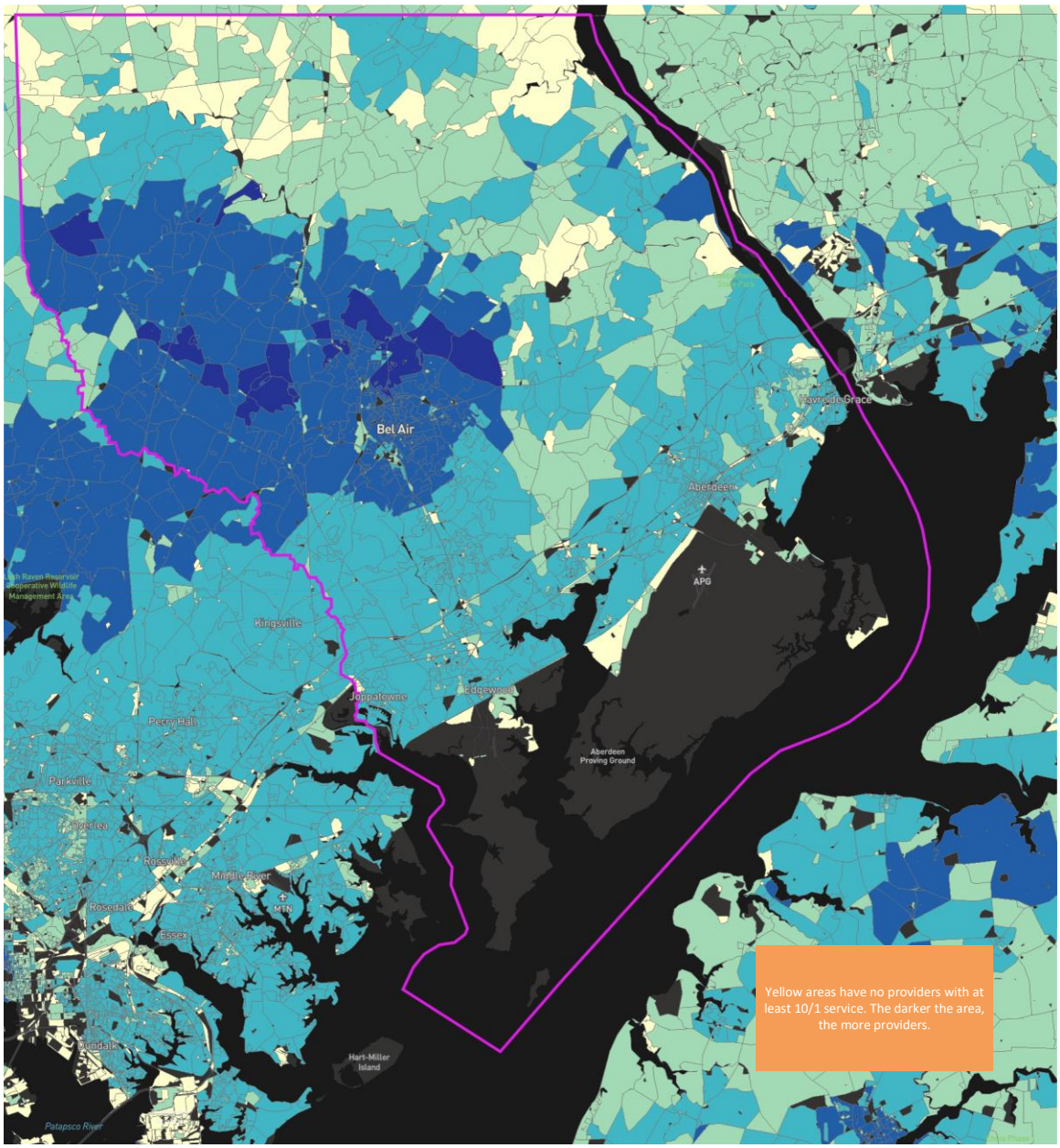
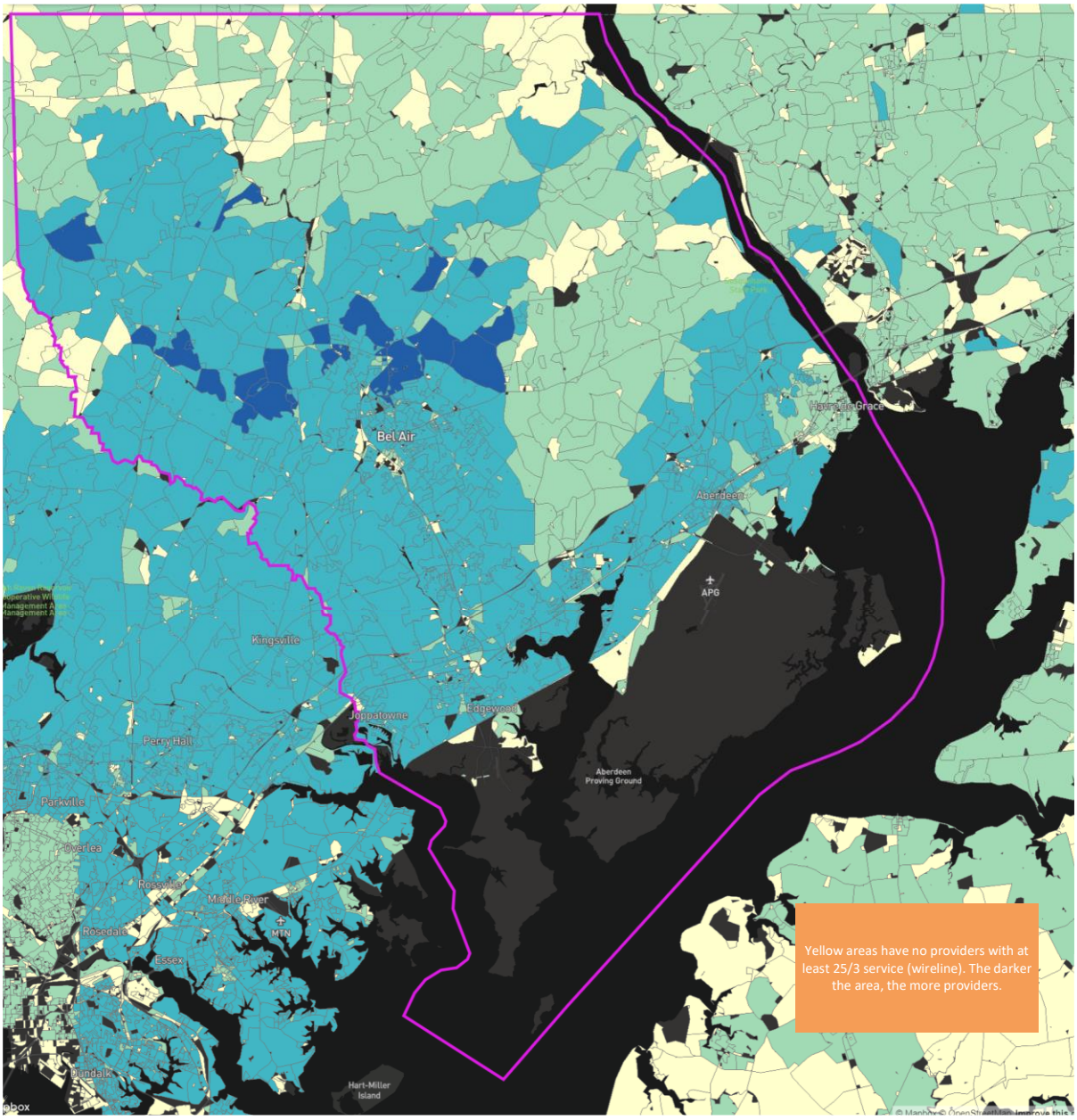


Figure 5: FCC Form 477 Data Depicting Served and Unserved Census Blocks (Wireline With at Least 25/3)



2.2 Market research results—refined with additional datasets and field surveys—identified preliminary unserved PFSA

In 2019, Harford County conducted an extensive market research study in the northern part of the County (anecdotally known to have significant gaps in broadband availability) to 1) assist in defining the specific boundaries of the County's unserved areas; and 2) to determine the level of interest in broadband services among households, farms, and other businesses.

The list of addresses used for the market research survey mailing was selected to broadly encompass all areas suspected to fit the criteria of "unserved." This was based on County GIS data identifying all areas of known broadband service (i.e., Armstrong, Comcast, and Verizon)—which was developed from data the County maintains for 911 purposes—as well as citizen-reported lack of service, online research, and field surveys.

A key focus of the survey was to assess respondents' use of internet services and whether customers' needs were being met. Respondents were segmented into groups based on their type of internet service in relation to ReConnect grant eligibility criteria:

- No internet service
- Below minimum criteria (dial-up, satellite, cellular/mobile)
- Possibly below minimum criteria (DSL, fixed wireless, other)
- Above minimum criteria (fiber, cable modem)

The market research conclusively demonstrated the lack of broadband availability in the targeted study area.[9] The survey responses indicated that 86 percent of the residents and businesses in the market research survey area fall within the first three categories listed above—meaning they likely lack access to internet service meeting the USDA's 10/1 threshold for ReConnect grant-eligible areas. The mailing address list thus became our initial candidate PFSA.

Because the County had established a partnership with Armstrong Cable to jointly explore the ReConnect opportunity, the company provided the County detailed datasets about its service area; we used those data to conducted additional engineering analyses of the survey data. As a result, the County's PFSA is accurate down to an individual address level. (This process also enabled us to leverage the market research data to verify our knowledge of other service providers' coverage in the County.)

In particular, to disambiguate the survey's "Possibly Below Minimum" category of addresses and surrounding areas, we filtered passings within the PFSA to exclude those already served by Armstrong's existing network plant.

We also eliminated residents and businesses within those areas reasonably expected to be capable of receiving either high-speed DSL or fixed wireless broadband service. To eliminate areas potentially capable of receiving high-speed DSL, for example, all passings within a 1.75-mile radius of known Verizon central offices (CO) and remote shelf cabinets were removed; that radius

[9] The survey questionnaire was sent to a total of 2,556 homes and businesses and produced a statistically valid dataset with 804 responses, yielding an extraordinarily high response rate of 32 percent. The aggregate results provided a ±3.1 percent margin of error with a confidence level of 95 percent.

represents a conservative, theoretical outer limit for availability of 10 Mbps service using an enhanced version of DSL called ADSL2+.[10]

To consider potential fixed wireless service meeting the 10/1 threshold, we reviewed publicly available coverage maps and spoke with service providers to determine existing service areas and the location of base station sites. FCC tower registration information and local permitting data were also consulted. Armstrong engineers performed field surveys of the areas to assess the likely impact of foliage and to determine the locations of existing customers based on antenna placement.

No areas within the candidate PFSA were determined to have conflicts with fixed wireless availability. We found the likelihood of achieving the necessary line-of-sight between existing base station assets and potential customers to achieve specified bandwidth thresholds within the PFSA to be extremely low.

To further confirm our conclusions Armstrong engineers conducted field surveys to identify external fixed wireless antennas at houses pointed in a particular direction where we knew there were towers; the engineers did not find any such antennas.

2.3 The County's final PFSA reflects ReConnect requirements for 90 percent unserved status

Using the PFSA developed through the extensive analysis described above, we then refined the boundaries for two different ReConnect opportunities. At the time of our analysis (i.e., Round 1 of the ReConnect program), ReConnect rules stipulated different requirements for 100 percent grant applications versus applications for 50 percent grant/50 percent loan. For the 100 percent grant applications, 100 percent of addresses in the PFSA need to be unserved by 10/1 or higher service. For the 50 percent grant/50 percent loan option, only 90 percent or more of addresses must be unserved within the proposed PFSA boundaries.

Since that time, however, the USDA has loosened the requirements for existing service. Instead of requiring that 100 percent of the PFSA have no service for 100 percent grant applications, the new rule (for Round 2 and, presumably, future applications) allows a PFSA to be 90 percent unserved by 10/1 or higher for 100 percent grant applications. Thus, the analysis we originally completed for the 50 percent grant/50 percent loan program now applies to the more desirable 100 percent grant program.

[10] The market research confirmed our assessment of the locations of these assets, with confirmed customer addresses located only within anticipated service boundaries of identified local exchange carrier (LEC) infrastructure. Both COs and remote shelf cabinets are digital regeneration points, and the signal attenuation caused by the cabling between the customer and the DSLAM equipment located within either is the same.

We initially expected there may be some availability of 10 Mbps to 15 Mbps DSL in the PFSA, and that that service would conservatively fall within the 90 percent unserved criteria along these routes. (Only 12 percent of all respondents to the survey indicated they have DSL service, and most of these would fall below the 10 Mbps service threshold.) Our analysis of Form 477 data, however, indicates no DSL service above 10 Mbps.

Other forms of internet service that might exceed the 10 Mbps threshold, such as fiber optic and fixed wireless, were indicated to be negligible in the survey responses. We retained those areas where a few customers indicate they have fixed wireless service—because even with these isolated addresses, the PFSA would still meet the 90 percent unserved threshold. This conservative approach yields a high confidence that the resulting boundaries meet the ReConnect program's 90 percent threshold for unserved addresses.

Final maps identifying specific unserved addresses and parcels within each PFSA were created by selecting all parcels within 150 feet of the refined streets for the respective PFSAs. That distance was chosen to capture potential passings at the edges of these refined boundaries, balancing average home setbacks (about 400 feet) against the 300-foot line extension requirement in the County's cable franchise agreements.

Based on the analysis described above, Figure 6 maps the County's 100 percent unserved roadways and addresses—the higher threshold originally required for purposes of the first-round ReConnect 100 percent grant eligibility. Figure 7 is a map of the 90 percent unserved roadways and addresses—originally for purposes of ReConnect 50 percent grant/50 percent loan eligibility, and now the target for 100 percent grant applications. Based on these PFSAs, we determined that the County has approximately 2,500 unserved addresses (for the 90 percent unserved PFSA) and that those unserved addresses are on roads with a density of just under 10 passings per mile.

These maps also include the locations of educational, healthcare, and critical facilities in the County—as well as areas funded under CAF II (which are ineligible for ReConnect funding)—which are included in the "Eligible Area Map Datasets" supplied by the USDA. (Schools and healthcare facilities, for example, confer extra points for a PFSA in ReConnect application scoring.) We note, too, that we used these maps to estimate the cost and complexity of building a fiber-to-the-premises network to fill the County's gaps; see Section 4.

Finally, Figure 8 is a map that clearly illustrate the general location of the County's unserved areas and addresses in light of the 90 percent threshold.

Figure 6: 100 Percent Unserved PFSA – Original, Higher Threshold for ReConnect Eligibility

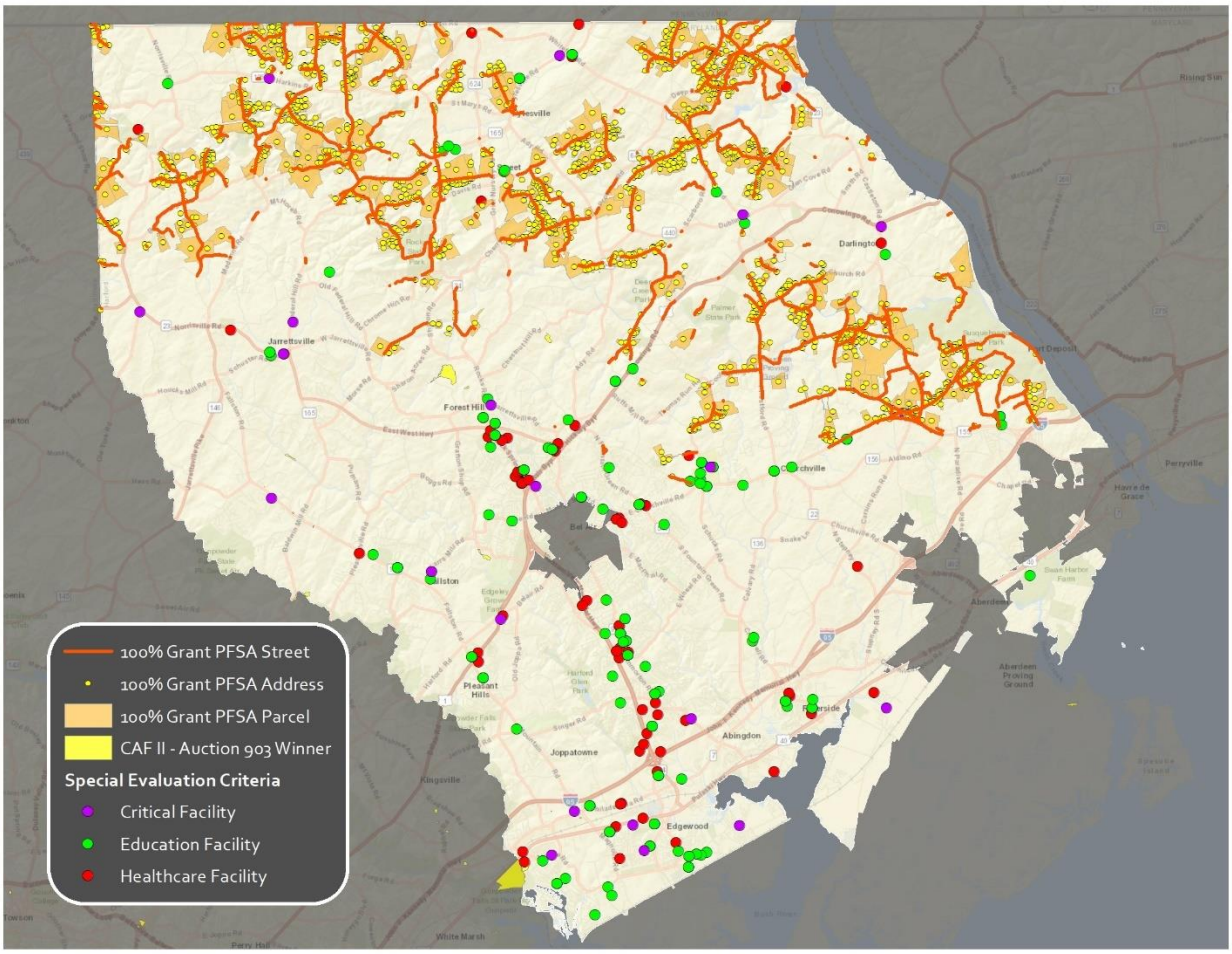


Figure 7: 90 Percent Unserved PFSA for ReConnect Eligibility

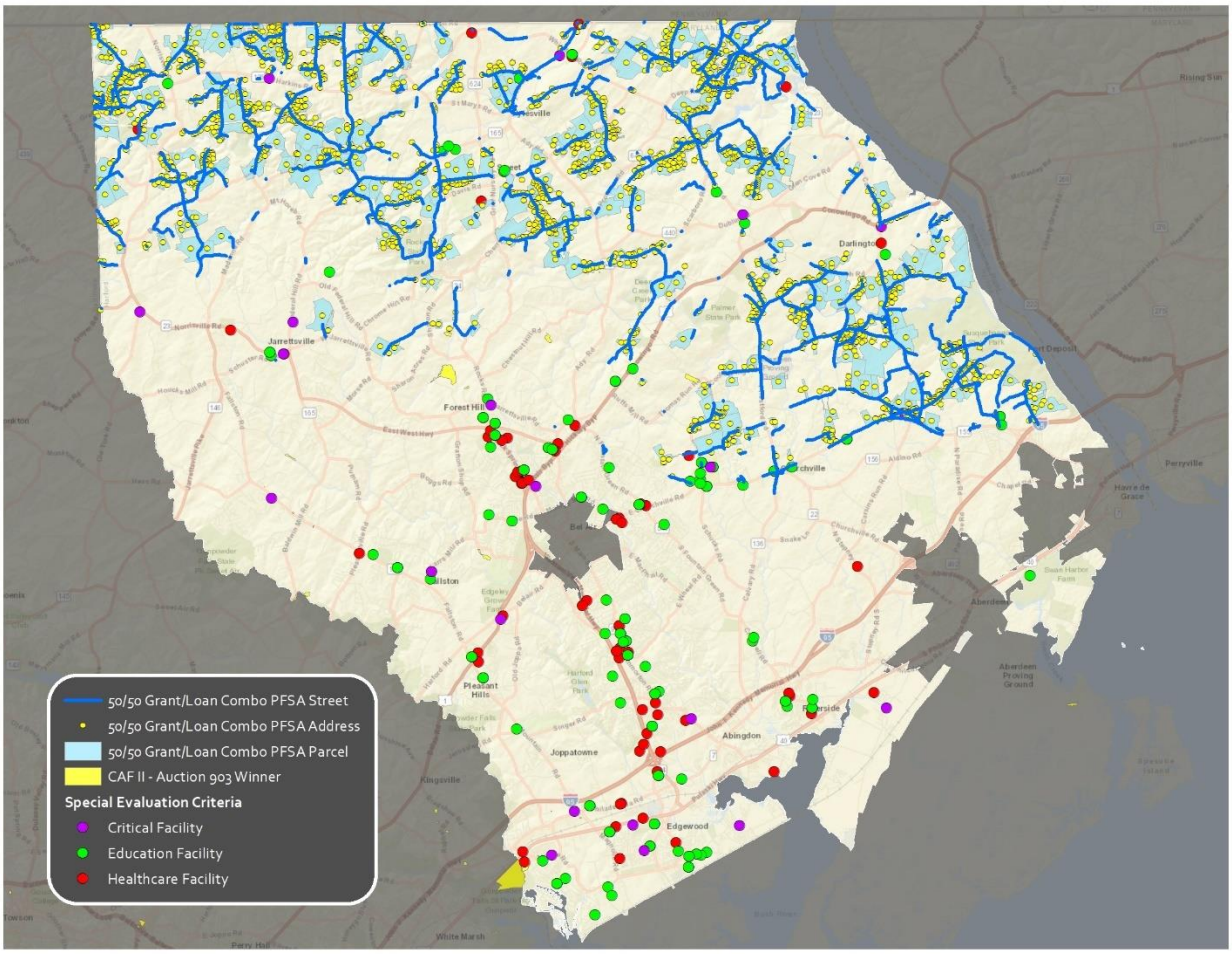
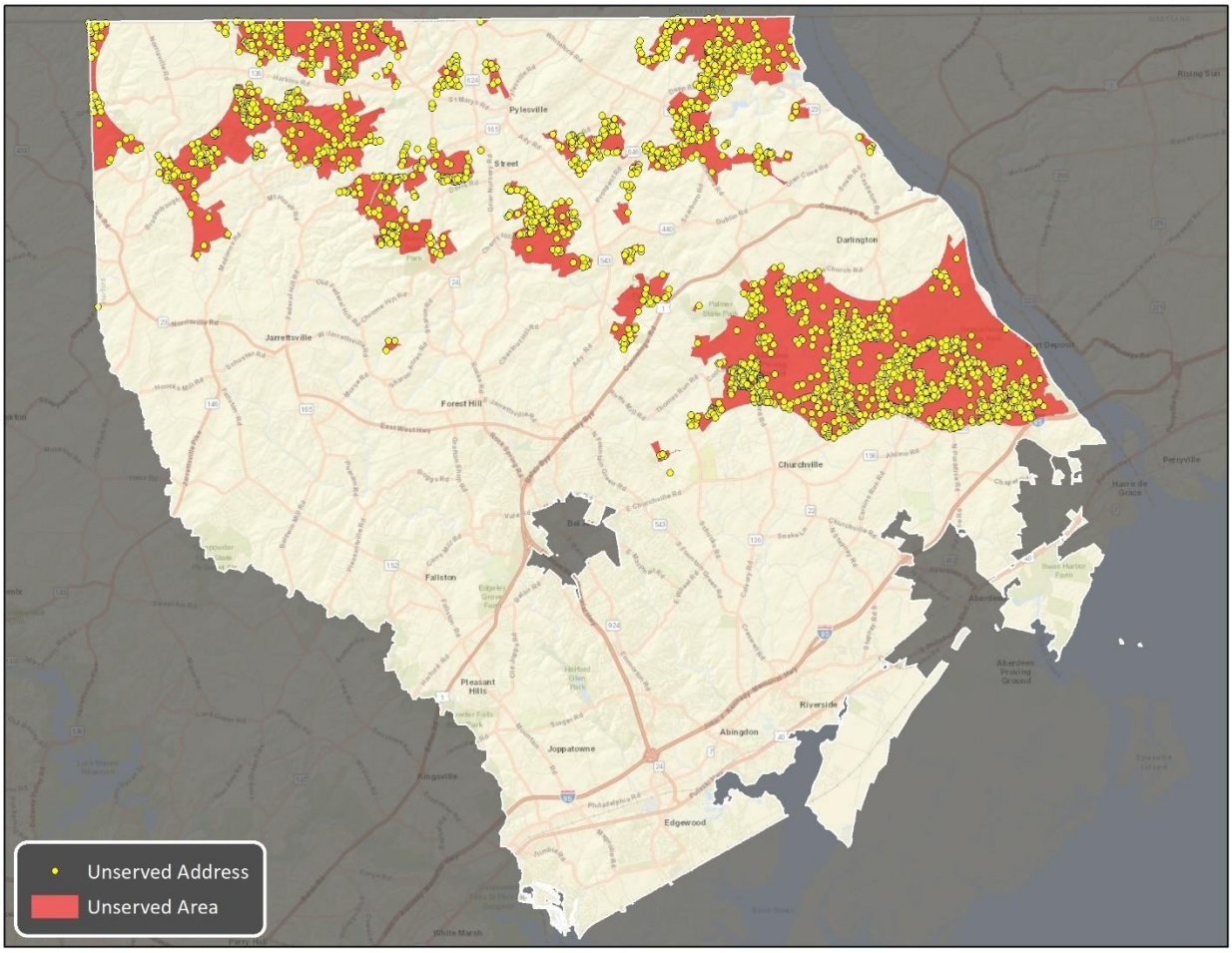


Figure 8: Unserved Areas and Addresses – 90 Percent Unserved PFSA for ReConnect Eligibility



3 Federal and State Funding Programs Present Opportunities for the County

Federal and state funding sources represent an important element of large-scale broadband deployments for unserved areas where no broadband is currently available. While these programs tend to have restrictions that affect their potential breadth of impact, our analysis is that the programs discussed below have the potential to assist the County's efforts to greatly reduce the number of unserved homes and businesses.

The County aligned this study to the ReConnect grant opportunity because Armstrong Cable, one of the County's franchisees, previously agreed to put its own capital, risk, and expertise into a ReConnect opportunity. While Armstrong subsequently withdrew its commitment to apply for federal funding to fill the County's gap, the ReConnect program remains an attractive possibility with another partner—and this study provides very robust documentation of eligible areas for that program. (In that vein, we note that while the delineation of eligible areas for this project—PFSAs—are aligned to ReConnect requirements, the PFSAs can be modified as needed to meet the eligibility requirements of other funding programs.)

A number of other important broadband funding programs could be worthwhile as well, including state programs and the FCC's Rural Digital Opportunity Fund.

Determining which funding programs the County should target will depend on the identification of a willing partner, the County's ability and willingness to contribute capital to the effort, and the timing of the grants. That said, the state's grant program provides a very attractive funding options because the state is faithful to the federal 25/3 broadband definition of unserved, and does not have exclusions—meaning that the County could target some of the areas that are ineligible for federal grants.

The Rural Digital Opportunity Fund also stands out with its massive budget and program design that favors fiber optic solutions. The FCC announced eligible areas that cover a large portion of the unserved areas in the County; while those eligible areas are subject to existing providers' challenges, the window for contesting eligibility closes soon—and much of the County's unserved areas are likely to remain eligible.

3.1 State of Maryland broadband grants are designed to address unserved areas and provide matching for federal funding applications

The Governor's Office of Rural Broadband (the Office), which is housed in the Department of Housing and Community Development, focuses on efforts to extend broadband service to unserved rural parts of the state "through partnerships with local jurisdictions and the private

sector."[11] The Office currently oversees both a small pilot program and a larger rural broadband grant initiative that explicitly seeks to complement federal and local funding sources—an approach that would enable the County or a partner, if it receives one of those larger grant awards, to use the state's funding as a match for a potential federal ReConnect grant application (if the County determines that such an application would be feasible).

The unserved areas we documented in the PFSAs in Section 2 would be eligible for state funding—as would additional areas, because the state adopts the federal definition of broadband to delineate unserved areas. This is in contrast to federal grants which have exclusions, restrictions, and requirements that effectively shrinks the areas eligible for funding under its programs. Should the County be interested in pursuing a state grant, we recommend that it update the PFSA maps to allow for the full unserved areas to be targeted.

The Office announced the details of its rural Broadband Infrastructure Network Buildout Program, with grants of $1 million to $3 million (with a total of at least $9 million in available funding program-wide), in late November 2019.[12] While the deadline for the first grants has passed, we expect several more phases—with largely the same requirements—beginning in the third or fourth quarter of 2020.

The applicant has to be a local jurisdiction or the jurisdiction's recognized partner. The grant will cover up to 50 percent of construction costs—with the applicant committing a 100 percent cash match—for a project that delivers at least 25/3 service to an unserved area.[13] Our sense is that these requirements intentionally put larger companies in a better position to apply because of their access to cash for the required match and ability to file for larger grants. The proposed service area does not have to be contiguous and can cross county boundaries.

Awardees will not be eligible for future grants from the program in the awarded jurisdiction for two years or until construction is complete, whichever is later.

The Office earlier solicited statements of interest from local jurisdictions for "Assistance for Broadband Expansion Pilot Projects." The state will award relatively small grants of up to

[11] "Maryland Rural Broadband," Maryland Department of Housing and Community Development, https://dhcd.maryland.gov/RuralBroadband/Pages/default.aspx (accessed December 2019).
[12] "Maryland Broadband Infrastructure Grant Program: Grant Application Guide," Governor's Office of Rural Broadband, State of Maryland, November 27, 2019, https://dhcd.maryland.gov/RuralBroadband/Documents/FY2020-Broadband-Infrastructure-Program-Grant-Application-Guide.pdf (accessed December 2019).
[13] The match must be in cash, not in-kind, and must be shown to be available at the time the grant contracts are executed. There is an exception to level of match requirements for Sustainable Communities (Maryland Department of Housing and Community Development) and Priority Funding Areas (Maryland Department of Planning).

$200,000 to local jurisdictions, in partnership with an ISP, to cover as much as "50 percent of the construction costs related to an ISP extending service [from the ISP's existing network] to unserved households." The County and its partner would be required to commit a 100 percent match for the funding, and to delivering at least 25/3 service. We anticipate that this pilot project program will have a similar timeline to the network buildout program, with a slightly earlier deadline in the next phase of funding.

3.2 USDA's ReConnect program represents a new, unique rural funding opportunity

The ReConnect program represents the most significant congressional appropriation of broadband funding since the Recovery Act in 2009—with $600 million allocated in 2019 and $550 million available in 2020. The program awards loans, grants, or a combination of the two for last-mile connections in rural areas—with priority given to private-sector applications and public-private partnerships. It is overseen by the Rural Utilities Service (RUS). The most recent round of grant applications opened on January 31, 2020, and closed March 31, 2020, but another $100 million will be added to the next round of ReConnect as part of the CARES Covid-19 response package.

Congress created a significant barrier to ReConnect funding for the County when it wrote the legislation: It made ineligible any areas for which another grantee or loan recipient has received a previous broadband award. This is not relevant for the upcoming round of funding in Harford County, since only a few smatterings of Verizon Fios areas received CAF II funding in the central portion of the County. But it is relevant for the County's consideration of appropriate partners for ReConnect applications: A fixed wireless provider receiving an award from this program would be protected from any other subsequent applicant for the entire originally funded service area for up to 10 years.

Fixed wireless, however, never reaches anywhere close to all unserved premises in a claimed service areas, and the County would therefore risk have no remedy for the entire, long protection period if the provider did not continue investing in fairly frequently needed refresh of its equipment to keep up with needs and potentially higher definitions of broadband thresholds in the future. We therefore recommend the County prioritize applications to ReConnect for wireline solutions, or write in robust remedies as conditions of support with the partner to manage risks.

The ReConnect program currently comprises three separate funding categories: 100 percent grants (covering up to 75 percent of eligible project costs, with a 25 percent match), 50 percent grants with a 50 percent loan or other form of match, and 100 percent loans. Funds will go to rural areas where 90 percent or more of the households lack access to broadband speeds of at

least 10 Mbps download and 1 Mbps upload. (In Round 1, 100 percent of the households in the PFSA had to lack access to 10/1 Mbps broadband for 100 percent grant awards.)

Applicants must propose networks capable of providing access to every premises in the PFSA at minimum speeds of 25 Mbps downstream and 3 Mbps upstream.

Matching funds are a point of distinction. Applicants for 100 percent grant awards will need to provide matching funds equivalent to 25 percent of the project's total cost—and that matching contribution must be expended first, followed by grant funds. For 50 percent grants with a 50 percent loan or other form of match, applicants can propose a cash alternative to the loan at the time of application. (For an awarded project in this scenario, all cash proposed must be expended first, followed by loan funds and then by grant funds.)

Generally, we anticipate that USDA will prioritize private-sector applications and public-private partnerships, so it will be important for local governments to build a public-private partnership strategy for this program. RUS will consider public networks that lack extensive experience to be startups and may disfavor their applications. We do not anticipate this to be a barrier should the County decide to take the lead, because its network has been operational for several years. However, it does mean that the County should partner only with entities with extensive experience as an ISP to compete for these funds. Any experienced ISP, whether public or private, will require the strong collaboration and support of its local (and state) government to present a compelling case for funding.

Applications to this program will require a detailed business plan and pro forma. RUS will grant application review points based on those plans, as well as many other factors. The rurality of the PFSA can earn almost 25 points alone. RUS will also award points to applications proposing to build networks capable of at least 100/100 Mbps. Additional points can be scored if the proposed area includes a healthcare center, education facility, or critical community facility. Furthermore, points will be awarded for projects in states with an updated broadband plan in the past five years.

We anticipate RUS will make grant/loan combinations in the $3 million to $10 million range. This is quite a bit more than RUS's Community Connect grants—and, because the program's funding is considerably larger in total dollars, we anticipate that ReConnect will make more awards. Further, ReConnect does not have the low-income requirements of Community Connect, making it a more flexible program.

3.3 The FCC's Rural Digital Opportunity Fund is a promising opportunity

3.3.1 The Rural Digital Opportunity Fund is the latest iteration of a 20-year-old effort

The Rural Digital Opportunity Fund represents the latest iteration of the FCC's Universal Service Fund's (USF) high cost program. Since 1996, the FCC has used the high cost program to subsidize telecommunications services in rural and remote areas, where the return on investment would otherwise be too low to prompt companies to invest in telecommunications infrastructure.

While the program initially provided subsidized telephone service on an ongoing basis, in 2011 the FCC began reorganizing the high cost program, creating the Connect America Fund (CAF) with the goal of accelerating the buildout of broadband-capable infrastructure to unserved and underserved areas. Instead of providing an ongoing subsidy in exchange for serving eligible areas, the CAF program provides an annual subsidy for a fixed period of time to help cover the initial cost of building out broadband-capable infrastructure in rural and remote areas.

The CAF program uses a cost model to estimate the appropriate subsidy for each eligible census block, and first made these funds available to incumbent price-cap carriers in exchange for a commitment to serve every household and business with service with speeds of at least 10 Mbps download and 1 Mbps upload. For those areas where the price-cap carrier declined CAF support, the FCC made funds available to any qualifying service provider through a multi-round, reverse, descending clock auction, with added weight given to those bids that committed to offering faster and lower latency broadband services.

The CAF Phase II auction took place in 2018 and was widely viewed as a success. The auction awarded just under $1.5 billion in support in exchange for a commitment to serve 713,176 homes and small businesses in 45 states, a total of 73 percent of eligible areas. Thanks to the weighting system that favored service providers willing to offer higher tiers of service, 99.75 percent of locations will have speeds of at least 25/3 Mbps, 53 percent will have at least 100/20 Mbps, and 19 percent will have 1 Gbps/500 Mbps. The 103 winning bidders will receive an annual sum each year for 10 years, provided they meet buildout requirements. Winners must offer service to 40 percent of homes and businesses by year 3 and continue to increase by 20 percent each year until year 6 when 100 percent of eligible homes and businesses must be served.[14] The total amount of support awarded was 70 percent less than the Connect America Cost Model (CAM) estimated would be needed.[15] Although the reverse auction process was complex, it secured

[14] "Connect America Fund Auction to Expand Broadband to Over 700,000 Rural Homes and Businesses," *FCC*, August 28, 2018, https://docs.fcc.gov/public/attachments/DOC-353840A1.pdf (accessed November 2019).
[15] Joseph Gillan, "Lessons from the CAF II Auction and the Implications for Rural Broadband Deployment and the IP Transition," *National Regulatory Research Institute,* https://pubs.naruc.org/pub/9F958420-E885-F843-1AEC-4D290DC9A28E (accessed November 2019).

higher-quality service for consumers at a significantly lower cost to the Universal Service Fund than previous methods of allocating subsidies.

3.3.2 Parts of Harford County's unserved areas are eligible for Rural Digital Opportunity Fund subsidies

The Rural Digital Opportunity Fund builds on the success of the CAF Phase II auction, and will allocate an additional $20.4 billion over the next decade in order to support the buildout of high-speed broadband networks in unserved areas of the country. The FCC announced that the $20.4 billion will be distributed in two phases. The first phase, which relies on highly misleading Form 477 self-reported coverage areas, will consist of up to $16 billion, while the remaining Phase I budget, along with $4.4 billion, will be awarded for Phase II of the auction. The Phase I auction is scheduled to begin on October 22, 2020, and "will target over six million homes and businesses in census blocks that are entirely unserved by voice and broadband with download speeds of at least 25 Mbps."[16] The FCC believes that by the time Phase II starts, it will be able to rely on more accurate maps of unserved areas, which will include areas that the FCC currently denote as partially served as well as locations not funded in Phase I. The FCC has not so far commented on what will happen to areas currently marked as served that could be found to be unserved if more accurate maps are used.

Unlike in the current round of ReConnect, the FCC will fund areas that lack 25/3 service—even those that have another subsidized competitor. Also, unlike the USDA or state funding programs, the Rural Digital Opportunity Fund grant does not involve a discovery and documentation process for delineating unserved areas. Instead, it relies on Form 477 data with some further restrictions as mentioned earlier. The initial maps of eligible areas were released March 17, 2020, and are illustrated in Figure 9 and Figure 10. These maps should not be taken literally as they depict census block groups and not census blocks (which are the units of unserved addresses), so they appear much larger than the actual physical areas of unserved addresses. An overlay of the PFSAs and these areas should therefore be taken as illustrative, but it nevertheless shows some promises for reaching a substantial number of unserved addresses in the County. The overlay can be seen in Figure 11 for the 100 percent PFSA and Figure 7 for the 90 percent PFSA.

[16] "Fact Sheet – Rural Digital Opportunity Fund Information." https://www.fcc.gov/auction/904/factsheet, accessed 4/1/2020

Figure 9: Areas Identified as Initially Eligible for Rural Digital Opportunity Fund

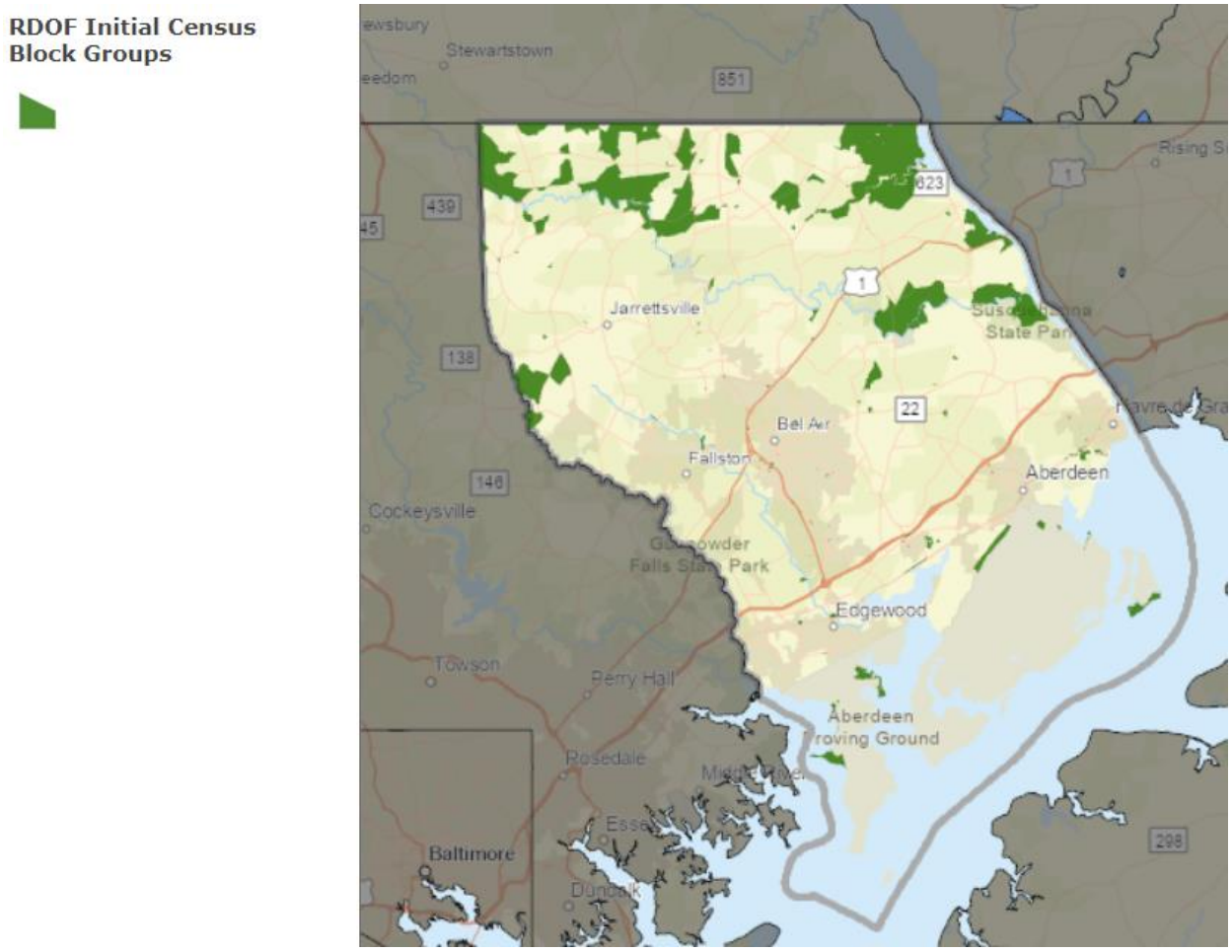


Figure 10: Areas Identified as Initially Eligible for Rural Digital Opportunity Fund – Unserved Address Locations

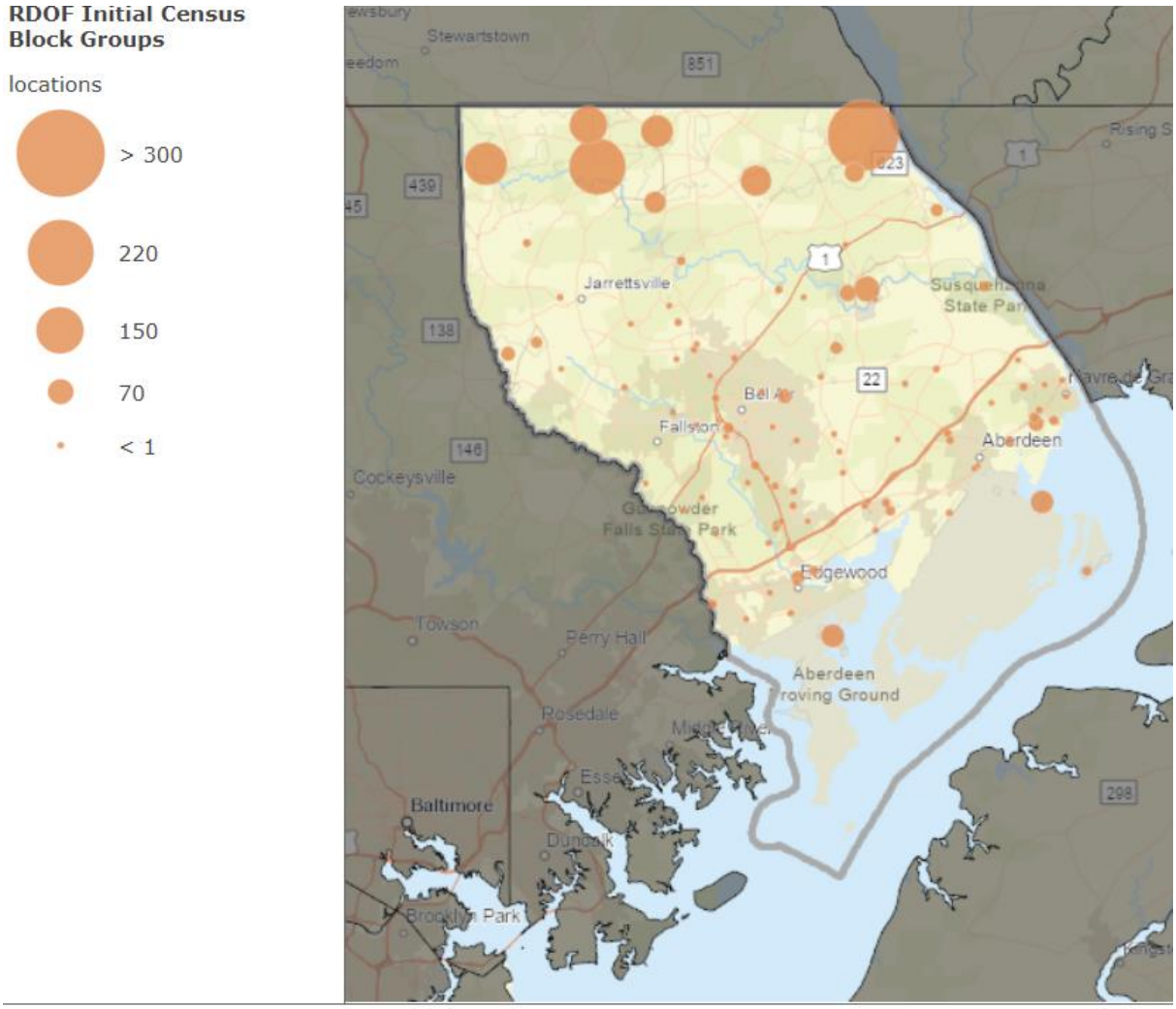


Figure 11: Initially Eligible Rural Digital Opportunity Fund Census Block Groups vs 100% PFSA

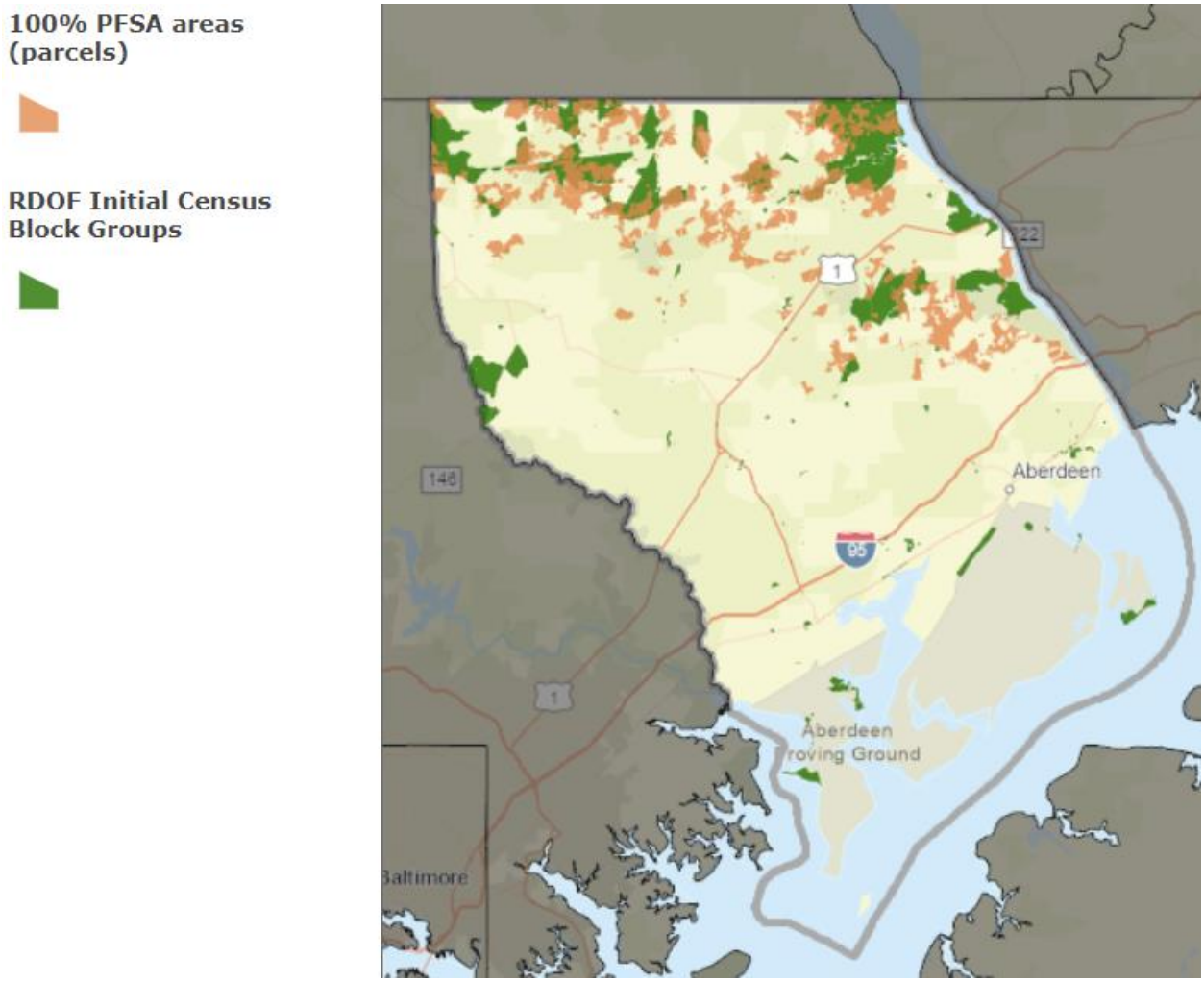
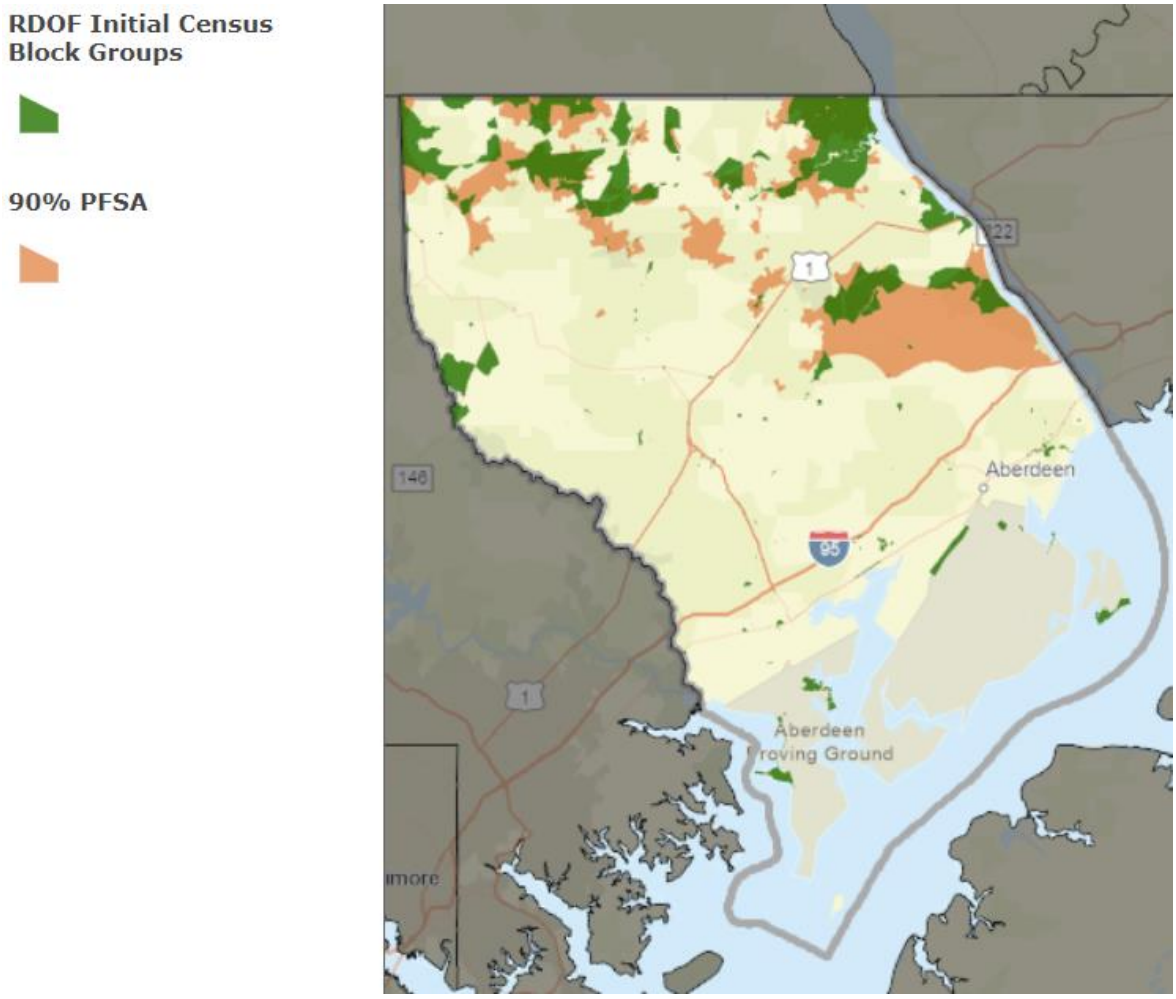


Figure 12: Initially Eligible Rural Digital Opportunity Fund Census Block Groups vs 90% PFSA



The FCC will be using a reverse auction mechanism almost identical to the one used in the CAF Phase II auction, though this time incumbent price-cap carriers will not have the right of first refusal. We anticipate the auction opening in late 2020.

The FCC has announced it will be awarding funds through two phases, the first focused on those areas wholly unserved by broadband at speeds of 25/3 Mbps, and the second on partially-served areas. As in the CAF Phase II auction, the FCC will use the CAM to establish the maximum subsidy available for each eligible area, and bidders compete for available subsidies with preference given to those bidders willing to commit to offering faster speeds and lower latency service. The bidder willing to commit to providing an area with the best quality service at the lowest subsidy amount wins the available support.[17] In fact, to incentivize more sustainable approaches to broadband

[17] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund," 84 FR 43543, August 21, 2019, https://www.federalregister.gov/documents/2019/08/21/2019-17783/rural-digital-opportunity-fund-connect-america-fund (accessed November 2019).

deployment such as fiber and cable approaches rather than fixed wireless and satellite, FCC changes the weights assigned to the different proposed technologies further in the direction of higher speeds and lower latency.[18]

The biggest change the FCC adopted was raising the service availability threshold to 25/3 Mbps, making even those areas where a provider received CAF funding for 10/1 Mbps service potentially eligible for support. The Commission is also considering a number of other minor adjustments, such as changing the minimum bidding areas from census blocks to census block groups, block tracts, or counties.

While the FCC had considered adding a subscribership benchmark[19] to the awardee to ensure that a high percentage of unserved addresses in the area would receive service, it ultimately decided not to include such a requirement as it concluded it would discourage bidders and change the program from a deployment to an adoption program. Should the County partner with a bidder or support a bidder directly or indirectly, it should therefore consider agreeing on targeted benchmarks of adoption as well.

The FCC adopted a deployment benchmark so 40 percent of the targeted buildout needs to be completed by year 3. If this benchmark is not met, the awardee will need to notify the FCC and will have six months to come into compliance to avoid a default.

In addition, the FCC has made changes from CAF II to incentivize bidders further to build in unserved areas: The threshold for allowing CAM subsidies for unserved areas have been lowered from $52.50 to $40 to reflect that areas that many areas that were thought to have sufficient ROI not to require federal subsidies to attract deployment have remained unserved. And to reflect the particular difficulties for deployment on tribal lands, the threshold was lowered to $30.[20]

We note, too, that a Rural Digital Opportunity Fund application would not exclude applying to other federal and state programs. The County could have a partner applying for funding from multiple sources. However, the Rural Digital Opportunity Fund does exclude previously funded and executed projects that include the same areas, so the timing of executing state funding awards for designated areas, and delineating those areas to which the County and its partner(s) apply for the Rural Digital Opportunity Fund, need to be aligned if the County and its partner want to leverage multiple funding sources to maximize support and the areas targeted.

[18] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund - A Rule by the Federal Communications Commission on 03/10/2020." https://www.federalregister.gov/documents/2020/03/10/2020-03135/rural-digital-opportunity-fund-connect-america-fund (accessed March 2020).
[19] Federal Communication Commission, "Rural Digital Opportunity Fund, Connect America Fund."
[20] Ibid.

3.4 USDA's Community Connect program represents another, more modest opportunity

Community Connect is another program to which the County could apply with a partner. The USDA administers this modestly sized grant program for local and tribal governments; it targets broadband deployment to unserved (defined as speeds less than 10 Mbps download and 1 Mbps upload), low-income rural communities with fewer than 20,000 residents in a contiguous PFSA (*and* not adjacent to cities with more than 50,000 residents). To prepare the most competitive Community Connect grant application possible, we would recommend the County target the lowest-income portions of its unserved areas. The eligible areas for funding are therefore identical to the PFSAs developed for the ReConnect grant, but with an additional low-income requirement.

Grantees must ultimately offer service at the broadband grant speed (defined as 25 Mbps download, 3 Mbps upload) to *all* households and community institutions in the PFSA, with free service for at least two years to a community center.

The application process is rigorous and competitive (i.e., only about 10 percent of applicants receive an award) and once awarded, program requirements can be demanding (e.g., requiring last-mile service be available for all households in the service area). The program has been funded consistently since it was introduced in 2002 and represents an important opportunity for qualifying communities.

Eligible applicants include local or state units of government, incorporated organizations, Indian tribes or tribal organizations, cooperatives, private corporations, and limited-liability companies organized on a for-profit or not-for-profit basis. Individuals or partnerships are not eligible. Any public or private applicant must have the legal capacity and authority to own and operate the proposed broadband facilities, to enter into contracts, and to otherwise comply with applicable federal statutes and regulations. Thus, awards cannot be granted to a local government entity that does not want to own or operate the broadband service.

Once awarded, projects must offer last-mile service at the broadband grant speeds (25 Mbps download and 3 Mbps upload) to *all* businesses, residents, and community facilities in the PFSA, with free service provided to all critical facilities,[21] and at least one community center (with weekend hours and two to 10 public computer access points) for at least two years from the grant award. Grants can be used to offset the cost of providing such service and to lease

[21] Critical community facilities include public schools, public libraries, public medical clinics, public hospitals, community colleges, public universities, law enforcement, and fire and ambulance stations.

spectrum, towers, and buildings as part of the project design.[22] The lesser of 10 percent of the grant or $150,000 can be used to construct, acquire, or expand an existing community center.[23]

3.5 Department of Commerce economic development grants assist distressed communities

The Department of Commerce's Economic Development Administration (EDA) oversees the Economic Development Assistance program, which has delivered funds to distressed communities for many years. Public broadband projects in economically distressed communities are eligible for funding under the Public Works and Economic Adjustment Assistance (PWEAA) programs—which do not require that an area is unserved, but do require that jobs be created or saved as a direct result of the proposed project.

The EDA program coordinates with a $587 million grant program[24] also under the oversight of the Department of Commerce. This opportunity attempts to remedy disaster-stricken areas of the economic burdens that such disasters impose. Disasters are defined per the President's declaration. If the County were to qualify, this opportunity would provide a similar application process to the broader, non-disaster Economic Development Assistance grants.

EDA's materials on Public Works funding explicitly mention broadband,[25] but it does not appear that broadband funding has been a significant part of the portfolio. Over a period of a decade (2007–2017), the EDA's annual reports included only eight references to relevant projects.[26]

While broadband funding to date through the EDA appears to be modest, both construction and technical assistance are clearly eligible. Moreover, applicants can apply existing federal funds toward the cost-share, which allows them to leverage available resources. Given this, we recommend the County consider this opportunity. Additionally, the program does not require proof of lack of service or poor service. Instead, a proposed project must demonstrate that it will positively affect the economic prospects of the area; generally, in the form of addition of or saving of jobs. A local community economic development plan that highlights a need for better broadband will be an essential first requirement.

[22] Leasing costs can only be covered for three years.
[23] Note that additional funds can be used to provide the computer access points and their connection to the network. Applicants may use their own resources to cover costs exceeding this limit. The program historically required provision of at least 10 computer access points in a public community center; however, now requires only two such access points—with a *maximum* of 10 computers.
[24] See https://www.grants.gov/view-opportunity.html?oppId=302953 (accessed November 2019).
[25] "Broadband Funding Guide," U.S. Department of Commerce EDA, December 12, 2018, https://broadbandusa.ntia.doc.gov/sites/default/files/funding_eda_01_0.pdf (accessed December 2019).
[26] EDA annual reports available online at: https://www.eda.gov/annual-reports/ (accessed November 2019).

The PWEAA Notice of Funding Opportunity (NOFO) emphasizes the importance of consulting with the appropriate regional EDA contacts.[27] Regional staff is available to review project proposals, assess proposed cost shares, and preview all application materials. Though optional, we believe that such consultation would ultimately be beneficial if the County were to consider applying.[28]

[27] "Notice of Funding Opportunity – FY 2020 EDA Public Works and Economic Adjustment Assistance Programs," https://www.grants.gov/web/grants/view-opportunity.html?oppId=321695 (accessed December 2019).
[28] EDA regional contacts available online at: https://www.eda.gov/contact/ (accessed November 2019).

4 A High-Level Fiber-to-the-Premises Cost Estimate Illustrates the Level of Funding Needed by the County or a Partner

In the sections below, we describe the assumptions underpinning a high-level cost estimate that was prepared for serving the PFSA with fiber-to-the-premises (and which would vary with different types of deployments and partnerships) as well as an earlier, much larger fiber-to-the-premises design and cost estimate.

4.1 A high-level cost estimate was completed for the PFSA

For purposes of understanding the level of federal funding a partner or the County might require to serve the County's PFSA, we note that a detailed fiber-to-the-premises design for serving the County's PFSA shows that deploying such a network would require an estimated $12.4 million capital investment.

Notably, the majority of the 185 miles of fiber routes would be existing fiber; only 39 miles of fiber would need to be constructed. The cost estimate assumes a high, 60 percent take-rate for the network, meaning that the capital investment would include customer drops and customer premises equipment installations for a majority of passings.

Operating expenses for this candidate network would vary depending on the partner's planned approach and assumptions about such factors as video and phone take-rates. Similarly, the network's capital costs will vary based on issue such as the provider's cost for middle-mile fiber construction (which would be lower for Verizon, for example, because it could overlash on existing plant), whether the provider offers video service, and the provider's cost for backhaul (such as to a point of presence in Baltimore).

4.2 A much larger fiber network designed during an earlier study would have served 13,000 addresses at a much higher price

By comparison to the limited cost estimate developed for serving the PFSA, a CTC study completed for the County in 2016 (in an earlier phase of the County's long-running efforts to solve its digital divide) depicted a scalable fiber-to-the-premises network for the North End encompassing a much larger scope than the ReConnect-grant-driven PFSA.[29]

That network, which would have served 13,000 premises (and included some overlap with existing cable service areas), had a projected capital cost of $58 million to $78 million, including service drops and customer premises equipment, at a take-rate of 35 percent. Our 2016 design had the following key metrics:

[29] CTC Technology & Energy, "Public-Private Partner Feasibility Study for Broadband in the North End."

Table 1: Metrics for Ubiquitous North End Fiber-to-the-Premises Network (2016)

Total passings	12,943
Average Passing density	26.2 passings per street mile
Total hubs	1
Total FDCs	26
Total backbone routes (new and existing)	80.9 miles
Total standalone backbone routes	4.1
Total distribution plant path	499 miles

This earlier fiber-to-the-premises network cost estimate assumed all new construction (with the exception of limited usage of HMAN backbone routes) and encompassed conservative numbers for underground and make-ready consistent with Inter-County Broadband Network (ICBN) and post-ICBN construction related to the HMAN.

4.3 Competitive and cost factors would have an impact on fiber deployment efforts

While it is not entirely inconceivable for a new entity to deploy a fiber-based service to serve the County's PFSA, the costs and level of competition for that provider would be high. In addition to competing against Armstrong Cable for the most lucrative parts of the County's North End (where Armstrong is already established), the competing service provider would in many cases need to build distribution plant between the PFSAs from which to initiate its buildout. The new provider might also need to construct a hub facility and purchase backhaul. And because it would likely lack pole attachments between and through the segments of the PFSAs, it would pay higher cost to overlash new fiber for much of the build.

The County's market survey specifically targeted addresses not already served by cable, so unfortunately we do not have a good sense of the level of satisfaction with existing service providers. Based on experience nationwide, however, we believe a new competitive provider's take-rate would be lower than the 60 percent projected in the estimate described above.

5 A Fixed Wireless Solution Could Also Serve A Portion of the County's Unserved Addresses, but Would Have Significant Technical Limitations Compared to a Fiber Network

As an alternative to deploying fiber-to-the-premises, the County could consider a fixed-wireless network to deliver broadband services to unserved members of the community. To that end, CTC's engineers developed a fixed wireless network model to assess the viability of serving the County's approximately 2,500 unserved addresses (i.e., in the 90 percent PFSA).

A fixed wireless solution would have clear technical limitations relative to a fiber optic network. Although a wireless scenario would offer a relatively low-cost way to serve a significant number of residents, this scenario has obvious drawbacks: It is not ubiquitously available, not "broadband," and not easily scalable. A fixed wireless network is likely to deliver only mediocre DSL-like service levels for most of the coverage area; speeds of 25/3 Mbps or greater would not be the norm. Coverage and capacity can be increased with new technologies—but in any conceivable scenario, the costs are heavily dominated by customer installations, with rooftop antennas or taller outdoor masts installed to get above the tree line.

That said, a fixed wireless network could cover more than 2,000 addresses (or approximately 90 percent of the homes in the PFSA) at an estimated cost of $12.4 million. The network would leverage existing telecommunications towers where available and build new support structures where needed. It would extend existing fiber for backhaul connectivity where feasible and use point-to-point wireless connections where fiber is not available.

The approach we outline below is broken into three primary phases, each with its own budget, time to market, and number of addresses covered. The cost per address increases with the phase number.

- Phase 1: Use 14 existing telecommunications towers to serve 1,194 addresses at a cost of $3.2 million
- Phase 2: Build nine new towers in strategic locations to cover an additional 633 addresses at a cost of $3.4 million
- Phase 3: Deploy 30 new wooden pole masts and 10 repeaters in neighborhoods to cover 450 addresses at a cost of $5.75 million

We also analyzed an incremental expansion of Phase 1 (which we refer to as Optional Phase 1A) utilizing additional existing towers to serve additional addresses *outside the PFSA*. Antennas installed on 10 additional existing towers could cover an additional 6,186 addresses in the northern part of the County (i.e., giving residents there another service option). The incremental cost of this phase would be about $4.7 million.

5.1 Overview of analysis

We developed three fixed wireless network models for serving Harford County's unserved PFSA addresses, and a fourth model for serving addresses outside the PFSA:

- **Phase 1:** Using existing towers to serve addresses in the PFSA
- **Phase 2:** Deploying new towers to serve additional unserved addresses in the PFSA
- **Phase 3:** Deploying new pole masts and repeaters to cover remaining clusters of unserved addresses in the PFSA
- **Optional Phase 1A:** Extending Phase 1 to cover addresses outside the PFSA using additional existing towers

Table 2 summarizes the cost of the phases.

Table 2: Fixed Wireless Analysis Results

Phase	Number of Towers	PFSA Addresses Served	Cumulative Percent Served	Capital Cost	Average Distribution Network Cost per Passing	Installation and CPE Cost per Customer
Phase 1	14	1,194	48	$3,200,000	$ 1,600	$1,800
Phase 2	9	633	74	$3,400,000	$4,200	$1,800
Phase 3	30	450	92	$5,750,000	$11,500	$1,800
Optional Phase 1A	10	NA	NA	$4,700,000	$300	$1,800

Note: Capital cost assumes penetration rate of 60% for phases 1, 2, and 3, and 30% for Optional Phase 1A.

In Phase 1, we found that an average of more than 85 addresses could be served by each of the 14 existing towers. In Phase 2, we found that an average of more than 70 addresses could be served by each of the nine new towers. In Phase 3, we found that an average of 13 and six clustered addresses would be served by each of the 30 new pole masts and 10 repeaters, respectively. For Phase 1A, an average of more than 257 addresses were covered by each of the 24 existing towers (14 existing towers from Phase 1 plus 10 additional existing towers).

Table 2 illustrates that fixed wireless technology can be a technically feasible approach to providing broadband to unserved addresses. Although there are technological limitations relative to a fiber optic service (as well as higher operational costs and a shorter technology lifetime), wireless technology has benefits in terms of lower capital costs and reduced time to deploy. Furthermore, as discussed below, new developments in wireless technology are improving the

reliability and speed of wireless broadband, and therefore these technologies are a better option now than they were in the recent past.

The following sections:

- Provide a high-level introduction to fixed wireless connectivity (including technologies, basic architecture, spectrum, and elements of costs)
- Describe the use of existing and new structures to deploy a fixed wireless solution for the County's unserved homes and businesses

5.2 Introduction to fixed wireless network connectivity

Broadband speeds in compliance with the FCC's definition (i.e., 25 Mbps download, 3 Mbps upload—which is also the definition of "served" approved by Harford County for this project) are more readily available from fixed wireless networks than in the past, owing to the recent introduction of the Citizens Broadband Radio Service (CBRS) spectrum into the market and new wireless technologies. While wireless internet service providers (WISP) typically are not able to offer connection speeds on a market-wide basis comparable to cable or fiber networks built to each premises, a fixed wireless connection may be a desirable solution if cable or fiber is not cost-effective. This is especially true in low-density rural areas where there are few homes and businesses per mile, and therefore the cost of building wired networks is often high.

As opposed to an underground or aerial cable, wireless broadband is delivered via access point antennas mounted on towers or rooftops. Customers' antennas may be mounted on a building (i.e., the home or business) or on a mast on a customer's premises (Figure 13).

Figure 13: Sample Fixed Wireless Network with Various Customer Antenna Configurations

5.2.1 Fixed wireless spectrum and architecture

Fixed wireless networks typically use the following spectrum:

- TV White Space (TVWS) 500 MHz
- Unlicensed 900 MHz, 2.4 GHz, 5 GHz
- Citizens Broadband Radio Service (CBRS) 3.5 GHz

It is useful to determine which band may be most effective to use in different areas. Each band will need its own set of equipment; if one or more band can be eliminated from specific sites, then the overall cost of deployment and operations will be reduced.

Of these bands, only CBRS and 5 GHz unlicensed technology have channel widths capable of delivering 25 Mbps down and 3 Mbps up—so those are the two primary bands we considered. The CBRS band is predicted to connect the most addresses. (In addition to the spectrum properties, the ability to connect is due to the antennas being allowed to be mounted higher than the TVWS antennas under the licensing rules of the FCC, and CBRS being allowed to have the greatest broadcast power of the three technologies.)

That said, we also considered TVWS—which delivers service over unused television frequencies (known as white space). TVWS bands have much better non-line-of-sight transmission qualities than the other bands; however, due to its narrower bandwidth, TVWS is not capable of delivering 25 Mbps down, and therefore should only be considered in cases where other connectivity is not available or feasible. Also, because white space technology is still in an early phase of development, compatible equipment is far more expensive than other off-the-shelf wireless equipment. Finally, because Harford County has many existing broadcast television channels, the potential TVWS spectrum may be limited.

Most fixed wireless network solutions require the antenna at the subscriber location to be in or near the line of sight of the base station antenna. This can be especially challenging in mountainous regions. It is also a problem in areas with dense vegetation or multiple tall buildings. WISPs often need to lease space at or near the tops of radio towers; even then, some customers may be unreachable without the use of additional repeaters. And because the signal is being sent through the air, climate conditions like rain and fog can impact the quality of service. In our model, we assumed that the tops of any existing towers are already utilized, and that any new equipment would be placed at 80 percent of the current tower height.

In addition, there is a tradeoff in these bands between capacity and the ability to penetrate obstructions such as foliage and terrain. The higher frequencies have wider channels and therefore the capability to provide the highest capacity. However, the highest frequencies are those most easily blocked by obstructions.

Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. The models in this document assume point-to-multipoint equipment, which is typical for a residential or small business connection. Point-to-point service would typically be chosen by a medium-sized business, because it would enable dedicated bandwidth (at a higher cost than a point-to-multipoint service); that said, point-to-point networks may have limited network capacity, particularly in the upstream, making the service inadequate for applications that require high-bandwidth connections.

5.2.2 Fixed wireless network deployment costs

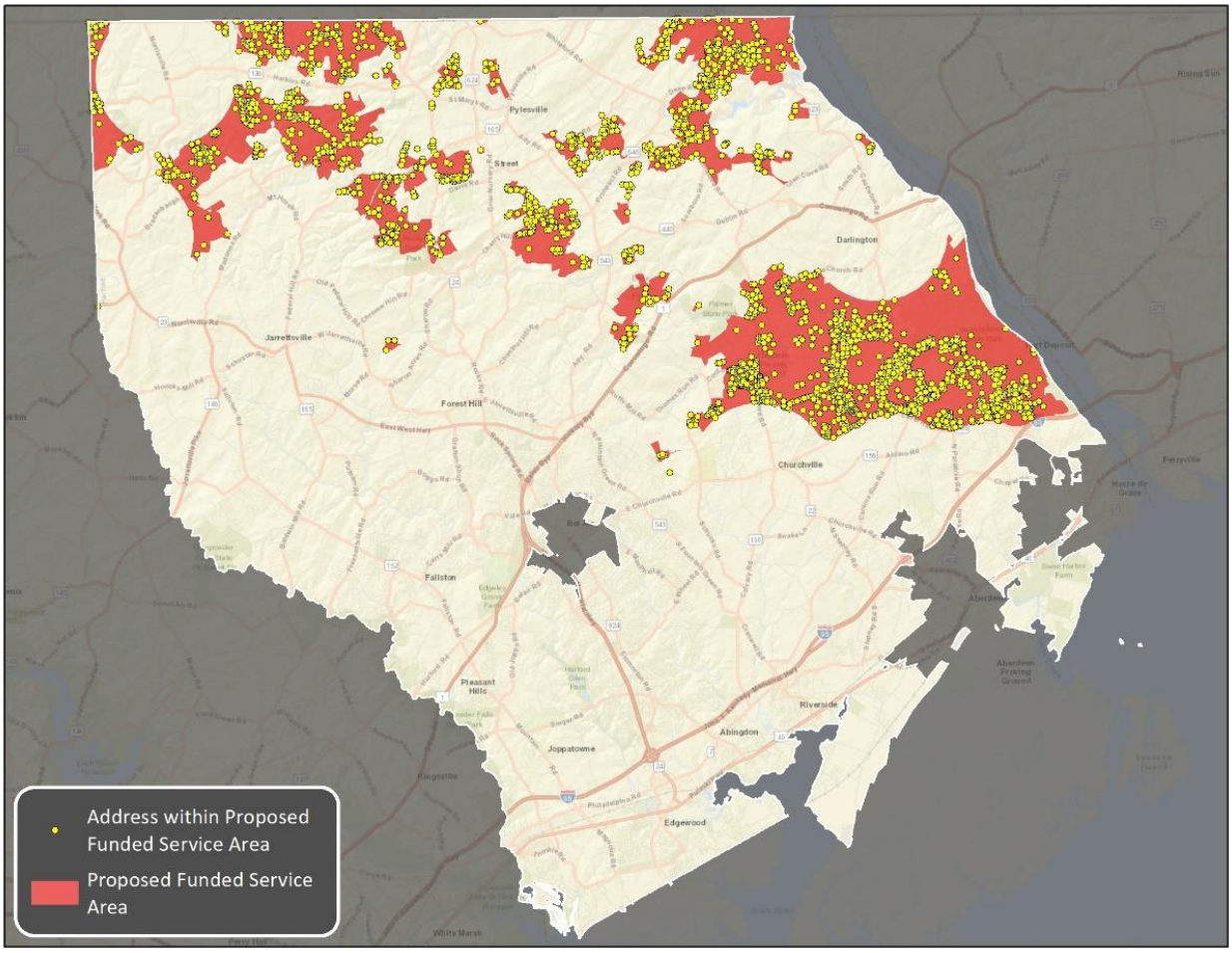
The following factors will determine the costs associated with a fixed wireless network:

- **Wireless equipment used:** Different wireless equipment has different aggregate bandwidth capacity and uses a range of different spectrum bands, each with its own unique transmission capabilities
- **Backhaul connection**: Although the bottleneck tends to be in the last-mile connection, if a WISP cannot get an adequate connection back to the internet from its tower, equipment upgrades will not be able to increase available speeds beyond a certain point
- **Future capacity and lifespan of investment:** Wireless equipment generally requires replacement every five to 10 years, both because exposure to the elements causes deterioration, and because the technology continues to advance at a rapid pace, making decade-old equipment mostly obsolete; the cost of deploying a wireless network is generally much lower than deploying a wireline network, but the wireless network will require more regular investment
- **Availability of unobstructed line of sight:** Most wireless networking equipment requires a clear, or nearly clear, line of sight between antennas for optimum performance; WISPs often lease space near the tops of radio towers, to cover the maximum number of premises with each base station

5.3 Determining unserved areas and addresses in Harford County

As described in Section 2, CTC defined the unserved areas within the County based on a detailed analysis of current broadband service. Figure 14 shows the County's PFSA and addresses.

Figure 14: Unserved PFSA and Addresses in Harford County



5.4 Analyzing radio frequency coverage

We conducted a wireless analysis to determine how the County's unserved address could be served via fixed wireless. The high-level model is for planning purposes only. The radio frequency (RF) coverage analysis was modeled using CloudRF, which is an online service available for modelling RF propagations. The software was chosen because of its ability to output coverage maps in a GIS layer than can be overlaid on the unserved address points, and therefore identify which of the addresses would be covered by the wireless model.

There are various propagation models used for RF analysis. Widely used models are the line of sight (LOS) model, cost 231 model, Okumura Hata model, and Longley-Rice model (also called the Irregular Terrain Model, or ITM). For our analysis we used ITM, which is the most conservative and takes into consideration the atmospheric conditions, the ground elevation, the deployment environment, the obstacles between the base and mobile stations, and the ground clutter.

We generated coverage propagation maps, such that the signal levels would achieve a minimum throughout for each of the frequencies used. For the 5 GHz and CBRS frequencies, the coverage maps indicate the coverage area where throughputs of 25 Mbps download and 3 Mbps upload speeds could be achieved at the cell edge. Because TVWS will not achieve these throughputs, the coverage maps indicate areas where 10 Mbps download and 2 Mbps upload speed could be achieved.

5.5 Tower selection methodology

To examine the potential of antennas mounted on existing towers to provide service to the County's unserved addresses using CBRS, unlicensed 5 GHz, and TVWS, we analyzed multiple commercial and government databases and identified approximately 50 existing tower locations in Harford County. We examined their height and ownership relative to their potential use as part of a solution, then selected 14 of these existing towers based on the number of addresses each could serve. (All towers that could cover fewer than five addresses were removed.)

For Phase 2, our analysis indicates that constructing nine new towers would enable the network to serve an additional 652 addresses that could not be served by the existing towers in the County.

CTC assessed the coverage provided by each of the selected tower sites using the three fixed wireless frequency band options (CBRS, 5 GHz, and TVWS) to determine how many of the unserved addresses would be within each spectrum band's predicted coverage area. We based our analysis on the following assumptions:

- New towers would be 180 feet high and new pole masts would be 75 feet nigh
- Antennas on towers would be placed at 80 percent of the tower height for 5 GHz and CBRS, and at the maximum allowable height of 30 meters for TVWS; antennas would be placed at the top of pole masts
- Broadcast power would be 10 Watts lower than the FCC limit for the CBRS band; broadcast power would be at the FCC limit for the TVWS and 5 GHz bands
- Channel bandwidth would be 10 MHz for the CBRS band
- Subscriber equipment antennas would be placed at 4.57 meters (15 feet) above the ground
- Ground elevation and clutter resolution would be 30 meters

5.6 Cost analysis

A cost analysis for each of the phases is provided in the sections below. The analysis makes the following assumptions:

- All served addresses will require subscriber equipment installed (60 percent penetration)
- Towers will be configured with three sectors for each frequency used
- All selected towers will have CBRS deployed
- 25 percent of the towers will also have 5 GHz deployed
- 25 percent of the towers will also have TVWS deployed
- Towers will be connected to backhaul using microwave links or via fiber backhaul to the County's existing fiber; 10 percent of the sites will require an additional hop
- For fiber backhaul, we assumed there is enough capacity in the network at the location we tie into, and the site can use open fiber to connect back to the core site; the $25 per foot cost includes engineering and construction, and splicing and termination is assumed at a single core site
- Engineering and design costs include propagation studies, RF path analysis for point-to-point connections, structural analysis, construction plans, permits
- Site acquisition costs include the preliminary equipment dimensioning, power needs, shelter requirements, RF suitability, escorts, and lease negotiations
- There is room within the shelter at the tower location for additional equipment
- The estimate includes core network equipment to manage functions such as authentication, billing, security, and connection to the internet; in each of the cases outlined below, CTC assumes $200,000 for equipment and setup of a core
- The costs outlined below are capital costs only and do not include operational costs

5.7 High-level coverage and cost estimate – Phase 1

Of the 50 existing telecommunications towers presently in the County, 14 were identified which could serve at least five addresses within the PFSA.

Base stations and antennas deployed to those 14 towers could deliver service to an estimated 48 percent of the County's PFSA premises. The blue shading in Figure 15 depicts the predicted

coverage areas. The red indicates the remaining unserved areas. The blue dots show the tower locations.

Figure 15: Phase 1 Coverage Using Existing Towers

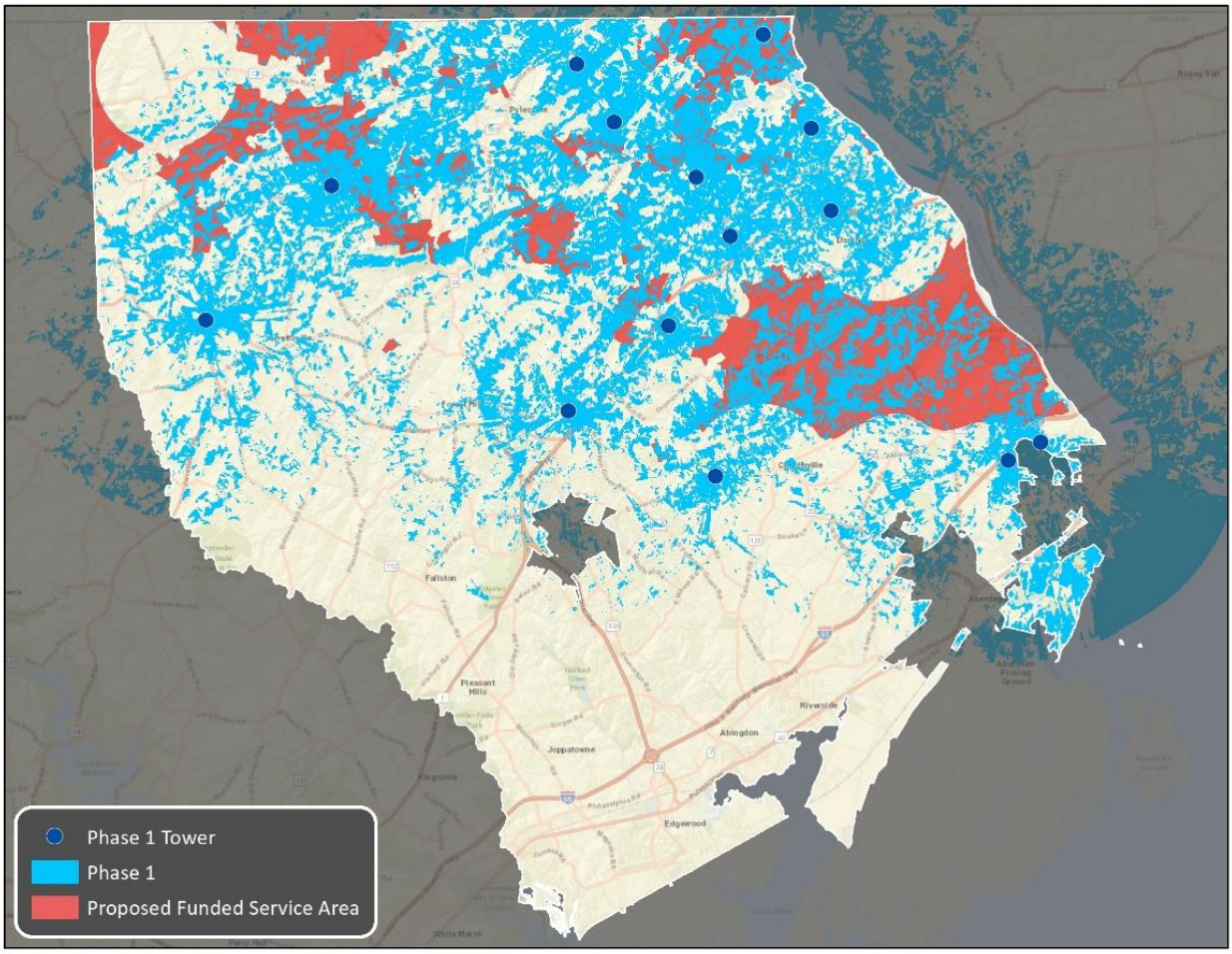


Table 3 indicates the penetration into the PFSA addresses.

Table 3: Predicted Coverage with Existing Towers (Phase 1)

Addresses	**Number**
Total addresses in unserved area	2,479
Addresses covered in Phase 1	1,194
Addresses not covered	1,285
Percent of addresses covered	48%

The cost breakdown for Phase 1 is shown in Table 4 and Table 5. Our cost analysis found that it would be less expensive to deploy fiber backhaul for seven of the 14 towers (as they are located close to the existing fiber links). For the remaining seven towers, microwave links are utilized.

Table 4: Capital Cost Estimate for Phase 1

	Cost
Network Core	$200,000
Access Point Equipment	$240,000
Microwave Backhaul	$105,000
Fiber Backhaul	$104,000
Installation, Engineering, and Design	$700,000
Site Acquisition	$560,000
Total Distribution Network Costs	$1,900,000
Total Addresses	1,194
Cost per Address (Distribution Network Only)	$1,600

Table 5: Total Cost Estimate for Phase 1 at 60 Percent Penetration Rate

Item	**Cost**
Incremental Premises Cost (60% Penetration)	$3,200,000
Total Cost per Customer (60% Penetration)	$4,500

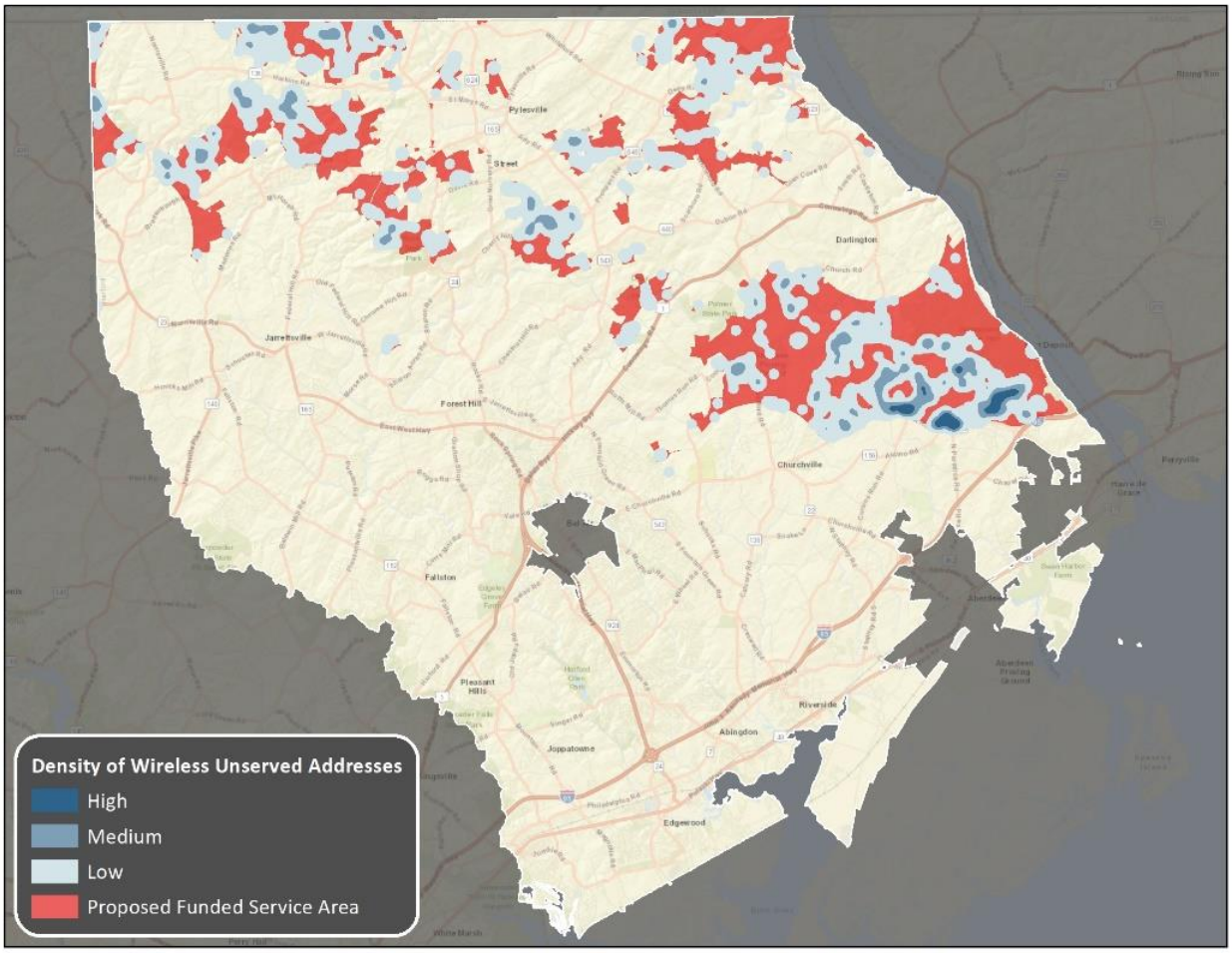
5.8 High-level coverage and cost estimate – Phase 2

Phase 1 does not reach all the addresses in the PFSA. Our propagation analysis predicts there would still be 1,285 addresses, or 52 percent, in the unserved areas that would not be covered.

To reach more addresses, we determined where new towers could be built.

Figure 16 shows the heat map indicating high-, medium-, and low-density populations that are not covered by the Phase 1. More homes are likely to be covered if antennas are deployed in high-density areas. We selected these areas for Phase 2 towers.

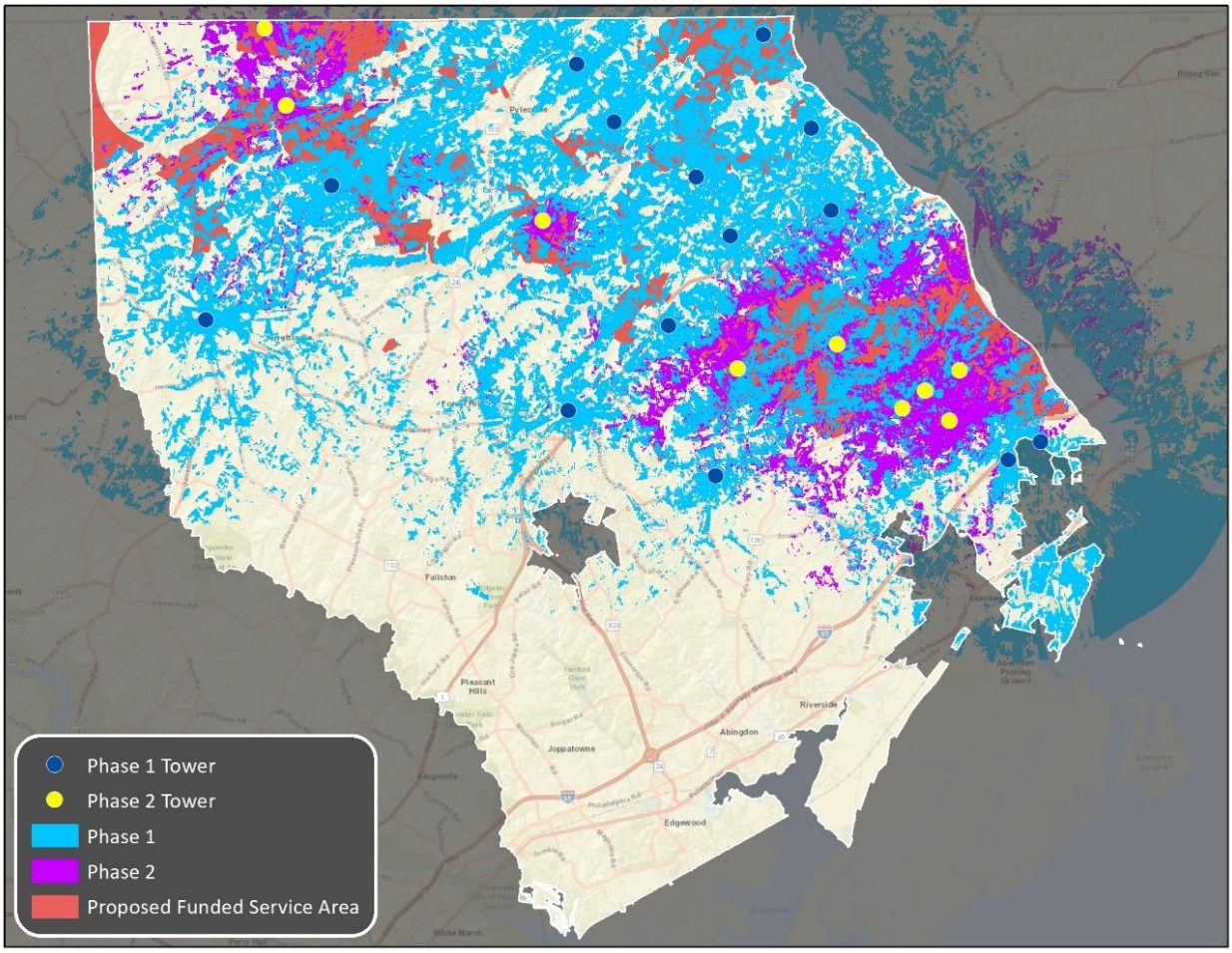
Figure 16: Population Density Heat Map for Remaining Addresses (Phase 2)



CTC determined optimal locations for new towers based on their ability to reach the most addresses, resulting in nine additional towers.

Figure 17 shows the resulting overall coverage (Phase 1 + Phase 2) after adding the nine new towers. An additional 633 addresses would be served, leaving 652 unserved addresses.

Figure 17: Phase 2 Coverage Using Existing Towers and New Towers



Our propagation analysis predicts that about 75 percent of the County's unserved addresses will be covered after building out Phase 1 and Phase 2.

Table 6: Predicted Coverage for Phase 2

Addresses	Number
Total addresses in unserved area	2,479
Addresses served by Phase 1 & 2	1,827
Addresses not served	652
Percent of addresses served by Phase 1 & 2	74%

The following table shows the costs for the additional nine new towers. The assumptions are the same as for the existing tower sites.

Table 7: Additional Capital Cost Estimate for Phase 2

	Cost
Building new towers	$1,350,000
Access Point Equipment	$153,750
Microwave Backhaul	$105,000
Fiber Backhaul	$119,150
Installation, Engineering and Design	$550,000
Site Acquisition	$360,000
Total Distribution Network Costs	$2,700,000
Total Addresses	633
Cost per Address (Distribution Network Only)	$4,200

Table 8: Additional Total Cost Estimate for Phase 2 at 60% Penetration Rate

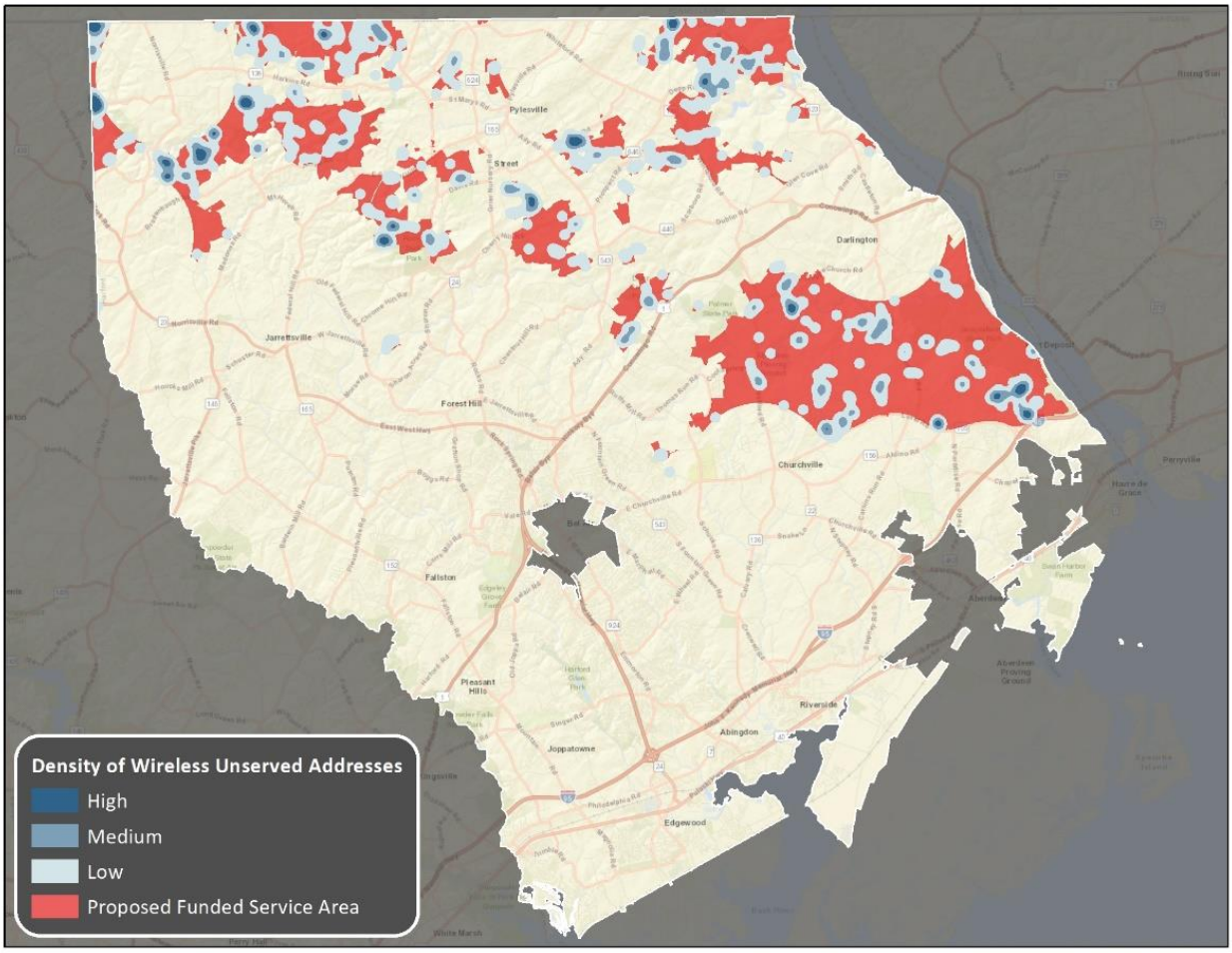
Item	Cost
Incremental Premises Cost (60% Penetration)	$3,400,000
Total Cost per Customer (60% Penetration)	$8,800

5.9 High-level coverage and cost estimate – Phase 3

After building out Phase 1 and Phase 2, we estimate there would still be 652 unserved addresses, or 26 percent of the total unserved premises, in the PFSA.

Again, a heat map is used to identify clusters of address still not covered. Figure 18 illustrates high-, medium-, and low-density areas not covered by Phase 1 and Phase 2. The high-density areas would be ideal spots to deploy new pole masts to cover the maximum number of unserved addresses.

Figure 18: Population Density Heat Map for Remaining Addresses (Phase 3)

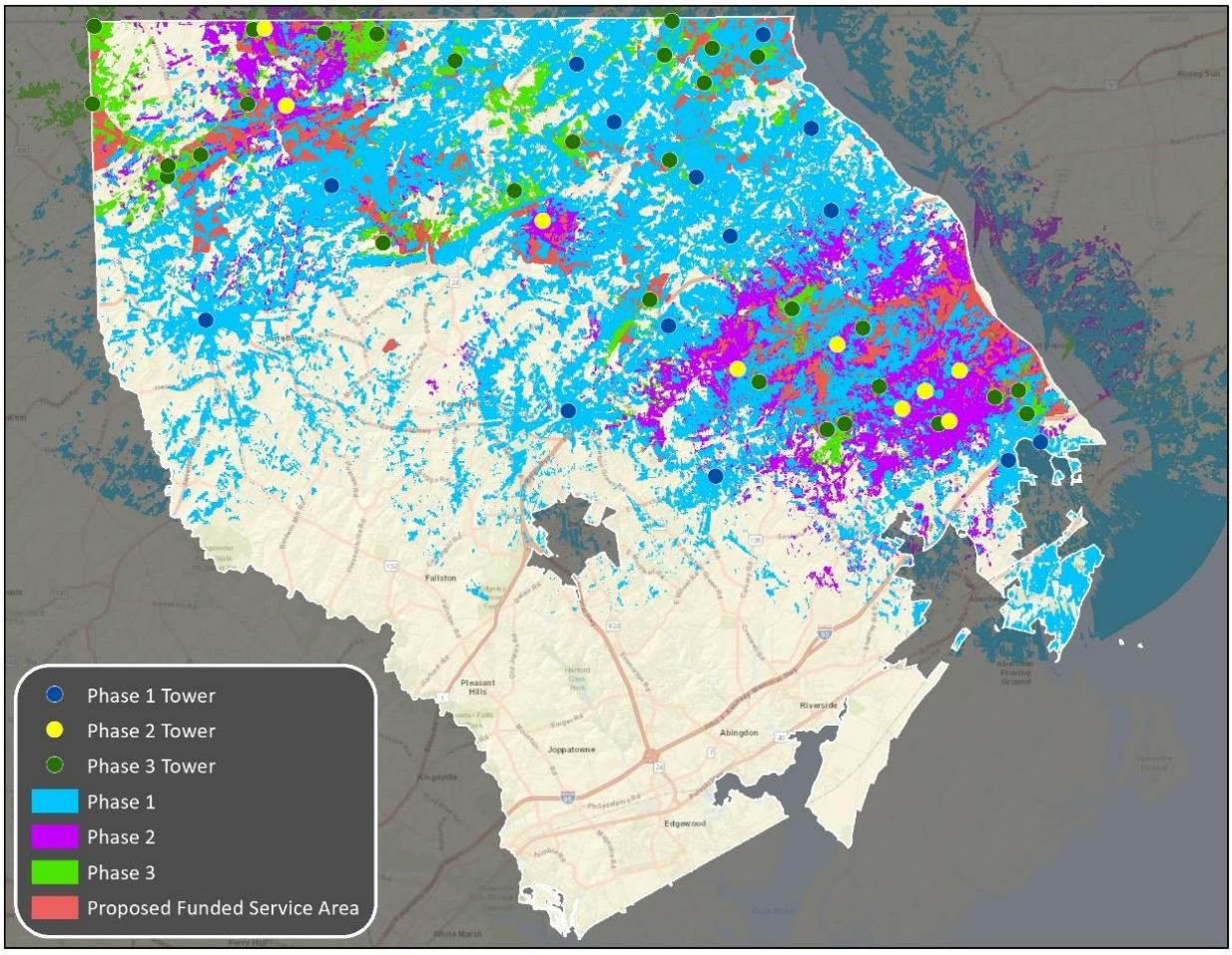


CTC determined optimal locations for placing these new pole masts based on their ability to reach the most addresses, resulting in 30 new pole masts. An additional 10 repeaters would be used to cover addresses that could not be covered in the areas close to the new pole masts. The repeaters, which would likely be mounted on customers' homes, are low-power (and low-cost) nodes that capture the antennas' signals and boost them in areas not reachable by the antennas mounted on towers or masts.

The pole masts would be connected to one of the Phase 1 or Phase 2 towers for backhaul connectivity. The locations of the pole masts and repeaters would likely be determined tactically based on demand.

Figure 19 shows the combined (Phase 1 + Phase 2 + Phase 3) coverage, which is 450 more covered addresses than Phase 1 and Phase 2. Blue shading indicates the areas covered in Phase 1. Purple shading indicates coverage for Phase 2 that could not be achieved in Phase 1. Green shading indicates coverage for Phase 3 that could not be achieved in Phase 1 and Phase 2.

Figure 19: Phase 3 Coverage Using Existing Towers, New Towers, and New Pole Masts



The following table shows the costs for the 30 pole masts and 10 repeaters. The assumptions are the same as for the existing tower sites. All the pole masts are assumed to have microwave backhaul links in this scenario.

Table 9: Capital Cost Estimate for Phase 3

	Cost
New Pole Masts	$1,350,000
Access Point Equipment	$510,000
Microwave Backhaul	$450,000
Repeaters	$18,000
Installation, Engineering, and Design	$2,100,000
Site Acquisition	$1,200,000
Total Distribution Network Costs	$5,200,000
Total Addresses	450
Cost per Address (Distribution Network Only)	$11,500

Table 10: Additional Total Cost Estimate for Phase 3 at 60% Penetration Rate

Item	Cost
Incremental Premises Cost (60% Penetration)	$5,700,000
Total Cost per Customer (60% Penetration)	$21,000

Our propagation analysis predicts there would still be 202 addresses, or 8 percent, in the unserved areas that would not be covered by the CBRS frequency band from equipment mounted on the pole masts. The following table breaks down the results.

Table 11: Predicted Phase 3 Coverage

Addresses	Number
Total addresses in unserved area	2,479
Addresses served by CBRS band	2,277
Addresses not served by the CBRS band	202
Percent of addresses served	92%

5.10 High-level coverage and cost estimate – Optional Phase 1A

For this phase we analyzed areas outside the PFSA as an alternative or incremental approach to Phase 1. By using additional existing towers, the County can reach addresses outside the PFSA—therefore giving residents a choice to purchase internet access from either the County's network or from Armstrong, the local WISP serving that area. This approach could also help the County generate additional revenue by delivering service to more addresses. Penetration here is assumed to be 30 percent (i.e., half the penetration rate of the unserved PFSA addresses) because these are areas where residents have an option to go with Armstrong's network.

An additional 6,186 addresses outside of the PFSA could be served by antennas mounted on the 14 existing towers from Phase 1 plus 10 additional existing towers in this phase. These would all be addresses outside the PFSA. Table 12 shows costs for the additional 10 existing towers. The assumptions are the same as for the existing tower sites used in Phase 1.

Table 12: Capital Cost Estimate for Optional Phase 1A

	Central
Access Point Equipment	$172,500
Microwave Backhaul	$90,000
Fiber Backhaul	$73,100
Installation, Engineering and Design	$540,000
Site Acquisition	$400,000
Total Distribution Network Costs	$1,300,000
Total Addresses	6,186
Cost per Address (Distribution Network Only)	$210

Table12: Total Cost Estimate for Optional Phase 1A at 30% Penetration Rate

Item	Cost
Incremental Premises Cost (30% Penetration)	$4,700,000
Total Cost per Customer (30% Penetration)	$2,500

Appendix A: Market Research

The market research analysis is attached separately.

ctc technology & energy

engineering & business consulting

Residential Broadband Survey Results

Prepared for Harford County, Maryland
April 2019

Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

Contents

Figures

Tables

1 Executive Summary

Harford County, Maryland, enjoys a diverse community, with farmland and rural areas to the north and suburban communities and towns to the south. A critical foundation for the area's quality of life is the use of technology, including reliable and robust internet access.

As part of its efforts to evaluate and improve the area's internet access and quality—and to support its application for a federal ReConnect rural broadband grant—Harford County conducted a survey of residents in underserved "north end" areas of the County in 2019. A key focus of the survey was to assess respondents' use of internet services and whether customers' needs are being met. Respondents were segmented into connectivity groups based on their type of internet service in relation to the grant criteria:

1. No internet service
2. Below minimum criteria (dial-up, satellite, cellular/mobile)
3. Possibly below minimum criteria (DSL, fixed wireless, other)[1]
4. Above minimum criteria (fiber, cable modem)

The survey achieved a high response rate of over 30 percent, providing a dataset from which to draw statistically valid conclusions and suggesting a high level of interest overall in the topic of broadband among the targeted population.

Key results from the survey include:

- **The market for a robust, high-speed product is extremely strong.** At a cost of $60 per month, 84 percent of the respondents report that they would purchase the service; at $80 per month, 57 percent of the respondents would purchase the service; and at $100 per month, 40 percent of respondents would purchase the service (see Figure 1, below).

[1] We have completed an engineering analysis of the "Possibly Below Minimum" category to estimate service performance in regard to the ReConnect grant requirements.

Figure 1: Willingness to Switch to High-Speed Internet at Price Levels (Mean Ratings)

- **The County's north end is conclusively unserved/underserved.** Most residents (94 percent) have some form of home internet access, although 79 percent of households have a connection below (61 percent) or possibly below (18 percent) minimum criteria. This includes 40 percent who use a cellular/mobile connection primarily and 18 percent with satellite internet. Another 12 percent of respondents have DSL, and only 12 percent have a cable modem as their primary home internet service.

- **Survey respondents prioritize service reliability and speed foremost.** Reliability and speed of the internet connection ranks as the most important service aspects. Residents are only slightly to moderately satisfied with the speed and reliability of their internet service overall, and the extremely high importance placed on these factors may signal some willingness to switch providers if needs are not being met.

- **Teleworking is a significant driver of demand for improved broadband access.** Although similar proportions of households across connectivity groups have a member who already teleworks, a greater share of households with a connection below the minimum criteria have a household member who *would like to* telework. They are also somewhat more likely to have a household member who plans to start a home-based business or who uses the internet for education.

- **Many unserved residents are willing to pay upfront fees or installation.** Willingness to switch to high-speed internet service (100 Mbps) is very high at $60 per month (84

percent extremely willing), but it drops considerably as the price increases. However, internet users with a slower connections would be more willing to switch providers at various price points, and they would be more willing to pay a one-time fee for access to high-speed internet, compared with those who already have internet service above the minimum criteria.

- **North end residents are generally unsatisfied with what the market has to offer.** Additionally, those with a connection below or possibly below minimum criteria were less likely to agree that the market offers affordable high-speed internet, and they were more likely to agree that high-speed internet is an essential service and that they would be willing to pay a premium for access.

- **North end residents want the County's help to address the lack of broadband availability.** Eight in 10 respondents indicated that Harford County should have some role in expanding broadband internet access, although they were split as to whether that role should be to install and lease to private companies, or to encourage private firms to build a high-speed network. There is strong support for County intervention to address broadband needs in a manner that would require some form of upfront financial investment.

This report documents the survey process, discusses methodologies, presents results, and provides key findings that will help Harford County assess the current state and ongoing needs of its residents regarding high-speed communications services.

2 Survey Process

As part of an effort to evaluate and improve high-speed communications services in the area, Harford County conducted a mail survey of residents in selected areas of the County in January 2019. The survey specifically targeted geographic areas that the County believes are significantly "unserved" on the basis of thresholds set by the U.S. Department of Agriculture (USDA) for its ReConnect grant program.[2] The survey omitted addresses for which cable modem services that exceed these thresholds are known to be available.

The survey captured information about residents' current communications services, satisfaction with those services, desire for improved services, willingness to pay for faster internet speeds, and opinions regarding the role of the County regarding internet access and service. A copy of the survey instrument is included in Appendix A.

The County acquired the services of CTC Technology and Energy (CTC) to help assess internet access in the region and evaluate options to improve service in select areas of the County. Coordination and Responsibilities

In the project planning phase, County staff and the CTC team discussed the primary survey objectives, the timing of the survey and data needs, and options for the survey process. The project scope, timeline, and responsibilities were developed based on those discussions.

The CTC team developed the draft survey instrument based on the project objectives and provided it to County staff for review and comment. County staff provided revisions and approved the final questionnaire and specified geographies to be included in survey sampling. The County provided a mailing list of residences in selected areas of Harford County. The CTC team coordinated all printing, mailing, and data entry efforts; provided regular updates regarding survey responses; and performed all data coding and cleaning, statistical analyses, response summaries, and reporting of results.

2.1 Survey Mailing and Response

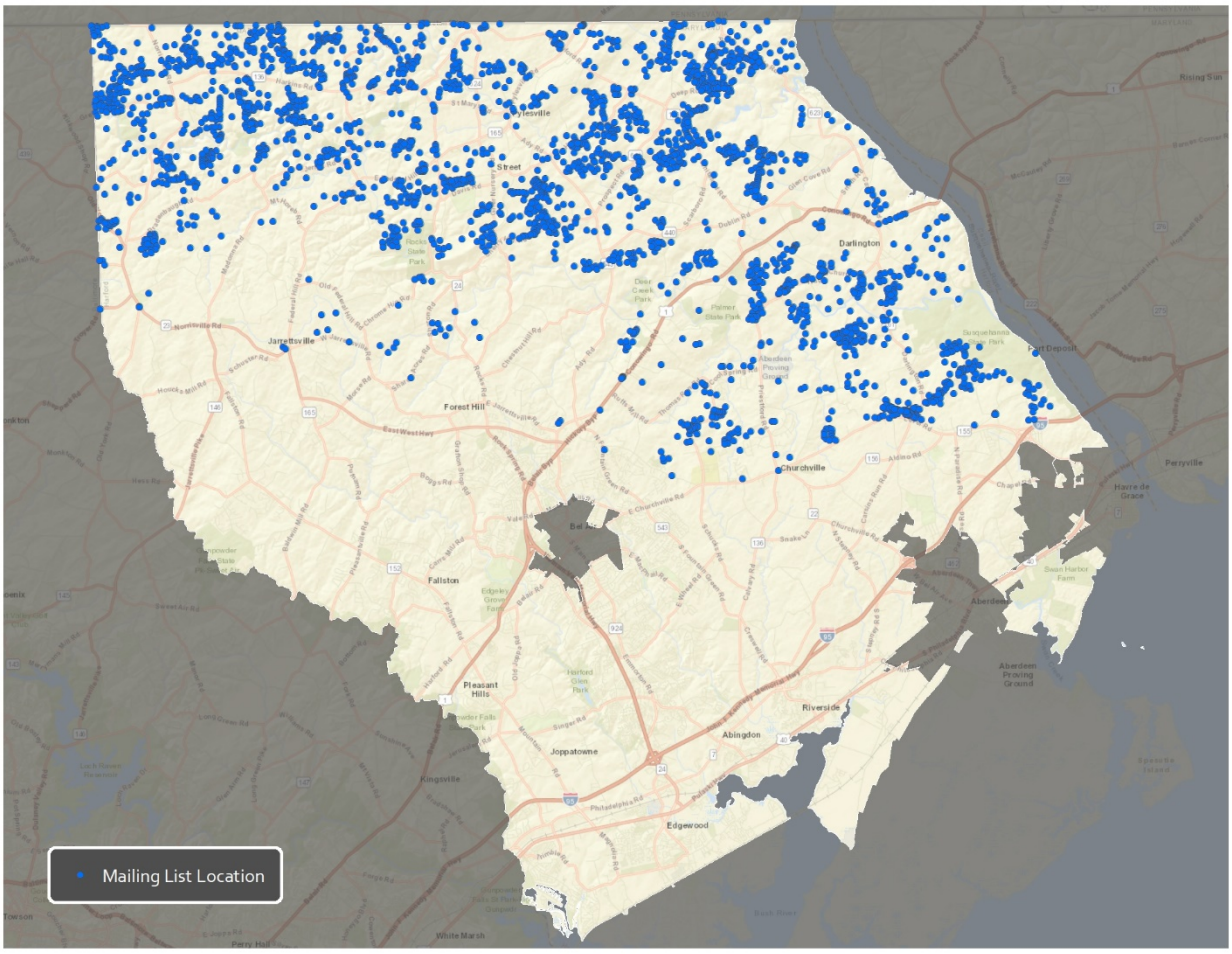
A total of 2,556 survey packets were mailed first-class to residential households in January 2019 with a goal of receiving at least 380 valid responses. Recipients were provided with a postage-paid business reply mail envelope in which to return the completed questionnaire.

[2] The USDA defines "unserved" as the lack of availability of a fixed broadband service providing capacity levels of 10 Mbps downstream and 1 Mbps upstream. See: "Program Overview," USDA, https://www.usda.gov/reconnect/program-overview.

Harford County provided a mailing list of approximately 4,000 addresses in underserved areas of the County, pulled from County property records, from which to draw the sample. Duplicate contact names and addresses were removed from the list.

Figure 2 illustrates the addresses to which surveys were mailed.

Figure 2: Locations of Survey Recipients

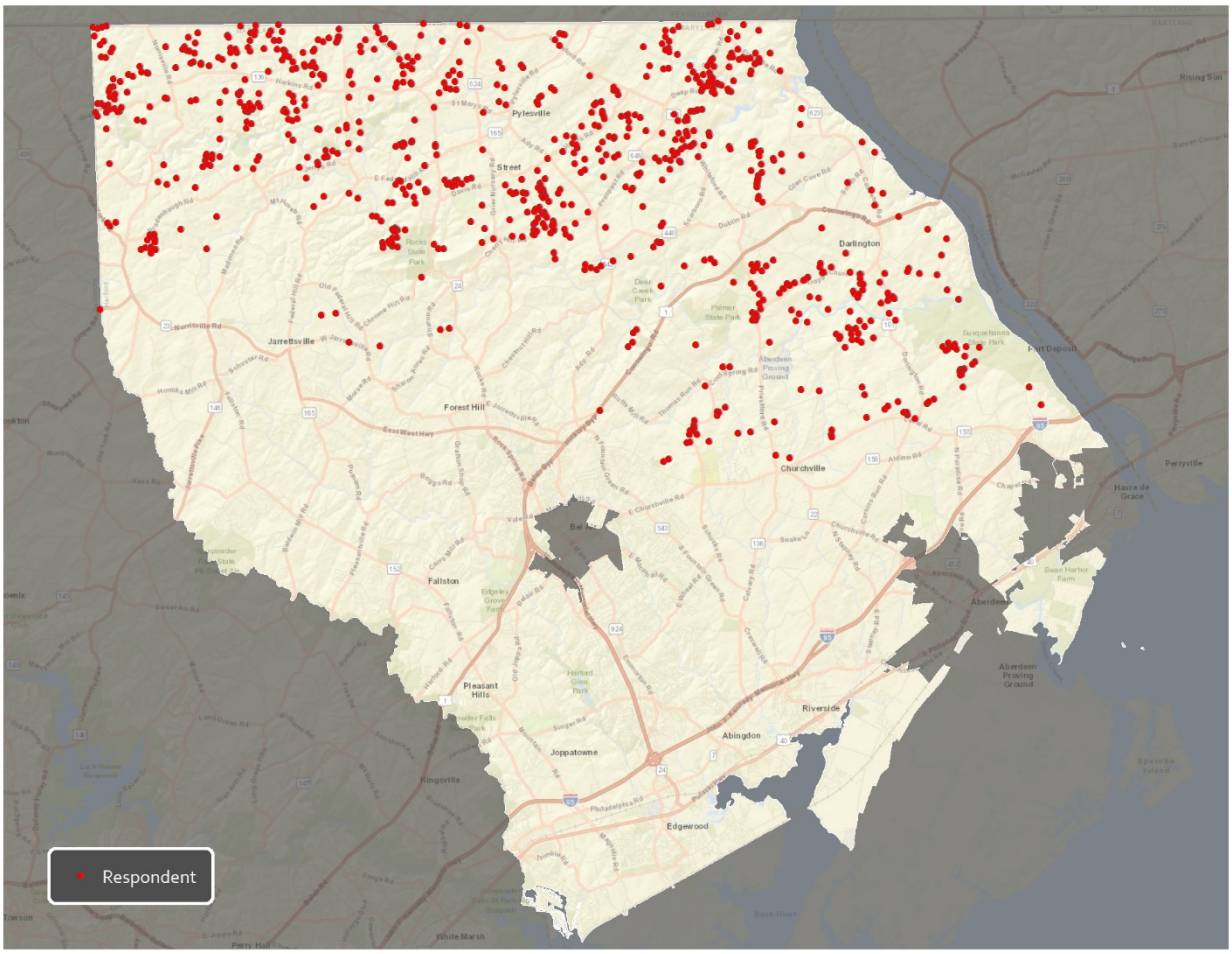


A total of 804 useable questionnaires were received by the date of analysis,[3] providing a gross[4] response rate of 31 percent. The margin of error for aggregate results at the 95 percent confidence level for 804 responses is ±3.1 percent, within the initial sample design criteria. That is, for questions with valid responses from all survey respondents, one would be 95 percent confident (19 times in 20) that the survey responses lie within ±3.1 percent of the target population as a whole.

[3] At least 62 responses were received after analysis had begun, and are not included in these results.
[4] 18 surveys were undeliverable, mostly vacant residences. The "net" response rate is 804/(2,556-18) = 31.7%.

Figure 3 illustrates the locations of residents who responded to the survey.

Figure 3: Locations of Survey Respondents



2.2 Data Analysis

The survey responses were entered into SPSS[5] software and the entries were coded and labeled. SPSS databases were formatted, cleaned, and verified prior to the data analysis. Address information was merged with the survey results using the unique survey identifiers printed on each survey. The survey data was evaluated using techniques in SPSS including frequency tables, cross-tabulations, and means functions. Statistically significant differences between subgroups of response categories are highlighted and discussed where relevant.

The survey responses were weighted based on the age of the respondent. Since older persons are more likely to respond to surveys than younger persons, the age-weighting corrects for the potential bias based on the age of the respondent. In this manner, the results more closely reflect

[5] Statistical Package for the Social Sciences (http://www-01.ibm.com/software/analytics/spss/)

the opinions of the County's adult population in the defined geographic area. Note that the age distribution of the market area's adult population is estimated using Census data for Harford County as a whole.

Table 1 and Figure 4 summarize the weighting used for survey analysis.

Table 1: Age Weighting

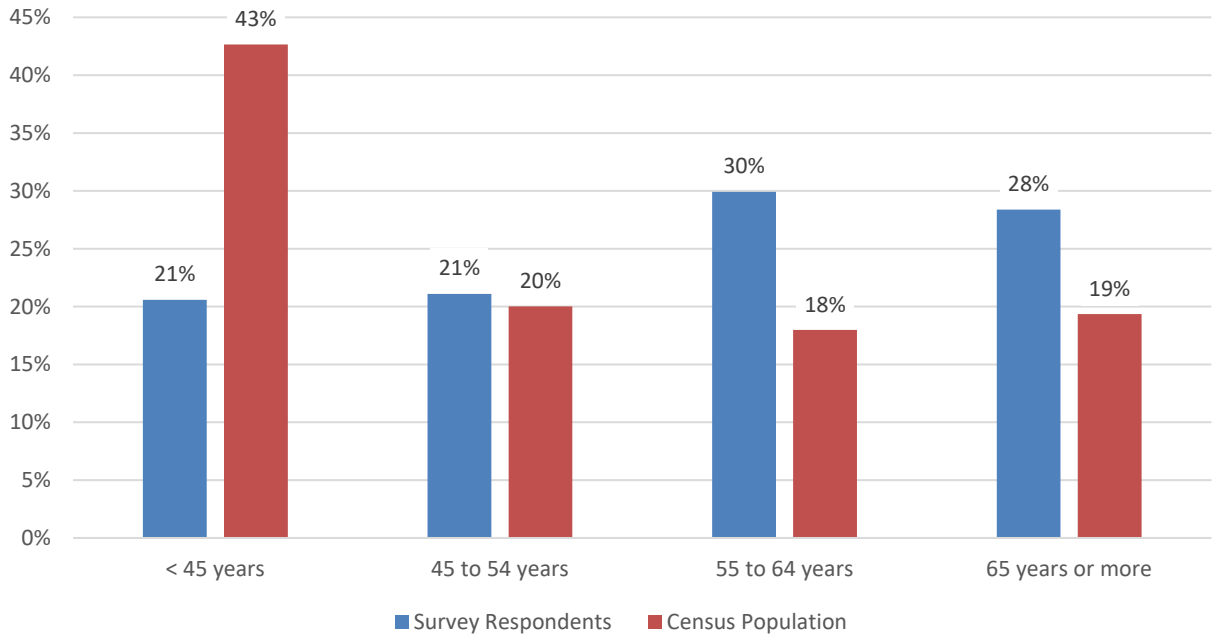
Age Cohort	Census Population (Adult)	**Survey Responses	Weight
18-44*	82,368	161	2.07
45-54	38,639	165	0.95
55-64	34,719	234	0.60
65+	37,368	222	0.68
Total	193,094	782	

The Census data used represents individuals in the entire Harford County area as a proxy for the selected areas included in the survey.

*The 18-34 and 35-44 age cohorts were grouped together due to small numbers in the sample.

**Not all respondents provided their age.

Figure 4: Age of Respondents and Adult Population



The following sections summarize the survey findings.

3 Survey Results

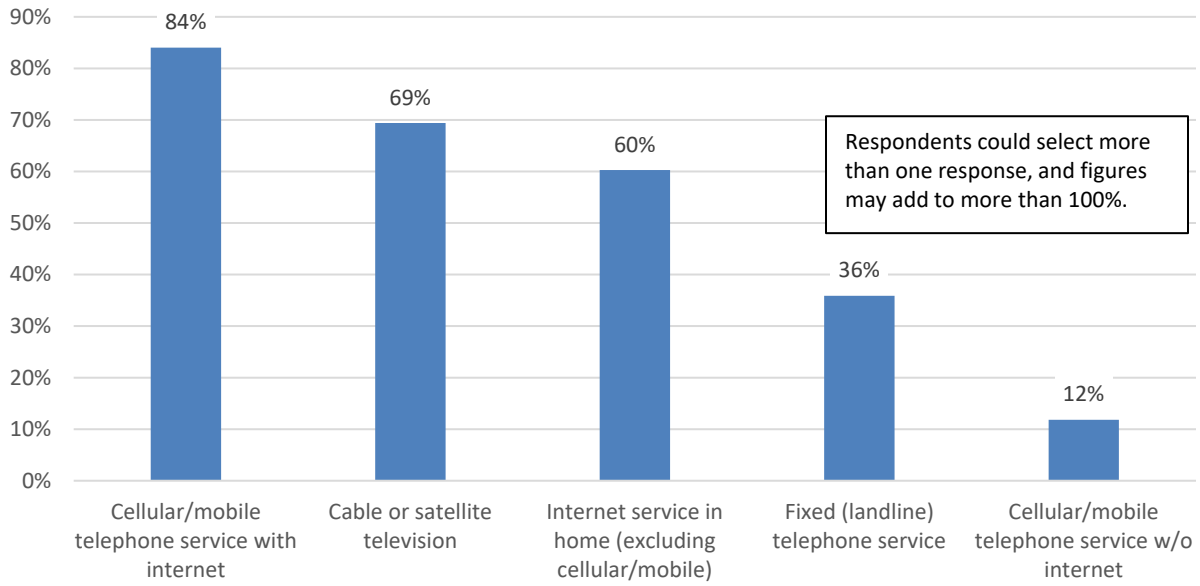
The results presented in this report are based on analysis of information provided by 804 respondents from an estimated 4,000 residences in selected areas of Harford County. Results are representative of the set of households with a confidence interval of ±3.1 percent at the aggregate level.

Unless otherwise indicated, the percentages reported are based on the "valid" responses from those who provided a definite answer and do not reflect individuals who said "don't know" or otherwise did not supply an answer because the question did not apply to them. Key statistically significant results ($p \leq 0.05$) are noted where appropriate.

3.1 Overview of Communications Services

Respondents provided information about the communications services currently purchased for their households. As illustrated in Figure 5, most respondents have cellular/mobile telephone service with internet, cable/satellite television service, and home internet service (excluding cellular/mobile), while fewer have landline telephone service or cellular/mobile phone without internet. Overall, 94 percent have some internet access—either a home connection or via smartphone.

Figure 5: Communications Services Purchased



Purchase of fixed (landline) telephone service or cellular/mobile service without internet is higher among those ages 65 and older, as well as those earning less than $75,000 per year (who are disproportionately older), while use of cellular/mobile telephone with internet is lower among these cohorts (see Figure 6 and Figure 7).

Figure 6: Services Purchased by Age of Respondent

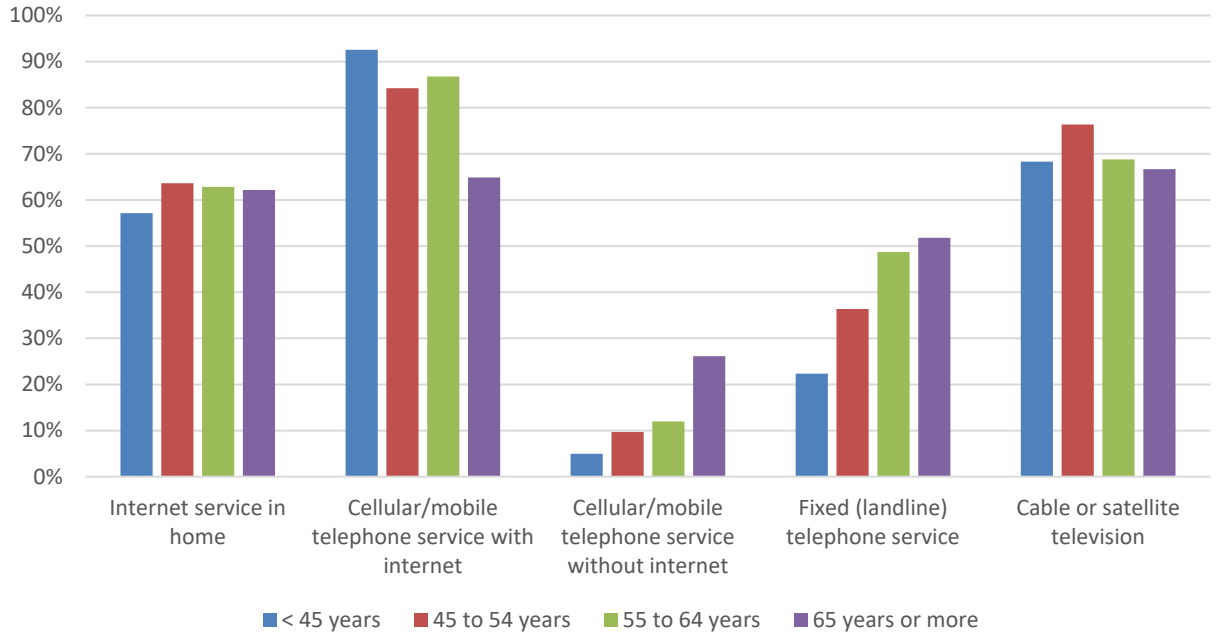
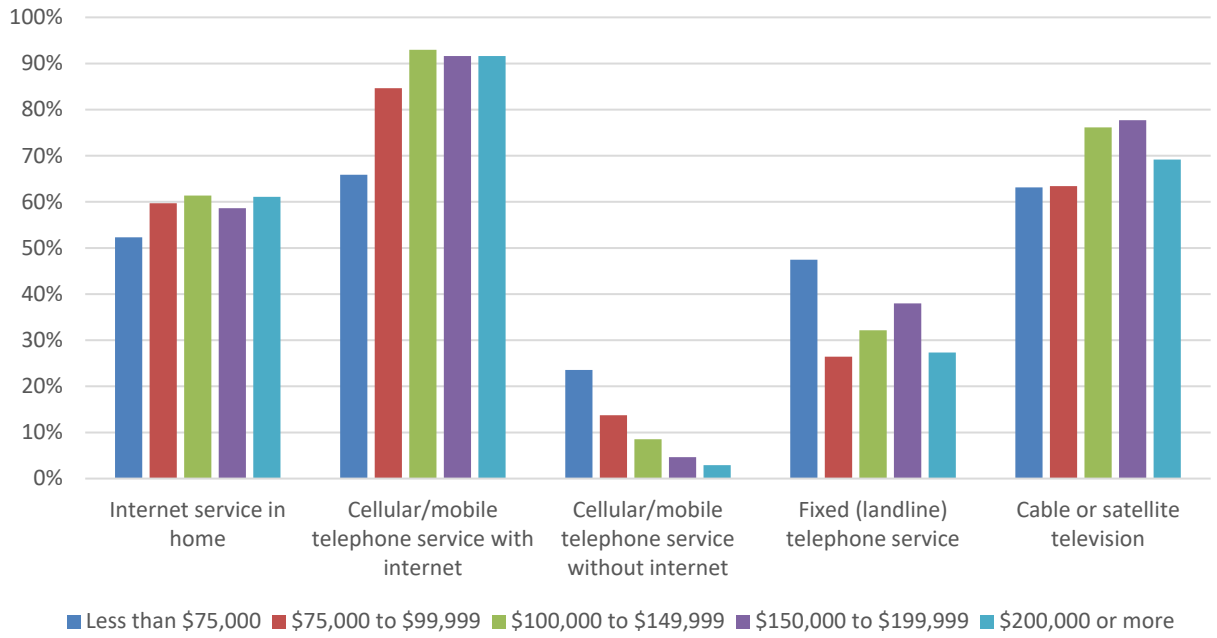


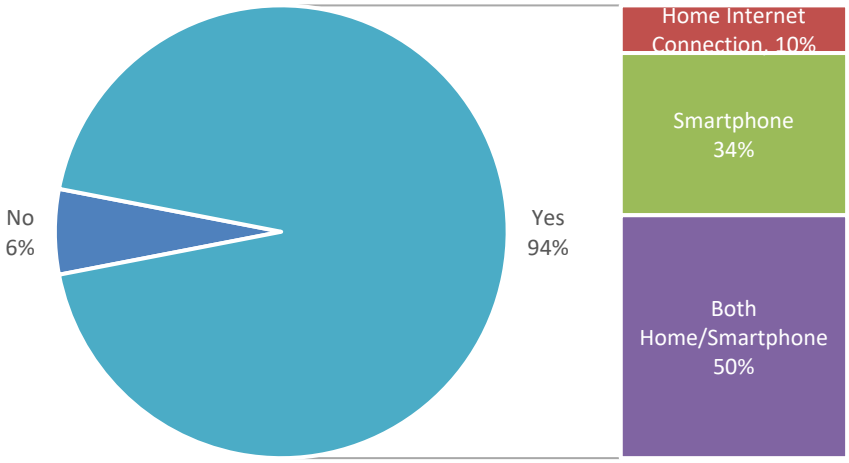
Figure 7: Services Purchased by Household Income



As discussed previously, a majority of respondents have some internet access, including 50 percent who have both home internet service and a cellular/mobile telephone service with internet (smartphone). Figure 8 illustrates that another 34 percent of respondents have a

smartphone only (no home internet), and 10 percent have a home connection only (no smartphone).

Figure 8: Purchase Internet Services



3.2 Importance of Communications Services

Respondents were asked to indicate the importance of various communications services to their households, using a scale where 1 is "Not at All Important" and 5 is "Extremely Important." The mean importance of various service aspects is illustrated in Figure 9, while detailed responses are illustrated in Figure 10. Cellular/mobile phone and internet services are extremely important to respondents, while premium cable television service and fixed (land-line) telephone service are significantly less important.

Figure 9: Importance of Communication Service Aspects (Mean Ratings)

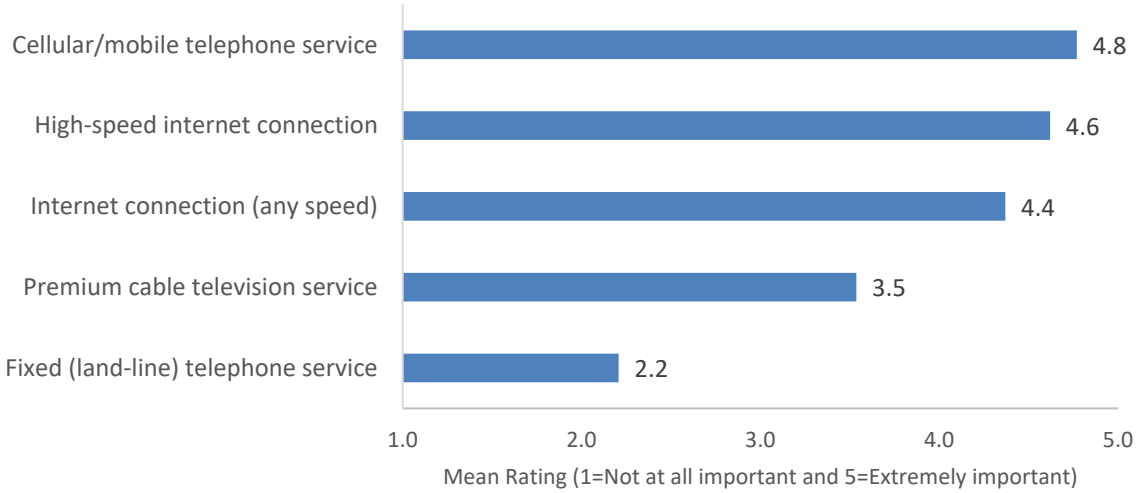
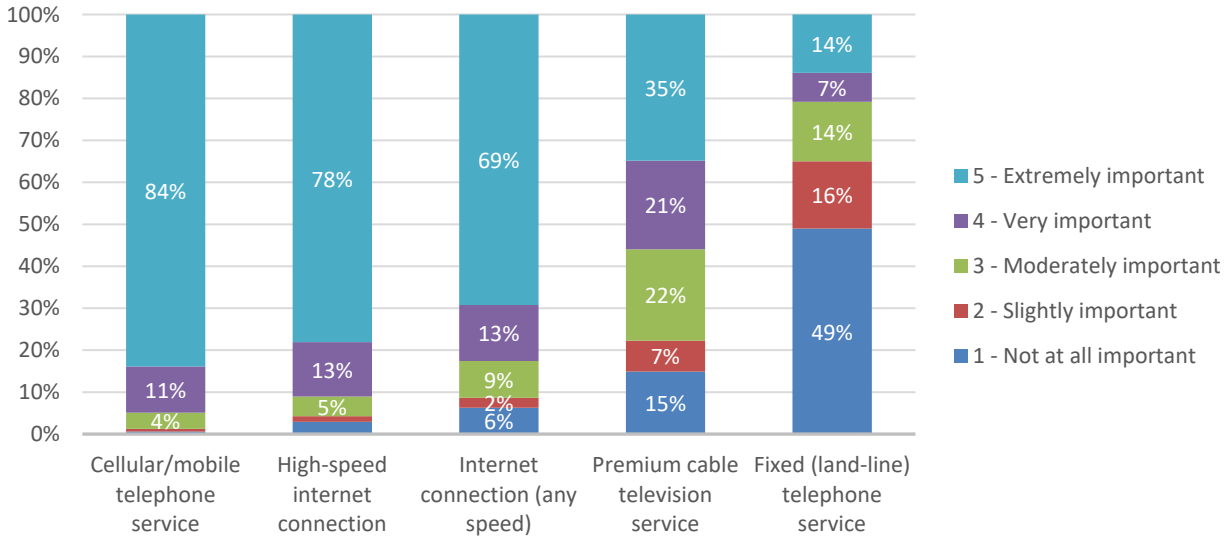


Figure 10: Importance of Communication Service Aspects



Specifically, 84 percent said cellular/mobile phone service is extremely important. More than three-fourths of respondents said high-speed internet is extremely important, while seven in 10 said an internet connection of any speed is extremely important, as illustrated in Figure 10.

Figure 11 and Figure 12 illustrate the importance of high-speed internet service by the age of the respondent and by household income, respectively. The importance of high-speed internet is lower for those ages 65 and older (51 percent "extremely important") and those earning under $75,000 annually (59 percent "extremely important"), compared with their counterparts.

Figure 11: Importance of High-Speed Internet by Age of Respondent

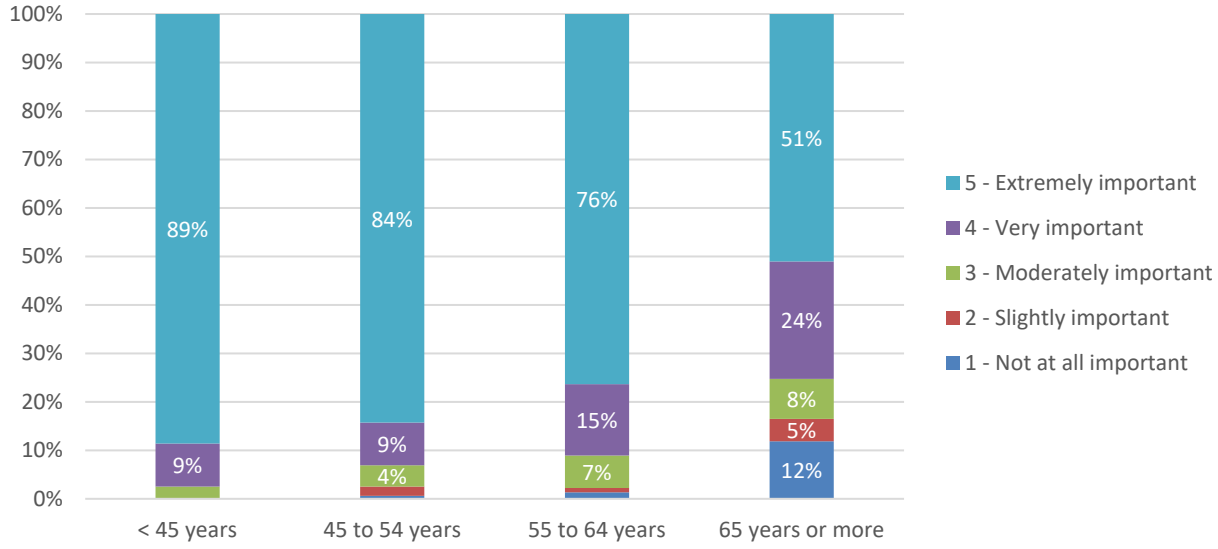
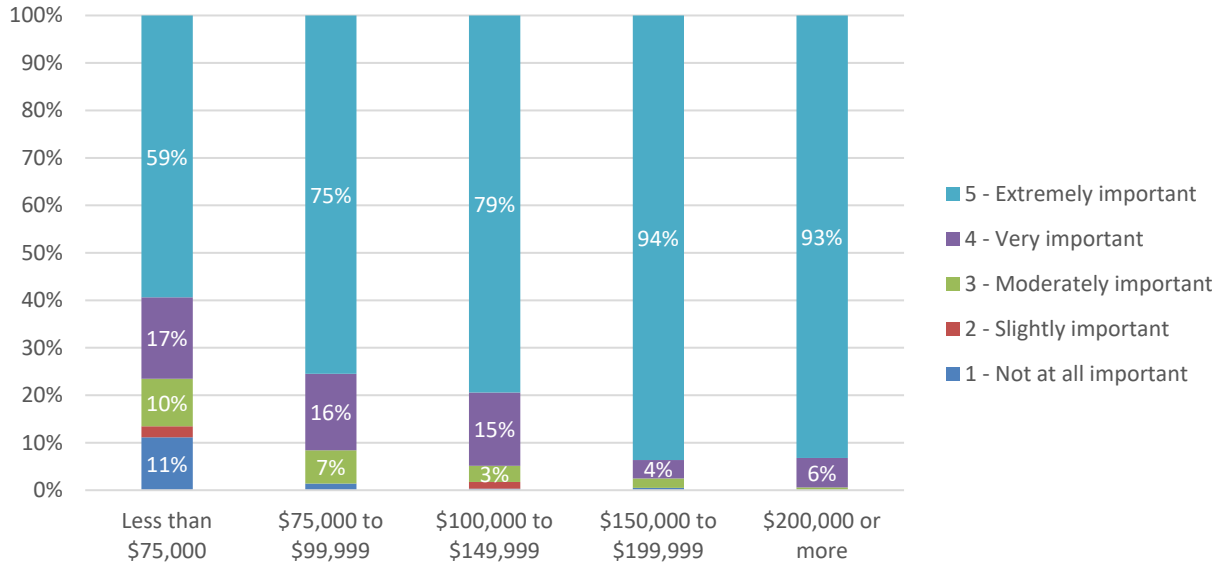


Figure 12: Importance of High-Speed Internet by Household Income



3.3 Internet Service

Respondents were asked about the types and providers of their various communications services, use of the internet for various activities, and satisfaction and importance of features related to these services. This information provides valuable insight into residents' need for various internet and related communications services.

3.3.1 Internet-Enabled Devices

Respondents were asked to indicate the number of personal computing devices and other internet-enabled devices they have in the home. Almost all respondents have a personal computing device, and 58 percent have five or more devices in the home. Additionally, three-fourths of respondents have other internet-enabled devices in the home (see Figure 13 and Figure 14).

Figure 13: Number of Personal Computing Devices

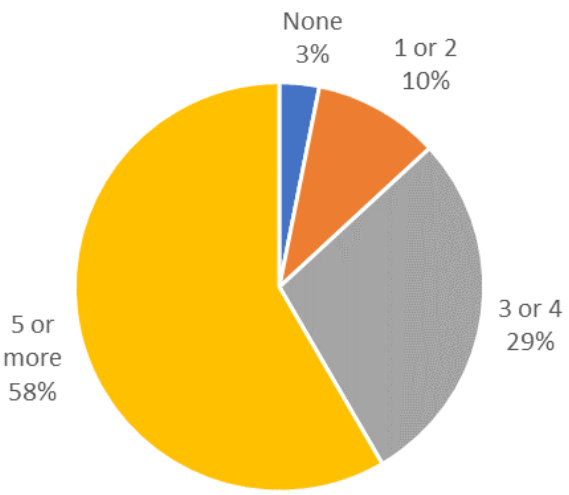
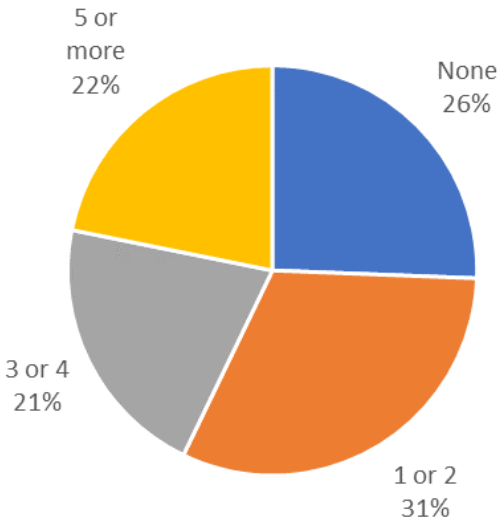
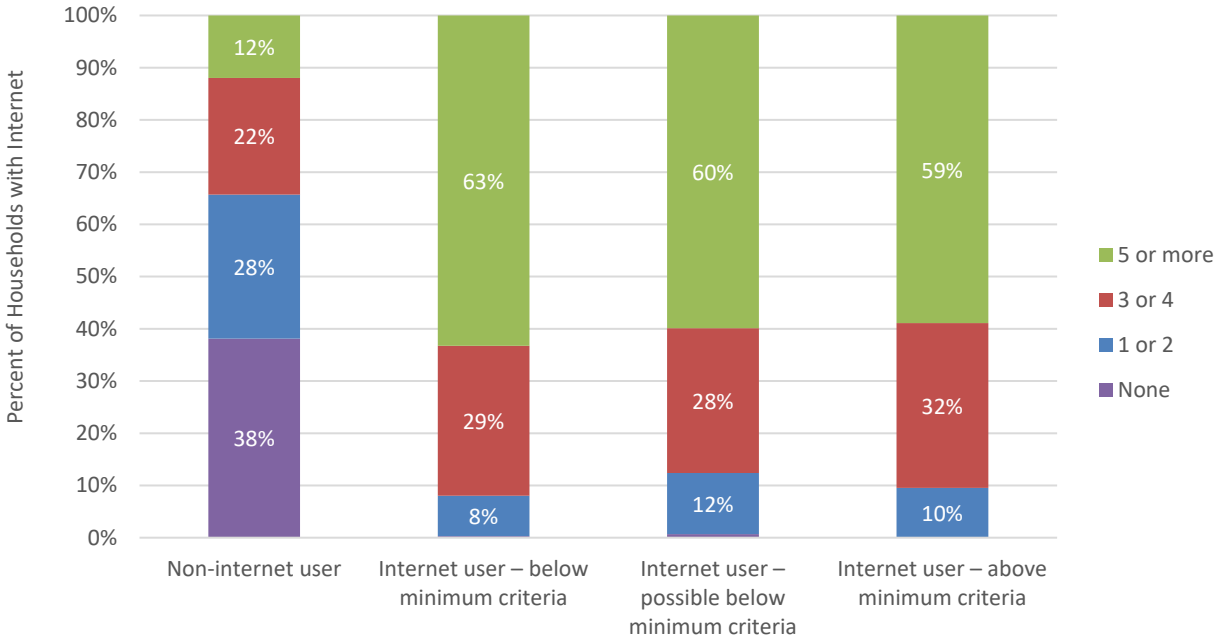


Figure 14: Number of Other Internet-Enabled Devices



For those households with internet service, the number of personal computing devices does not vary greatly by level of internet service (see Figure 15).

Figure 15: Number of Personal Computing Devices in Home by Internet Connectivity Group



Saturation of personal computing devices and other internet-enabled devices is high among households with multiple members. Households with at least three members are significantly more likely than smaller households to have at least five personal computing devices and to have any other internet-enabled devices (see Figure 16 and Figure 17).

Figure 16: Number of Personal Computing Devices in Home by Household Size

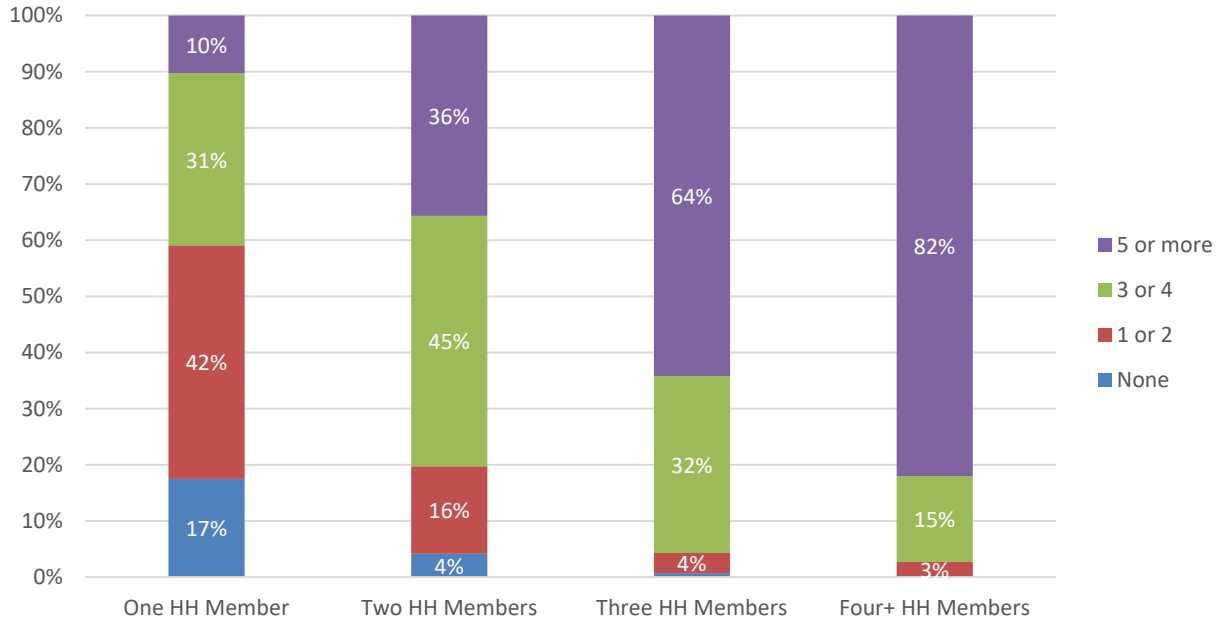
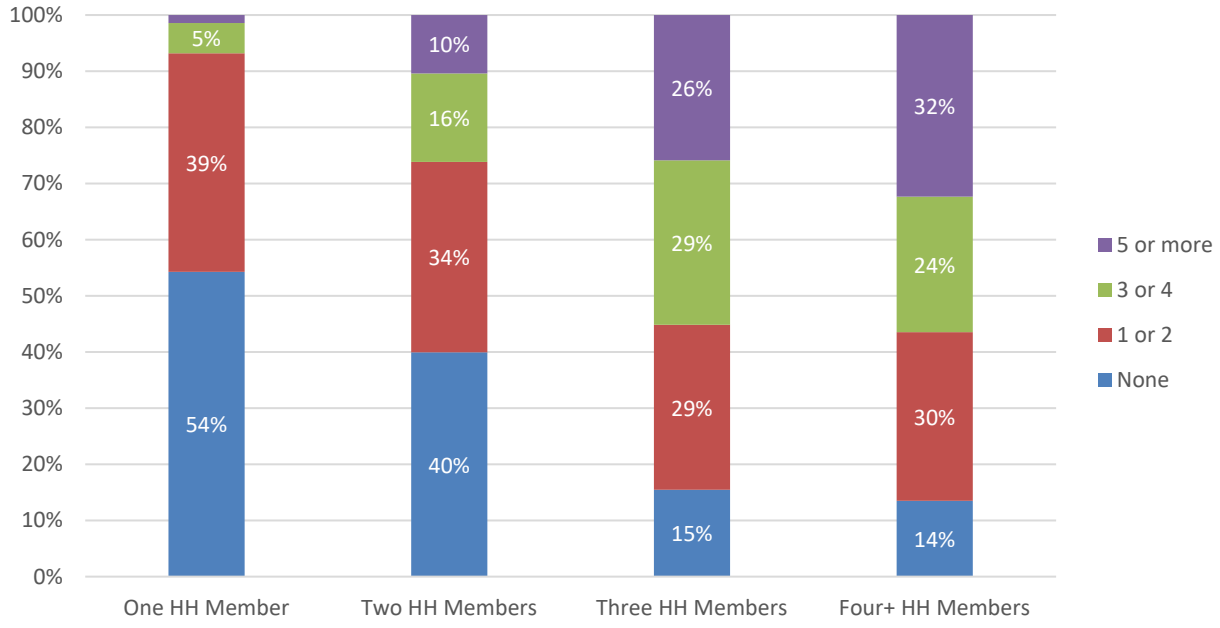


Figure 17: Number of Other Internet-Enabled Devices in Home by Household Size



The number of computing devices in the home is also correlated with household income. Two-thirds of those earning $100,000 to $150,000 and approximately three-fourths of those earning $150,000+ per year have at least five computing devices, compared with fewer than one-half of those earning less than $75,000 (see Figure 18).

Figure 18: Number of Personal Computing Devices in Home by Household Income

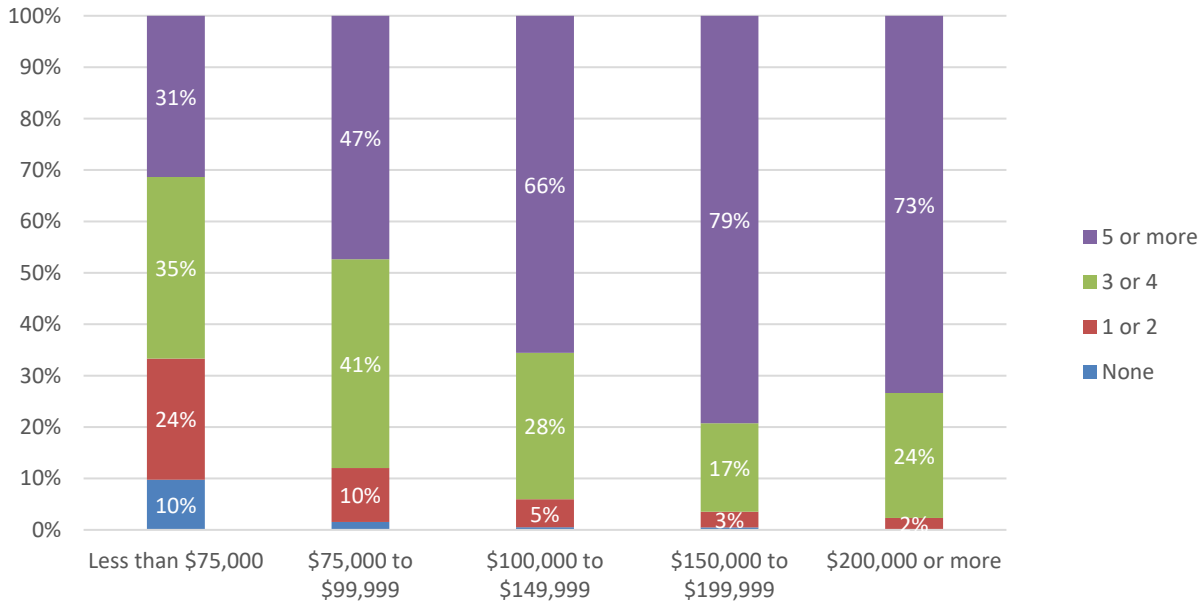
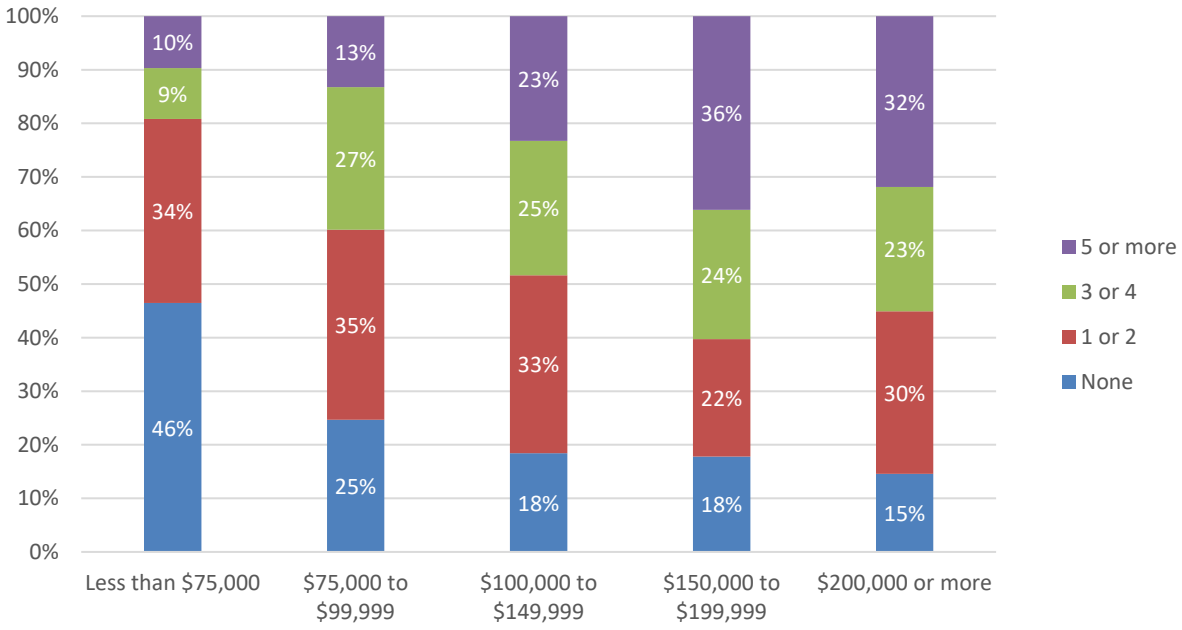


Figure 19: Number of Other Internet-Enabled Devices in Home by Household Income

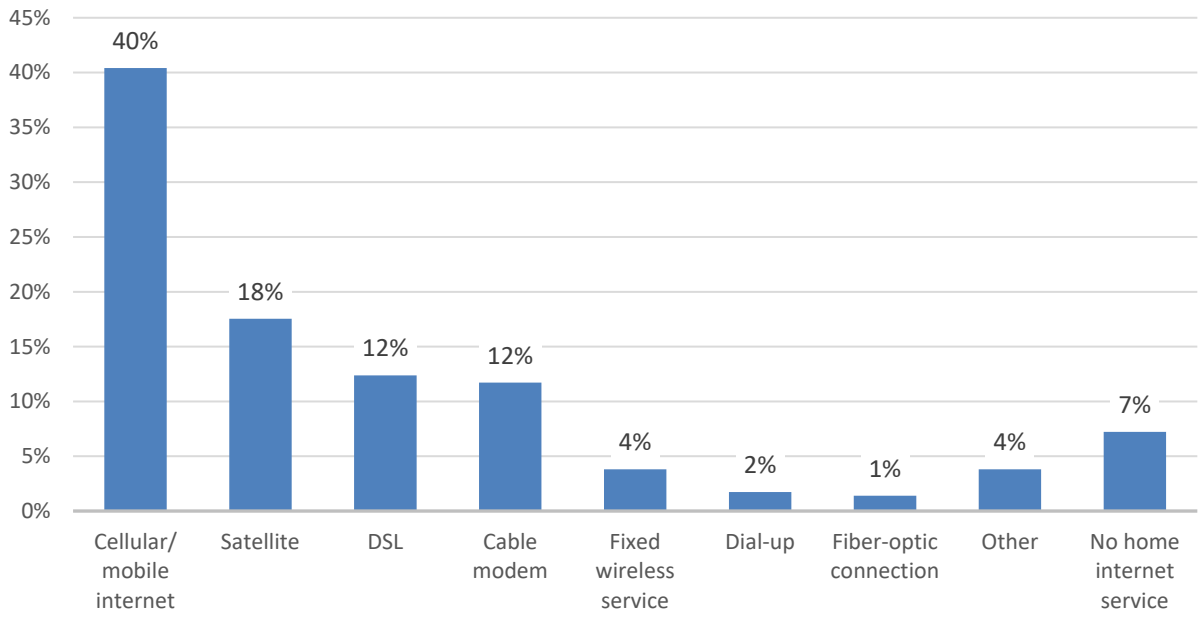


3.3.2 Internet Services Purchased

Respondents were asked about their purchase of internet services for their home, as well as the cost and speed of services purchased. As shown in Figure 20, a majority of homes (93 percent) reported having home internet service, consistent with 94 percent reporting internet access via a home connection or via a smartphone in Question 1. Four in 10 households use a

cellular/mobile connection as their primary home internet service, while other connection types represent much smaller shares of the Harford County market area.

Figure 20: Primary Home Internet Service



Respondents were segmented into connectivity groups based on type of internet service:

1. No internet service
2. Below minimum criteria (Dial-up, satellite, cellular/mobile)
3. Possible below minimum criteria (DSL, fixed wireless, other)
4. Above minimum criteria (fiber, cable modem)

Figure 21 illustrates the types of internet services used by respondents' locations, while Figure 22 illustrates the category of services used (i.e., internet service above or below the minimum criteria, or non-internet users).

Figure 21: Communications Services Purchased (by Location)

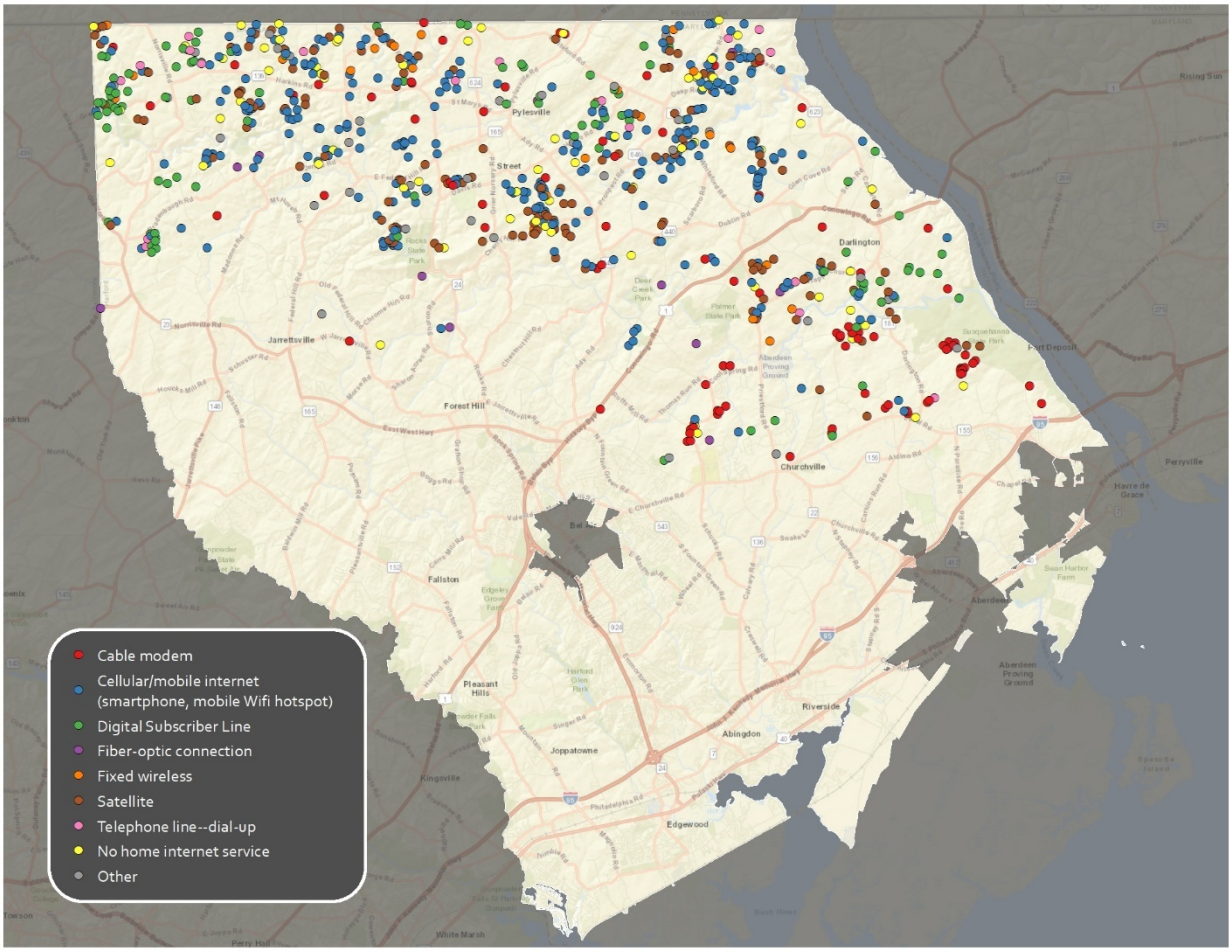
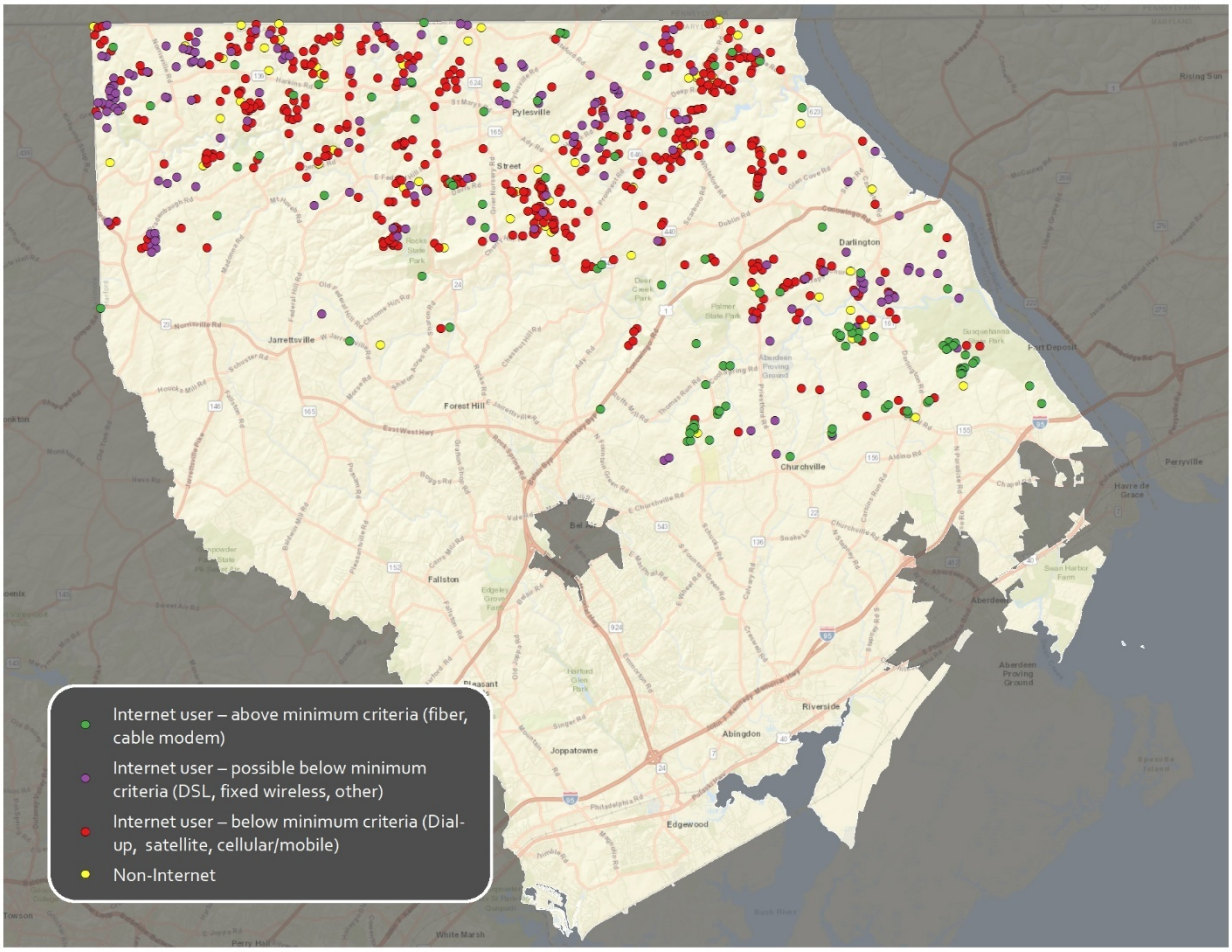


Figure 22: Category of Internet Used (by Location)



Although most households have internet access in the home, six in 10 have service that is below the minimum criteria, and another 18 percent have service that is possibly below the minimum criteria (see Figure 23).

At the same time, no statistically significant difference in importance of internet service was found between those with service below or possibly below the minimum criteria and those with service above the minimum criteria. In other words, the results suggest that high-speed internet service is just as highly important to households with below criteria service, as shown in Figure 24. ***This also suggests that service needs are possibly not being met for a large number of households in the market area.***

Figure 23: Internet Connectivity Groups

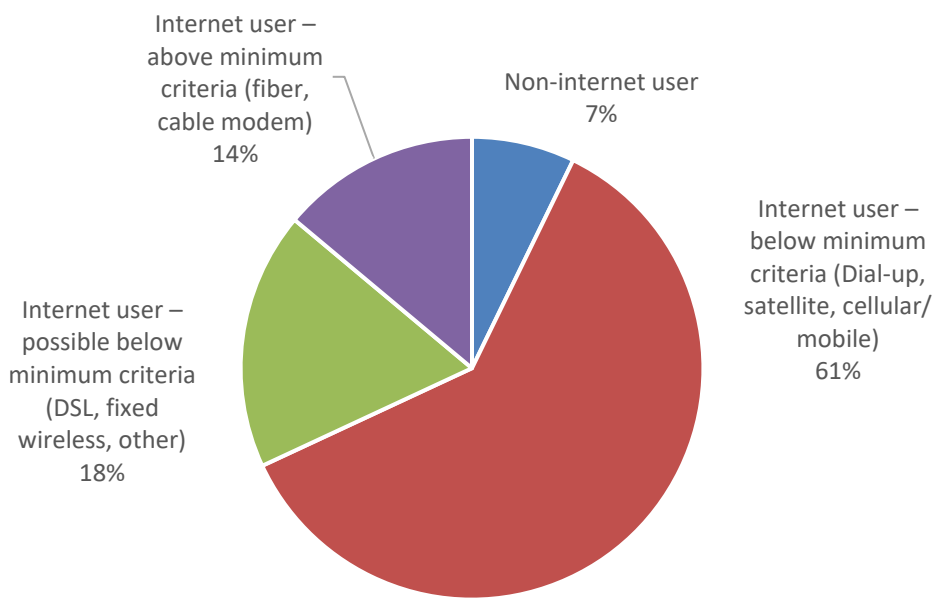
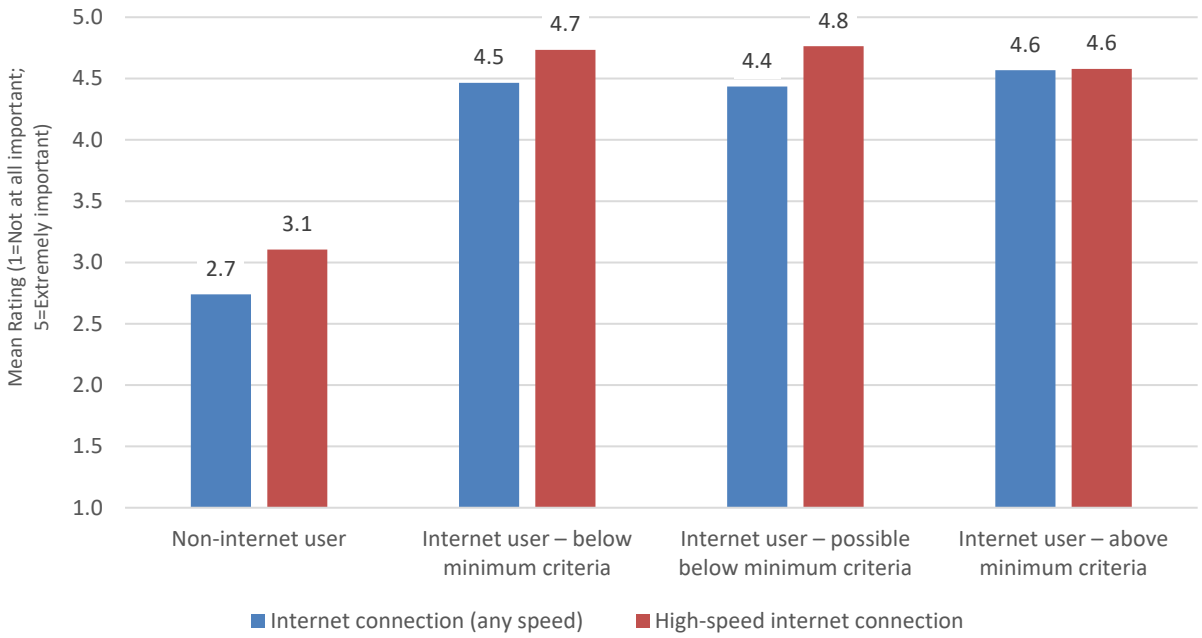


Figure 24: Importance of Internet Services by Internet Connectivity Group



Older respondents, those with a lower household income, those with a lower level of education, and those with one household member (and no children in the household) are among those who are somewhat less likely to have internet, although saturation is high among all demographic groups, as illustrated in Table 2.

Table 2: Internet Connectivity Group by Key Demographics

		Non-Internet User	Below Minimum Criteria	Possible Below Minimum Criteria	Above Minimum Criteria	Total Internet Access	*Weighted Count*
TOTAL		**6%**	**10%**	**34%**	**50%**	**94%**	**804**
Age group	< 45 years	4%	67%	15%	13%	**96%**	*323*
	45 to 54 years	5%	61%	25%	9%	**95%**	*156*
	55 to 64 years	4%	62%	20%	13%	**96%**	*136*
	65 years or more	17%	49%	15%	19%	**83%**	*147*
Highest level of education	HS education or less	16%	53%	20%	12%	**84%**	*137*
	Two-year college or technical degree	7%	63%	19%	11%	**93%**	*172*
	Four-year college degree	4%	66%	14%	16%	**96%**	*267*
	Graduate degree	3%	60%	23%	13%	**97%**	*186*
Approximate 2018 household income	Less than $75,000	19%	57%	11%	13%	**81%**	*122*
	$75,000 to $99,999	9%	66%	16%	9%	**91%**	*118*
	$100,000 to $149,999	2%	61%	21%	17%	**98%**	*183*
	$150,000 to $199,999	5%	71%	15%	9%	**95%**	*135*
	$200,000 or more	2%	63%	24%	10%	**98%**	*107*
Children in Household	No Children in HH	11%	56%	18%	15%	**89%**	*408*
	Children in HH	1%	68%	19%	12%	**99%**	*354*
Total Household Size (Adults + Children)	One HH member	33%	39%	15%	12%	**67%**	*47*
	Two HH members	9%	57%	17%	17%	**91%**	*247*
	Three HH members	4%	69%	18%	9%	**96%**	*137*
	Four+ HH members	2%	65%	20%	13%	**98%**	*330*
Number of years lived at current residence	Less than 1 year	10%	81%	5%	5%	**90%**	*45*
	1 to 2 years	1%	81%	5%	13%	**99%**	*62*
	3 to 4 years	6%	67%	20%	7%	**94%**	*82*
	5 or more years	7%	58%	20%	15%	**93%**	*571*

3.3.3 Cost of Internet Service

As illustrated in Figure 25 and Figure 26, more than one-third of subscribers pay over $100 per month for home internet, and the estimated monthly average cost for internet service is $86. DSL internet subscribers pay slightly less per month on average, compared with cable modem, satellite, and cellular/mobile internet subscribers (the leading connection types).

Figure 25: Monthly Price for Internet Service

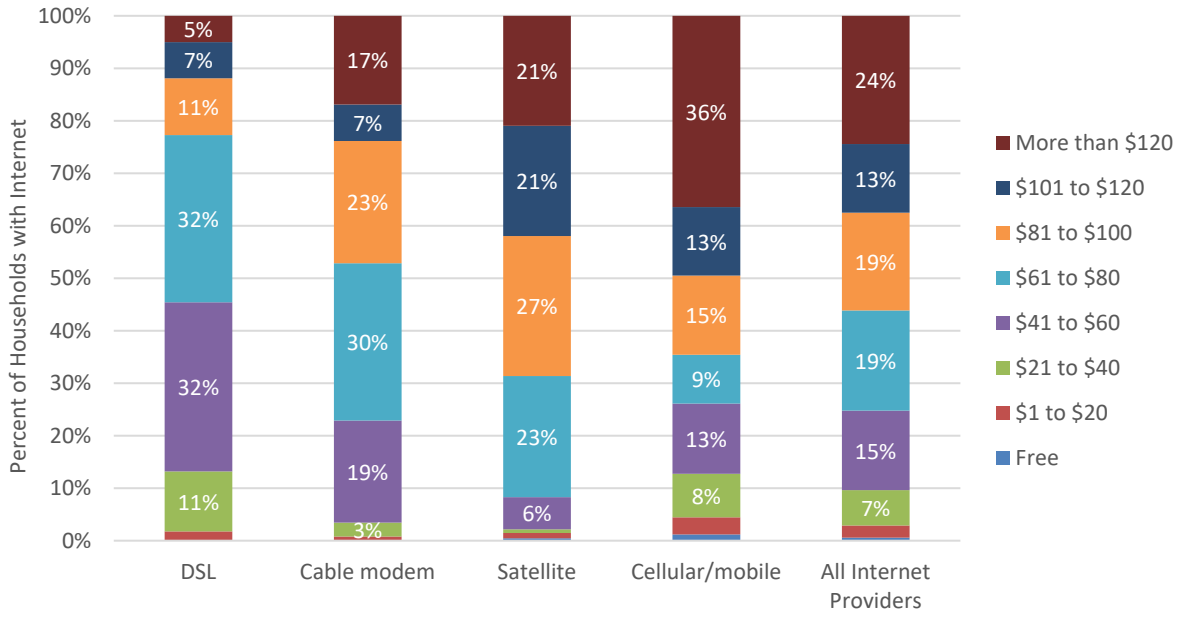
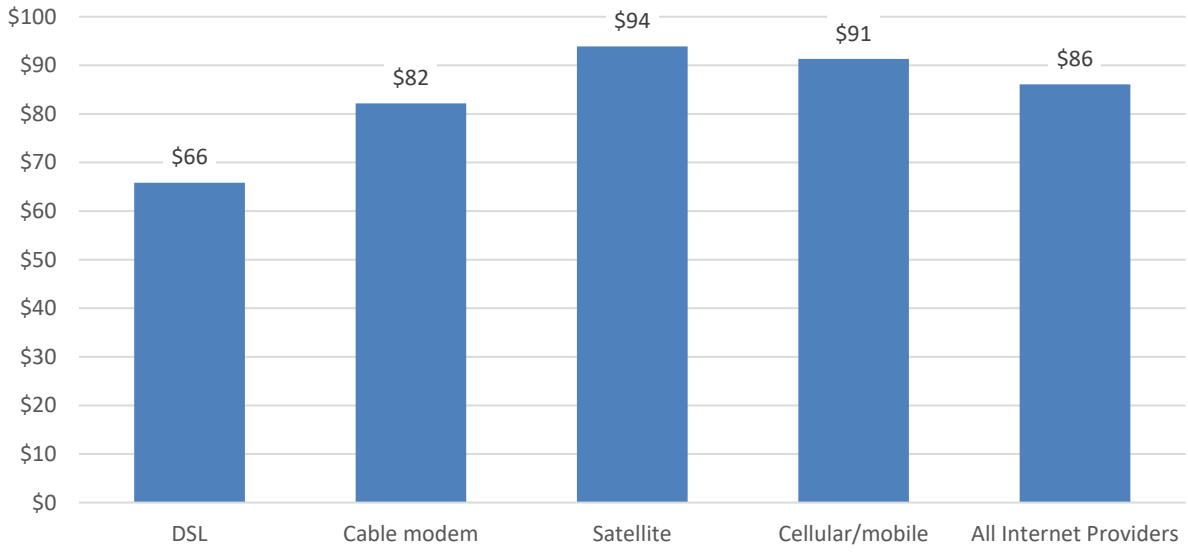


Figure 26: Estimated Average Monthly Price for Internet Service



Four in 10 internet subscribers said their monthly internet fee is part of a bundled service (see Figure 27). Estimated monthly prices for bundled and unbundled services is shown in Figure 28.

Figure 27: Monthly Internet Fee Is Part of Bundled Service

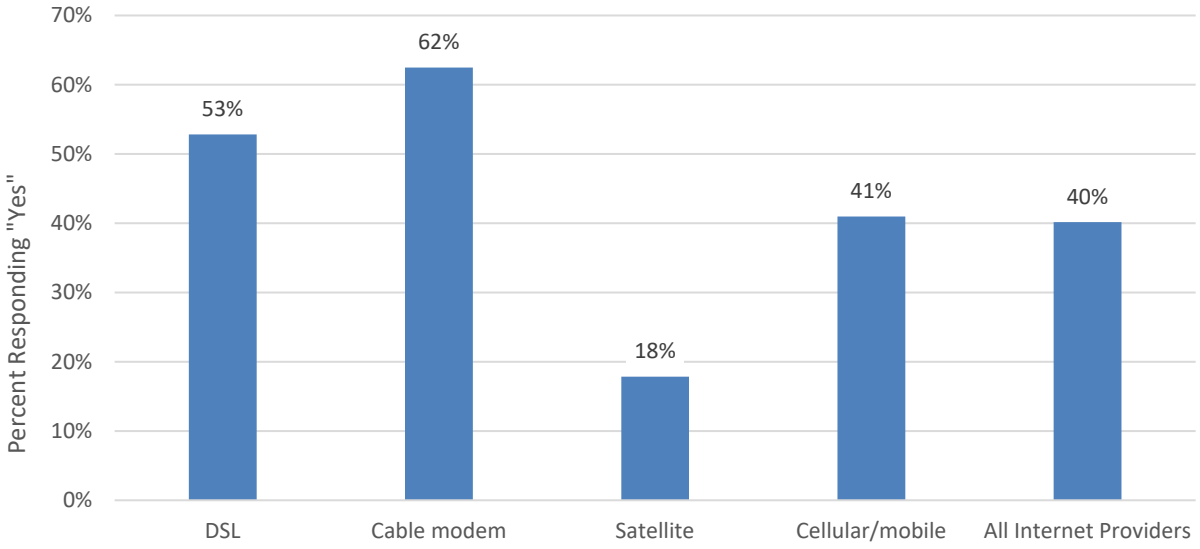
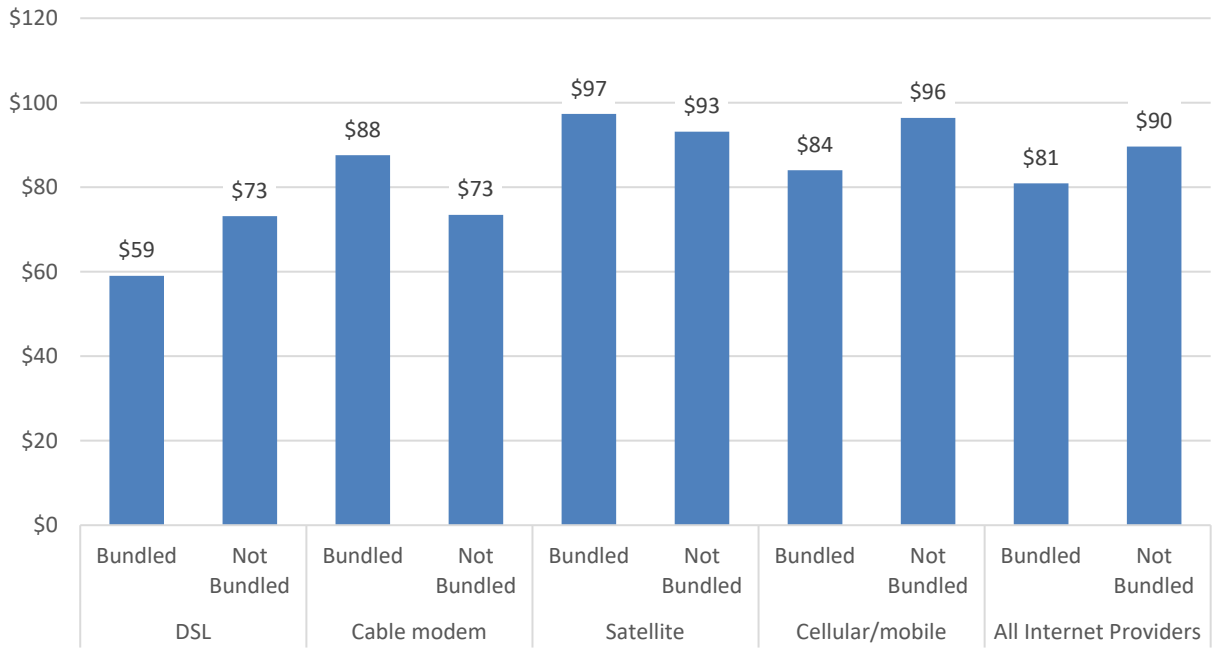


Figure 28: Estimated Average Monthly Price for Bundled and Non-Bundled Internet Service

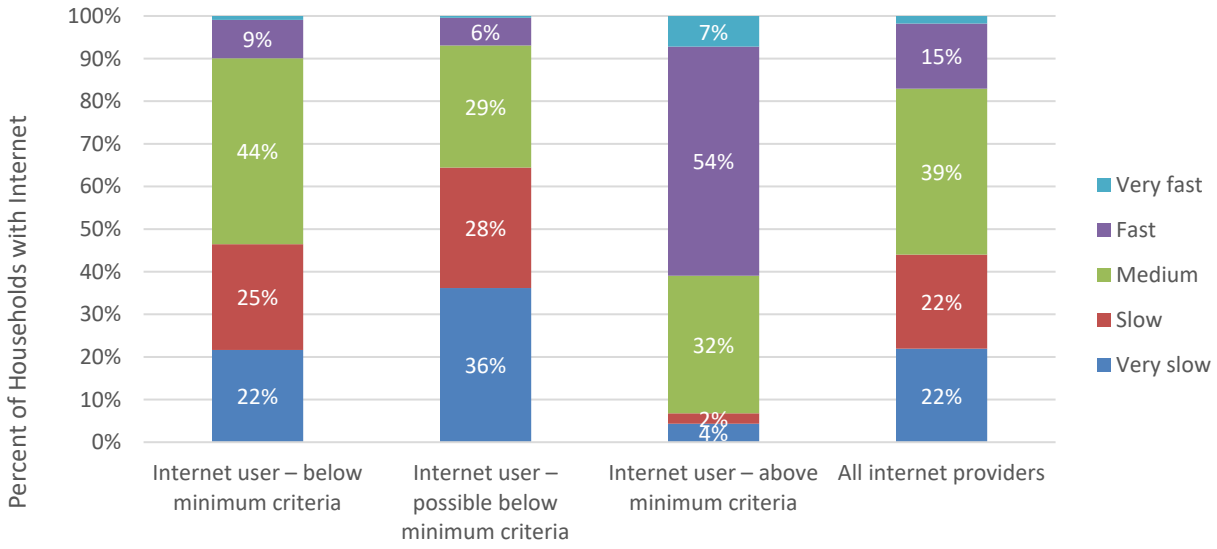


3.3.4 Speed of Internet Service

Overall, very few internet subscribers in the market area have “fast” or “very fast” internet service, according to respondents. Six in 10 subscribers with internet service above the minimum

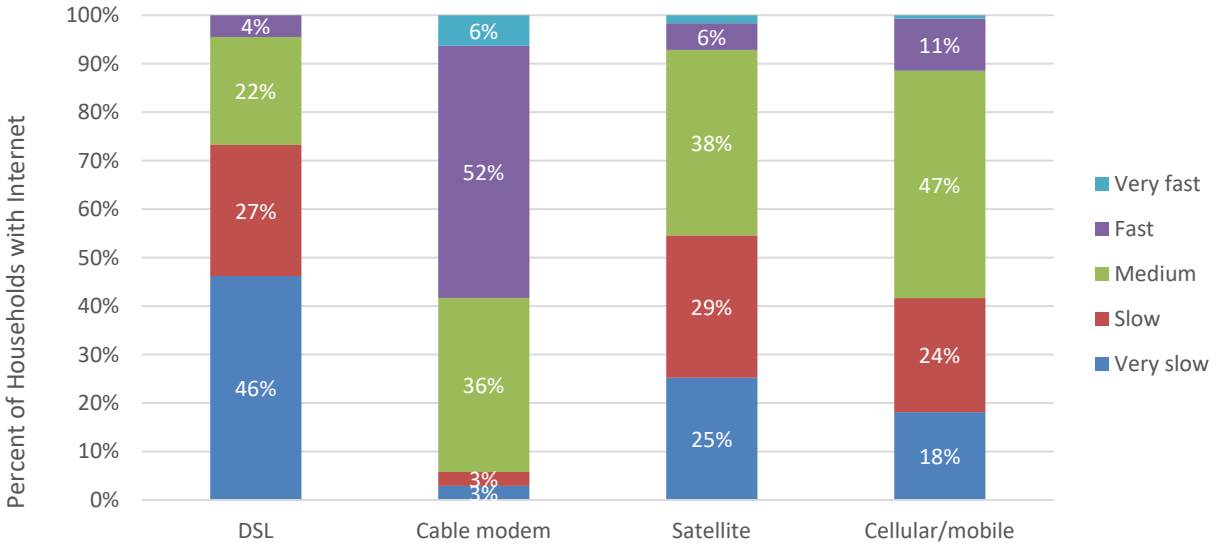
criteria (cable modem, fiber) have fast or very fast service, compared with less than one in 10 of those with internet service below or possibly below the minimum criteria (see Figure 29).

Figure 29: Internet Speed (Respondent Opinion) by Internet Connectivity Group



Specifically, most DSL subscribers perceive their internet service to be slow, while most cable modem subscribers view their service as fast (see Figure 30).

Figure 30: Internet Speed (Respondent Opinion) by Primary Home Internet Service



3.3.5 Internet Service Aspects

Respondents were also asked about the importance of, and satisfaction with, a number of internet service aspects. The importance and satisfaction levels are compared in the following tables and graphs.

3.3.5.1 Importance

Respondents were asked to rate their levels of importance and satisfaction with various internet service aspects. Respondents rated connection reliability and speed as the most important aspects, as shown in Table 3. The ability to bundle with television service is moderately important compared with other service aspects.

Table 3: Importance of Internet Service Aspects

Service Aspect	Mean	Percentages
Speed of Connection	4.7	5% 17% 77%
Reliability of Connection	4.8	10% 88%
Price of Services	4.3	16% 23% 57%
Overall Customer Service	4.3	15% 29% 52%
Ability to Bundle with TV service	3.0	24% 14% 26% 13% 23%

1 - Not at all important; 2 - Slightly important; 3 - Moderately important; 4 - Very important; 5 - Extremely important

3.3.5.2 Satisfaction

Overall, respondents are only slightly to moderately satisfied with aspects of their internet service, as shown in Table 4. Respondents rated overall customer service and reliability of service as the aspects with which they are most satisfied. The lowest satisfaction aspects are for the price of service, ability to bundle service, and connection speed.

Specifically, more than one-half of subscribers are not at all satisfied or only slightly satisfied with price of services, ability to bundle service, and connection speed. Nearly one-half of subscribers are not at all satisfied or only slightly satisfied with connection reliability, while more than one-fourth are very satisfied or extremely satisfied.

Table 4: Satisfaction with Internet Service Aspects

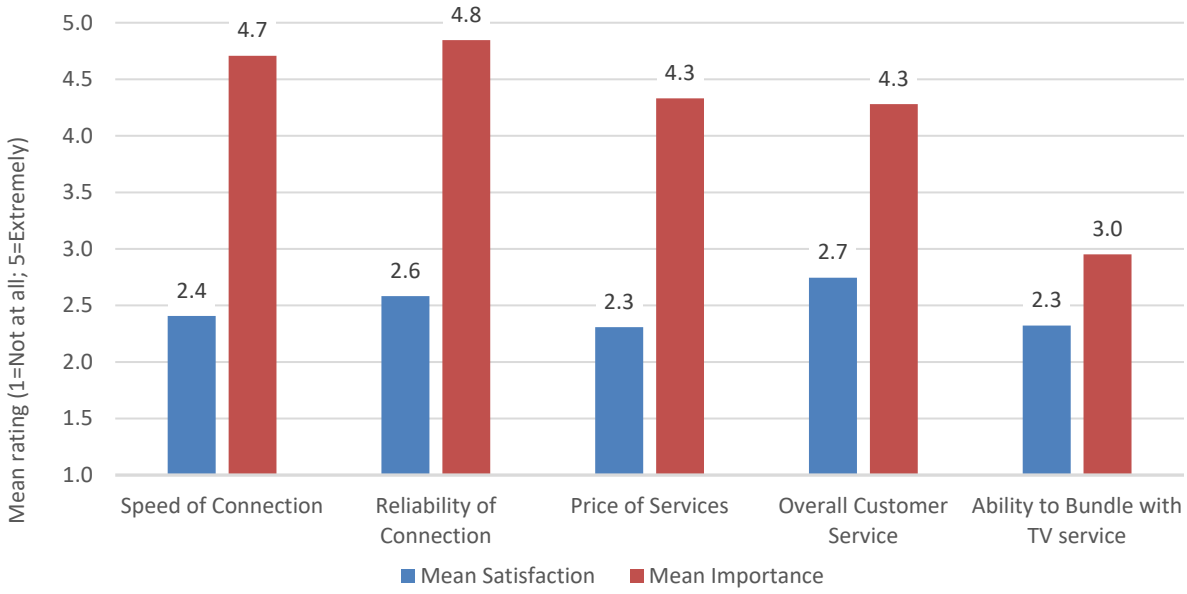
Service Aspect	Mean	Percentages
Speed of Connection	2.4	34% 18% 27% 17% 4%
Reliability of Connection	2.6	28% 19% 27% 19% 7%
Price of Services	2.3	32% 22% 31% 11% 3%
Overall Customer Service	2.7	19% 17% 37% 22% 5%
Ability to Bundle with TV service	2.3	40% 14% 26% 13% 7%

1 - Not at all satisfied; 2 - Slightly satisfied; 3 - Moderately satisfied; 4 - Very satisfied; 5 - Extremely satisfied

3.3.5.3 Performance

Comparing respondents' stated importance and satisfaction with service aspects allows an evaluation of how well internet service providers are meeting the needs of customers (see Figure 31). Aspects that have higher stated importance than satisfaction can be considered areas in need of improvement. Aspects that have higher satisfaction than importance are areas where the market is meeting or exceeding customers' needs. However, it should be cautioned that the extremely high level of importance placed on some aspects (such as reliability) may make it nearly impossible to attain satisfaction levels equal to importance levels.

Figure 31: Importance of and Satisfaction with Internet Service Aspects



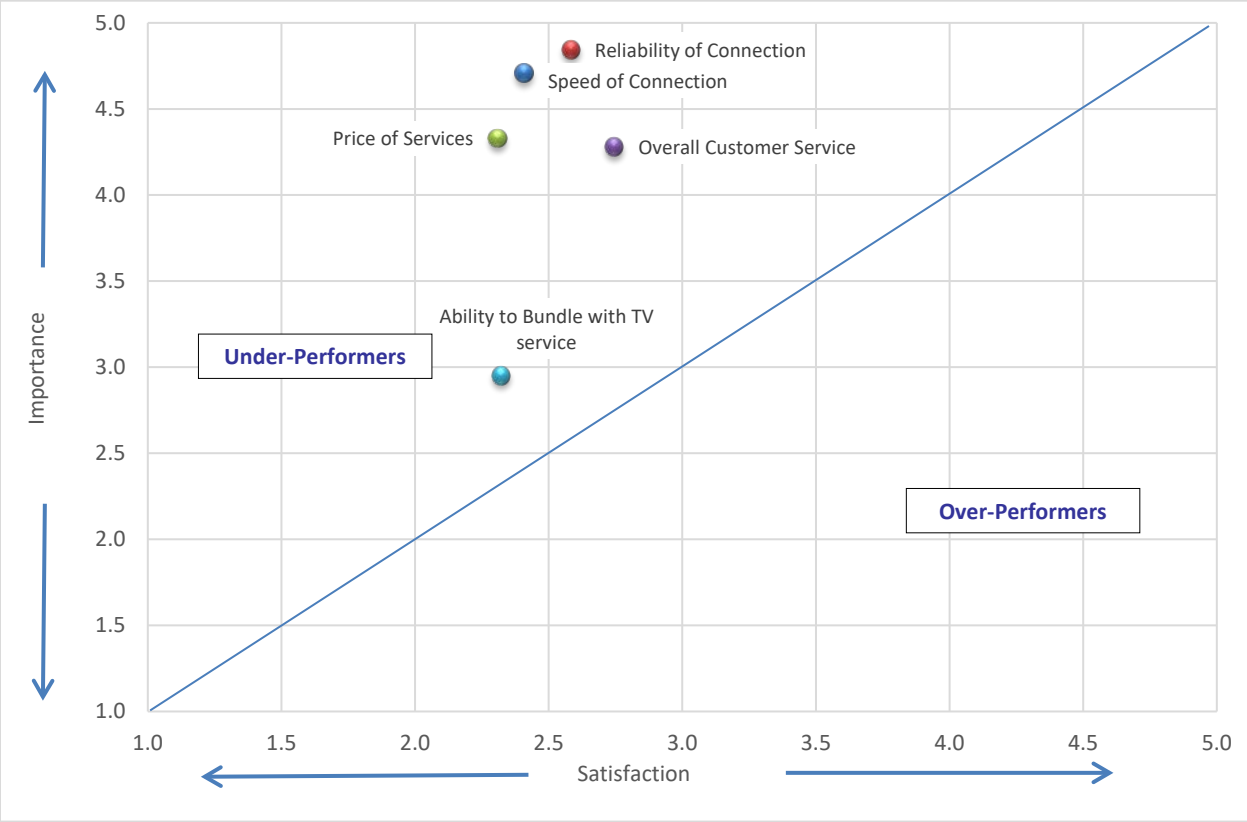
The difference between importance and satisfaction of home internet aspects is also presented in the "gap" analysis table (see Table 5). The largest gap between importance and performance is for speed of connection and reliability of connection, followed by price of services.

Table 5: Internet Service Aspect "Gap" Analysis

	Mean Satisfaction	Mean Importance	GAP < = >	Customer Expectations
Speed of Connection	2.4	4.7	-2.3	Not Met
Reliability of Connection	2.6	4.8	-2.3	Not Met
Price of Services	2.3	4.3	-2.0	Not Met
Overall Customer Service	2.7	4.3	-1.5	Not Met
Ability to Bundle with TV service	2.3	3.0	-0.6	Not Met

The importance scores and performance scores were plotted to help visually determine areas in which internet service providers are doing well and areas that might need improvement. Figure 32 compares the importance and satisfaction in a "quadrant" analysis. Those aspects for which importance is higher than satisfaction are above the equilibrium line and are defined as "underperformers." As is typical, the cost of internet service is well off the line, as satisfaction with costs is typically low. Reliability, connection speed, and customer service are other under-performing service areas. The low satisfaction levels could indicate a desire for improved service offerings or a willingness to switch internet service providers if needs are not being met.

Figure 32: Internet Service Aspect "Quadrant" Analysis



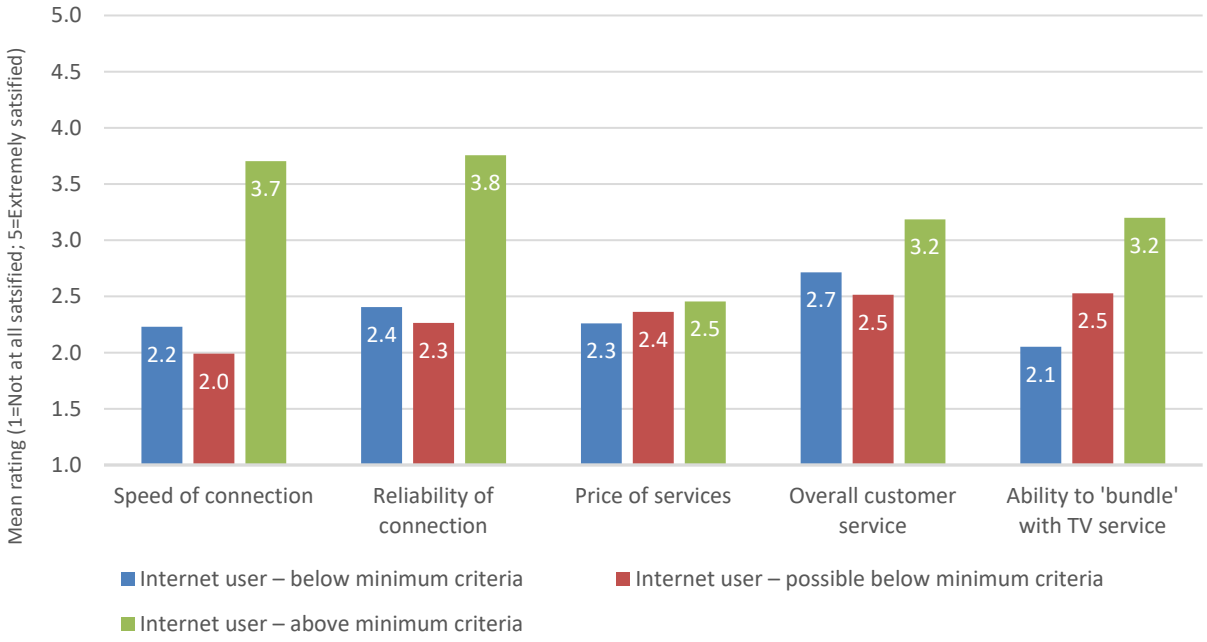
3.3.5.4 Internet Connectivity Group

As indicated in Figure 33, respondents with internet service above the minimum criteria placed more importance on price of service, compared with other internet subscribers. No other statistically significant differences were found for importance of service aspects by internet connectivity group.

However, there are significant differences in satisfaction by internet connectivity for most key aspects of service, as illustrated in Figure 34. Specifically, those with internet service above the minimum criteria are more satisfied with connection speed, reliability, overall customer service, and ability to bundle services compared with subscribers with service below or possibly below the minimum criteria.

Figure 33: Importance of Internet Service Aspects by Internet Connectivity Group

Figure 34: Satisfaction with Internet Service Aspects by Internet Connectivity Group



The gap between importance and satisfaction for the leading connection types was converted to an index score for each service aspect. This illustrates "the percentage of expectations fulfilled." Gap index scores are shown in Table 6. Providers of internet service above the minimum criteria are better meeting expectations (high ratio of satisfaction to importance) for all services except price, as discussed previously.

Table 6: Gap Index Score by Internet Connectivity Group

	Satisfaction / Importance Gap Index*				
	Speed of connection	Reliability of connection	Price of service	Customer service	Ability to bundle
Internet user – below minimum criteria	47%	50%	53%	64%	69%
Internet user – possible below minimum criteria	42%	47%	55%	57%	88%
Internet user – above minimum criteria	81%	78%	53%	73%	107%
ISP Average	51%	53%	53%	64%	79%
Percent of expectations met = Satisfaction / Importance					

Specifically, cable modem subscribers have a higher level of satisfaction with connection speed, connection reliability, customer service, and ability to bundle service, compared with DSL, satellite, and cellular/mobile internet users (the leading connection types in the market area) as

shown in Figure 36. At the same time, importance of these services is equally high across connection types, which indicates that cable modem providers are better meeting customer needs (see Figure 35).

Figure 35: Importance of Internet Service Aspects by Primary Home Internet Service

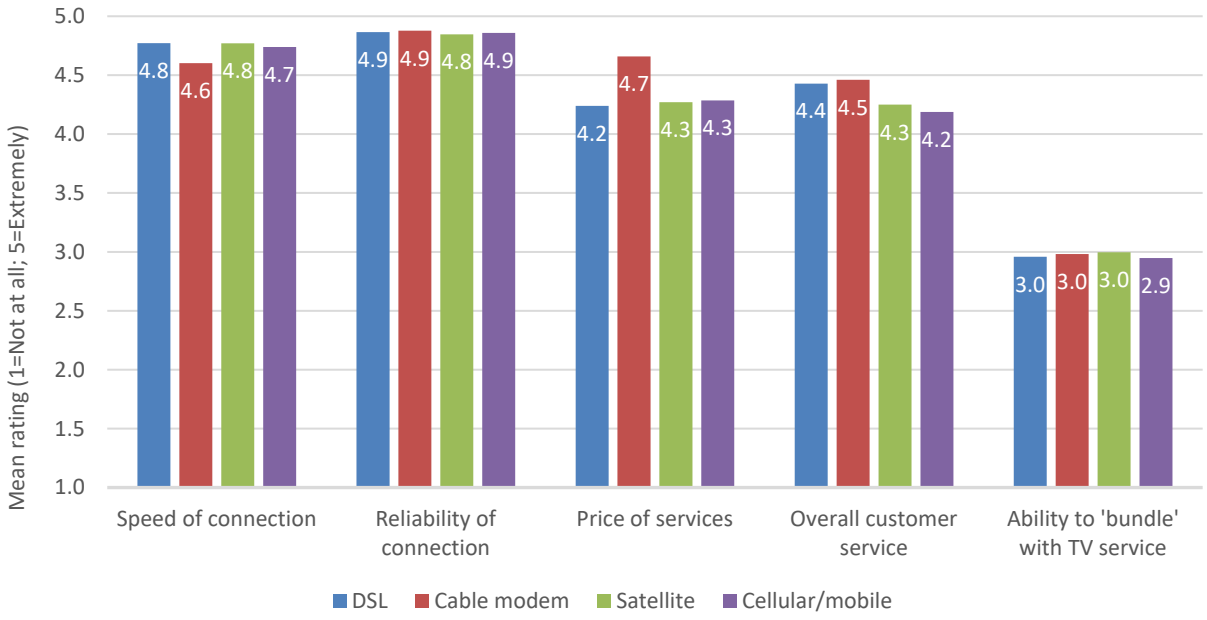
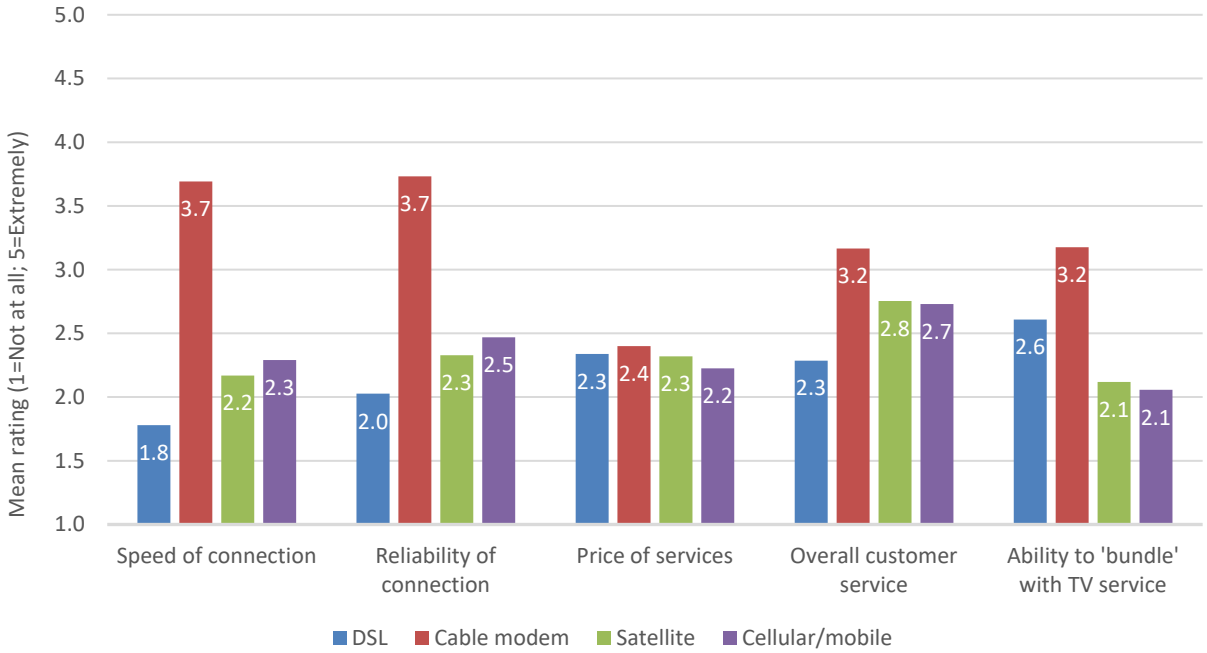


Figure 36: Satisfaction with Internet Service Aspects by Primary Home Internet Service



As indicated above and illustrated in Table 7, cable modem providers are better meeting customer expectations compared with DSL, satellite, and cellular/mobile internet providers, particularly for speed and reliability of internet connection.

Table 7: Gap Index Score by Primary Home Internet Service

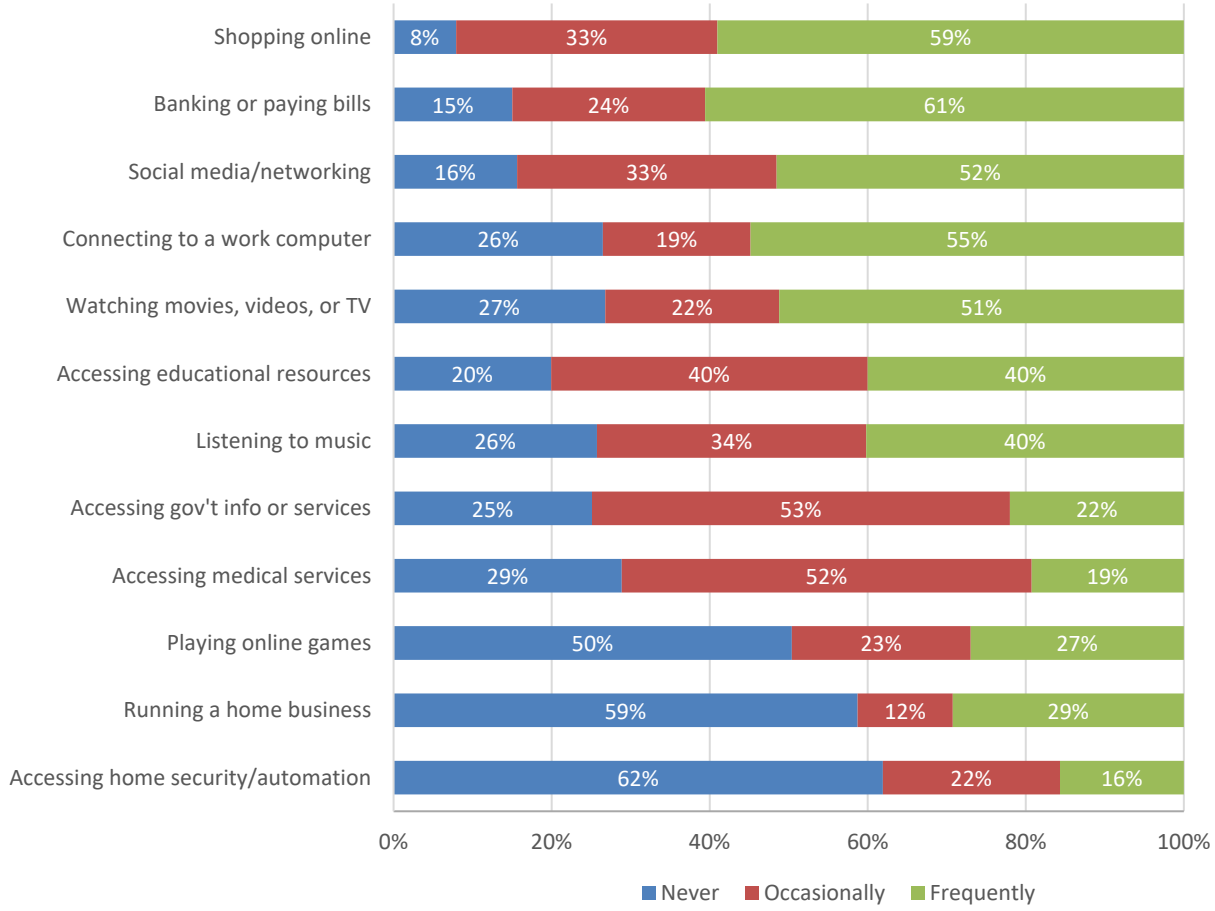
	Satisfaction / Importance Gap Index*				
	Speed of connection	Reliability of connection	Price of service	Customer service	Ability to bundle
DSL	37%	42%	55%	52%	88%
Cable modem	80%	77%	52%	71%	107%
Satellite	45%	48%	54%	65%	71%
Cellular/mobile	48%	51%	52%	65%	70%
ISP Average	51%	53%	53%	64%	79%
Percent of expectations met = Satisfaction / Importance					

3.3.6 Internet Uses and Importance

Respondents were asked about their use of the internet for various activities, as illustrated in Figure 37. Among those items listed, the internet is most frequently used for shopping online, with 92 percent of subscribers using the internet at least occasionally for this activity, and six in 10 using it frequently. Other top activities include banking or paying bills, social media networking, connecting to a work computer, and watching movies, videos, or TV, with at least one-half of subscribers using the internet frequently for these activities.

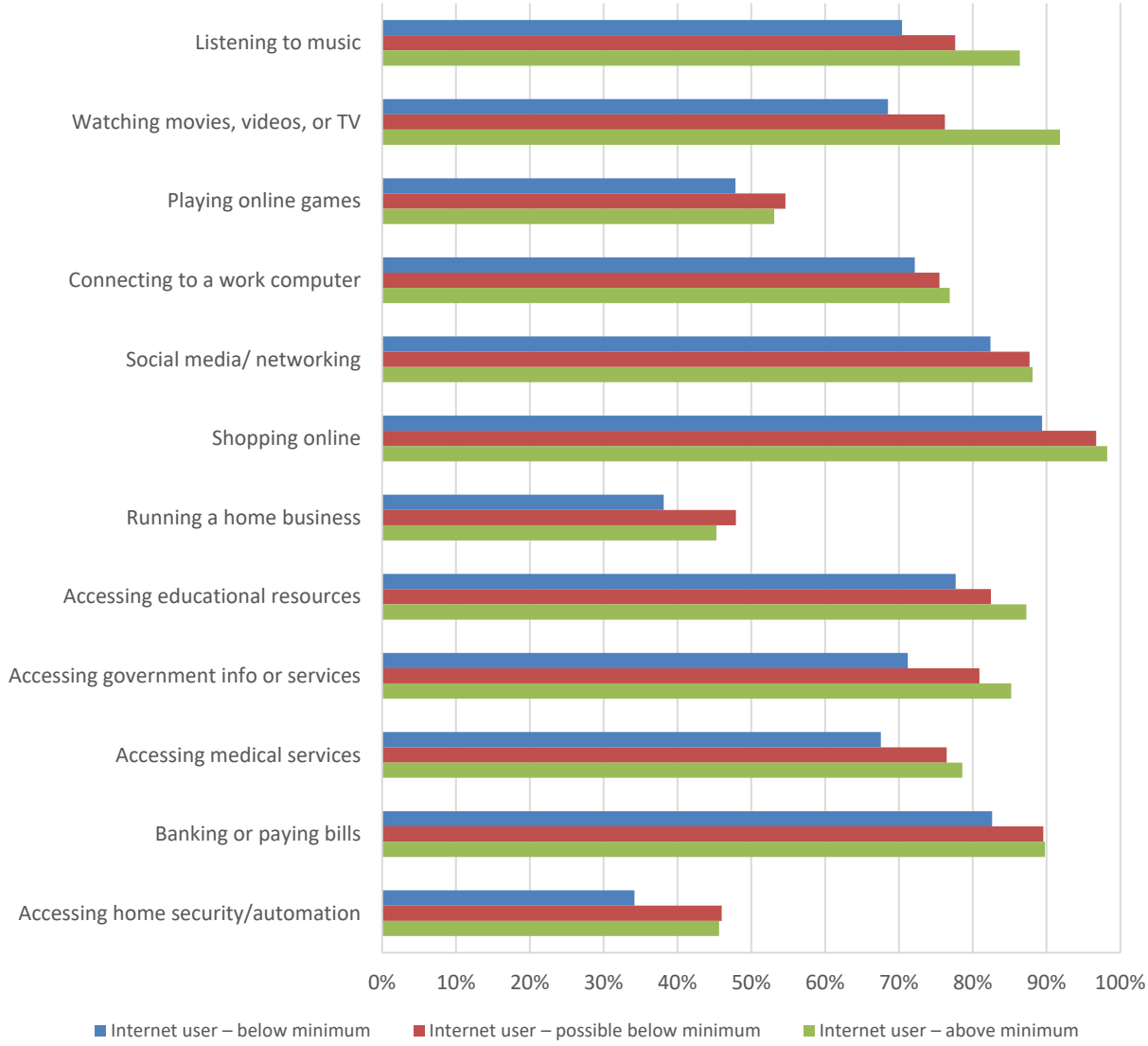
Four in 10 subscribers frequently access the internet for education or for listening to music. A small segment of subscribers (less than one-fourth) use the internet frequently to access government information or services or medical services, but more than one-half of subscribers use the internet occasionally for these activities. Use of the internet for playing online games, running a home business, and accessing home security/automation applications is less frequent than the other activities included in this question.

Figure 37: Frequency of Home Internet Activities



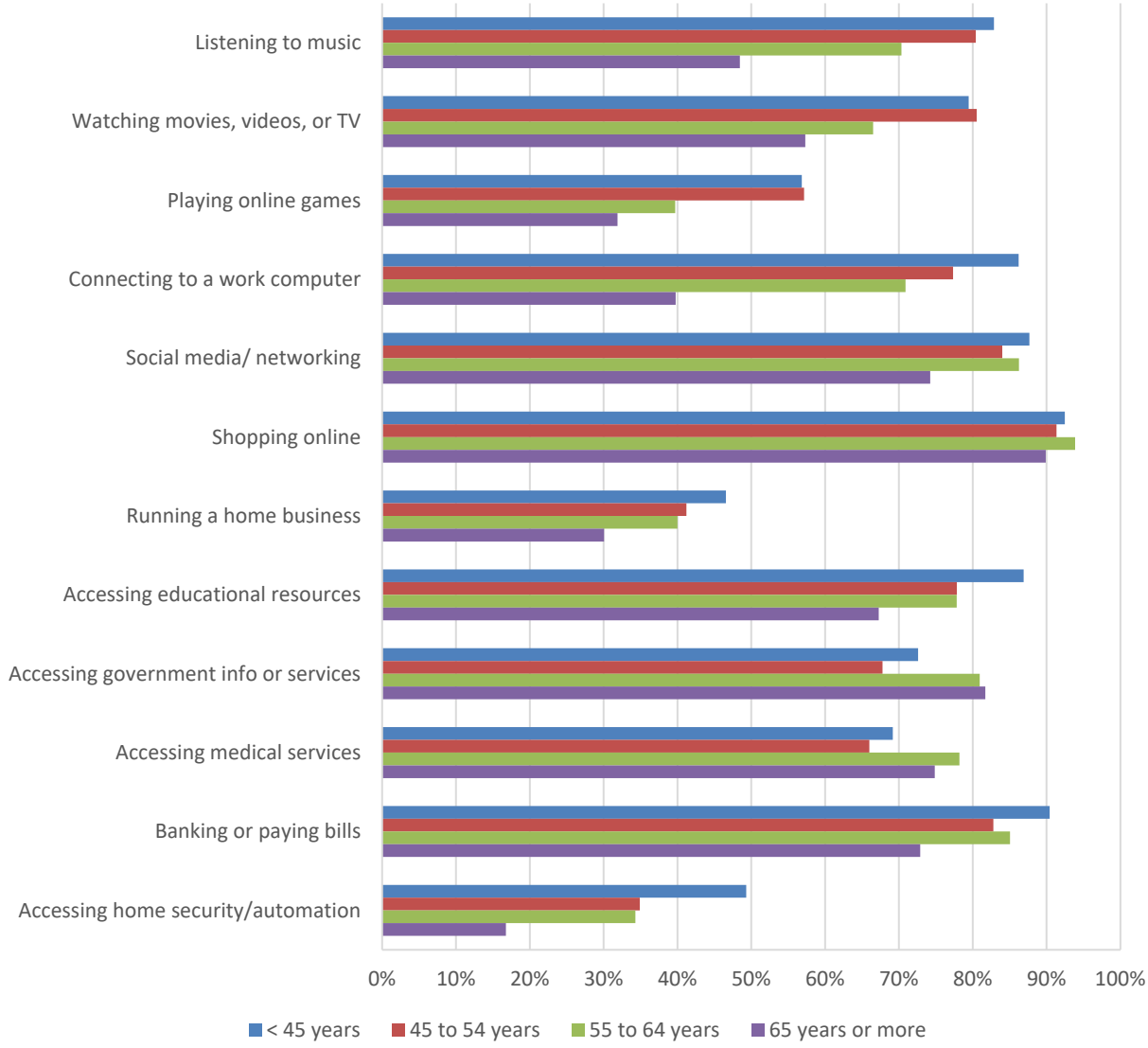
As may be expected, internet subscribers with a connection above the minimum criteria are the most likely to make use of the internet for various activities, while those with a connection below the minimum connection are the least likely to use their internet, particularly for listening to music and watching movies, videos, or TV (see Figure 38).

Figure 38: Home Internet Activity by Internet Connectivity Group (Percent Ever Using)



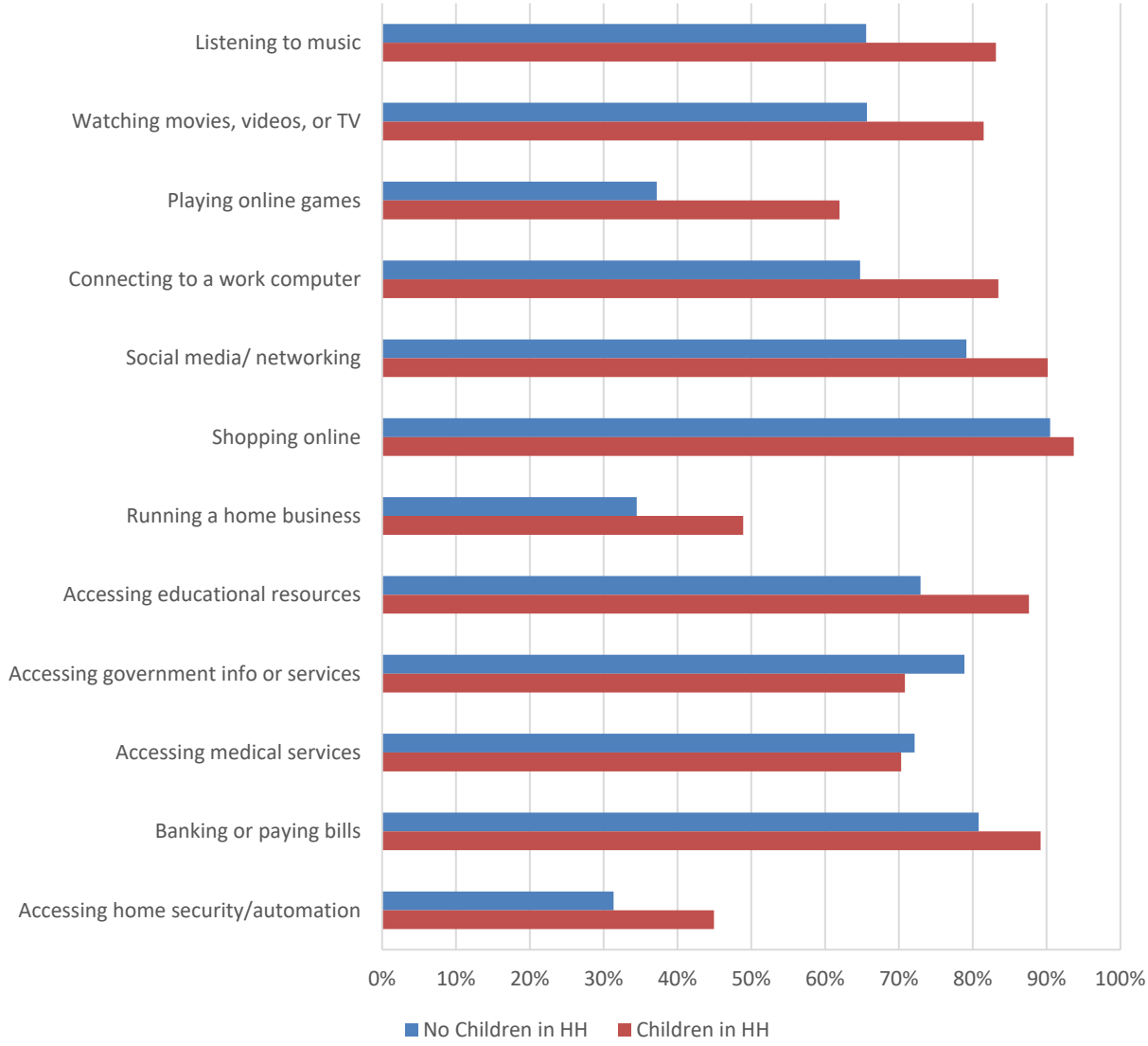
The use of the internet for some activities varies by age, as illustrated in Figure 39. Younger respondents are much more likely to use the internet for many applications, especially listening to music, watching videos or movies or TV, playing online games, connecting to a work computer, accessing educational resources, and accessing home security/automation applications. Internet subscribers ages 65 and older are less likely to ever use the internet for most activities, with the exception of online shopping and accessing government or medical services.

Figure 39: Home Internet Activity by Age of Respondent (Percent Ever Using)



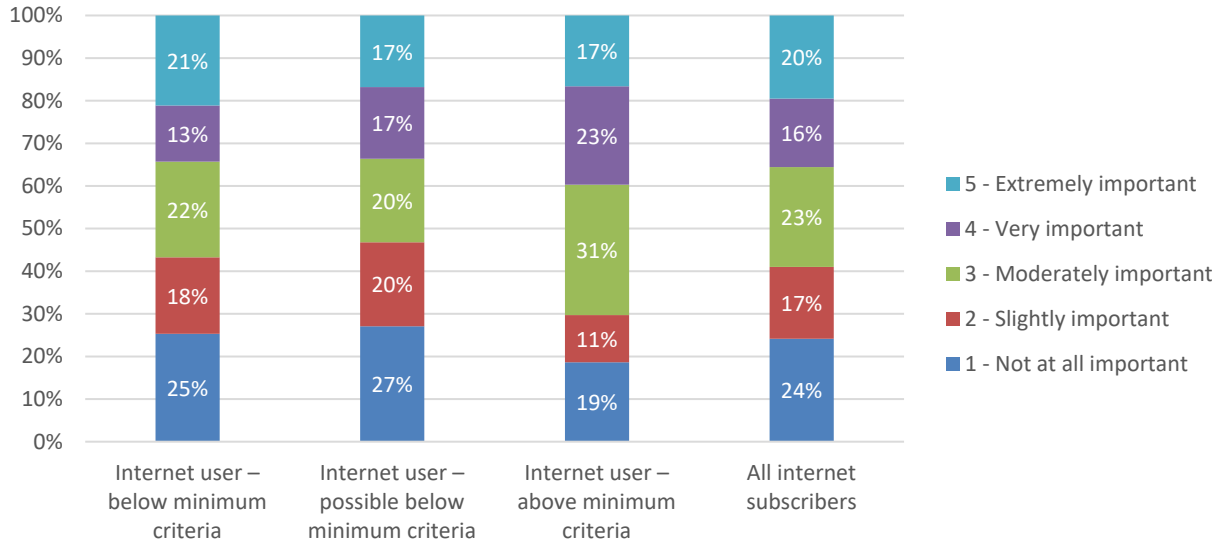
Similarly, respondents with children under age 18 in the household are more likely to use the internet for various activities, particularly for listening to music, watching movies or videos or TV, playing online games, connecting to a work computer, social media, accessing educational resources, and accessing home security/automation applications (see Figure 40).

Figure 40: Home Internet Activity by Children in Household (Percent Ever Using)



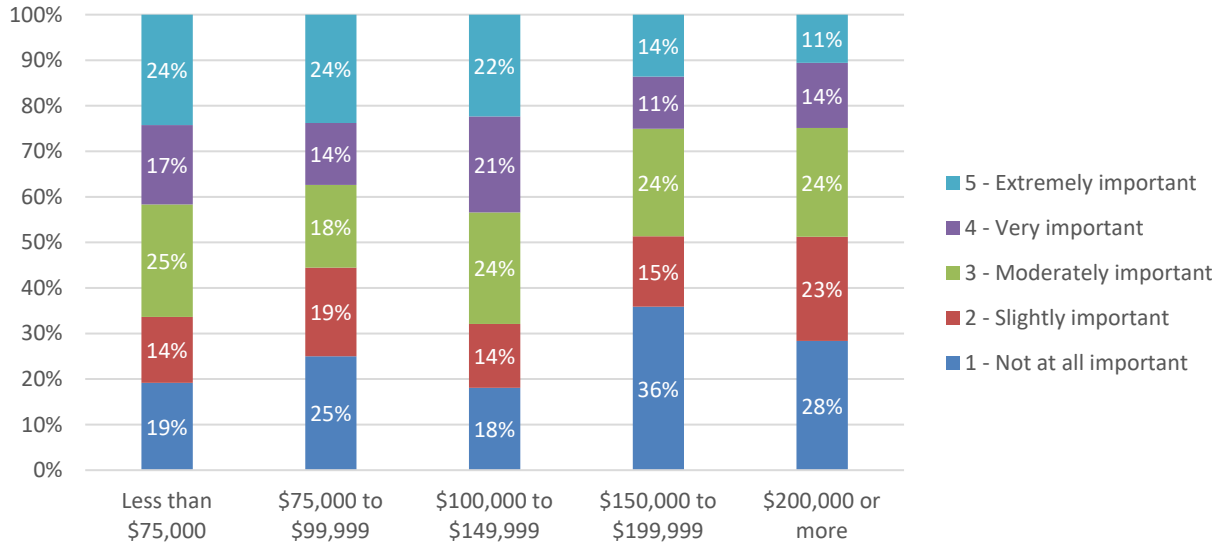
Additionally, respondents were asked to evaluate the importance of access to free Wi-Fi hotspots at libraries and community centers. As illustrated in Figure 41, there was sizeable variation in responses, with one-fourth of all internet subscribers saying access is not at all important, and one-fifth saying it is extremely important. Internet users with service above the minimum criteria placed slightly more importance on this service, compared with other internet users.

Figure 41: Importance of Access to Free Wi-Fi Hotspots at Libraries and Community Centers



Respondents with a household income below $150,000 placed somewhat more importance on having access to free Wi-Fi at libraries and community centers, compared with those with a higher household income (see Figure 42).

Figure 42: Importance of Access to Free Wi-Fi Hotspots by Household Income



3.3.7 Willingness to Switch Internet Service

Respondents were asked if they would be willing to switch to high-speed internet service (defined as 100 Mbps) for various price levels. The mean willingness to switch across this array of questions is illustrated in Figure 43, while detailed responses are illustrated in Figure 44.

Figure 43: Willingness to Switch to High-Speed Internet at Price Levels (Mean Ratings)

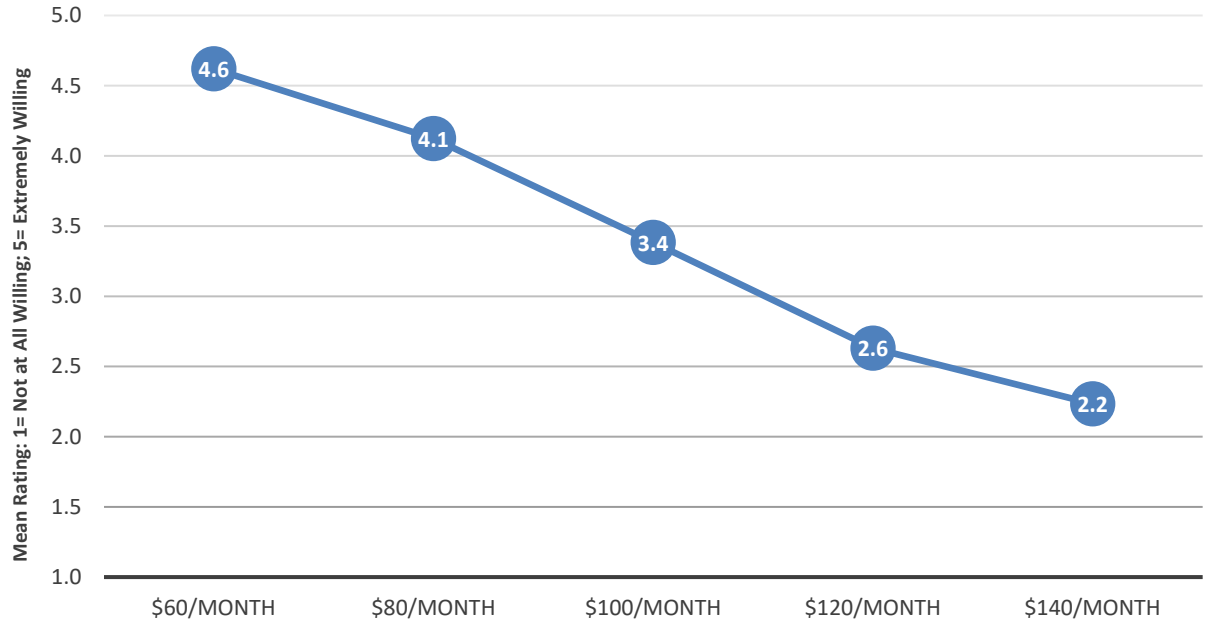
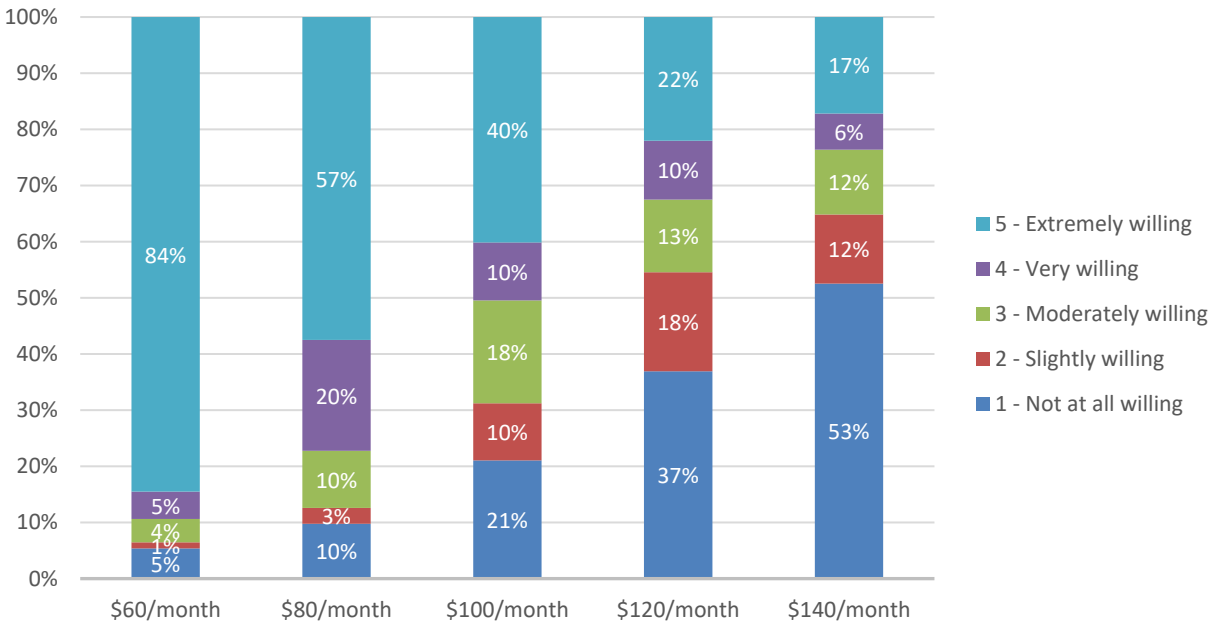


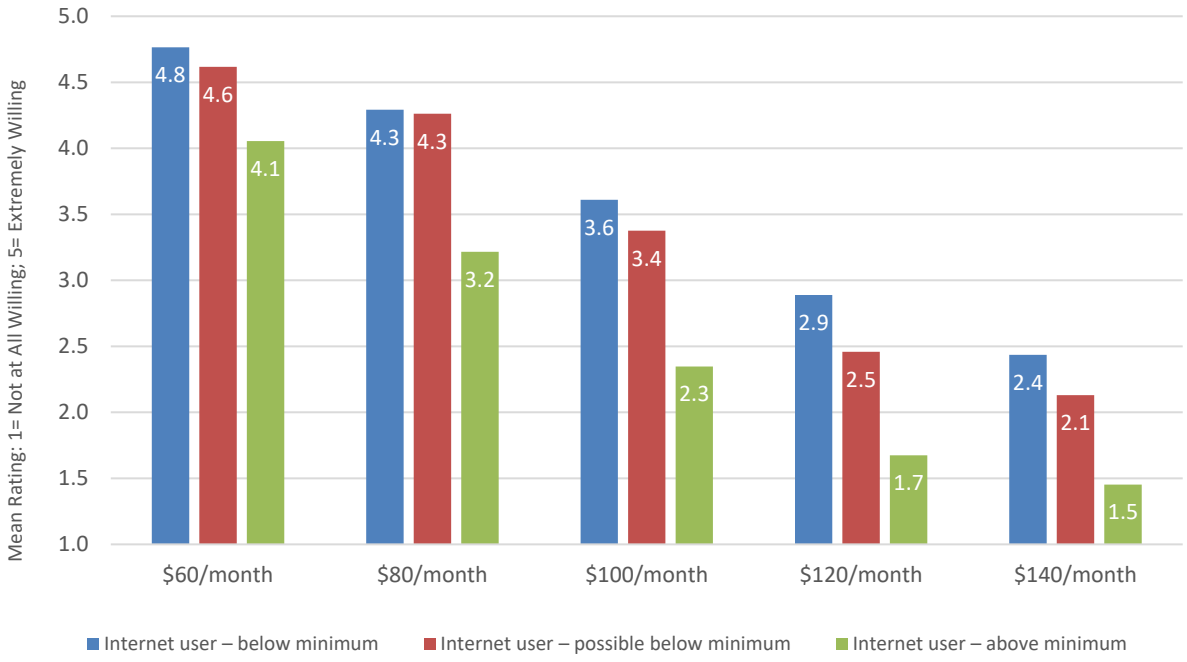
Figure 44: Willingness to Switch to High-Speed Internet at Various Price Levels



As depicted in Figure 43 and in Figure 44, respondents' willingness to switch to high-speed internet service (100 Mbps) is very high at $60 per month, but it drops considerably as the price increases. At a price of approximately $120 per month, the mean rating falls to 2.6 (slightly to moderately willing). From another perspective, 84 percent are extremely willing to switch to high-speed internet for $60 per month, dropping to 17 percent at $140 per month.

Subscribers with an internet connection above the minimum criteria (i.e. who already have sufficiently fast internet service) would be less likely to switch internet service, as might be expected (see Figure 45). Respondents with internet service below or possibly below the minimum criteria would be very to extremely likely to switch providers for $60 or $80 per month.

Figure 45: Willingness to Switch to High-Speed Internet by Internet Connectivity Group



Similarly, cable modem subscribers (service above the minimum criteria) would be less likely than DSL, satellite, or cellular/mobile internet subscribers to switch service, as illustrated in Figure 46.

The willingness to switch to very fast internet service is also correlated with some demographic characteristics of the respondents, including respondent age, education, and household income, as depicted in Figure 47 through Figure 44. Specifically, those ages 65 and older would be less likely than younger respondents to switch to a high-speed connection at various price points. Similarly, those with children in the household, who are younger on average, would be more willing to switch providers. Additionally, the likelihood of switching providers tends to increase as education and household income increases.

Figure 46: Willingness to Switch to High-Speed Internet by Primary Home Internet Service

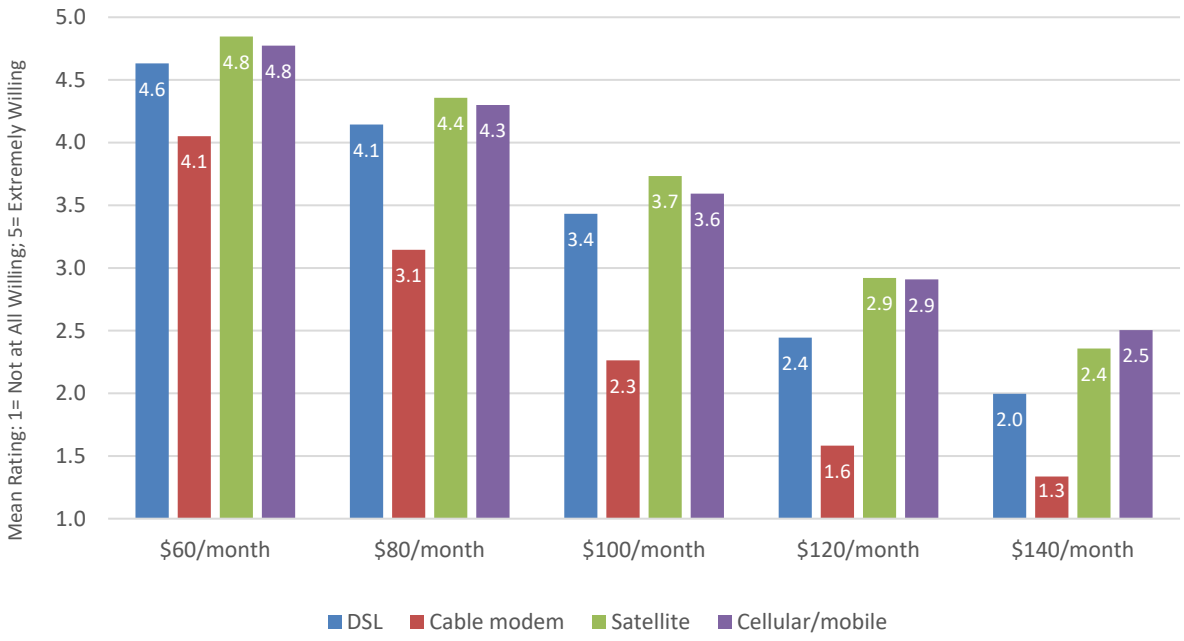


Figure 47: Willingness to Switch to High-Speed Internet by Age of Respondent

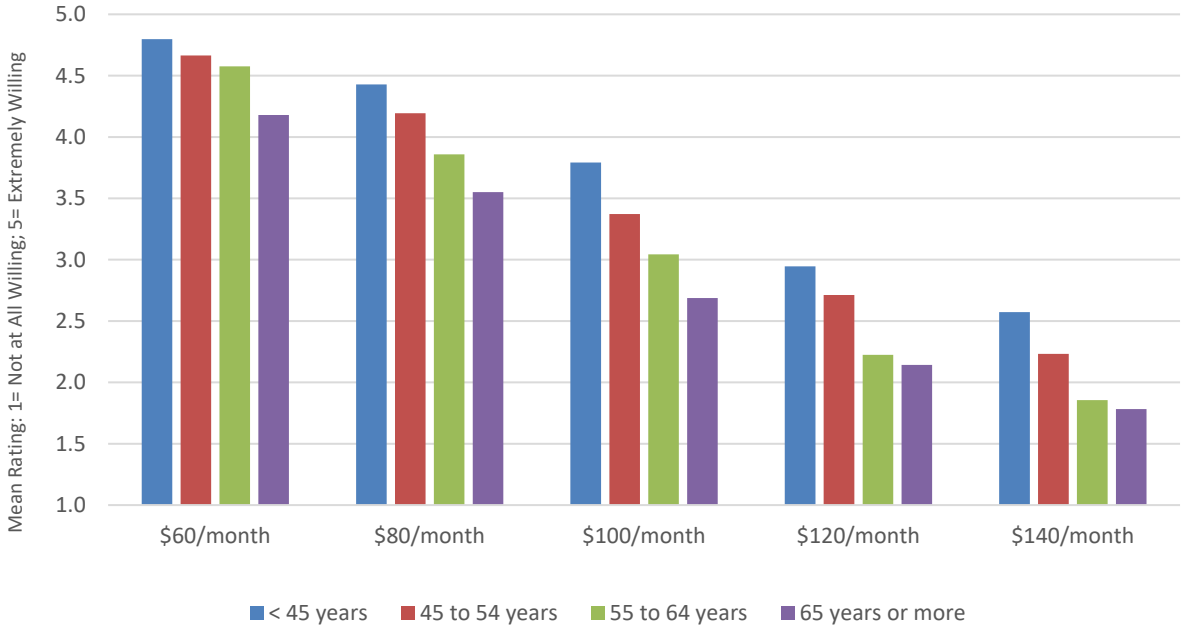


Figure 48: Willingness to Switch to High-Speed Internet by Education

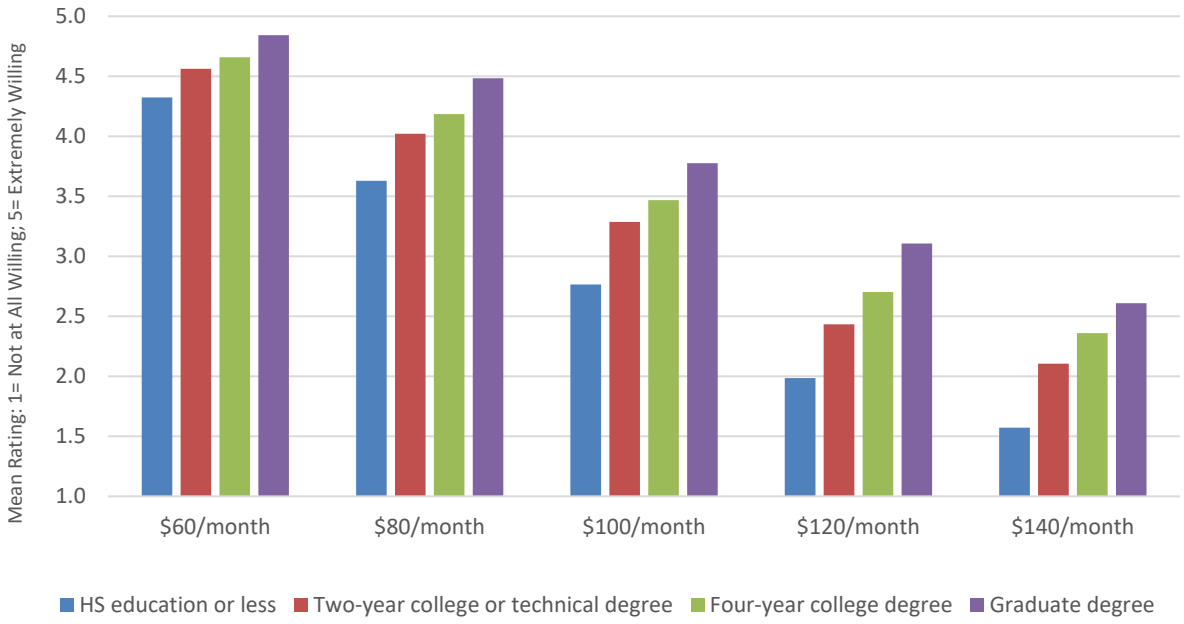


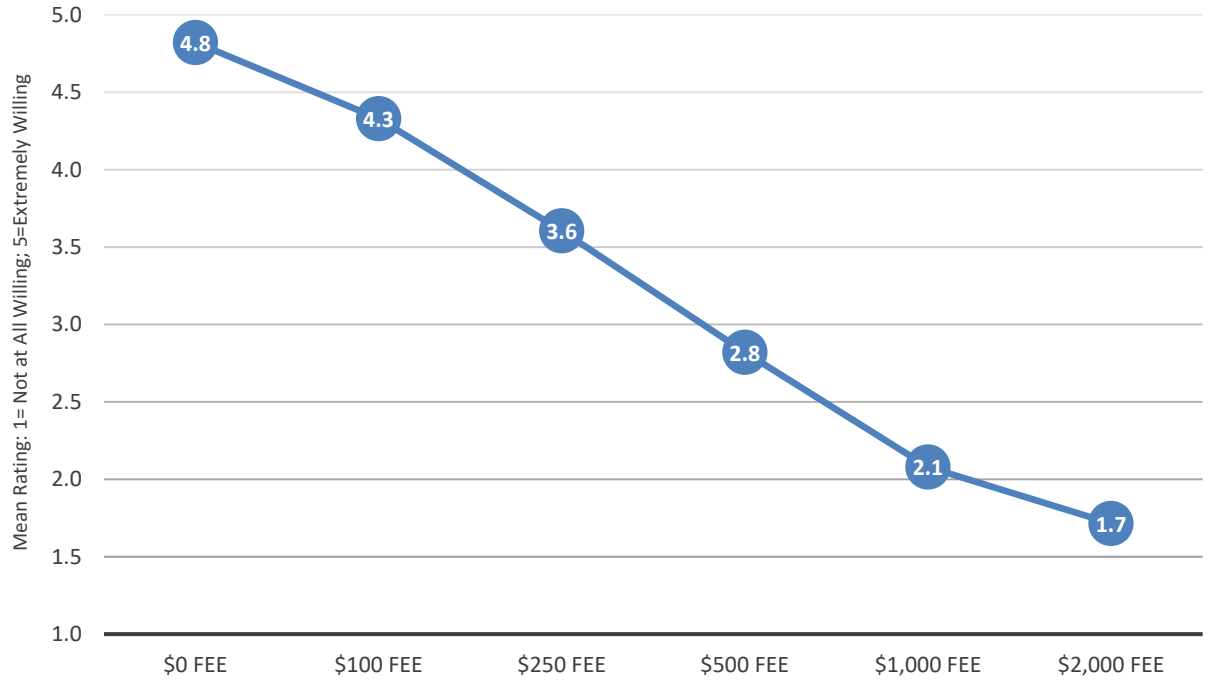
Figure 49: Willingness to Switch to High-Speed Internet by Household Income

3.3.8 Willingness to Pay Hook-Up Fee for High-Speed Network

Respondents were asked if they would be willing to pay an upfront hook-up fee to connect to 100 Mbps internet service. Almost all respondents would be extremely willing to switch to the

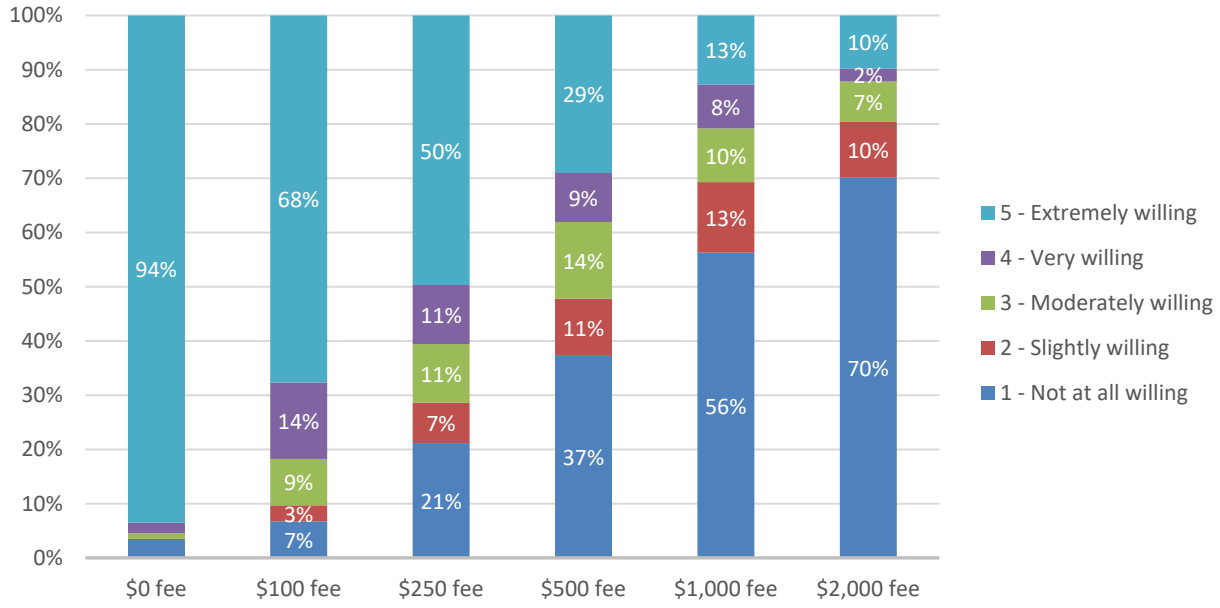
network for no hook-up fee, as would be expected. They would be very willing to pay a $100 hook-up fee and moderately willing to pay a $250 hook-up fee. Willingness to pay a hook-up fee falls sharply at higher price points, as shown in Figure 50.

Figure 50: Average Willingness to Pay Upfront Hook-Up Fee for High-Speed Internet



Specifically, two-thirds of subscribers would be extremely willing to pay a $100 hook-up fee for fast internet service, and one-half of subscribers would be extremely willing to pay a $250 hook-up fee for this service. Respondents were split at the $500 price point and overall would not be willing to pay a hook-up fee of $1,000 or more (see Figure 51).

Figure 51: Willingness to Pay Upfront Hook-Up Fee for High-Speed Internet



Those who already have internet service above the minimum criteria would be less likely to pay an upfront hook-up fee for access to 100 Mbps service. Similarly, cable modem subscribers would be less likely than connections below or possibly below the minimum criteria to pay a fee for fast service (see Figure 52 and Figure 53).

Figure 52: Willingness to Pay Upfront Hook-Up Fee by Internet Connectivity Group

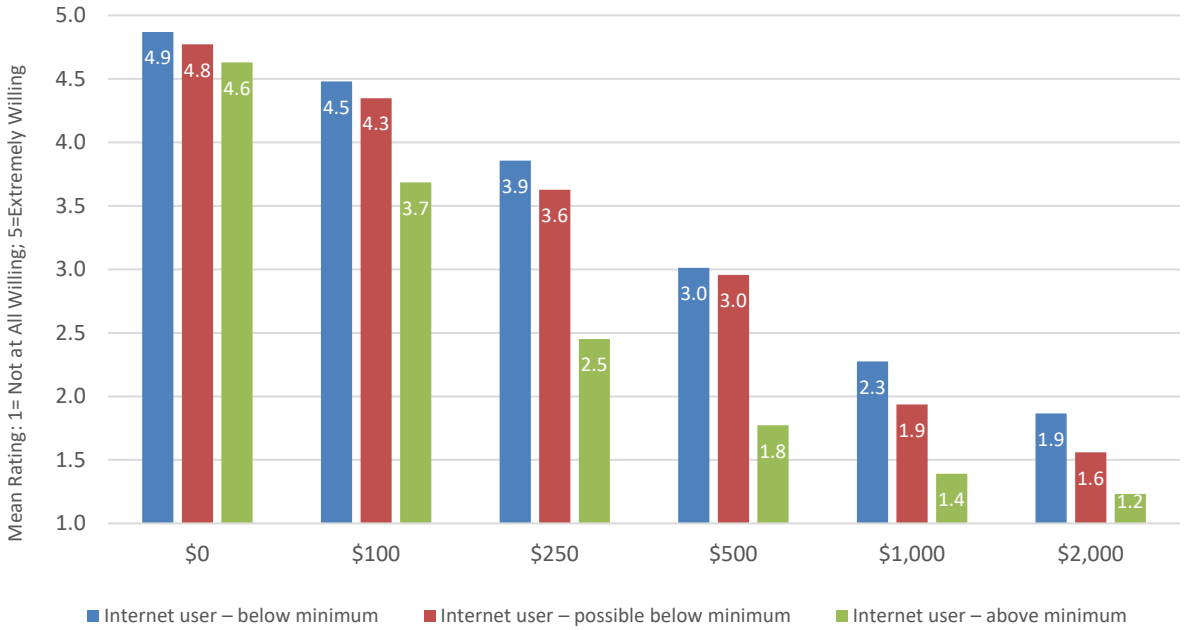
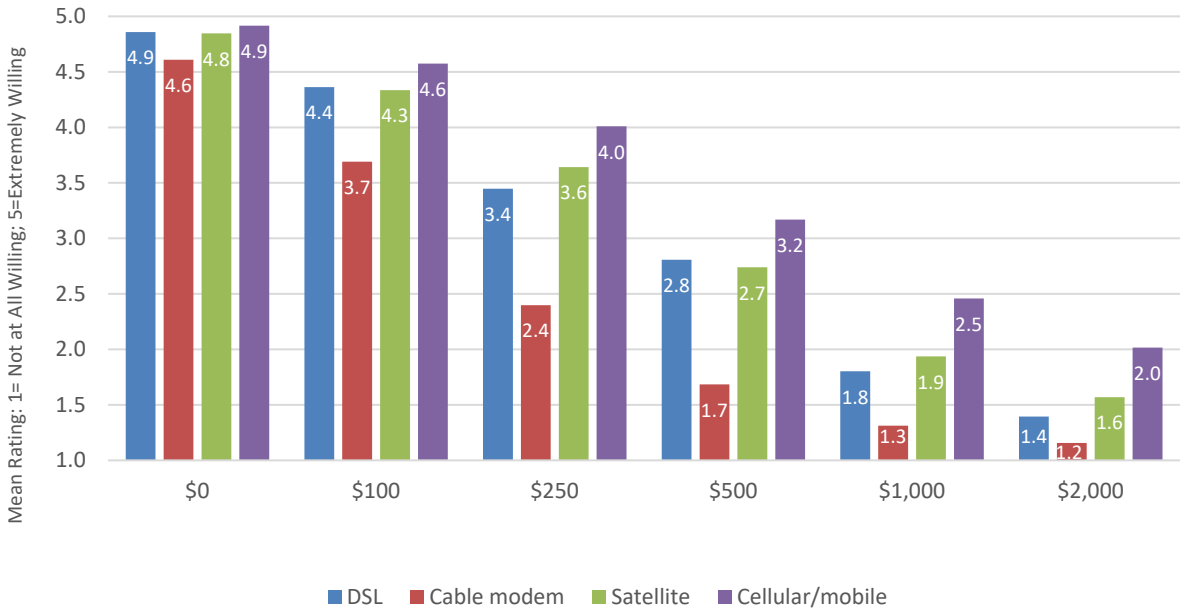
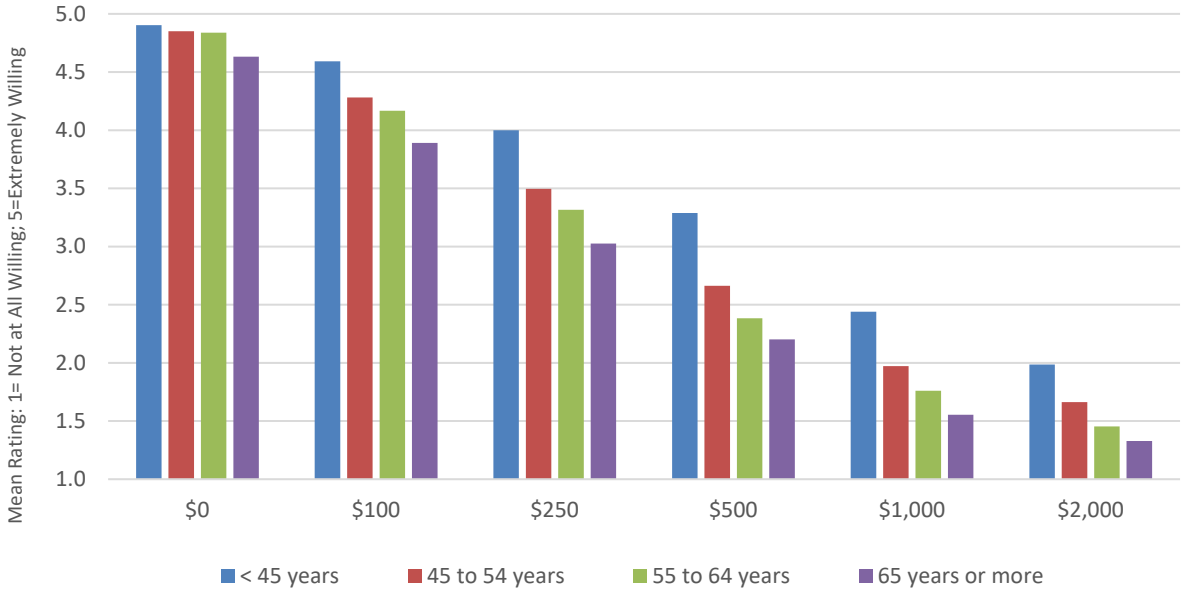


Figure 53: Willingness to Pay Upfront Hook-Up Fee by Primary Home Internet Service



Willingness to pay an upfront hook-up fee for fast internet service is correlated with respondent age, as illustrated in Figure 54. Those ages 65 and older are less willing to pay a hook-up fee for access to fast internet.

Figure 54: Willingness to Pay Upfront Hook-Up Fee by Household Income



Willingness to pay an upfront hook-up fee increases as household income increases. Similarly, those with more than a high school level of education, which is correlated with household income, would be more willing to pay the hook-up fee (see Figure 55 and Figure 56).

Figure 55: Willingness to Pay Upfront Hook-Up Fee by Education

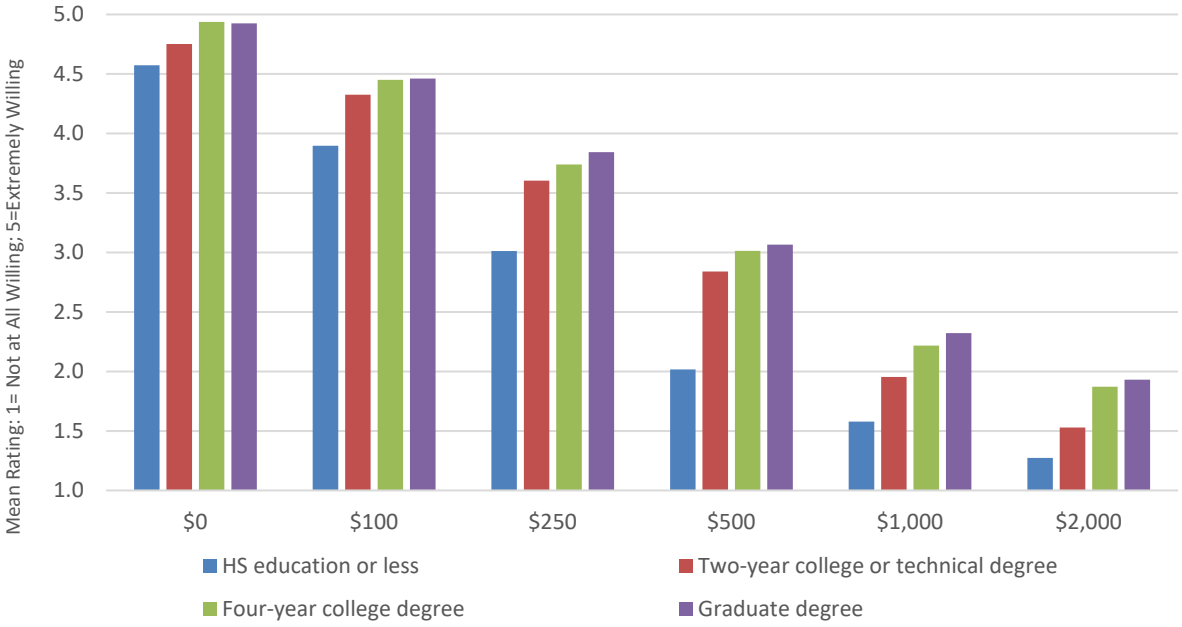
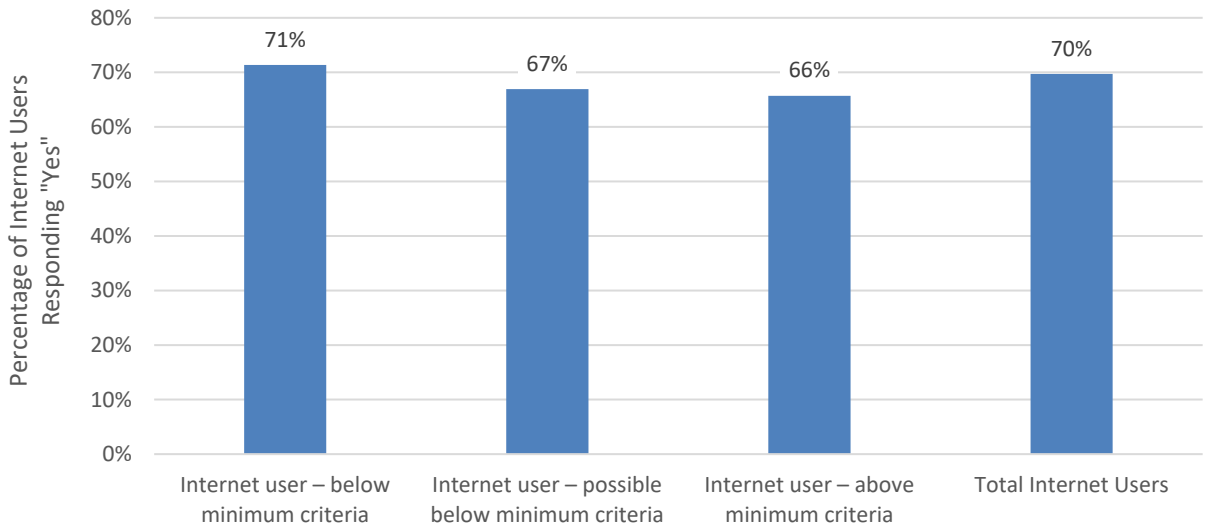


Figure 56: Willingness to Pay Upfront Hook-Up Fee by Household Income

3.3.9 Internet Use for Jobs/Careers

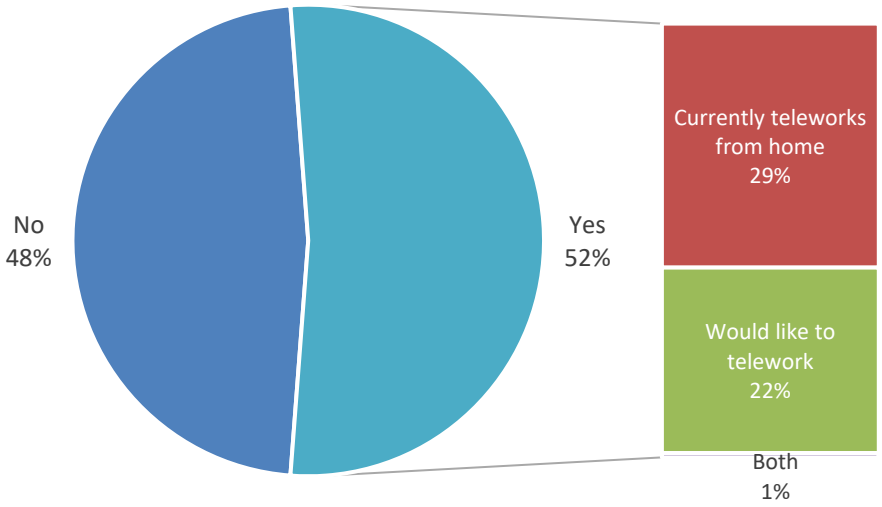
Internet subscribers were asked if their job requires internet access at home. As illustrated in Figure 57, the results point to a high need for internet access across all connectivity groups. No statistically significant difference was found, suggesting that respondents with internet service below or possibly below the minimum criteria have similar needs as those with service above the minimum criteria. Overall, seven in 10 internet subscribers need internet access at home for their job.

Figure 57: Internet Access Required for Job



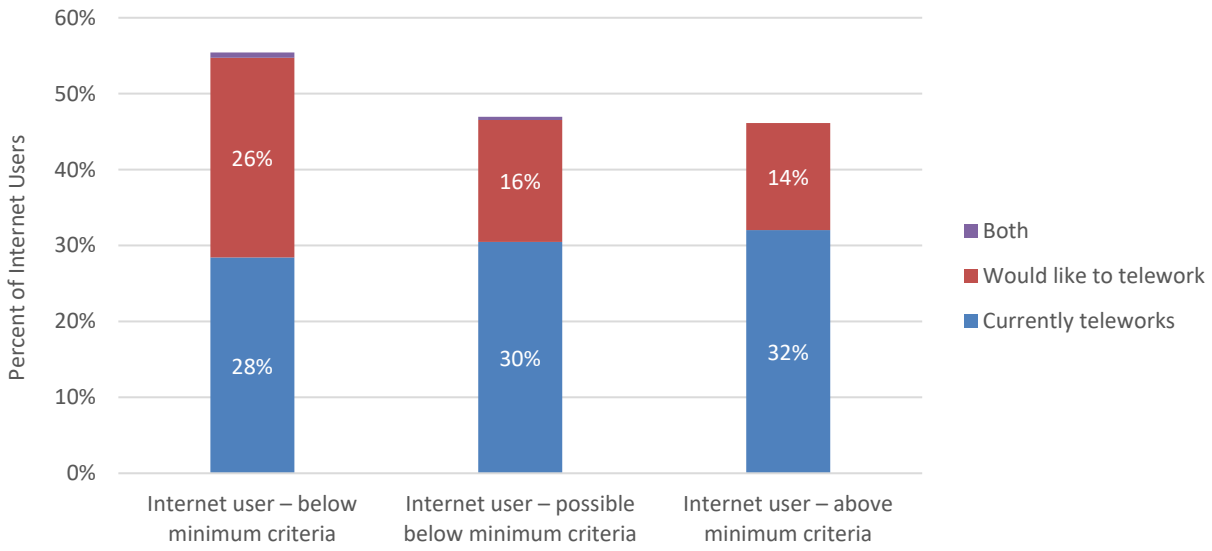
As shown in Figure 58, 29 percent of respondents indicated that someone in their family already teleworks from home, and another 22 percent would like to telework.

Figure 58: Household Member Teleworking



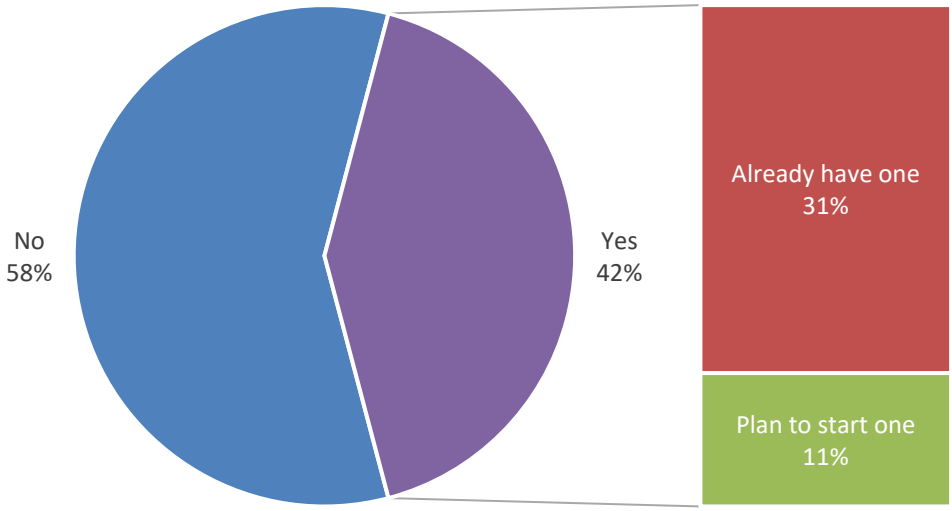
Internet users with service below the minimum criteria are more likely than other subscribers to have a household member who would like to telework, as shown in Figure 59. This highlights a possible gap in service, where those without sufficient internet service want to telework but do not, although the correlation between desire to telework (but not currently) and internet connectivity may be spurious.

Figure 59: Teleworking Status by Internet Connectivity Group



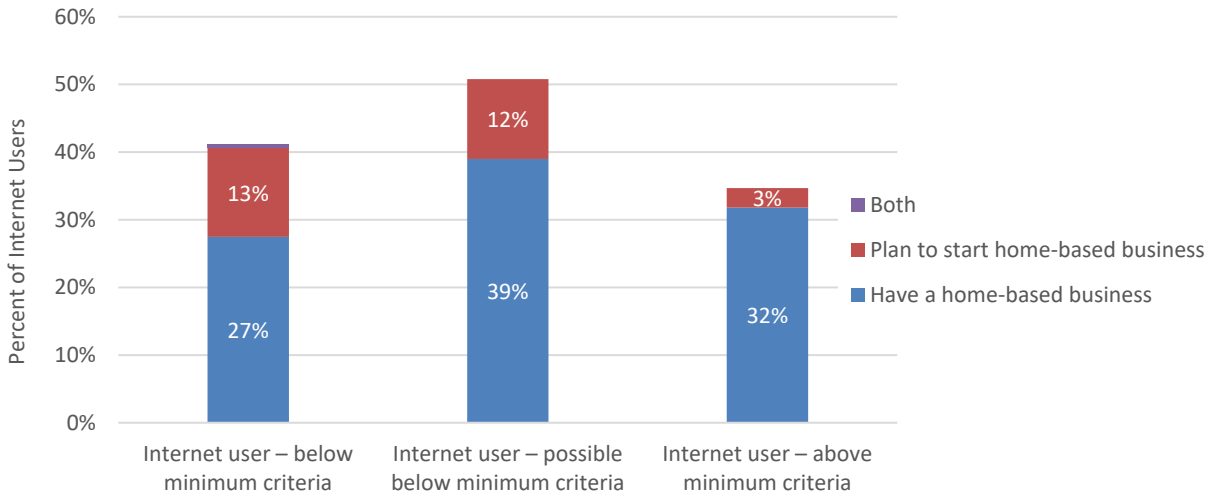
More than four in 10 respondents either have a home-based business or are planning to start one within the next three years, as illustrated in Figure 60.

Figure 60: Own or Plan to Start a Home-Based Business



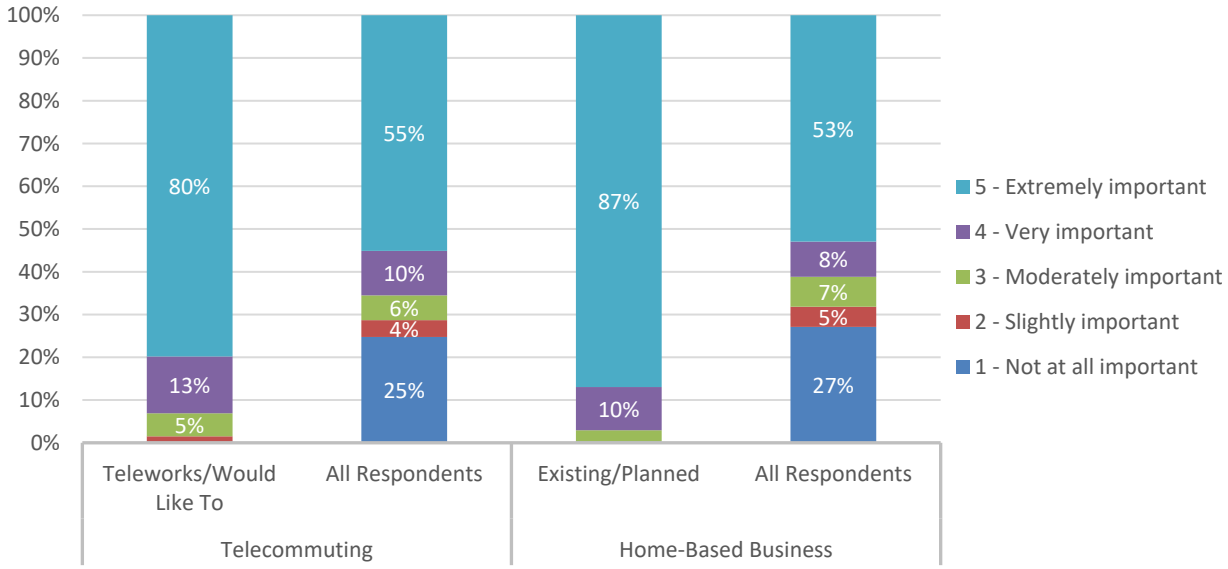
As shown in Figure 61, those with an internet service below or possibly below the minimum criteria are more likely than those with internet above the minimum criteria to plan to start a home-based business in the next three years. This suggests a greater need for fast internet service for individuals with insufficient internet service to support home businesses.

Figure 61: Own or Plan to Start a Home-Based Business by Internet Connectivity Group



A high-speed data or internet connection is extremely important for most of those who telework or would like to telework (80 percent) and for those with a planned or existing home-based business (87 percent), as shown in Figure 62. Intuitively, those who do not telework or have a planned/existing home-based business find the need for high-speed internet for these aspects to be less important.

Figure 62: Importance of High-Speed Internet for Teleworking and Home-Based Business



Respondents ages 65 and older (who are more likely to be retired) are less likely to have a job that requires internet access, to telecommute, or to have a home-based business. Additionally, those with lower levels of education or a lower household income are less likely to need internet access for a job, to telecommute, or to have a home-based business (see Table 8).

Table 8: Saturation of Internet Use, Telecommuting, and Home-Based Businesses by Demographic Groups

		Job Requires Internet	Telecommute/ Would Like To	Have/Plan to Start Home-Based Business	*Total Count*
Age group	< 45 years	86%	68%	48%	*334*
	45 to 54 years	77%	57%	43%	*156*
	55 to 64 years	59%	45%	43%	*141*
	65 years or more	29%	17%	26%	*151*
Highest level of education	HS education or less	48%	29%	35%	*139*
	Two-year college or technical degree	69%	55%	36%	*177*
	Four-year college degree	78%	61%	51%	*272*
	Graduate degree	73%	54%	40%	*194*
Household income	Less than $75,000	47%	35%	35%	*126*
	$75,000 to $99,999	60%	40%	41%	*122*
	$100,000 to $149,999	75%	60%	38%	*187*
	$150,000 to $199,999	83%	65%	46%	*138*
	$200,000 or more	88%	71%	51%	*107*
Children in Household	No Children in HH	56%	43%	37%	*419*
	Children in HH	84%	63%	48%	*363*
	One HH member	34%	25%	17%	*51*

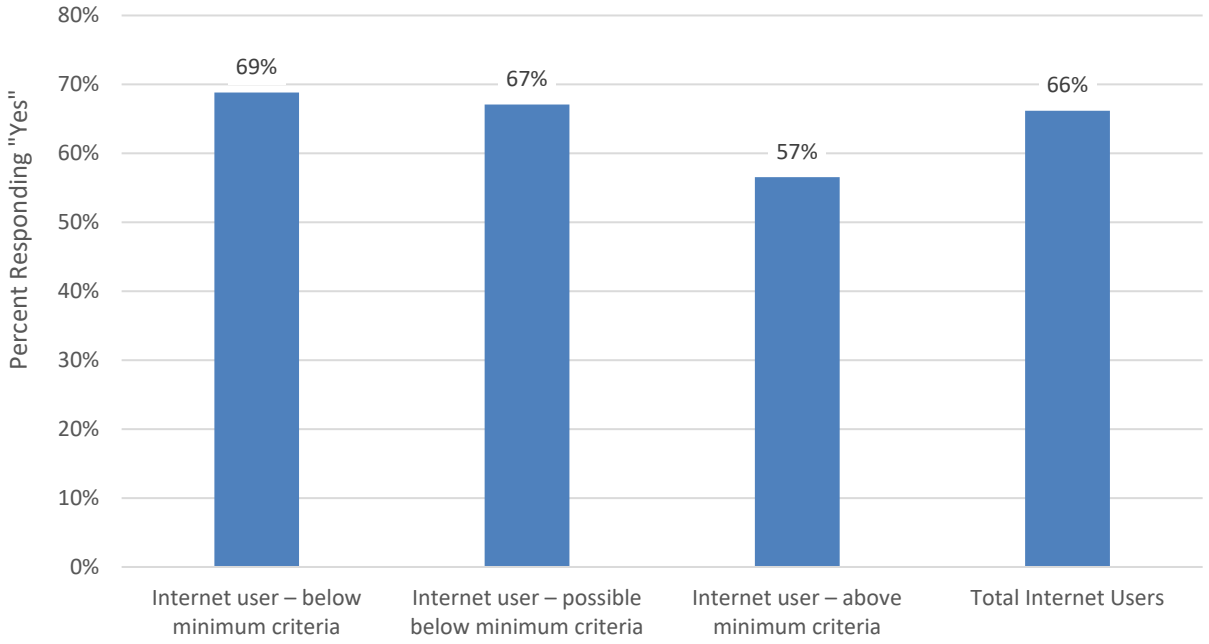
		Job Requires Internet	Telecommute/ Would Like To	Have/Plan to Start Home-Based Business	*Total Count*
Total Household Size (Adults + Children)	Two HH members	54%	41%	34%	*253*
	Three HH members	72%	64%	45%	*138*
	Four+ HH members	83%	59%	50%	*339*
Number of years lived at current residence	Less than 1 year	85%	69%	36%	*45*
	1 to 2 years	83%	63%	49%	*64*
	3 to 4 years	82%	73%	40%	*84*
	5 or more years	65%	47%	42%	*587*

The table shows the percentage of each demographic group who answered "yes" to each question related to internet use for job/careers. Read across rows for the percentage within each demographic group who answered "yes" to these aspects (e.g. 86% of respondents under age 45 have a job that requires internet access, 68% have a household member who telecommutes or would like to telecommute, and 48% have a household member who has a home-based business or would like to start one). Read down columns to compare responses by demographic groups for a particular question (e.g. 86% of respondents under age 45 have a job that requires internet access, compared with 77% of those ages 45-54, 59% of those ages 55-64, and 29% of those ages 65 and older).

3.3.10 Internet Use for Education

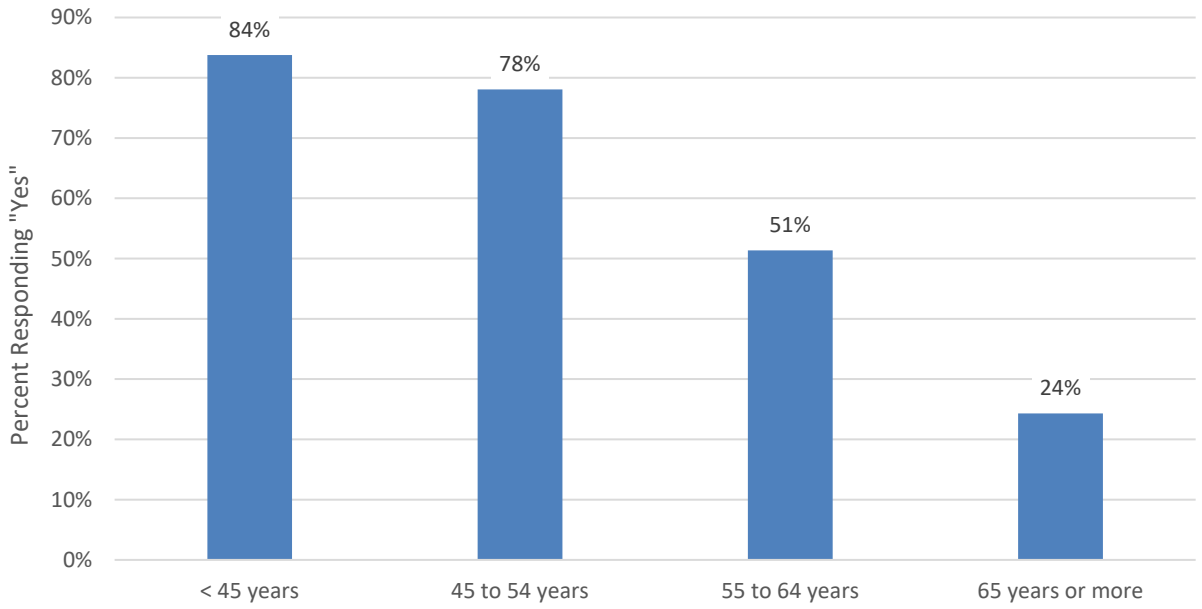
Respondents were asked if they or a household member use an internet connection for educational purposes, such as completing assignments, research, or study related to coursework or formal education. Households with an internet connection below or possibly below the minimum criteria are somewhat more likely to use the internet for educational purposes, compared with households with an internet connection above the minimum criteria. Overall, two-thirds of subscribers reported using the internet for educational reasons, as shown in Figure 63.

Figure 63: Use of Internet for Educational Purposes



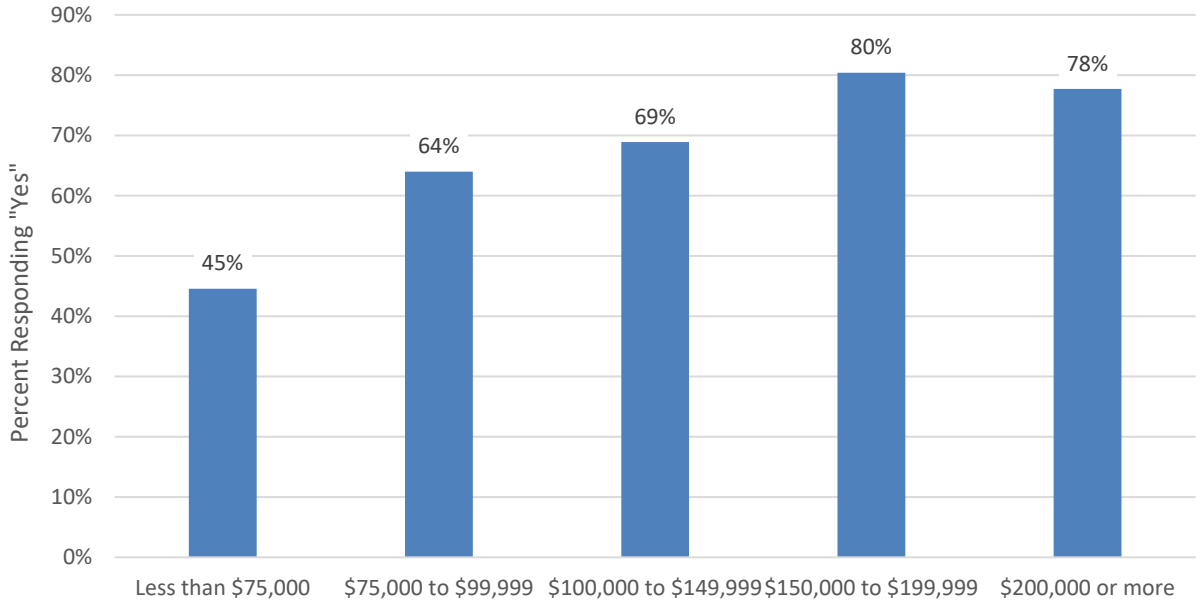
Respondents younger than age 55 are more likely than older respondents to have a household member who uses the internet for educational purposes (see Figure 64); they are also more likely to have children age 18 and under in the household. Nine in 10 of those with children in the household use the internet for educational purposes, compared with 44 percent of those without children in the home.

Figure 64: Use of Internet for Educational Purposes by Age of Respondent



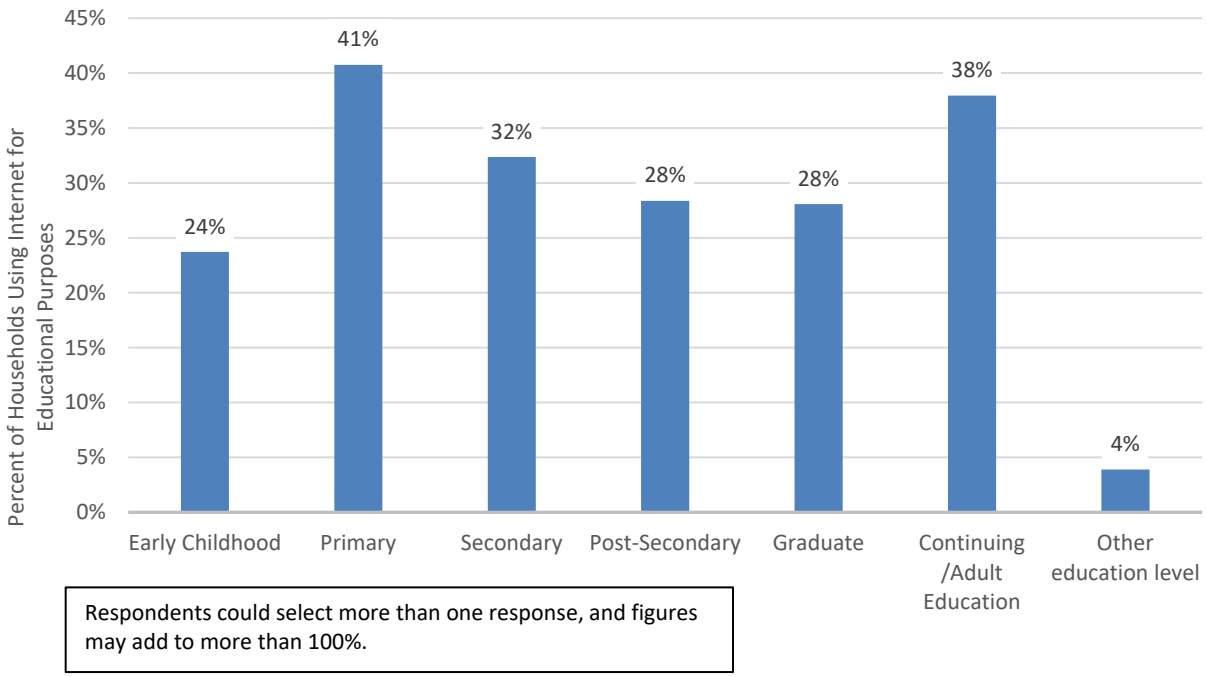
Respondents with a household income of less than $75,000 are also less likely to use the internet for educational purposes, although the lower-income group is also more likely to be age 65 or older and to have no children in the home (Figure 65).

Figure 65: Use of Internet for Educational Purposes by Household Income



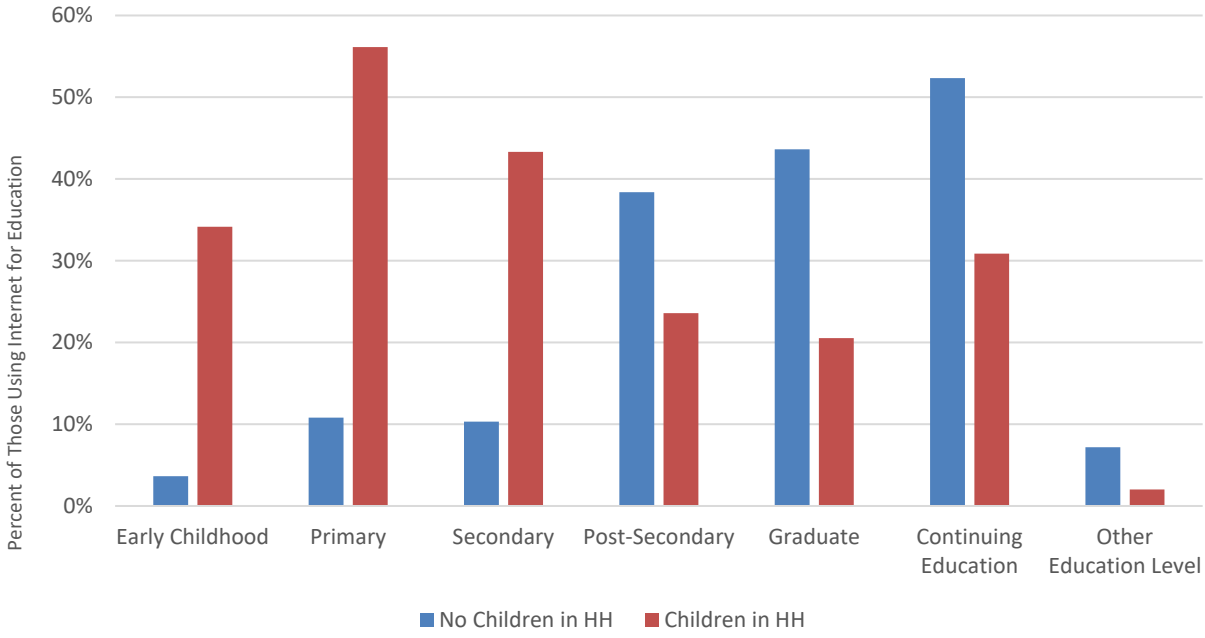
Respondents use the internet for a range of education levels. Among those who use the internet for educational purposes, 41 percent use it for primary education, 32 percent use it for secondary education, and 24 percent use it for early childhood education. Additionally, 28 percent use the internet for post-secondary, 28 percent use it for graduate level education, and 38 percent use it for continuing/adult education (see Figure 66).

Figure 66: Education Level for Which Internet Connection Is Used



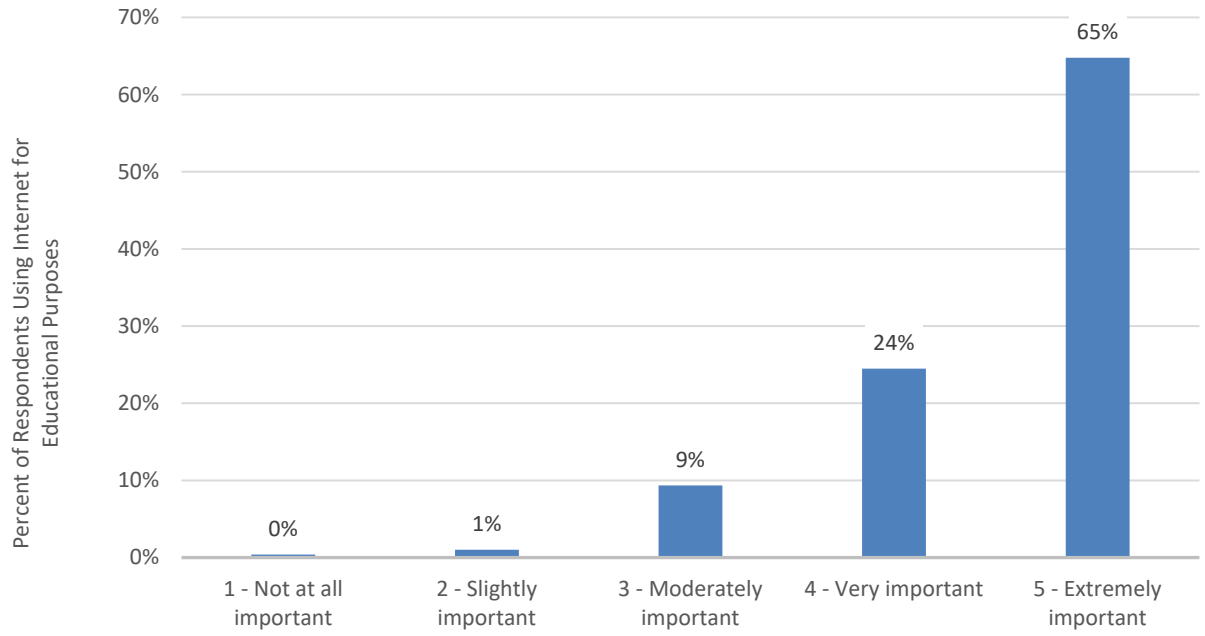
Use of the internet for educational purposes is related to presence of children in the household, as might be expected, particularly for early childhood, primary, and secondary education needs. Those without children in the home are more likely to use the internet for post-secondary, graduate, or continuing education (see Figure 67).

Figure 67: Education Level for Which Internet Connection Is Used by Children in Household



Among those who use the internet for educational purposes, 65 percent said that a high-speed internet connection is extremely important, and 24 percent said it is very important for their education needs (see Figure 68).

Figure 68: Importance of High-Speed Internet for Education Needs



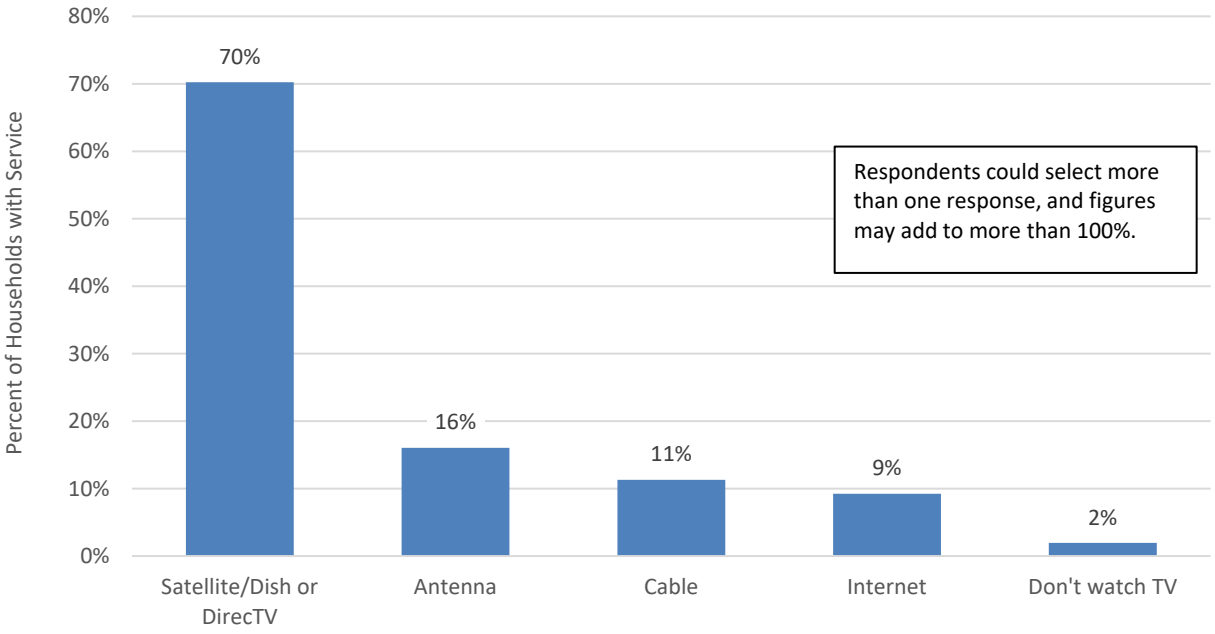
3.4 Television and Telephone Service

Respondents were asked to indicate what television and telephone services are used, as well as cost of services and the importance of various features.

3.4.1 Television Service

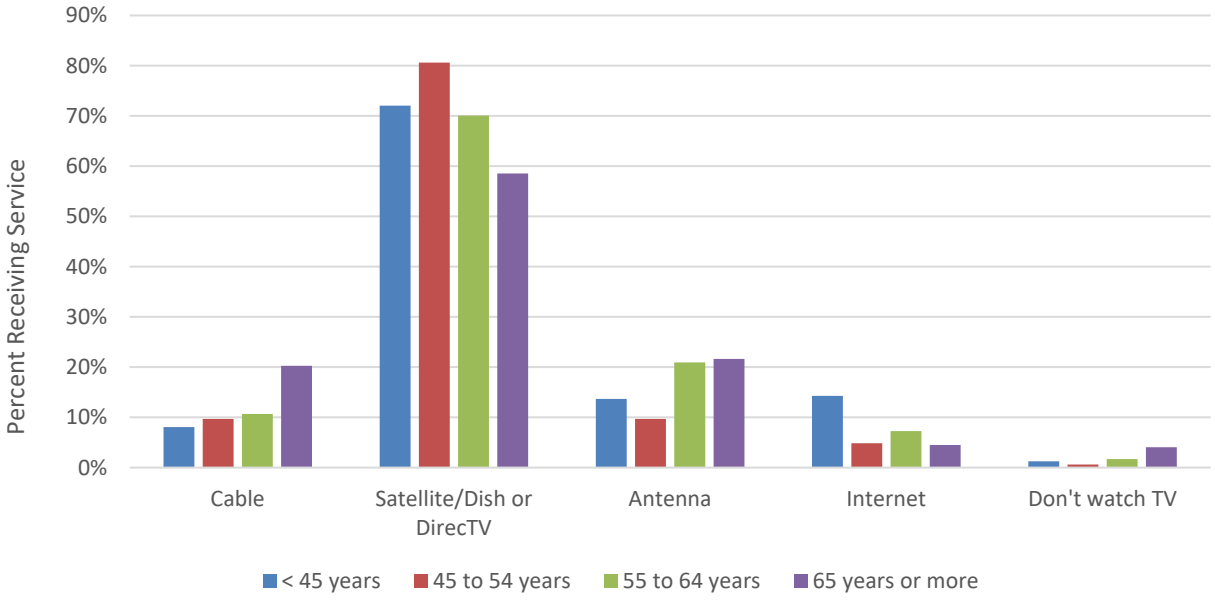
Seven in respondents purchase satellite/Dish or DirecTV service. Much smaller shares of the market have antenna (over-the-air) service (16 percent), cable television service (11 percent), or internet-based television service (9 percent). Just two percent do not watch television (see Figure 69).

Figure 69: Types of Television Service in Home



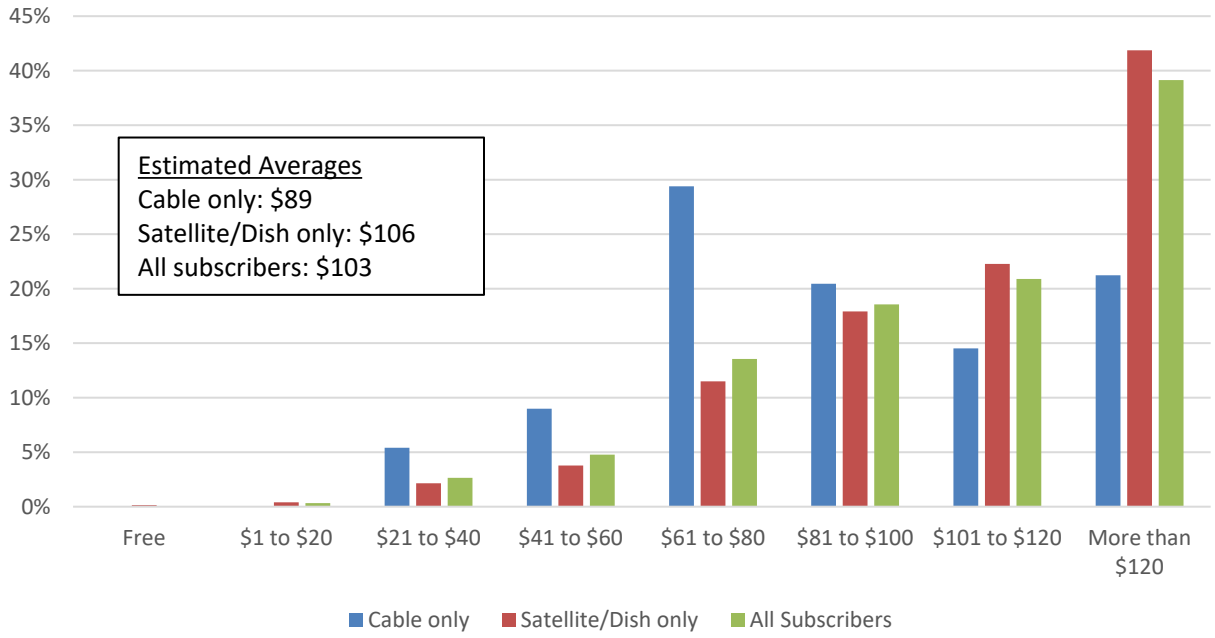
The use of television service is correlated with respondent age. Respondents ages 65 and older are more likely than younger respondents to have cable television service and are less likely to have satellite/Dish or DirecTV (although the latter is the leading service type among all age cohorts). Additionally, those under age 45 are more likely than older respondents to use internet television services (see Figure 70).

Figure 70: Types of Television Service in Home by Age of Respondent



The estimated average monthly price for satellite/Dish or DirecTV service is $106, with more than four in 10 paying over $120 per month, as illustrated in Figure 71. The estimated average monthly price is slightly higher for satellite services vs. cable services ($106 vs. $89), but this is based on a relatively small number of respondents who subscribe to cable television.

Figure 71: Monthly Price of Cable or Satellite TV Service



Respondents were asked to evaluate the importance of television programming features. The most important aspects are local programming and news programming, while the least important is children's programming, as shown in Figure 72 and Figure 73. Specifically, six in 10 respondents said local programming is extremely important, and 54 percent said news programming is extremely important.

Figure 72: Importance of Television Programming Features

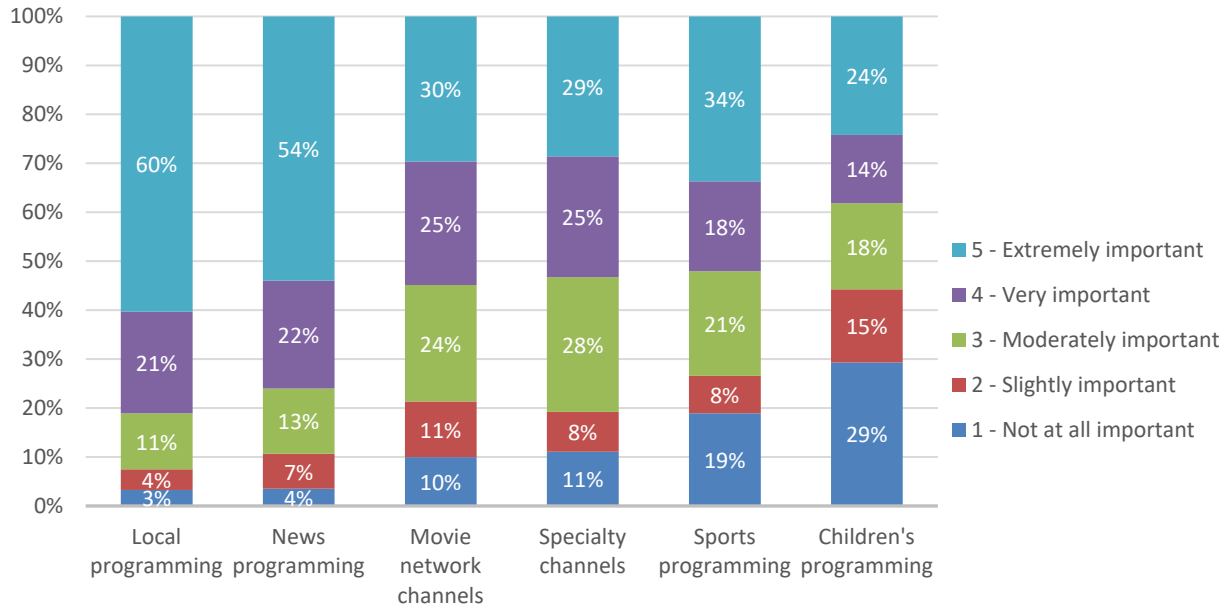
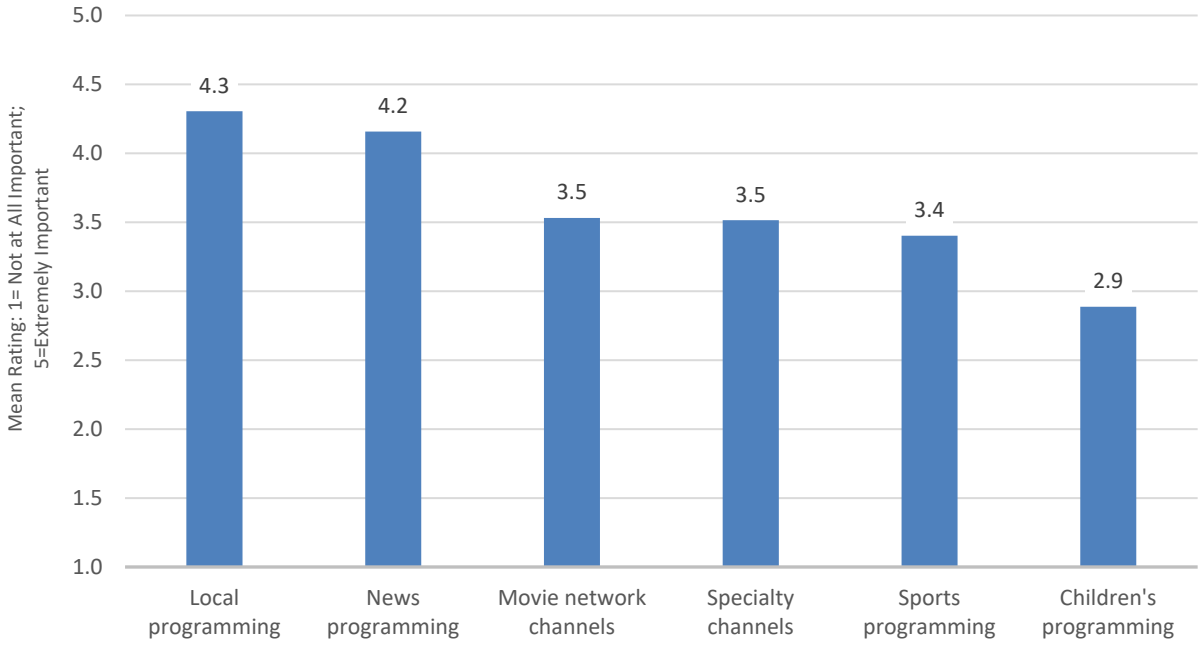
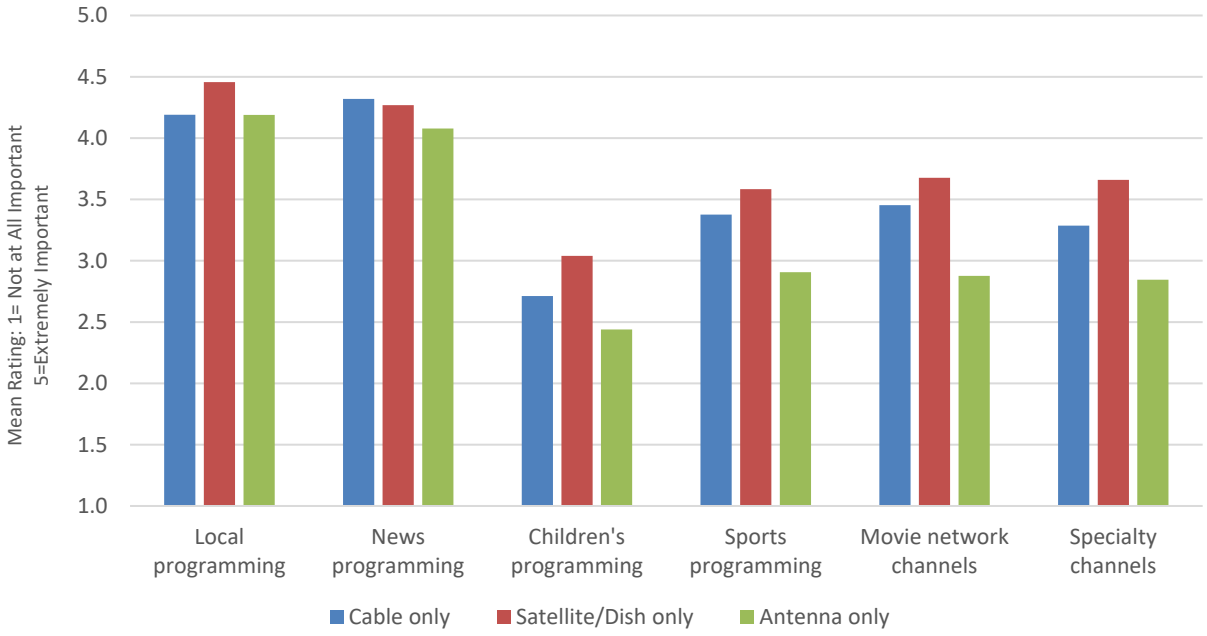


Figure 73: Mean Importance of Television Programming Features



Respondents with cable or satellite television service placed more importance on key programming features (children's programming, sports programming, movie network channels, and specialty channels) compared with those with over-the-air service (see Figure 74). Also, respondents with children in the household (who are more likely to be under age 45 and have a higher household income) placed more value on children's programming compared with those with no children in the household (3.7 vs 2.2 mean rating).

Figure 74: Importance of Television Programming Aspects by Television Service



3.4.2 Telephone Service

Respondents were asked about their home and mobile telephone services. As illustrated in Figure 75, nine in 10 respondents have a cellular/mobile telephone. More than one-third of respondents have a landline from a traditional telephone provider, and five percent have a landline from a cable provider. Just three percent of respondents have internet-based phone service.

The saturation of landline telephone service increases as the age group of householder increases, although cellular/mobile is the leading service across all age cohorts (see Figure 76). Landline use from a traditional provider increases from 24 percent of those ages 18 to 44 to 56 percent of those ages 65 and older.

Figure 75: Home Telephone Service(s)

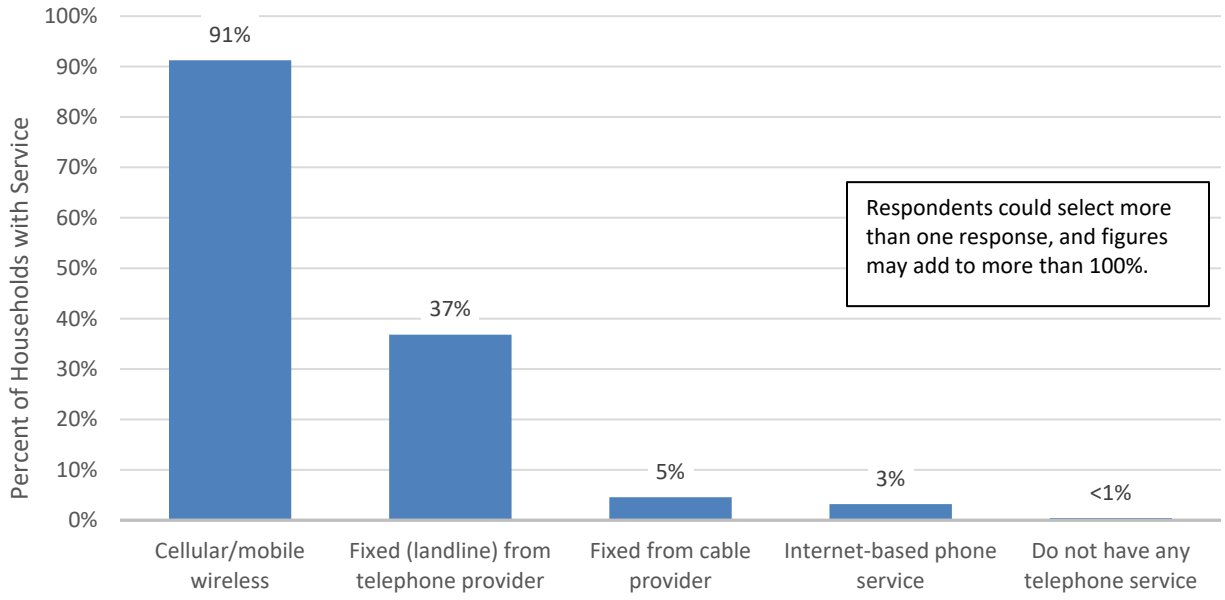
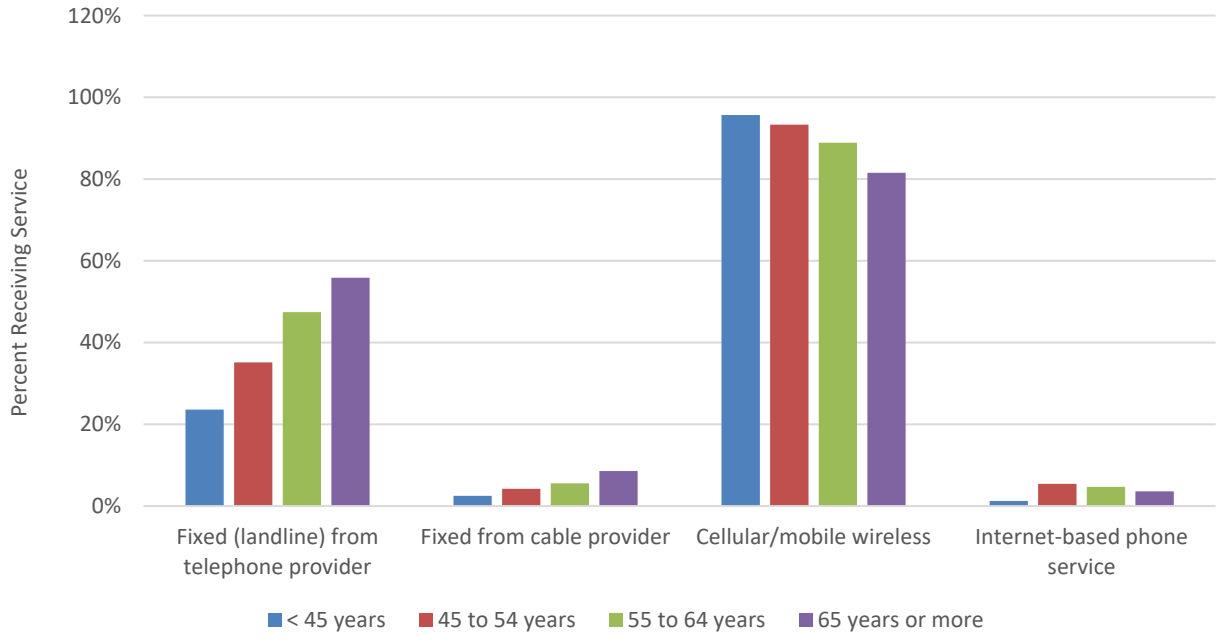


Figure 76: Home Telephone Service(s) by Age of Respondent



3.5 Respondent Opinions

Respondents were asked their opinions about the County's role in providing or promoting broadband communications services within the area. The most favorable opinions were for the County to help ensure that all residents, students, and teachers have access to competitively-priced broadband services. A majority of respondents strongly agreed with these statements. Overall, there is moderate agreement that the County should build a publicly-financed network. Figure 77 illustrates the mean ratings, while Figure 78 provides detailed responses to each portion of the question.

Figure 77: Opinions About the Role(s) for Harford County (Mean Ratings)

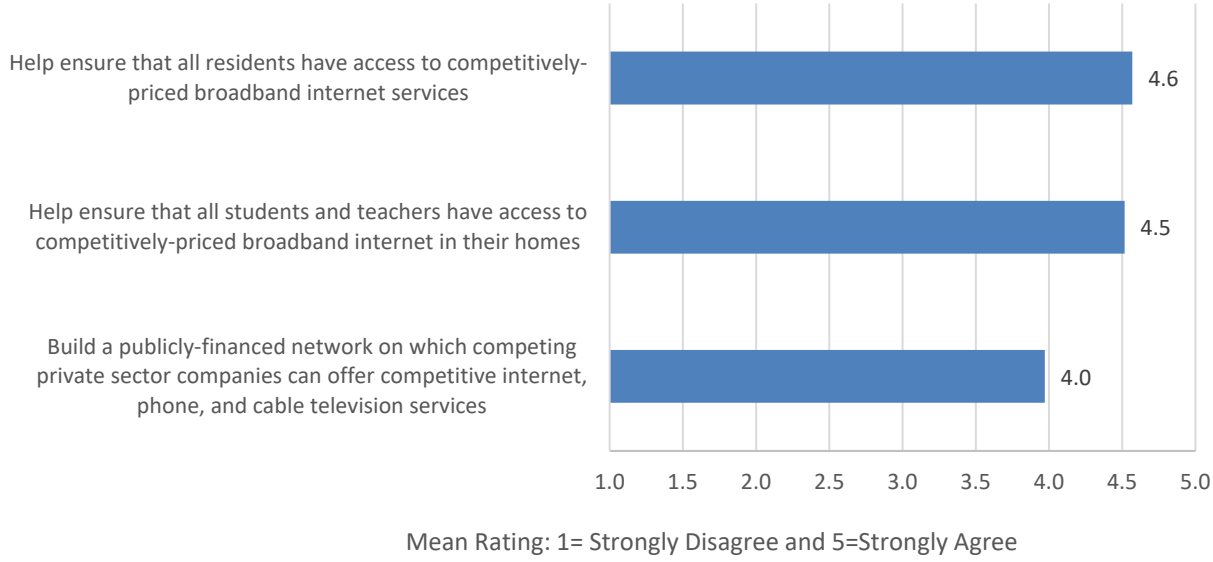
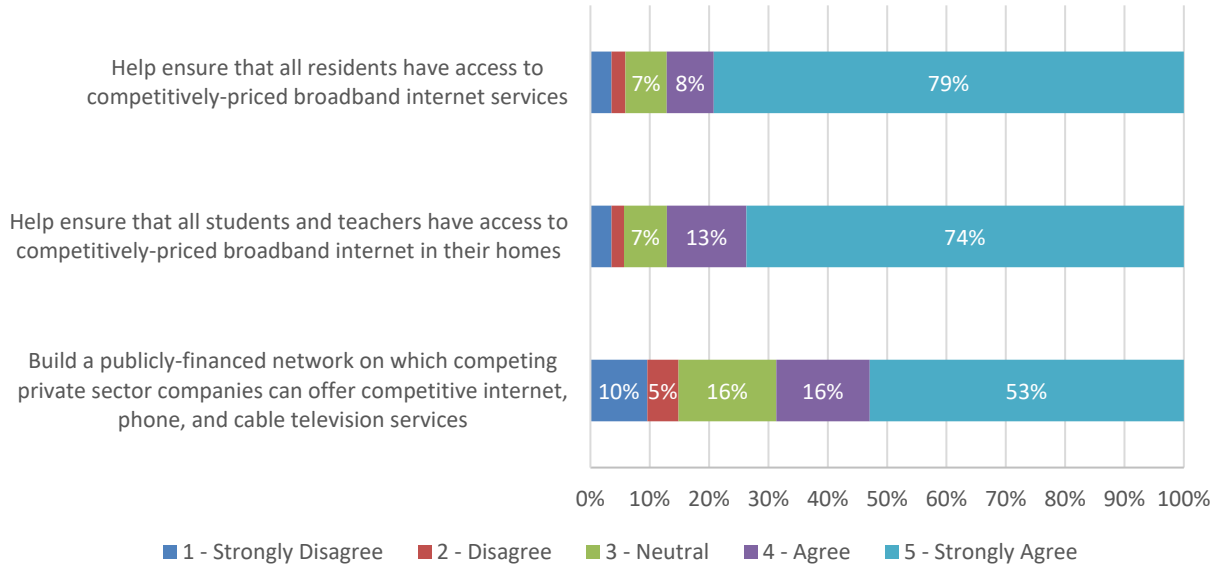
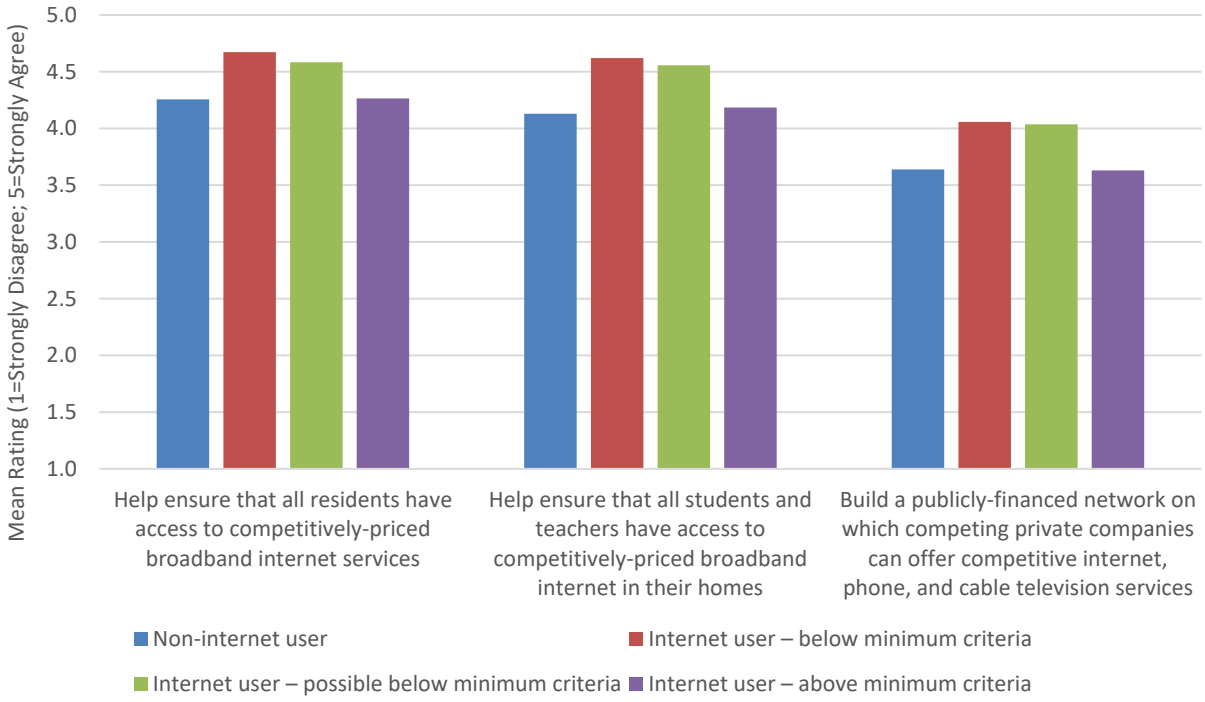


Figure 78: Opinions About the Role(s) for Harford County



As illustrated in Figure 79, internet users with a connection below or possibly below the minimum criteria were more likely to agree with statements about internet service in Harford County, compared with non-internet users and internet users with a connection above the minimum criteria.

Figure 79: Opinions About the Role(s) for Harford County by Age of Respondent



Respondents were also asked their opinion of the current broadband market. More than one-half of respondents strongly agreed that high-speed internet is important for their work/job (and seven in 10 agreed or strongly agreed). One-half of respondents agreed or strongly agreed that high-speed internet is an essential service. At the same time, 38 percent strongly disagreed, and another 16 percent disagreed, that the market currently provides high-speed internet at prices they can afford; only one-fifth agreed or strongly agreed, suggesting a need for affordable broadband internet among a sizeable segment of respondents.

Detailed responses to statements about broadband availability are illustrated in Figure 80. The average agreement with broadband availability statements are shown in Figure 81.

Figure 82 shows that respondents with an internet connection below or possibly below the minimum criteria are more likely to agree that high-speed internet is an essential service and are more willing to pay a premium for access to high-speed internet. These results reinforce other survey results that show a gap between customers' desire for fast internet and the service they are receiving.

Figure 80: Opinions About the Broadband Internet Market

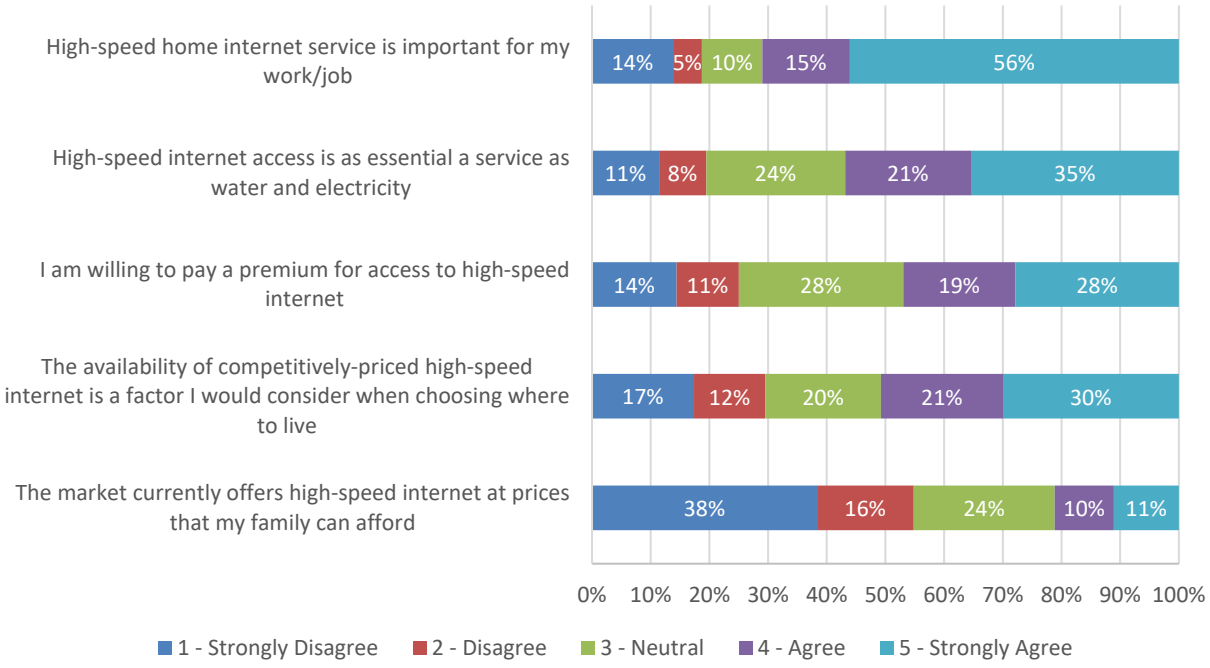


Figure 81: Opinions About the Broadband Internet Market (Mean Ratings)

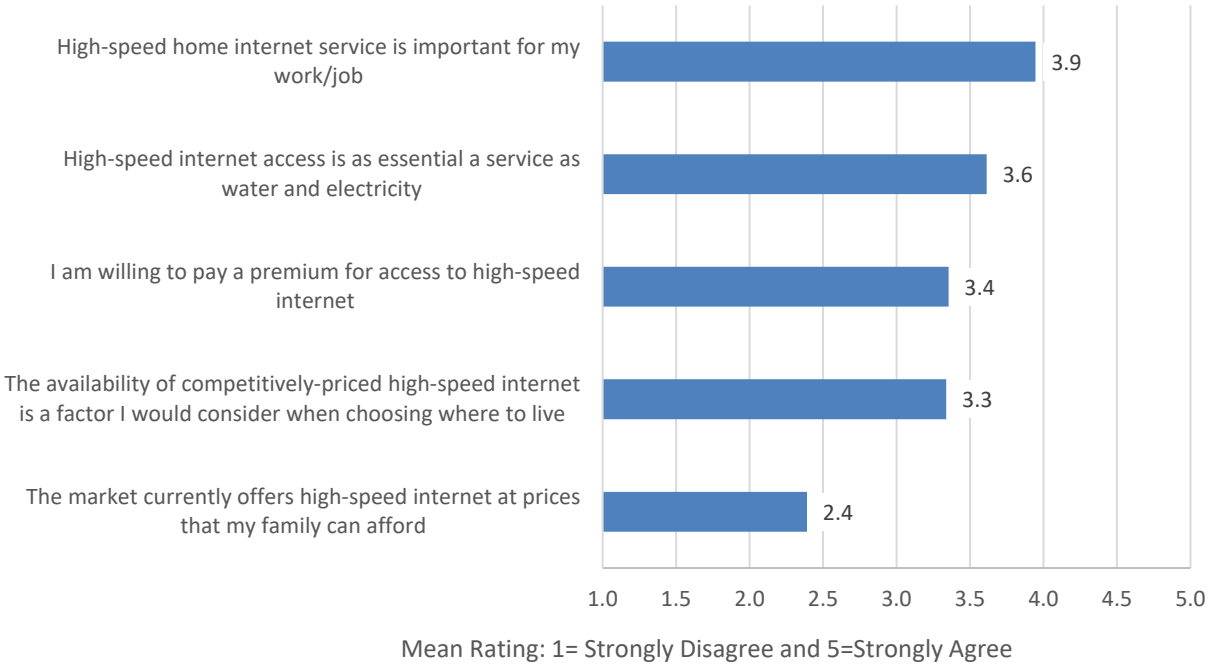
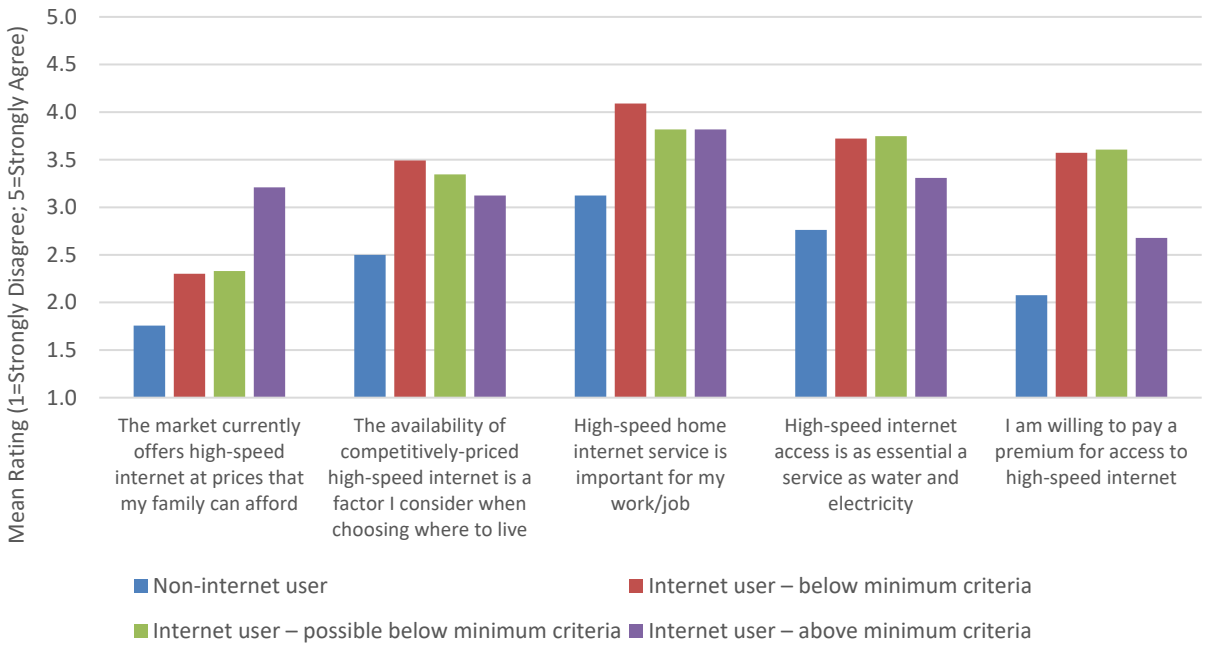
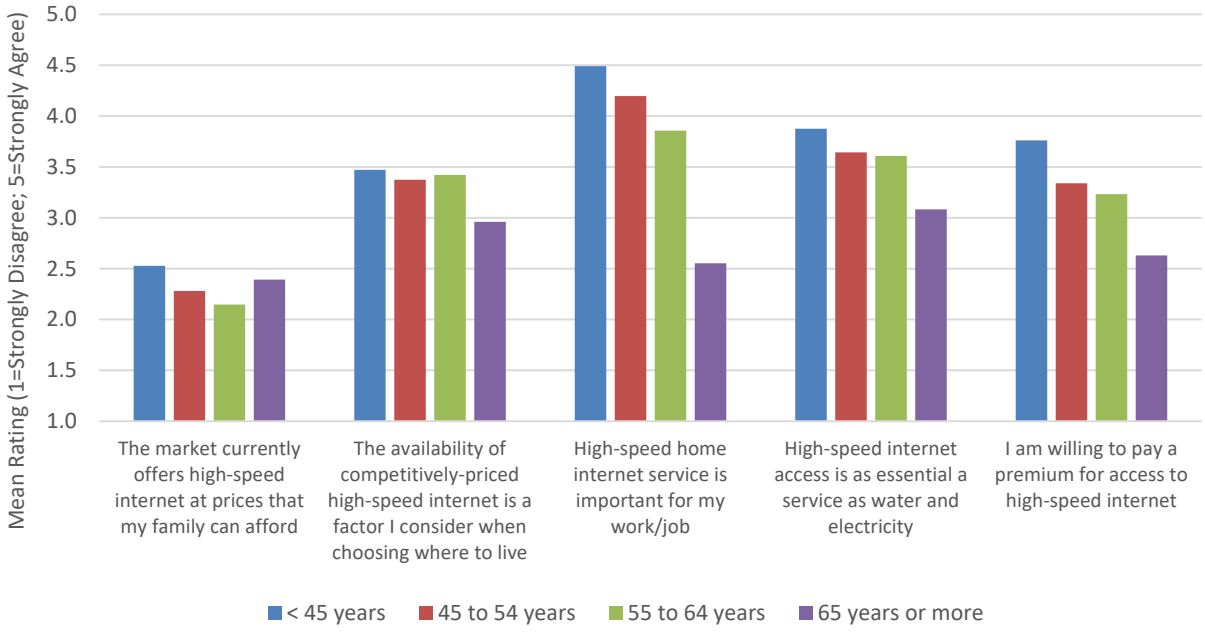


Figure 82: Opinions About Broadband Internet by Internet Connectivity Group



As illustrated in Figure 85, respondents ages 65 and older were less likely to agree with most statements about the broadband internet market in Harford County.

Figure 83: Opinions About Broadband Internet by Age of Respondent



Also, agreement with statements about the broadband internet market tends to increase as education and household income increases (see Figure 84 and Figure 85).

Figure 84: Opinions About Broadband Internet by Education

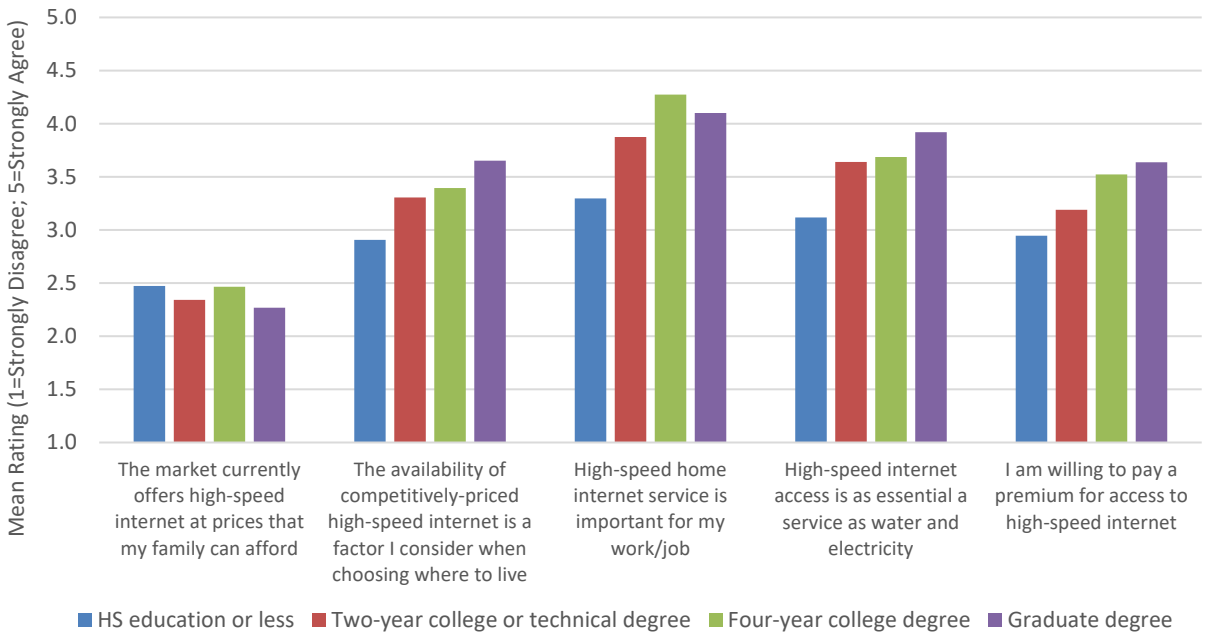
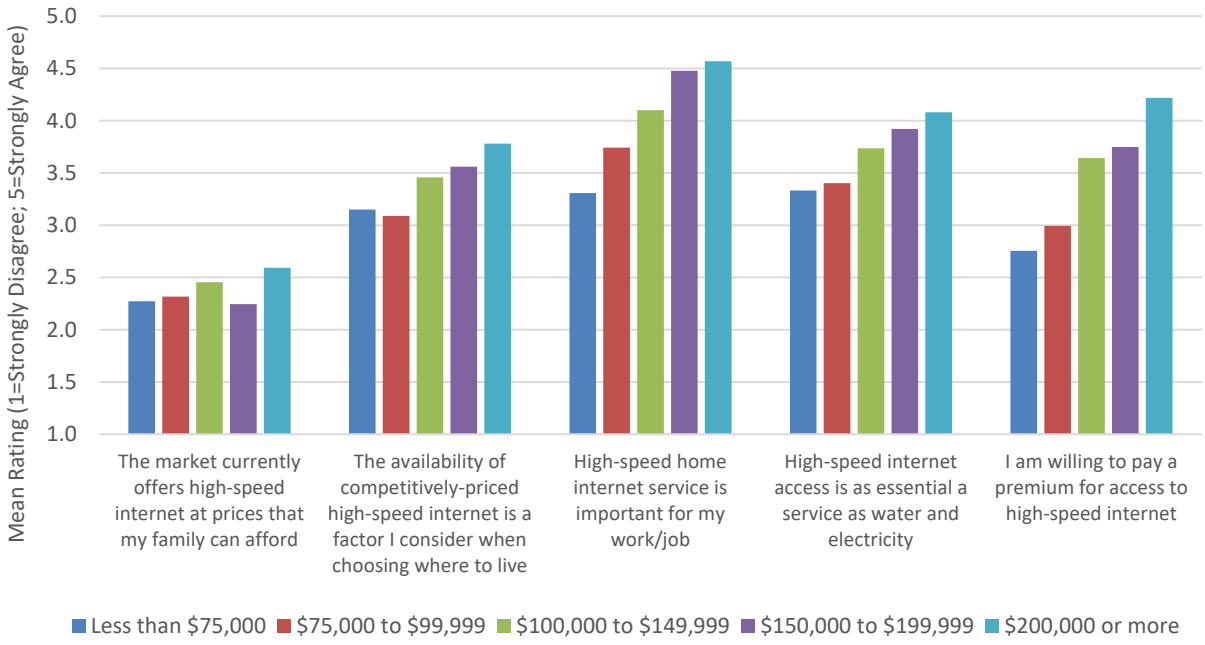


Figure 85: Opinions About Broadband Internet by Household Income



Respondents were asked what Harford County's ***main*** role should be with respect to broadband internet access. About 37 percent of respondents indicated that the County should install a state-of-the-art network and lease it to private companies, and 35 percent said the County should encourage a private firm to build a high-speed network. Only five percent said the County should play no role, and 15 percent of respondents were unsure, as illustrated in Figure 86.

Figure 86: Main Role of Harford County in Broadband Access

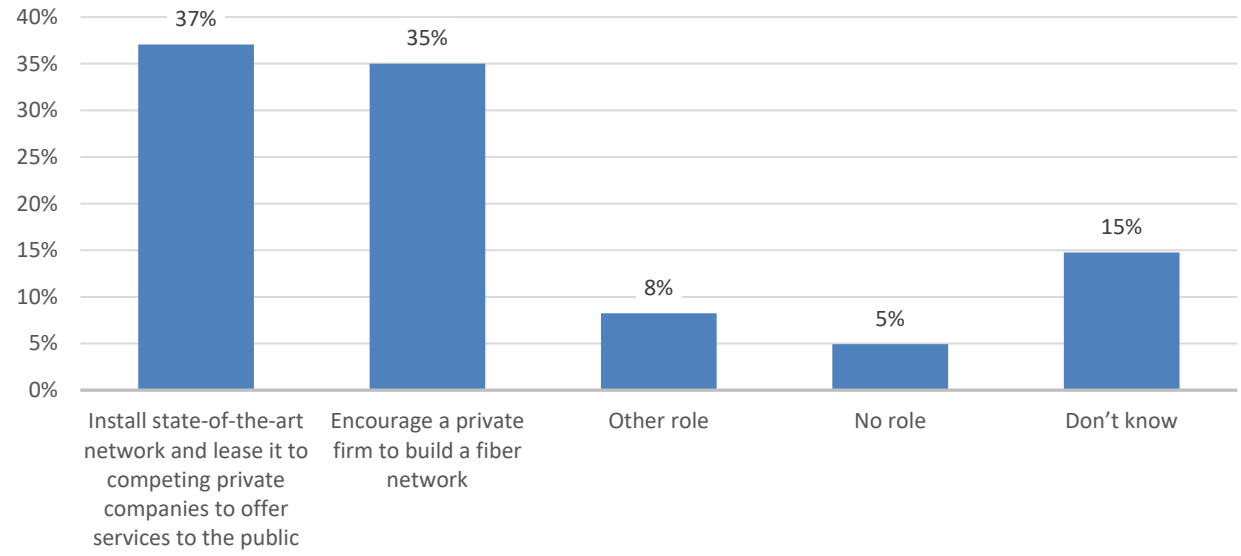
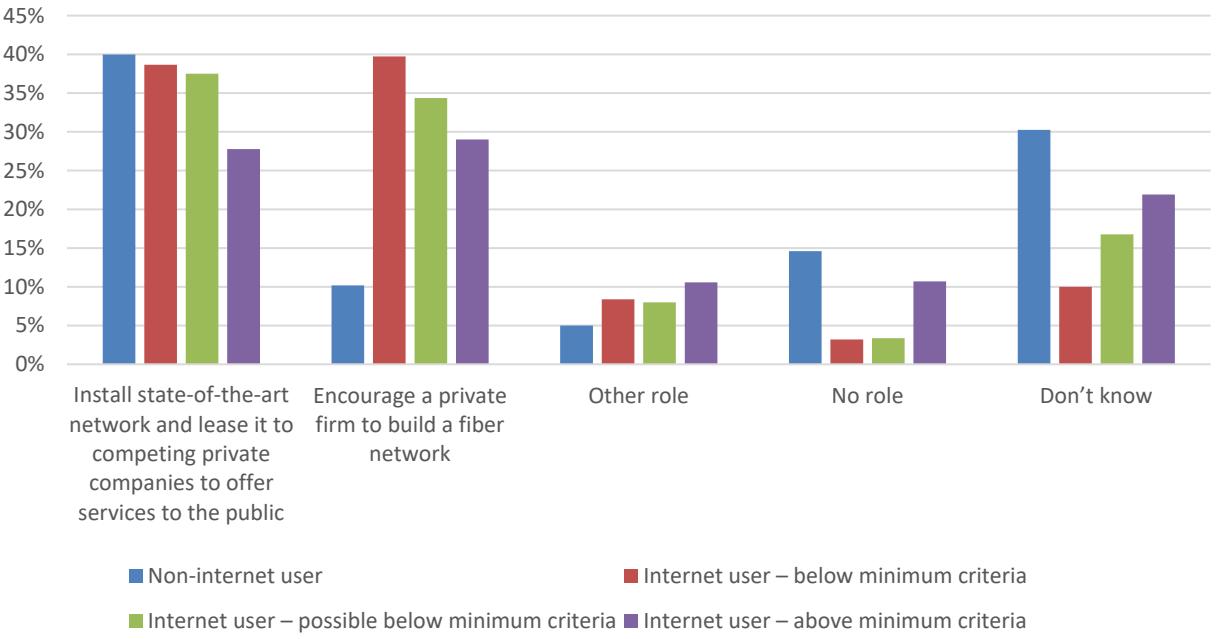
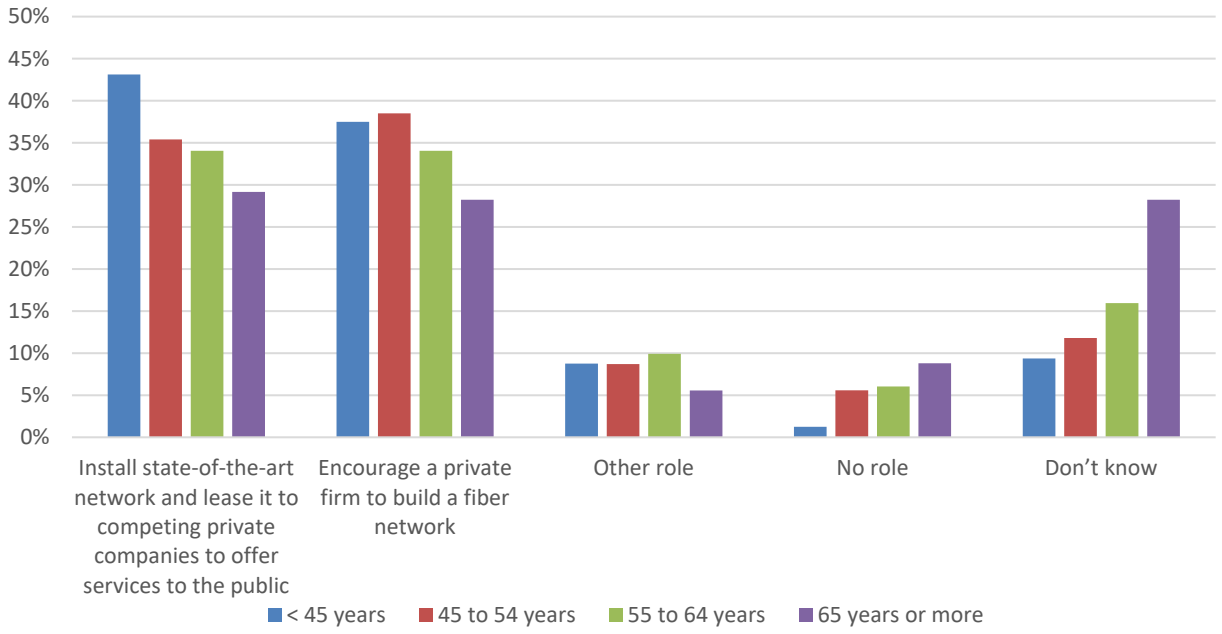


Figure 87: Main Role of Harford County in Broadband Access by Internet Connectivity Group



As shown in Figure 87, internet users with a connection below or possibly below the minimum criteria were more likely to indicate that the County should have some role in providing broadband internet access, compared with non-users and internet-users with a connection above the minimum criteria.

Figure 88: Main Role of Harford County with Respect to Broadband Access by Income



The proportion of respondents who said the County should install a state-of-the-art network and lease it to competing private companies increases as age of the respondent increases. Respondents ages 65 and older were less likely to state that the County should have some role with respect to broadband access, and they were more likely to be unsure (see Figure 88).

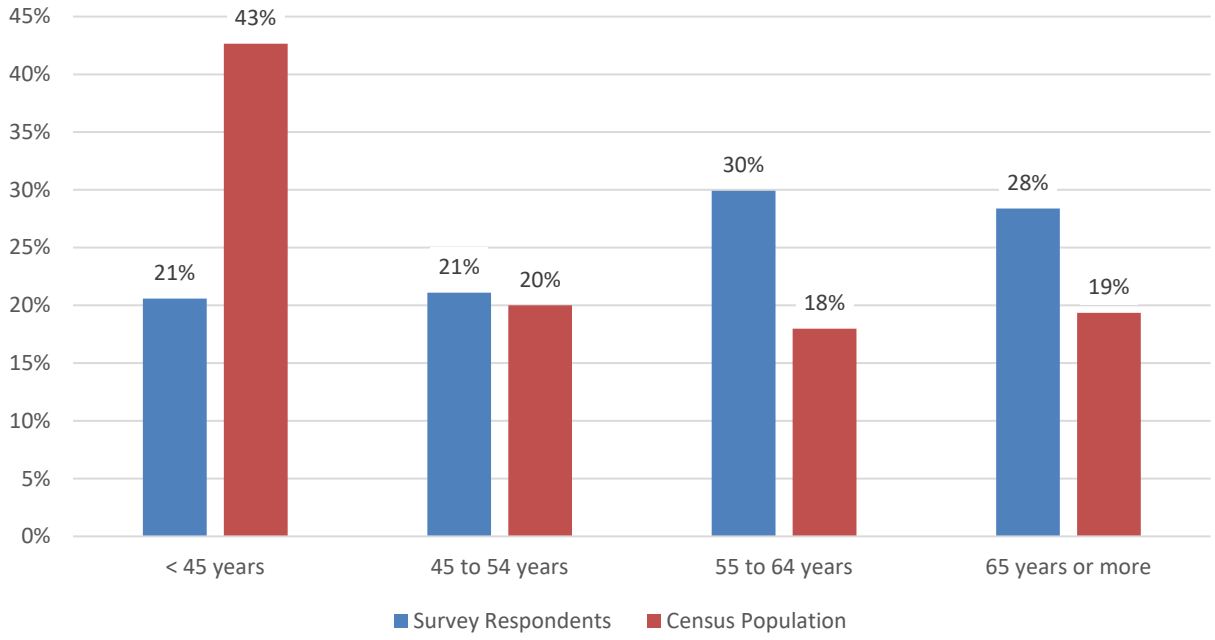
These responses indicate a relatively clear signal about residents' desire to have a state-of-the-art communications network and for Harford County to play *some* role in its installation. It should be noted that this question did not specifically ask about how that network should be financed or funded. Questions regarding consumers' willingness to pay monthly fees or hook-up costs for access to that network were presented previously.

3.6 Respondent Information

Basic demographic information was gathered from survey respondents and is summarized in this section. Several comparisons of respondent demographic information and other survey questions were provided previously in this report.

As indicated previously in Figure 1 regarding age-weighting, disproportionate shares of survey respondents were in the older age cohorts relative to the County's adult population as a whole. Approximately 28 percent of survey respondents are ages 65 and older, compared with only 19 percent of the population. Conversely, only 21 percent of survey respondents are under age 45, compared with 43 percent of the population (see Figure 89). The weighted survey results presented in this report are adjusted to account for these differences and to provide results that are more representative of the County's population, as discussed previously.

Figure 89: Age of Respondents and Harford County Adult Population



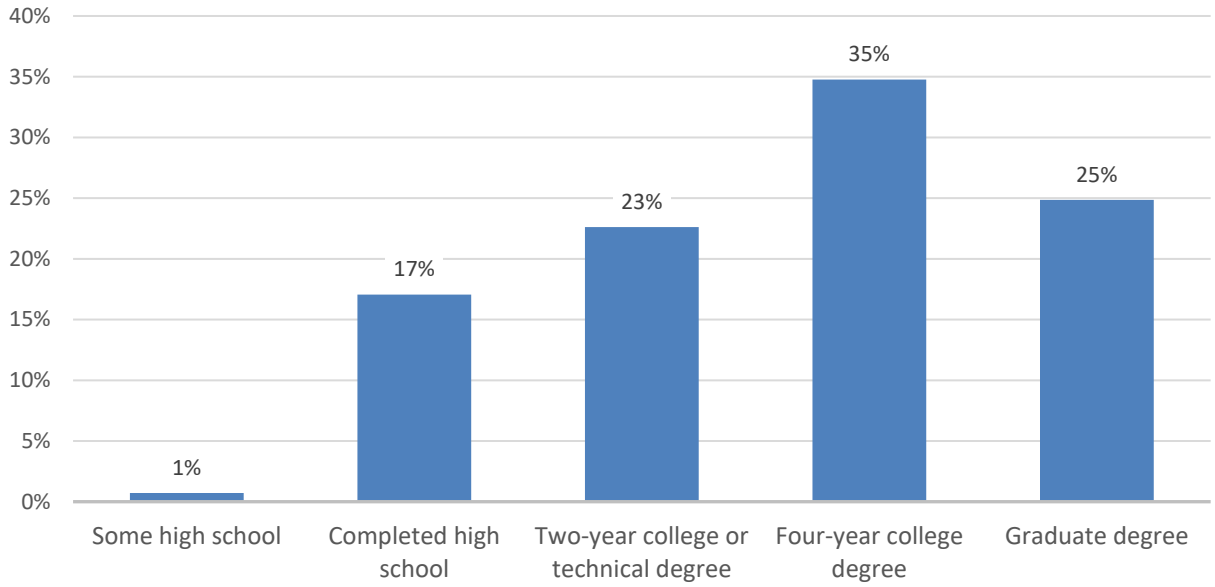
Respondents younger than age 55 are more likely than older respondents to have children in the household. Two-thirds of those younger than age 45 have four or more household members, as do 57 percent of those ages 45 to 54. Respondents ages 55 or older are most likely to live in a two-person household. Additionally, respondent ages 65 and older are much more likely than younger respondents to earn under $75,000 per year (see Table 9).

Table 9: Demographic Profile by Age of Respondent

AGE COHORT		< 45	45-54	55-64	65+	Total
Internet connectivity group	Non-internet user	4%	5%	4%	17%	7%
	Below minimum criteria	67%	61%	62%	49%	61%
	Possibly below minimum criteria	15%	25%	20%	15%	18%
	Above minimum criteria	13%	9%	13%	19%	14%
	Weighted Count	*323*	*156*	*136*	*147*	*783*
Highest level of education	HS education or less	10%	18%	26%	28%	18%
	Two-year college or technical degree	24%	18%	27%	20%	23%
	Four-year college degree	40%	43%	27%	23%	35%
	Graduate degree	26%	21%	21%	30%	25%
	Weighted Count	*334*	*156*	*140*	*150*	*782*
Approximate 2018 household income	Less than $75,000	8%	16%	22%	48%	18%
	$75,000 to $99,999	19%	12%	20%	19%	18%
	$100,000 to $149,999	30%	30%	26%	20%	28%
	$150,000 to $199,999	27%	21%	15%	8%	20%
	$200,000 or more	16%	22%	17%	6%	16%
	Weighted Count	*311*	*138*	*118*	*112*	*680*
Presence of children in household	No Children in HH	24%	44%	87%	97%	54%
	Children in HH	76%	56%	13%	3%	46%
	Weighted Count	*334*	*155*	*140*	*151*	*782*
Total Household Size (Adults + Children)	One HH member	2%	3%	3%	23%	7%
	Two HH members	16%	20%	53%	63%	32%
	Three HH members	17%	20%	25%	10%	18%
	Four+ HH members	65%	57%	20%	5%	43%
	Weighted Count	*334*	*155*	*140*	*151*	*782*
Number of years lived at current address	Less than 1 year	11%	2%	3%	0%	6%
	1 to 2 years	14%	5%	3%	2%	8%
	3 to 4 years	18%	11%	3%	1%	11%
	5 or more years	56%	81%	91%	97%	75%
	Weighted Count	*332*	*156*	*140*	*149*	*779*

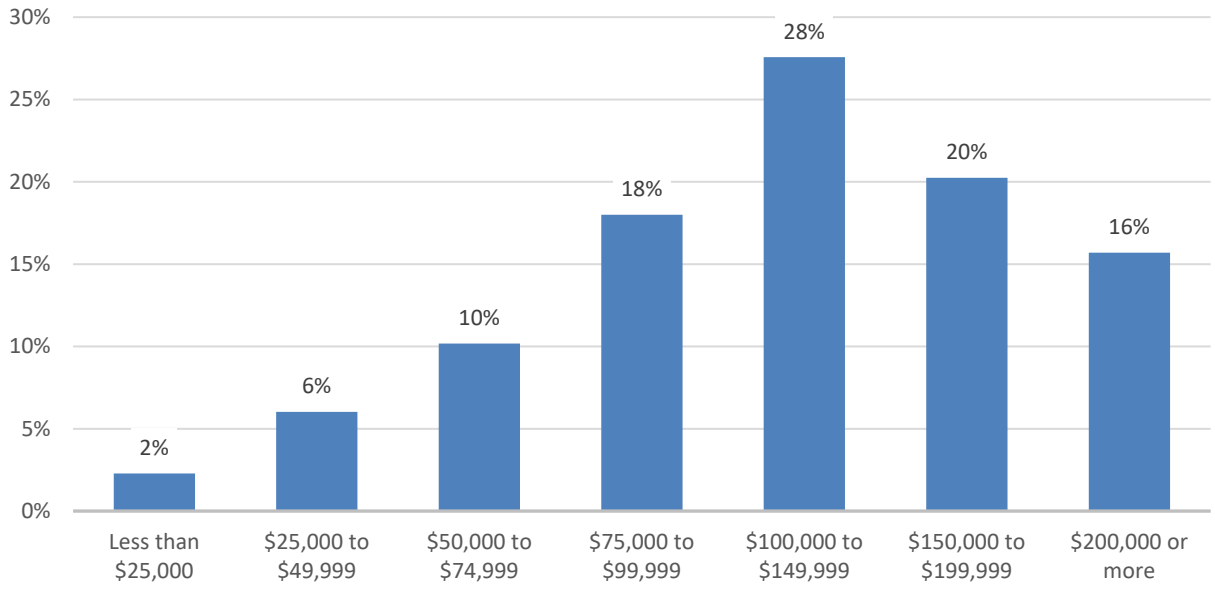
The respondents' highest level of education attained is summarized in Figure 90. One-fourth of respondents have a graduate degree, and 35 percent have a four-year college degree.

Figure 90: Education of Respondent



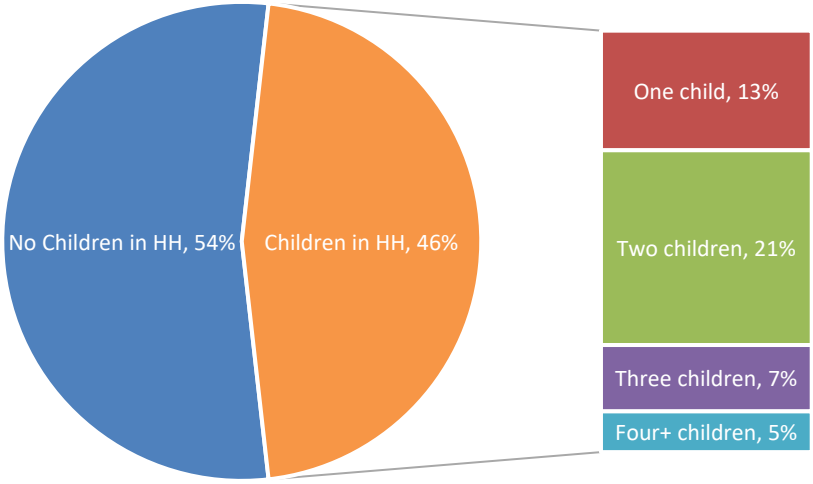
Nearly one-fifth of respondents earned under $75,000 in 2018, while 18 percent earned $75,000 to $99,999. Nearly two-thirds of respondents had a household income of at least $100,000, including 16 percent earning $200,000 or more, as shown in Figure 91.

Figure 91: 2018 Household Income



Respondents were asked to indicate the number of adults and children in their household. Nearly one-half of respondents have at least one child under age 18 living at home, as shown in Figure 92.

Figure 92: Number of Children in the Household



Only seven percent of respondents have just one person living in the household, and 32 percent have two household members (including both adults and children). Another 18 percent have three household members, and 43 percent have four or more household members.

The majority of respondents own their home. Three-fourths of respondents have lived at their residence for five or more years, as shown in Figure 93.

Figure 93: Length of Residence at Current Address

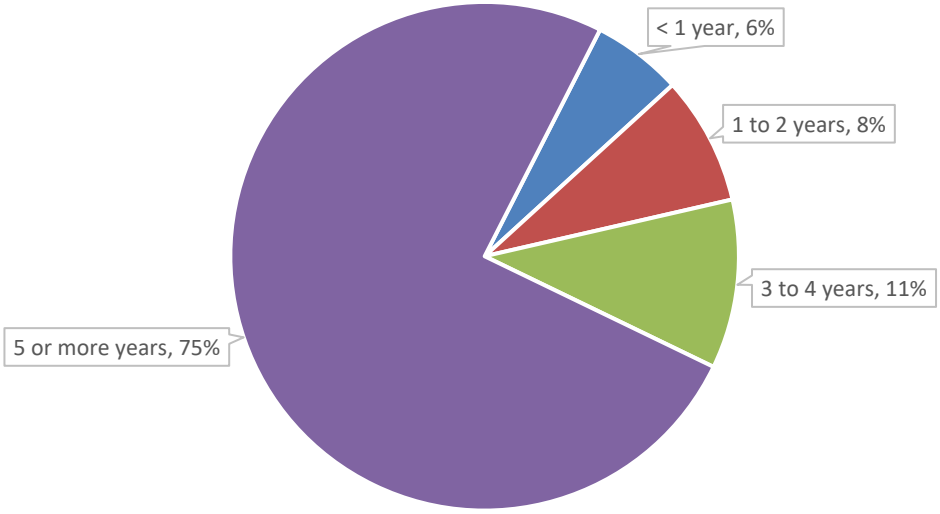


Table 10 shows the demographic profile for each internet user group. As previously discussed, non-internet users are more likely than internet users to be ages 65 and older, have a high school education or less, earn less than $75,000, and to have one household member (and no children in the household). The demographic profile among internet users in the various connectivity groups does not vary significantly.

Table 10: Demographic Profile by Internet Connectivity Groups

		Non-Internet User	Below Minimum Criteria	Possible Below Minimum Criteria	Above Minimum Criteria	Total
Age Group	< 45 years	25%	46%	36%	42%	43%
	45 to 54 years	15%	20%	29%	14%	20%
	55 to 64 years	12%	18%	19%	17%	18%
	65 years or more	49%	15%	16%	26%	19%
	Weighted Count	*51*	*469*	*139*	*103*	*782*
Highest level of education	HS education or less	43%	15%	19%	16%	18%
	Two-year college or technical degree	26%	23%	23%	18%	23%
	Four-year college degree	19%	38%	26%	42%	35%
	Graduate degree	13%	24%	31%	24%	25%
	Weighted Count	*50*	*470*	*139*	*103*	*782*
Approximate 2018 household income	Less than $75,000	51%	17%	11%	20%	18%
	$75,000 to $99,999	24%	19%	16%	13%	18%
	$100,000 to $149,999	6%	26%	33%	38%	28%
	$150,000 to $199,999	15%	23%	18%	15%	20%
	$200,000 or more	4%	16%	22%	14%	16%
	Weighted Count	*45*	*423*	*116*	*81*	*680*
Children in household	No Children in HH	89%	49%	52%	60%	54%
	Children in HH	11%	51%	48%	40%	46%
	Weighted Count	*50*	*470*	*139*	*103*	*782*
Total Household Size (Adults + Children)	One HH member	31%	4%	5%	6%	7%
	Two HH members	46%	30%	30%	40%	32%
	Three HH members	10%	20%	18%	12%	18%
	Four+ HH members	12%	46%	47%	42%	43%
	Weighted Count	*50*	*470*	*139*	*103*	*782*
Number of years lived at current address	Less than 1 year	9%	8%	2%	2%	6%
	1 to 2 years	1%	11%	2%	8%	8%
	3 to 4 years	10%	12%	12%	6%	11%
	5 or more years	79%	70%	84%	85%	75%
	Weighted Count	*49*	*471*	*136*	*103*	*779*

Appendix A: Survey Instrument

Harford County, Maryland

Residential Internet Survey

January 2019

Even if you do not have home internet access, please complete the relevant portions of this survey form and return to us. Your opinions, experiences, and information are important to us.

Conducted by CTC Technology and Energy

on behalf of

CTC Technology and Energy, an independent IT engineering consulting firm, has been contracted by Harford County, Maryland to conduct research into the availability and use of internet services in Northern Harford County.

The information gathered will not be used to sell you anything.

The information will not be used for any purpose other than its stated intention – *to provide an opportunity to understand how Harford County residents use internet services and to explore strategies to improve internet accessibility and affordability throughout the northern part of the County.*

Even if you do not have internet access at your home, please complete the relevant portions of this survey. We value your input.

How long will the survey take?
This survey should take approximately 10 minutes to complete. It should be completed by the person who makes purchase decisions for your household's internet services.

What is the due date to complete the survey?
Please return your completed form in the enclosed postage-paid envelope by **January 26, 2019**.

What if I have questions about the survey?
If you have questions regarding this survey, please contact:

Nicholas Kuba, Director,
Office of Information and Communication Technology
Harford County Government
410.638.3213
nlkuba@harfordcountymd.gov

Thank you in advance for your participation!

HOME INTERNET CONNECTION AND USE

1. **Which of the following services do you currently purchase for your household?** *(✓ all that apply)*

   - [1] Internet service in my home (excluding cellular/mobile)
   - [2] Cellular/mobile telephone service with internet (smartphone)
   - [3] Cellular/mobile telephone service without Internet (basic phone)
   - [4] Fixed (land line) telephone service
   - [5] Cable or satellite television
   - [6] Don't know
   - [7] None of the above

2. **How important are the following services to your household?** *(please circle your response for each aspect, where 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=Very important, 5=Extremely important)*

Aspect	*Not at all important*				*Extremely important*
(a) Internet connection (any speed)	1	2	3	4	5
(b) High-speed internet connection	1	2	3	4	5
(c) Cable television service	1	2	3	4	5
(d) Fixed (land-line) telephone service	1	2	3	4	5
(e) Cellular/mobile telephone service	1	2	3	4	5

3. **How many personal computing devices (desktop/laptop computers, tablets, smartphones) do you have in your home?**

   - [1] 1 or 2
   - [2] 3 or 4
   - [3] 5 or more
   - [4] I do not have any personal computing devices in my home

4. **How many other internet-enabled devices (smart TV, home security system, doorbell camera, gaming system) do you have in your home?**

   1 1 or 2
   2 3 or 4
   3 5 or more
   4 I do not have any other internet-enabled devices in my home

5. **What is your primary home internet service connection?** *(✓ only one)*

   1 No home internet service **(Please skip to Question 22)**
   2 Telephone line—dial-up
   3 Digital Subscriber Line (DSL) (from Verizon, or other)
   4 Cable modem (from Armstrong, Comcast, or other)
   5 Satellite (from DirecTV, Dish Network, or HughesNet, etc.)
   6 Cellular/mobile internet (Smartphones)
   7 Fiber-optic connection
   8 Fixed wireless service (not just wireless router in home)
   9 Other (Please specify: _____)

6. **Approximately how much does your family pay PER MONTH for your *home* internet service (not including television or phone service if you bundle services)?**

   1 Free
   2 $1 to $20
   3 $21 to $40
   4 $41 to $60
   5 $61 to $80
   6 $81 to $100
   7 $101 to $120
   8 More than $120

7. **Is the fee in Question 6 part of a bundled package?**

   1 Yes
   2 No

8. **How would you describe the speed of your *home* internet connection?**

   1 Very Slow
   2 Slow
   3 Medium
   4 Fast
   5 Very Fast

2

9. **How IMPORTANT are the following aspects of *home* internet service to you?** *(please circle your response for each aspect, where 1=Not at all important,3=Moderately important, and 5=Extremely important)*

Aspect	*Not at all important*				*Extremely important*
(a) Speed of connection	1	2	3	4	5
(b) Reliability of connection	1	2	3	4	5
(c) Price of services	1	2	3	4	5
(d) Overall customer service	1	2	3	4	5
(e) Ability to "bundle" with TV and phone	1	2	3	4	5

10. **How SATISFIED are you with the following aspects of current *home* internet access?** *(please circle your response for each aspect, where 1=Not at all satisfied, 3=Moderately satisfied, and 5=Extremely satisfied)*

Aspect	*Not at all Satisfied*				*Extremely Satisfied*
(a) Speed of connection	1	2	3	4	5
(b) Reliability of connection	1	2	3	4	5
(c) Price of services	1	2	3	4	5
(d) Overall customer service	1	2	3	4	5
(e) Ability to "bundle" with TV and phone	1	2	3	4	5

3

11. How often does your family use your *home* internet connection (excluding cellular/mobile) for: *(please circle your response for each activity)*

Home Internet Activity	Never	Occasionally	Frequently
(a) Listening to music (streaming)	1	2	3
(b) Watching movies, videos, or TV	1	2	3
(c) Playing online games	1	2	3
(d) Connecting to a work computer	1	2	3
(e) Using social media	1	2	3
(f) Shopping online	1	2	3
(g) Running a home business	1	2	3
(h) Accessing educational resources	1	2	3
(i) Accessing government information	1	2	3
(j) Accessing medical services	1	2	3
(k) Banking or paying bills	1	2	3
(l) Accessing home security/automation applications	1	2	3

12. How IMPORTANT is access to free Wi-Fi hotspots at libraries and community centers?

- 1 Not at all important
- 2 Slightly important
- 3 Moderately important
- 4 Very important
- 5 Extremely important

13. Consider what price level would make you interested in switching to another internet service. How willing would you be to switch to 100 Mbps (fast cable modem or fiber optic level of service) for the following monthly price? *(please circle your response at each price level, where 1=Not at all willing, 2=Slightly willing, 3=Moderately willing, 4=Very willing, 5=Extremely willing)*

Monthly Price	Not at all willing				Extremely willing
(a) $60 per month	1	2	3	4	5
(b) $80 per month	1	2	3	4	5
(c) $100 per month	1	2	3	4	5
(d) $120 per month	1	2	3	4	5
(e) $140 per month	1	2	3	4	5

14. How willing would you be to pay a one-time fee in exchange for having access to a 100 Mbps service (fast cable modem or fiber optic level of service)?: *(please circle your response at each price level, where 1=Not at all willing, 2=Slightly willing, 3=Moderately willing, 4=Very willing, 5=Extremely willing)*

Price of Installation (one-time)	Not at all willing				Extremely willing
(a) $0 (zero)	1	2	3	4	5
(b) $100	1	2	3	4	5
(c) $250	1	2	3	4	5
(d) $500	1	2	3	4	5
(e) $1,000	1	2	3	4	5
(f) $2,000	1	2	3	4	5

INTERNET USE FOR JOBS/CAREERS

15. Does your job require you to have internet access at your home?

- [1] Yes
- [2] No

16. Are you or is any member of your household currently teleworking, or interested in telework opportunities?

- [1] Someone in my household currently does telework from home
- [2] Someone in my household would like to telework
- [3] No

17. Does someone in your household have a home-based business or plan to start a home-based business in the next three years?

- [1] Yes, I/we already have a home-based business
- [2] Yes, I/we plan to start one in next three years
- [3] No

18. How important is a high-speed data or internet connection for: *(please circle your response for each aspect, where 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=Very important, 5=Extremely important)*

Aspect	*Not at All Important*				*Extremely important*	*N/A*
(a) Teleworking	1	2	3	4	5	9
(b) Planned/existing home-based business	1	2	3	4	5	9

INTERNET USE FOR EDUCATION

19. Does a member of your household use the internet connection for educational purposes, such as completing assignments, research, home schooling, or study related to coursework or formal education?

- [1] Yes
- [2] No **(Please skip to Question 22)**

20. For what education level is your internet connection used?
(✓ all that apply)

- [1] Early Childhood (Preschool, 3K, 4K)
- [2] Primary (Grades 5k – 8)
- [3] Secondary (Grades 9 – 12)
- [4] Post-Secondary (Technical/vocational training, college, etc.)
- [5] Graduate (Graduate, post-graduate, professional degree)
- [6] Continuing/Adult Education
- [7] Other _____

21. How important is a high-speed internet connection for your education needs?

- [1] Not at all important
- [2] Slightly important
- [3] Moderately important
- [4] Very important
- [5] Extremely important

TELEVISION AND TELEPHONE SERVICE

22. How do you receive television service at your home? *(✓all that apply)*

- [1] Cable
- [2] Satellite/Dish or DirecTV
- [3] Antenna (over-the-air)
- [4] Internet
- [5] Don't watch television

→ **Please answer Question 23**

23. Approximately how much do you pay PER MONTH for cable or satellite television service (not including internet or phone)?

- [1] Free
- [2] $1 to $20
- [3] $21 to $40
- [4] $41 to $60
- [5] $61 to $80
- [6] $81 to $100
- [7] $101 to $120
- [8] More than $120

24. How important are the following television programming features to you? *(please circle your response for each aspect, where 1=Not at all important, 2=Slightly important, 3=Moderately important, 4=Very important, 5=Extremely important)*

Programming Content	*Not at all important*				*Extremely important*
(a) Local programming	1	2	3	4	5
(b) News programming	1	2	3	4	5
(c) Children's programming	1	2	3	4	5
(d) Sports programming	1	2	3	4	5
(e) Movie network channels	1	2	3	4	5
(f) Specialty channels	1	2	3	4	5

25. Please indicate which type(s) of telephone service you have: *(✓all that apply)*

- [1] Fixed (landline) from telephone provider (Verizon or other)
- [2] Fixed from cable provider (Armstrong, Comcast, other)
- [3] Cellular/mobile wireless (AT&T, Verizon, Sprint, T-Mobile, etc.)
- [4] Internet-based phone service (Vonage, Skype, Ooma, etc.)
- [5] Do not have any telephone service
- [6] Other phone service (please specify: _____)

8

ROLE OF THE COUNTY AND YOUR OPINION

26. Please indicate to what degree you agree or disagree that Harford County should do the following: *(please circle your response for each statement, where 1=Strongly Disagree, 3=Neutral, 5=Strongly Agree)*

Aspect	*Strongly Disagree*				*Strongly Agree*
(a) Help ensure that all residents have access to competitively priced broadband internet services	1	2	3	4	5
(b) Help ensure that all students and teachers have access to competitively priced broadband internet in their homes	1	2	3	4	5
(c) Build a publicly financed network on which competing private sector companies can offer competitive internet, phone, and cable television services	1	2	3	4	5

27. Please indicate to what degree you agree or disagree with the following statements: *(please circle your response for each statement, where 1=Strongly Disagree, 3=Neutral, 5=Strongly Agree)*

Aspect	*Strongly Disagree*				*Strongly Agree*
(a) The market currently offers high-speed internet at prices that my family can afford	1	2	3	4	5
(b) The availability of competitively priced high-speed internet is a factor I would consider when choosing where to live	1	2	3	4	5
(c) High-speed home internet service is important for my work/job	1	2	3	4	5
(d) High-speed internet access is as essential a service as water and electricity	1	2	3	4	5
(e) I am willing to pay a premium for access to high-speed internet	1	2	3	4	5

28. What do you think the MAIN role for the County should be with respect to broadband access? *(✓MAIN role)*

- [1] Install state-of-the-art network and lease it to competing private companies to offer services to the public
- [2] Encourage a private firm to build a high-speed network
- [3] Other role _____
- [4] No role
- [5] Don't know

9

INFORMATION ABOUT YOUR HOUSEHOLD

The following questions will help describe the total group of survey respondents. Your individual information will not be reported separately—it will be reported only as a part of a larger group to help ensure that the respondents are a representative sample of the citizens of Harford County.

29. Which of the following best describes your age?

- [1] 18 to 34 years
- [2] 35 to 44 years
- [3] 45 to 54 years
- [4] 55 to 64 years
- [5] 65 years and older

30. What is the highest level of education you have completed?

- [1] Some high school
- [2] Completed high school
- [3] Two-year college or technical degree
- [4] Four-year college degree
- [5] Graduate degree

31. What was your approximate 2018 household income?

- [1] Less than $25,000
- [2] $25,000 to $49,999
- [3] $50,000 to $74,999
- [4] $75,000 to $99,999
- [5] $100,000 to $149,999
- [6] $150,000 to $199,999
- [7] $200,000 or more
- [8] Prefer not to answer

32. How many people reside in your home (adults and children)?

Adults (including yourself)	Children age 18 and younger
[1] 1	[0] None
[2] 2	[1] 1
[3] 3	[2] 2
[4] 4 or more	[3] 3
	[4] 4 or more

33. Do you own or rent your residence?

- [1] Own
- [2] Rent

34. How long have you lived at your current address?

- [1] Less than 1 year
- [2] 1 to 2 years
- [3] 3 to 4 years
- [4] 5 or more years

Thank you for completing this survey!