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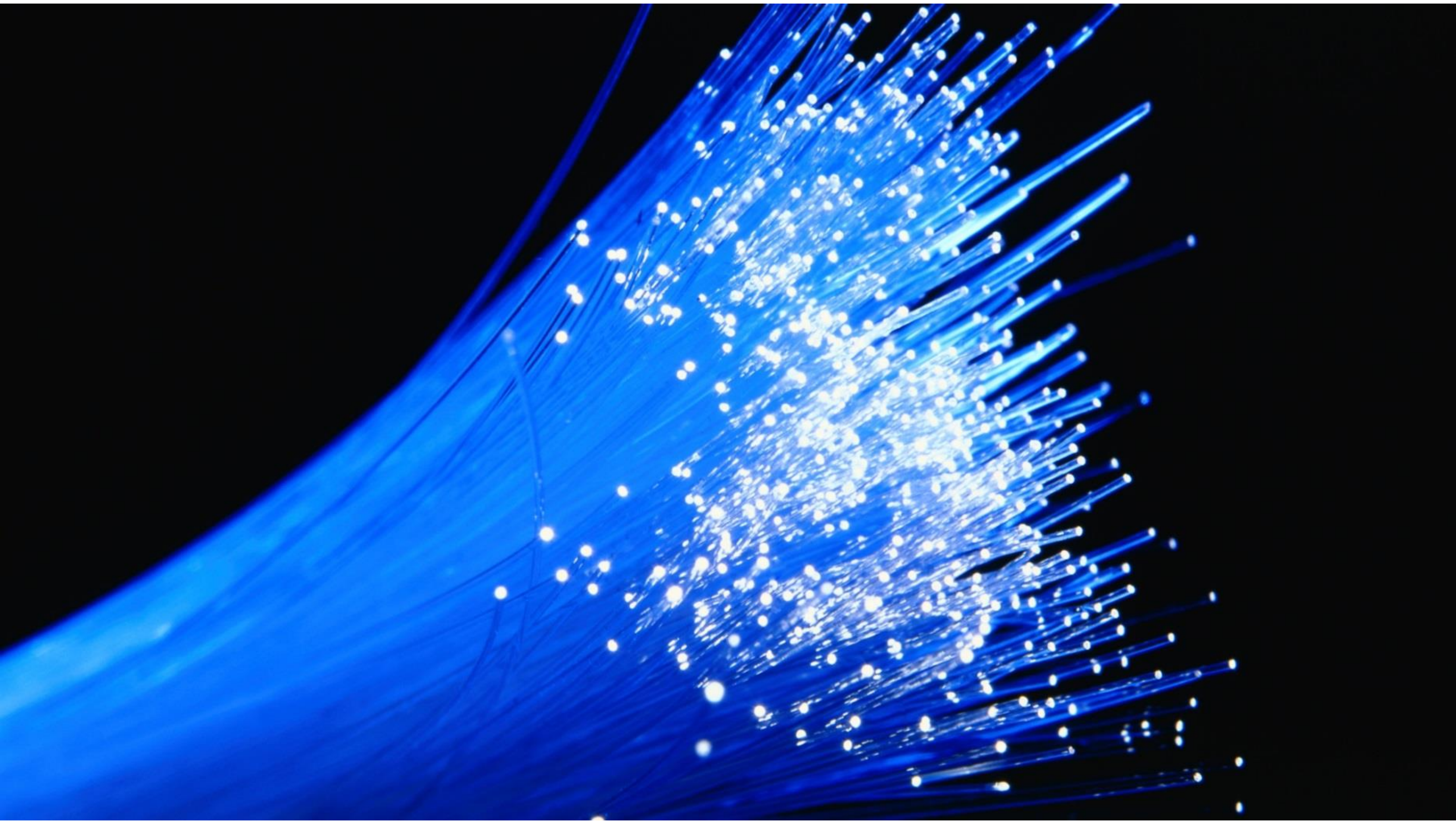

Strategies for Improving Broadband Service in Wildwood

Prepared for the City of Wildwood, Missouri
September 2019

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1 Executive Summary

The City of Wildwood, Missouri (City) faces supply constraints on the provision of high-speed broadband access. In particular, residents on the west side of the City have limited—if any—broadband choices. The City engaged CTC Technology & Energy (CTC) to explore options for addressing the City's broadband deficits and has stated a willingness to potentially commit some public funds to deploying broadband infrastructure so long as this funding supports scalable, futureproof, tangible assets that make the most difference to the largest number of people.

1.1 Report Overview

This study provides:

- A range of approaches and alternatives to addressing the City's broadband gap, and a discussion of which ones are most practical.
- Designs for a fiber-to-the-premises (FTTP) network serving the whole City, an FTTP network in just the western part of the City, a middle-mile network to encourage "last mile" investment to homes by internet service providers (ISP) and wireless ISPs (WISPS), and buildouts in three representative neighborhoods.
- Capital and operating costs for each of the above fiber designs, and potential sources of funding: public (the City); private (ISP or WISP); and homeowners or homeowner associations (HOA).
- Potential financing methods and financial security requirements.
- An initial exploration of interest on the part of local ISPs and WISPS in participating, and in what roles.
- An outline of the parameters under which Ameren, the electric utility, will help facilitate a buildout, including to allow attachments on its poles.
- Options for how ownership and operational responsibilities are split among the three categories of stakeholders (City, ISP/WISP, and homeowner), based on the identified costs and sources of funding, subject to a legal review.

1.2 Key Findings

Our report's findings are summarized in these points:

1. **The cost of building an FTTP network is very high**: about $59 million for the "outside plant" alone, plus the costs of "drops" from the street to the premises (another $10 million if 35 percent of residents take service). This high cost is driven largely by the cost

of providing last-mile service in sparsely developed parts of the City. It is apparent that an expense of this magnitude is not feasible for the City.

2. **The City could potentially build a backbone (often called a "middle-mile") fiber network at a cost of about $4.3 million and seek to bring in private providers to deliver last-mile service**. The private ISPs could use a hybrid of FTTP and wireless solutions. This option would certainly be less expensive than building a full FTTP network but comes with no guarantees that private providers will actually step up to provide near-ubiquitous service. (The City could build a more-extensive middle-mile network, but the costs will rise sharply.) Section 4 spells out business model variations on these options, but the core options and cost magnitudes are roughly the same.

3. **As an alternative, the City could consider an incentive approach, and issue a request for proposals that encourages ISPs to develop plans for providing near-ubiquitous service.** The RFP would need to be structured to allow ISPs to respond by stating in detail what they are willing to do and what incentive they would require to proceed. The City would then review the proposals and engage in a negotiation process. We estimate in this report that incentives of $2.5 million to $3.5 million might be required. The final subsidy number could be higher or lower than the bounds of this range.

1.3 Observations and Recommendations

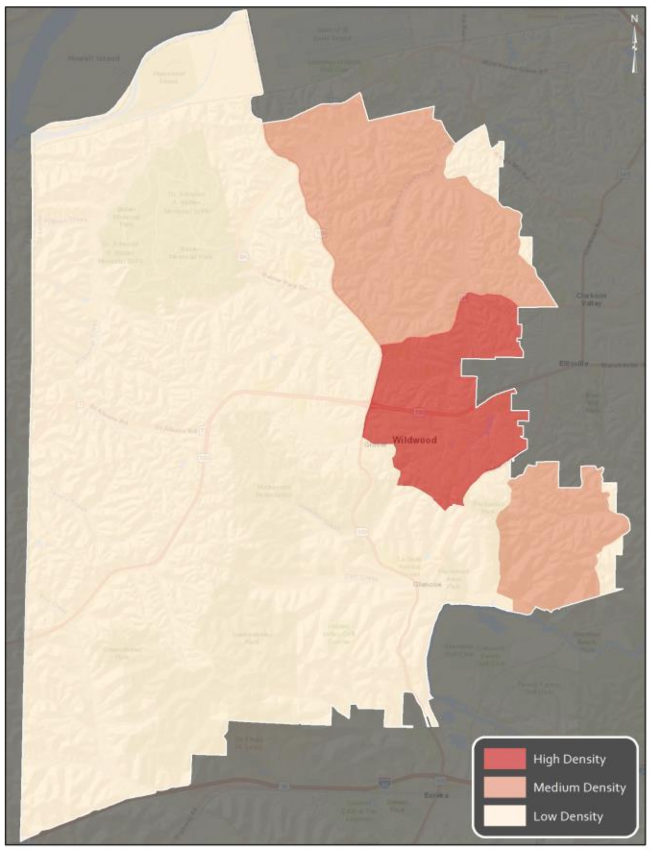
During the process of developing the report we received input from the City's leadership. Among other things, they noted that several residents have indicated that they receive excellent wireless broadband service—thus potentially calling in to question the need for additional broadband infrastructure investment. In response we note that the residents of Wildwood who receive excellent wireless service are receiving it because they happen to live in an area where it is technically feasible and cost-effective for local ISPs to provide this service. Similar service is not available everywhere in Wildwood due to technical challenges related to wireless propagation—for example, in the western portion of the City. There is also no wireless solution that magically solves the problem of providing near-ubiquitous service at a lower cost than fiber. Although a wireless deployment is less expensive than fiber initially, wireless solutions result in uneven service quality—and some service gaps—and entail higher operating costs over time.

The reasons for the City's broadband deficits are simple: The cost of fiber construction is extremely high, and wireless coverage is challenging. This is the result of a combination of factors: low development density, long driveways, requirements for underground construction, hard rock in the soil, and topography. In short, ISPs cannot provide ubiquitous coverage and obtain a reasonable rate of return.

There are some ways to reduce broadband construction costs, such as by using internal crews rather than contractors. Such steps will help, but not come close to solving the cost issue. And while wireless expansion has helped in some areas it will not result in coverage that is both ubiquitous and robust. The WISPs operating in Wildwood—Bayes ET and Wisper—have indicated that wireless is not the long-term or comprehensive solution in Wildwood.

Population density tells part of the story. The high, medium, and low household density areas of the City are shown in Figure 1.

Figure 1: High, Medium, and Low Household Densities



As seen in Table 1 there is more than a seven-fold difference in the number of households passed (passings) per mile between the high-density and low-density areas of the City. The differences in the densities is the key driver in the cost to build and the reason why most portions of the high- and medium-density areas are served while the majority of the low-density areas remain unserved.

Table 1: Summary of High-, Medium-, and Low-Density Areas

Attribute	High Density	Medium Density	Low Density
Street Miles	59.33	79.88	259.67
Total Passings (households)	5,904	3,544	3,473
Average Passings per Mile (PPM)	99.51	44.37	13.37
Median PPM	101.82	44.37	13.37

To deliver more robust broadband for most of Wildwood a FTTP or hybrid fiber-coaxial (HFC) buildout is required, with wireless solutions perhaps deployed on a case-by-case basis for particularly hard-to-reach premises. (If Spectrum were to expand into the west side of the City, they would use HFC because this is their existing network platform. If another ISP were to build, it would most likely use FTTP.) From Wildwood's perspective, working with a smaller ISP would allow more control, but would entail some risk that the provider cannot scale to maintain the system as subscribers and infrastructure are added. A larger company like Spectrum would be less likely to face such difficulty, but the tradeoff for the City or homeowners is that they would have less control.

Solving the cost problem will require some kind of subsidy. Otherwise, ISPs will tend to serve only those areas of the west side where their costs of construction are lower, or where they can serve a location wirelessly. In other areas, ISPs or other providers will not perform a buildout unless funding is made available. Potential sources of funds include:

- **Investment funding from an ISP.** However, the ISP will need a rate of return on the investment. The City of Wildwood cannot expect an ISP to fund a project that does not provide a reasonable rate of return.
- **Contribution from the City.** The City should not expect a recovery of these funds in the short or long term.
- **Contribution from residents (homeowner's associations, individual groups, others).** Residents should not expect a recovery of these funds in the short or long term. However, an indirect benefit to homeowners is the potential for increased home value and faster resale once a robust broadband connection is in place.
- **Grants, if any are available.** Unfortunately, it does not appear that Wildwood is eligible for any current federal or other grant programs.

CTC examined eight approaches to solving these problems; these are described in Section 4. Of the eight, three appear the most reasonable:

1: City Builds and Leases Dark Middle-Mile Fiber. Under this scenario, the City would build middle-mile fiber—that is, the fiber running along main roads leading to neighborhoods—and provide ISPs access to this fiber. (We note that for a ubiquitous buildout, the middle-mile portion represents a low percentage of the total cost.) The ISPs would then deploy, own, and operate last-mile fiber—that is, the fiber on neighborhood streets to individual homes—as well as the electronics on the network, and provide retail services.

A disadvantage of this approach is that it allows providers to connect neighborhoods on a case-by-case basis, meaning that neighborhoods in which build costs are highest may still not be served.[1] An advantage is that this may provide a relatively fast solution and relatively low-cost way to solve the problem—at least in neighborhoods where the cost of construction is lowest.

In many neighborhoods, residents will need to contribute to the cost. And when residents help subsidize the cost to build the last-mile infrastructure, they may prefer to own the fiber, or indeed prefer to avoid owning the fiber. A variety of approaches and models could be considered. And if the residents prefer to own the fiber, one possible approach is that the ISP could form a cooperative with the neighborhood. An example of such a cooperative model is provided in Appendix A.

Bays ET suggested a variation on the above approach in which the City just installs conduit, then Bays ET (or another provider selected following an RFP process) pulls fiber when required. This would reduce the City's implementation and operation costs but might limit attractiveness to other ISPs. From a control and protection perspective, the City might be better served with owning and controlling both the middle-mile fiber and conduit.

2: City Offers Cash Incentives. Under this scenario, the City would issue an RFP offering funds for any ISP willing to provide broadband coverage guarantees as specified in the RFP. This approach has the potential of meeting core objectives—availability on a near-ubiquitous basis and contractually guaranteed coverage and performance. Spectrum would be expected to respond, and others might, as well. This approach would require a legal review and it appears that the City may need to own a portion of the assets in order to provide a cash incentive.

3: City Expands Wireless Assets. Under this scenario, the City would expand placement of poles and other assets for WISPs, and streamline permitting and other processes for underground fiber placement. However, by itself, this approach is unlikely to achieve much more than what the City is doing today. This approach might be more effective if done in conjunction with one of the

[1] The high cost to build is driven by last-mile costs. Many neighborhoods will require other funding sources (homeowners associations, residents, other) for last mile construction. The availability of middle-mile fiber does not address the high cost of last mile fiber.

previous two approaches, with the goal of reaching only the very hardest-to-reach areas and leveraging wired networks built with one of the other approaches.

These approaches come with advantages and disadvantages, which are discussed in Section 4 and summarized in Appendix B. A hybrid of the above three basic approaches may be needed.

We also note that while Ameren is not a provider, it could play a supporting role. Fiber on Ameren poles could potentially serve as one source for backhaul and bandwidth by connecting Wildwood back to a carrier hotel in St. Louis; some segments of fiber Ameren might be building could overlap with a middle-mile network; and Ameren could provide pole attachments for middle mile and last-mile fiber. These possibilities could be of some help and are described in Section 2.

CTC recommends that Wildwood engage in an RFP/RFI approach to solicit interest from ISPs for each approach and allow a range of ISPs to respond. It is expected that the various ISPs will have preferences in terms of the basic approach: cash incentive, middle-mile construction, or facilitation of wireless expansion. But only through an RFP process will Wildwood really be able to see what the providers will respond and what commitments they will make on either a middle-mile construction approach or a cash incentive approach. Before issuing an RFP and evaluating the responses, it would not be wise to try to negotiate an agreement in detail, given the many permutations in how Wildwood's broadband problems can be solved.

1.4 Evaluation of Available City Infrastructure

CTC evaluated the City's existing broadband infrastructure and the City's potential use of fiber for its own purposes to see whether it might achieve economies of scale through a buildout for two purposes (fiber for City needs and fiber for broadband service). The City has installed multiple poles to encourage wireless facilities. The City does not already have any fiber, and in terms of its own municipal needs, does not have multiple facilities or other significant drivers that would justify building middle-mile fiber for City purposes.

To date the City has built poles to support two WISPs in some areas of the western part of the City. But the local terrain, large lot sizes, spread-out development characteristics, and foliage have made it challenging, technically and economically, to provide widespread coverage. The City now recognizes that it needs to explore new approaches that go beyond such steps.

The City likely will not be eligible for federal grants and possibly state grants. The City's relatively high family income—and the fact that it is considered part of the St. Louis metropolitan area from the perspective of the federal government—make Wildwood ineligible for current federal programs (see Section 5.2). For example, current federal grant opportunities generally apply only to rural and unserved areas. As a result, any commitment of public funds will need to be City funds. An RFP process will determine what kind of City investment will produce what response and commitment from private providers.

2 Engagement with Potential Partners

CTC engaged with private entities who could become potential partners to gauge their level of interest in participating in a solution. CTC held discussions with local ISPs and utility pole owners to explore joint opportunities and the shared benefits that might result.

2.1 Overview of Engagement

We gathered input on perceived demand, identified the WISPs' fiber backhaul needs in various parts of the City, and discuss potential partnership arrangements. We emphasize at the outset that the only way to fully understand the willingness of private providers to help solve the broadband problem in Wildwood is to issue an RFI/RFP, and then evaluate responses.

We contacted:

- Ameren
- Bays-ET
- Wisper ISP and
- Spectrum

The takeaways from these interactions can be summarized as follows: Ameren is not a broadband provider but does control assets that could play a role in an overall solution. Spectrum and Bayes are providers who potentially could be engaged, and have some ideas, but they generally favor different approaches. Spectrum favors a straight subsidy; Bayes would prefer City middle-mile, which again have respective advantages and disadvantages, as discussed in detail in Section 4. An RFP would be the way to get into these details and determine the magnitude of their willingness to participate and to understand the pros and cons. Procurement laws need to be followed, with all providers given equal treatment.

Bayes has been more active in terms of looking at a fiber solution. They have engaged in building fiber in two neighborhoods and is examining how to work with the City in moving forward. But as noted, without external funding Bayes cannot afford to address the issue on its own.

Already, with the help of the City in setting poles, wireless service from Bayes and Wisper are reaching some premises. And Bayes is engaged in building FTTP in two neighborhoods in the southwestern part of the City, where the geography and the economics made sense. These efforts are only in the construction stage, and even if these pilots succeed they will not suffice to solve the City's larger broadband challenges.

Bayes and Wisper are interested in expanding their business in Wildwood, but cannot make a business case for doing so, given the challenging geography and spread-out development patterns. Wisper, which currently serves the northern part of the western half of the City, indicated that it would like to expand its wireless business if it were economically feasible to do so. The company does not have a strong interest in providing last-mile fiber service at this stage. Bayes currently serves the southern portion of the western half of the City with wireless service and is undertaking the FTTP pilots. It would be interested in fiber if the infrastructure costs were substantially borne by the City. As described later, these costs will be very high.

Spectrum indicated it would be interested in expanding service in Wildwood if the City provided a subsidy to Spectrum and Spectrum owned the resulting infrastructure. In 2011, Spectrum proposed expanding service if it got a $1.9 million subsidy from the City. In our conversations, company representatives also stated that if Spectrum were to undertake design and cost estimation work on its side, it would want some assurances that the City was serious about this approach. The City would need to get a legal opinion on the feasibility of this approach, which would likely have to be implemented by issuing an RFP that included specifications, conditions and requirements.

2.2 The Role of Ameren

Ameren, the electric utility, has expressed a willingness to work with Wildwood in a variety of potential roles; in all cases, Ameren[2] will need to strictly follow their internal policies and regulations set forth by the Missouri Public Service Commission (PSC).

- First, Ameren has existing fiber on transmission lines. But transmission routes do not permit mid-span splices or handholds, so these routes cannot be used for middle mile or last mile service. However, this fiber could potentially serve as one competitive source (there are others) for backhaul and bandwidth by connecting Wildwood back to a carrier hotel in St. Louis.

- Second, Ameren is considering installing more fiber to support distribution automation assets located on sub-transmission and distribution circuits. The potential exists that a few of the segments involved could overlap with a City middle mile network, and that Ameren could lease some strands of fiber to the City. However, these assets do not extend deeply into neighborhoods. The problem here is that there is no clear timetable on when Ameren might undertake construction of additional fiber. And Ameren understands that an AMI deployment will not drive a FTTP deployment.

- Third, Ameren could provide pole attachments for middle mile and last-mile fiber. However, the entity making the attachment would need to be a registered telecommunications carrier. The City is not a registered carrier. It could become one, but

[2] Ameren is regulated by the Missouri Public Utility Commission for rates, services, and other business activities.

will need to decide whether it wishes to do so. If the City decides against this, another entity would need to make these attachments. Bayes ET and Wisper are registered carriers.

- Ameren could prioritize upgrades in Wildwood as part of a 5-year plan to upgrade distribution system in portions of their service territory (this plan is still being formulated). This would potentially reduce make-ready costs.

- Ameren is looking at constructing utilities underground. In detailed design, we will need to understand where and when any underground construction will be occurring, as it may also force the City to install fiber underground.

We reiterate that a major consideration when working with Ameren is that it will need to strictly follow state PSC rules and rates, whether for leading or attachment fees. They area investor owned utility and the City would need to follow their and PSC rules. They will not be able to provide help or subsidies for pole attachments or other work.

3 Conceptual Fiber Network Design and Cost Estimates

CTC prepared a high-level network design for the City's deployment of a gigabit-capable FTTP network to all homes and businesses in the City. Based on the high-level FTTP design, we developed three cost examples.

The first is the cost to deploy just the FTTP OSP infrastructure, which we refer to as a "dark FTTP" model. This is the total capital cost for the City to build a dark FTTP network for lease to a private partner. This dark FTTP model forms the basis for our FTTP financial analysis. The dark FTTP model is presented with two alternatives—one in which the cost for the fiber drop cable is the responsibility of the partner, and one in which the drop costs are the City's responsibility.[3]

The second estimate is the cost to deploy an FTTP infrastructure, all electronics, consumer drops, and customer premises equipment (CPE), which we refer to as a "lit" model. This estimate shows the *total capital costs*[4] (by the City or the City and partners) to build an FTTP network to support a ubiquitous Gigabit data service.

The third cost estimate is to deploy a backbone network to enable third party providers and wireless internet access providers to use the network to decrease costs for providing broadband services, particularly to the western part of the City.

The difference between these three cost estimates reflects the general range of costs that a private partner would incur to deploy FTTP within the City. Please note that the partner's costs (electronics) are subject to a seven- to 10-year replacement cycle, as compared to the 20- to 30-year lifespan of a City fiber investment.

The CTC cost estimate provides data relevant to assessing the financial viability of network deployment, and to developing a business model for a potential City construction effort (including the full range of models for public–private partnerships). This estimate also enables financial modeling to determine the approximate revenue levels necessary for the City to service any debt incurred in building the network.

In this section we present costs for:

- City deployed fiber backbone (middle-mile),
- Dark FTTP for the western portion of the City (low density),
- Dark FTTP for the entire City, and
- Lit model for the entire City

[3] A fiber drop cable connects the customer's premises to the distribution network.
[4] Capital costs are distinct from ongoing operations costs that the City or the City and partners will incur during ongoing maintenance and operation of the fiber enterprise.

The CTC design and cost estimate are underpinned by data and insight gathered by CTC engineers through discussions with City stakeholders, an extensive desk survey and on-site survey of candidate fiber routes, and a detailed sample design of the City.

Actual costs may vary due to factors that cannot be precisely known until the detailed design is completed, or until construction commences. These factors include:

1. Costs of private easements;
2. Utility pole replacement and make-ready costs;
3. Variations in labor and material costs;
4. Subsurface hard rock; and
5. The City's operational and business model.

We have incorporated suitable assumptions to address these items based on our experience in similar markets.

3.1 Survey Methodology for Developing Design and Cost Estimates

To develop estimates of per-mile cost for aerial infrastructure in the communications space and per-mile costs for underground infrastructure where poles are not available, CTC engineers performed a survey of the City in person and via Google Earth Street View. The engineers reviewed available green space, necessary make-ready on poles, and pole replacement—all of which have been factored in to the design and cost estimate.

Table 2, below, summarizes the conditions determined through our field and desk survey.

Table 2: Field Survey Findings

Attribute	High Density	Medium Density	Low Density
Aerial Construction	35%	35%	35%
Poles per Mile	45	40	35
Moves per Pole	1.3	1.3	1.3
Poles Requiring Make-Ready	18%	18%	18%
Cost Per Move	$350	$350	$350
Poles Requiring Replacement	8%	8%	8%
Average Pole Replacement Cost	$7,000	$7,000	$7,000
Intermediate Rock	5%	5%	5%
Hard Rock	1%	1%	1%

CTC's OSP engineer noted that the quality of the poles and pole attachments in the City varied, as they do in many cities and counties—but that overall, most of the poles along the primary electrical distribution path would support an additional attachment. Within neighborhoods with aerial utilities, the poles tend to be older and may not support additional attachments without upgrading the poles.

Figure 2, Figure 3, and Figure 4, below, show examples of poles in various conditions throughout Wildwood.

Figure 2: Utility Pole Line Showing where Tree Trimming is Needed

Figure 3: Congested Pole where Make-Ready will be Required

Figure 4: Example of Low Make-Ready Pole Lines

3.2 Fiber-to-the-Premises Network Design

We developed a conceptual, high-level FTTP design that reflects the City's goals and is open to a variety of architecture options. The design assumes a combination of aerial and underground construction based on the placement of the existing utilities.

Figure 5, below, shows a logical representation of the high-level FTTP network architecture we recommend based on the conceptual design in this report. This design is open to a variety of architecture options.[5] The drawing illustrates the primary functional components in the FTTP network, their relative position to one another, and the flexibility of the architecture to support multiple subscriber models and classes of service.

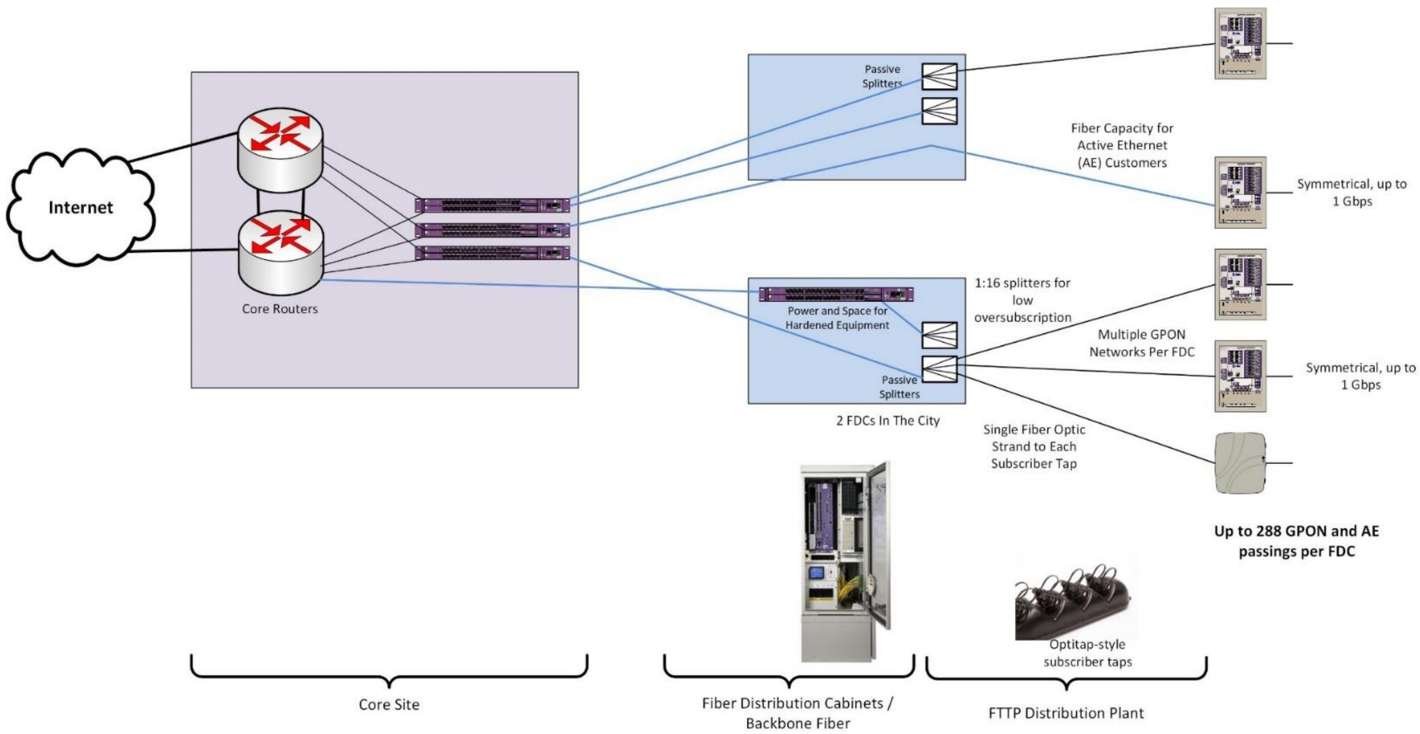
The recommended architecture is a hierarchical data network that provides critical scalability and flexibility, both in terms of initial network deployment and its ability to accommodate the

[5] The network's OSP is both the most expensive and the longest-lasting portion. The architecture of the physical plant determines the network's scalability for future uses and how the plant will need to be operated and maintained; the architecture is also the main determinant of the total cost of the deployment.

increased demands of future applications and technologies. The characteristics of this hierarchical FTTP data network are:

- **Capacity** – ability to provide efficient transport for subscriber data, even at peak levels
- **Availability** – high levels of redundancy, reliability, and resiliency; ability to quickly detect faults and re-route traffic
- **Failsafe operation** – physical path diversity to minimize operational impact resulting from fiber or equipment failure
- **Efficiency** – no traffic bottlenecks; efficient use of resources
- **Scalability** – ability to grow in terms of physical service area and increased data capacity, and to integrate newer technologies
- **Manageability** – simplified provisioning and management of subscribers and services
- **Flexibility** – ability to provide different levels and classes of service to different customer environments; can support an open access network or a single-provider network; can provide separation between service providers on the physical layer (separate fibers) or logical layer (separate Virtual Local Area Network (VLAN) or Virtual Private Network (VPN) providing networks within the network)
- **Security** – controlled physical access to all equipment and facilities, plus network access control to devices

Figure 5: High-Level FTTP Architecture



This architecture offers scalability to meet long-term needs. It is consistent with best practices for an open-access network model that may be required to support multiple network operators, or at least multiple RSPs requiring dedicated connections to certain customers. This design would support a combination of Gigabit Passive Optical Network (GPON) and direct Active Ethernet (AE) services (with the addition of electronics at the fiber distribution cabinets), which would enable the network to scale by migrating to direct connections to each customer, or reducing splitter ratios, on an as-needed basis.

The design assumes placement of manufacturer-terminated fiber tap enclosures within the PROW or easements, providing watertight fiber connectors for customer service drop cables, and eliminating the need for service installers to perform splices in the field. This is an industry-standard approach to reducing both customer activation times and the potential for damage to distribution cables and splices. The model assumes the termination of standard lateral fiber connections within larger multi-tenant business locations and MDUs. The model also assumes that the City obtains easements or access rights to the gated communities and private drives within the communities to access the homes in those neighborhoods.

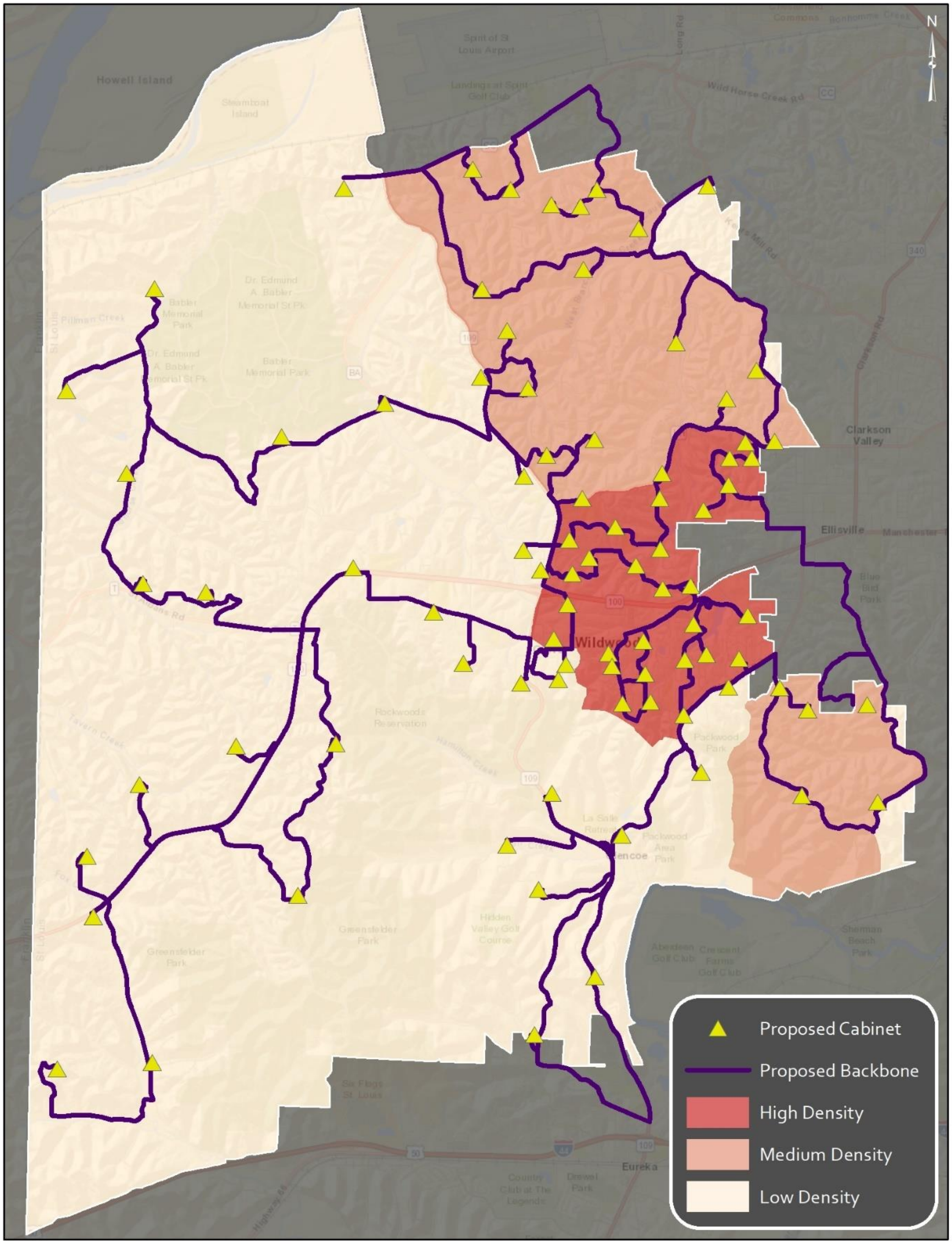
3.2.1 Network Design

The network design and cost estimates assume the City will:

- Use existing City land to locate a core and distribution hub facility. The cost estimate includes the facility costs with adequate environmental and backup power systems to house network electronics, and provide backhaul to the internet
- Construct a robust backbone network to connect to connect the distribution hub to the new fiber distribution cabinets (FDC)
- Construct fiber optics from the FDCs to each residence and business (i.e., from termination panels in the FDC to tap locations in the PROW or on City easements)
- Obtain easements or access rights to the gated communities and private roads where PROW do not exist; and
- Construct fiber laterals into large, multi-tenant business facilities and MDUs

Wildwood is unique in that the density varies from the denser eastern areas of the City to the low-density western areas. It is important to construct a robust backbone that can serve the needs of the future community. The backbone should provide redundancy where possible and extend to the outer edges of the City so that it will be near new subdivisions, which will enable service to be extended to these areas as they are built. Figure 6, below, shows an example backbone design for the City.

Figure 6: FTTP Network Example Backbone (Middle-Mile) Design



The backbone design could also be used to provide backhaul to wireless internet service providers who may be looking to deploy wireless where existing wireless service is inadequate or where FTTP services may not be cost effective

The FTTP network and service areas were defined based on the following criteria:

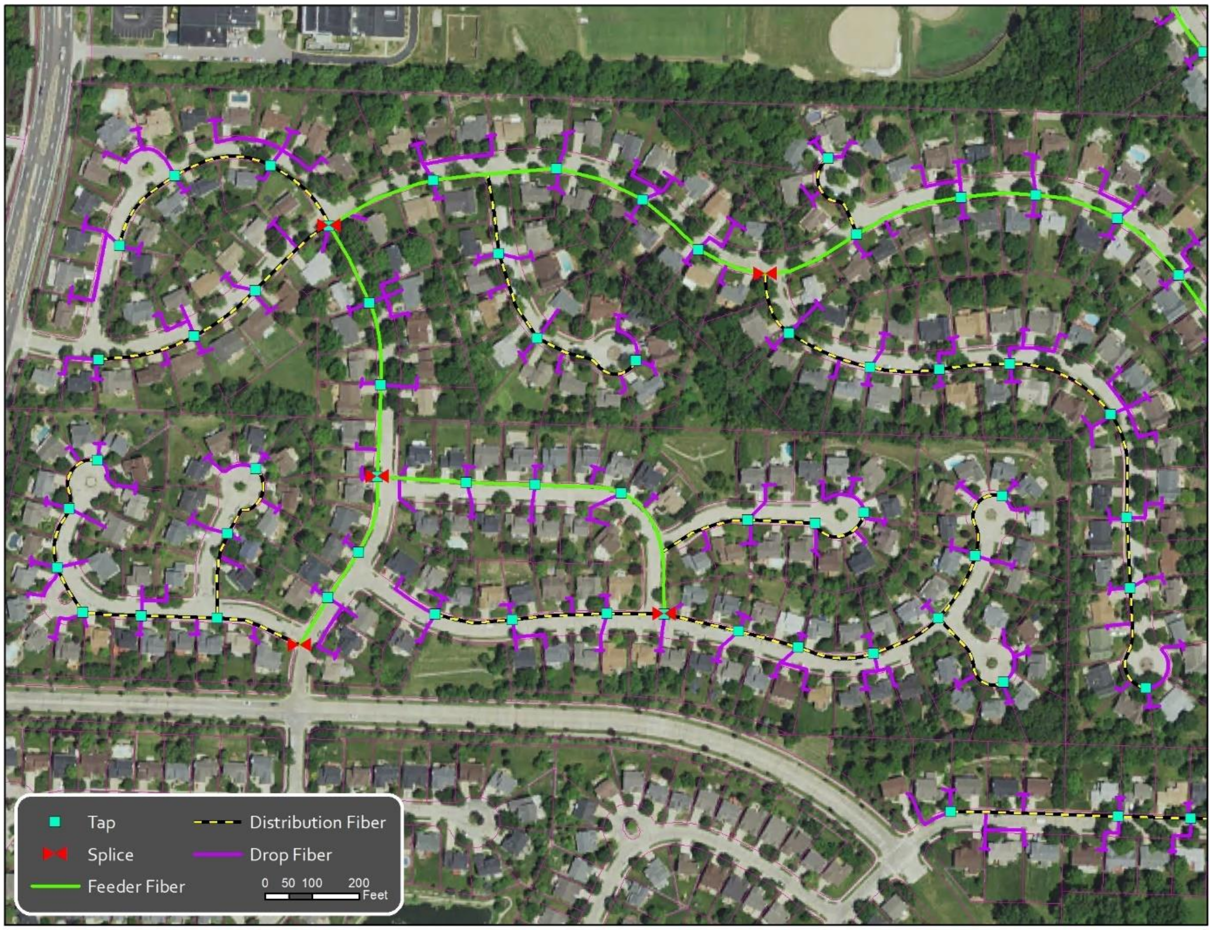
- Fiber will be installed in the communications space of utility poles where present, and in newly constructed conduit in underground areas
- Targeting up to 288 passings per FDC with 124 passings per FDC is the western part of the City
- The service area is the entire City
- Multiple FDCs per service area
- FDCs suitable to support hardened network electronics, providing backup power and an active heat exchange[6]
- Avoiding the need for distribution plant to cross major roadways and railways

Coupled with an appropriate network electronics configuration, this design serves to greatly increase the reliability of fiber services provided to the customers compared to that of more traditional cable and telephone networks. The backbone and hub design minimizes the average length of non-diverse distribution plant between the network electronics and each customer, thereby reducing the probability of service outages caused by a fiber break.

The access layer of the network, encompassing the fiber plant from the FDCs to the customers, dedicates a single fiber strand from the FDC to each passing. This traditional FTTP design allows either network electronics or optical splitters in the FDCs. See Figure 7, below, for a sample design.

[6] These hardened FDCs reflect an assumption that the City's operational and business model will require the installation of provider electronics in the FDCs that are capable of supporting open access among multiple providers. We note that the overall FTTP cost estimate would decrease if the hardened FDCs were replaced with passive FDCs (which would house only optical splitters) and the providers' electronics were housed only at the hub facility.

Figure 7: Sample FTTP Access Layer Design



This architecture offers scalability to meet long-term needs and is consistent with best practices for an open access network model that may be required to support multiple network operators, or at least multiple RSPs requiring dedicated connections to certain customers.

3.2.2 Network Core and Hub Site

The core site is the bridge that links the FTTP network to the public internet and delivers all services to end users. The proposed network design includes a core location that shares space with the distribution and access electronics; however, if consumer demand dictates, a second internet point of presence (PoP) could be added to increase network redundancy or to decrease distances to customers.

For the cost estimate, we assumed that the core site electronics would be housed in a pre-fabricated telecommunications shelter located near the meet point with the ISP chosen to provide internet access for the FTTP network.

Figure 8: Sample Hub Facility

The core location in this plan will house providers' Operational Support Systems (OSS), such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. The core location is also where any business partner or content / service providers will gain access to the subscriber network with their own PoP. This may be via remote connection, but collocation is recommended.

The core location is typically run in a High Availability (HA) configuration, with fully meshed and redundant uplinks to the public internet and/or all other content and service providers. It is imperative that core network locations are physically secure and allow 24x7x365 unencumbered access to authorized engineering and operational staff.

The operational environment of the network core and hub location is like that of a data center. This includes clean power sources, uninterruptable power supply (UPS) batteries, and diesel power generation for survival through sustained commercial outages. The facility must provide strong physical security, limited/controlled access, and environmental controls for humidity and temperature. Fire suppression is highly recommended.

Equipment is to be mounted securely in racks and cabinets, in compliance with national, state, and local codes. Equipment power requirements and specification may include -48-volt DC and/or 120/240 volts AC. All equipment is to be connected to conditioned / protected clean power with uninterrupted cutover to battery and generator.

For the cost estimate, we assumed that the core will be located on existing City land with adequate space for the shelter.

3.2.3 Distribution and Access Network Design

The distribution network is the layer between the core hub and the FDCs, which provide the access links to the taps. The distribution network aggregates traffic from the FDCs to the core. Fiber cuts and equipment failures have progressively greater operational impact as they happen closer to the network core, so it is critical to build in redundancies and physical path diversities in the distribution network, and to seamlessly re-route traffic when necessary.

The distribution and access network design proposed in this report is flexible and scalable enough to support two different architectures:

1. Housing both the distribution and access network electronics at the hub, and using only passive devices (optical splitters and patches) at the FDCs
2. Housing the distribution network electronics at the hub and pushing the access network electronics further into the network by housing them at the FDCs

By housing all electronics at the hub, the network will not require power at the FDCs. Choosing a network design that only supports this architecture may reduce costs by allowing smaller, passive FDCs in the field. However, this architecture will limit the redundancy capability from the FDCs to the hubs.

By pushing the network electronics further into the field, the network gains added redundancy by allowing the access electronics to diversely connect to the hub. In the event of a fiber outage on one link, the subscribers connected to the FDC would still have network access.

A design that supports both models would allow the City to accommodate many different service operators and their network designs. This design would also allow service providers to start with a small deployment (i.e., place electronics only at the hub site, and grow by pushing electronics closer to their subscribers).

3.2.3.1 Access Network Technologies

FDCs can sit on a curb, be mounted on a pole, or reside in a building. The model recommends installing sufficient FDCs to support higher-than-anticipated levels of subscriber penetration. This approach will accommodate future subscriber growth with minimal re-engineering. Passive optical splitters are modular and can be added to an existing FDC as required to support subscriber growth, or to accommodate unanticipated changes to the fiber distribution network with potential future technologies.

Figure 9: Fiber Distribution Cabinet

The FTTP design also includes the placement of indoor FDCs and splitters to support MDUs. This would require obtaining the right to access the equipment for repairs and installation in whatever timeframe is required by the service agreements with the customers. Lack of access would potentially limit the ability to perform repairs after normal business hours, which could be problematic for both commercial and residential services.

In this model, we assume the use of GPON electronics for most subscribers and AE for a very small percentage of subscribers (typically high-end business customers) that request a premium service or require greater bandwidth. GPON is the most commonly provisioned FTTP service—used, for example, by AT&T Fiber, Verizon (in its FiOS systems), Google Fiber, and Chattanooga EPB.

Further, providers of gigabit services typically provide these services on GPON platforms. Even though the GPON platform is limited to 1.2 Gigabits per second (Gbps) upstream and 2.4 Gbps downstream for the subscribers connected to a single PON, operators have found that the variations in actual subscriber usage generally means that all subscribers can obtain 1 Gbps on demand (without provisioned rate-limiting), even if the capacity is aggregated at the PON. Further, many GPON manufacturers have a development roadmap to 10 Gbps and faster speeds as user demand increases.

GPON supports high-speed broadband data, and is easily leveraged by triple-play carriers for voice, video, and data services. The GPON optical line terminal (OLT) uses single-fiber (bi-directional) Small Form-factor Pluggable (SFP) modules to support multiple (most commonly less than 32) subscribers.

GPON uses passive optical splitting, which is performed inside the FDC, to connect fiber from the OLTs to the customer premises. The FDCs house multiple optical splitters, each of which splits the fiber link to the OLT between 16 to 32 customers (in the case of GPON service).

AE provides a symmetrical (up/down) service that is commonly referred to as Symmetrical Gigabit Ethernet. AE can be provisioned to run at sub-gigabit speeds, and—like GPON—easily supports legacy voice, Voice over Internet Protocol (VoIP), and video. AE is typically deployed for customers who require specific service level agreements that are easier to manage and maintain on a dedicated service.

For subscribers receiving AE service, a single dedicated fiber goes directly to the subscriber premises with no splitting. Because AE requires dedicated fiber (also known as "home-run fiber") from the OLT to the CPE, and because each subscriber uses a dedicated SFP on the OLT, there is a significant cost difference in provisioning an AE subscriber versus a GPON subscriber.

The fiber plant is designed to provide AE service or PON service to all passings. The network operator selects electronics based on the mix of services it plans to offer and can modify or upgrade electronics to change the mix of services.

3.2.3.2 Expanding the Access Network Bandwidth

GPON is currently the most commonly provisioned FTTP technology, due to inherent economies when compared with technologies delivered over home-run fiber,[7] such as AE. Based on our experience, the cost differential between constructing an entire network using GPON and AE is 40 percent to 50 percent. GPON is used to provide services up to 1 Gbps per subscriber and is part of an evolution path to higher-speed technologies that use higher-speed optics and wave-division multiplexing (WDM).

This model provides many options for scaling capacity, which can be done separately or in parallel:

1. Reducing the number of premises in a PON segment by modifying the splitter assignment and adding optics—for example, by reducing the split from 16:1 to 4:1, the per-user capacity in the access portion of the network is quadrupled.

2. Adding higher-speed PON protocols can be accomplished by adding electronics at the FDC or hub locations; since these use different frequencies than the GPON electronics, none of the other CPE would need to be replaced.

[7] Home-run fiber is a fiber optic architecture in which individual fiber strands are extended from the distribution sites to the premises. Home-run fiber does not use any intermediary aggregation points in the field.

3. Adding WDM-PON electronics as they become widely available, which will enable each user to have the same capacity as an entire PON; again, these use different frequencies than GPON and are not expected to require replacement of legacy CPE.

4. Option 1 could be taken to the maximum, and PON replaced by a 1:1 connection to electronics—an AE configuration.

These upgrades would all require complementary upgrades in the backbone and distribution Ethernet electronics, as well as in the upstream internet connections and peering—but they would not require increased fiber construction.

3.2.3.3 Customer Premises Equipment and Subscriber Services

In the final segment of the FTTP network, fiber runs from the FDC to customers' homes, apartments, and office buildings, where it terminates at the subscriber tap—a fiber optic housing located in the PROW closest to the premises. The service installer uses a pre-connectorized drop cable to connect the tap to the subscriber premises without the need for fiber optic splicing.

The drop cable extends from the subscriber tap (either on the pole or underground) to the building, enters the building, and connects to CPE.

3.3 Dark Fiber-to-the-Premises Cost Estimate

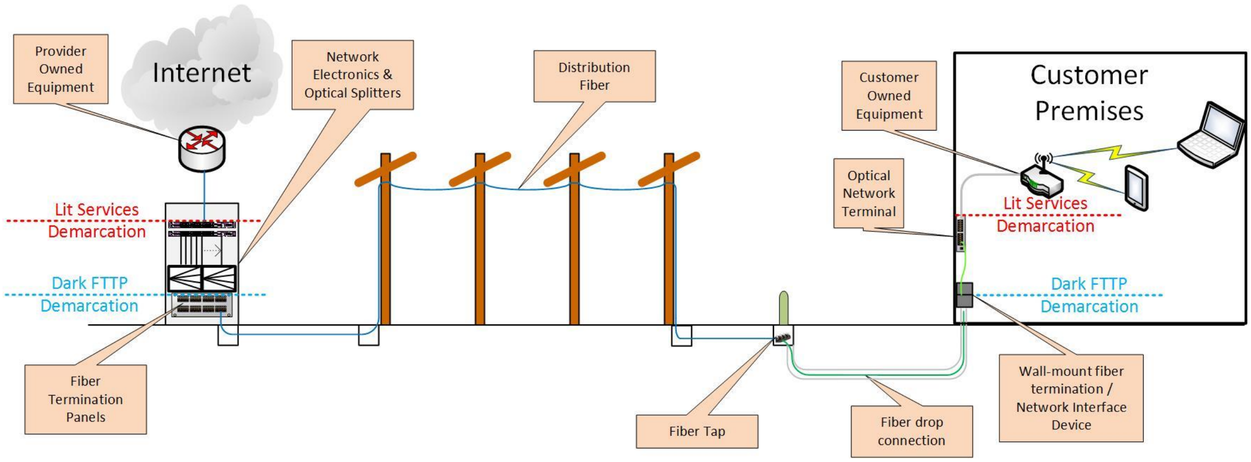
A dark FTTP network deployment will cost approximately $69 million, inclusive of OSP construction labor, materials, engineering, permitting, lateral drops, and drop materials. This estimate assumes a 35 percent take rate. This estimate does not include any electronics or subscriber equipment.

Table 3: Estimated Dark FTTP Cost with Drops (Assuming a 35 Percent Take Rate)

Cost Component	Total Estimated Cost
OSP	$49.0 million
FTTP Service Drop and Lateral Installations	10.0 million
Total Estimated Cost:	$59.0 million

This estimate assumes that the City constructs and owns the FTTP infrastructure up to a demarcation point (a network interface device) at each residence and business, and leases the dark fiber backbone, distribution, and drop fiber to a private partner. The private partner would be responsible for all network electronics and CPE—as well as network sales, marketing, and operations.

Figure 10: Demarcation Between City and Partner Network Elements in the Lit and Dark Models



3.4 Lit Fiber-to-the-Premises Cost Estimate

Assuming a take rate (i.e., the percentage of residents and businesses that subscribe to the service) of 35 percent, the full FTTP network deployment will cost more than $64.2 million, inclusive of OSP construction labor, materials, engineering, permitting, network electronics, drop installation, CPE, and testing.

Table 4: Estimated Lit FTTP Cost

Cost Component	Total Estimated Cost
OSP	$49.0 million
Central Network Electronics	2.3 million
FTTP Service Drop and Lateral Installations	10.0 million
CPE	2.9 million
Total Estimated Cost:	$64.2 million

3.4.1 Cost per Passing

On a per-passing basis, the lit FTTP deployment will cost $3,800 on average. The $3,800 per passing cost for the City of Wildwood is similar to other communities we have worked with that contain a high percentage of underground infrastructure with relatively low density housing. Figure 11 and Figure 12, below, show the potential range of costs for a variety of communities with which CTC has been engaged. Please note that the City of Wildwood is “MO - City 1” in the figures below. Further the per passing costs for the high, medium, and low densities split the backbone costs evenly between them.

Figure 11: FTTP Cost per Passing Comparison

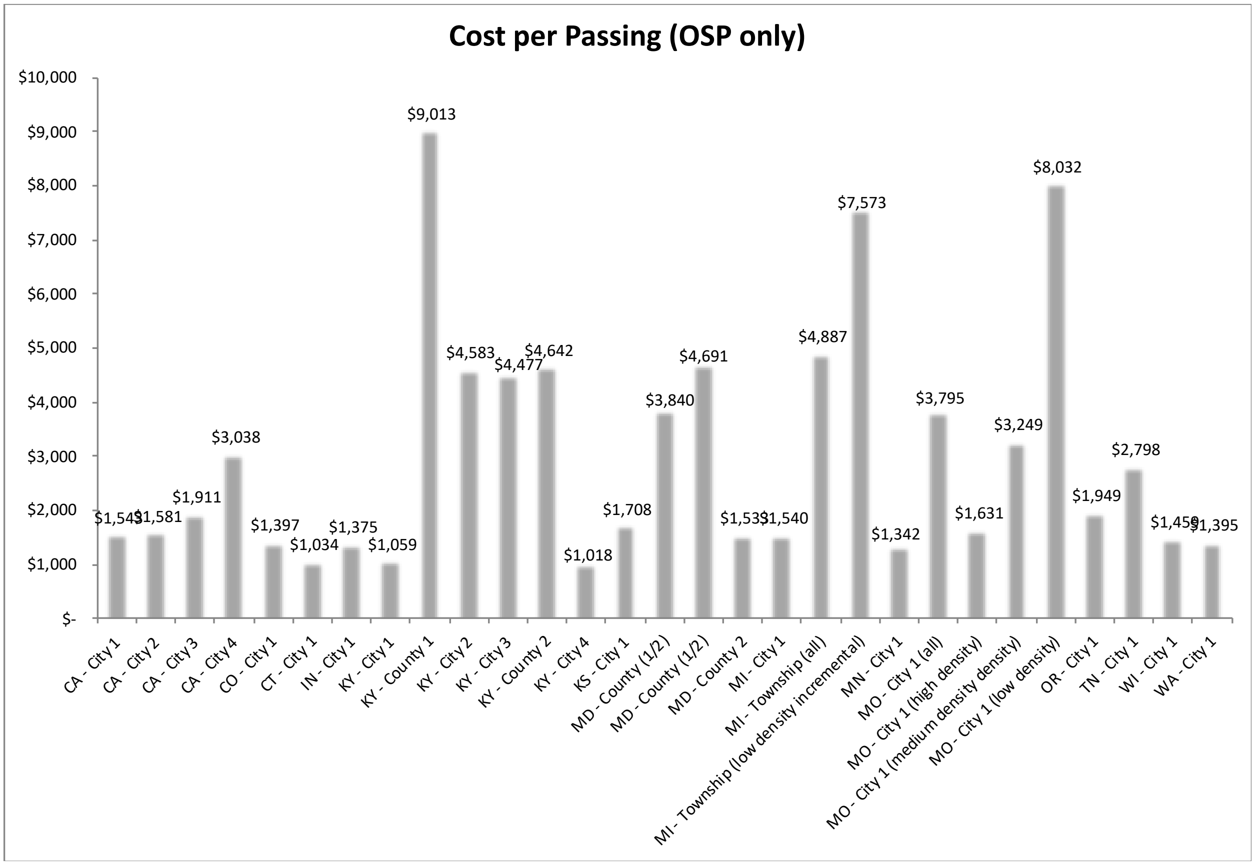
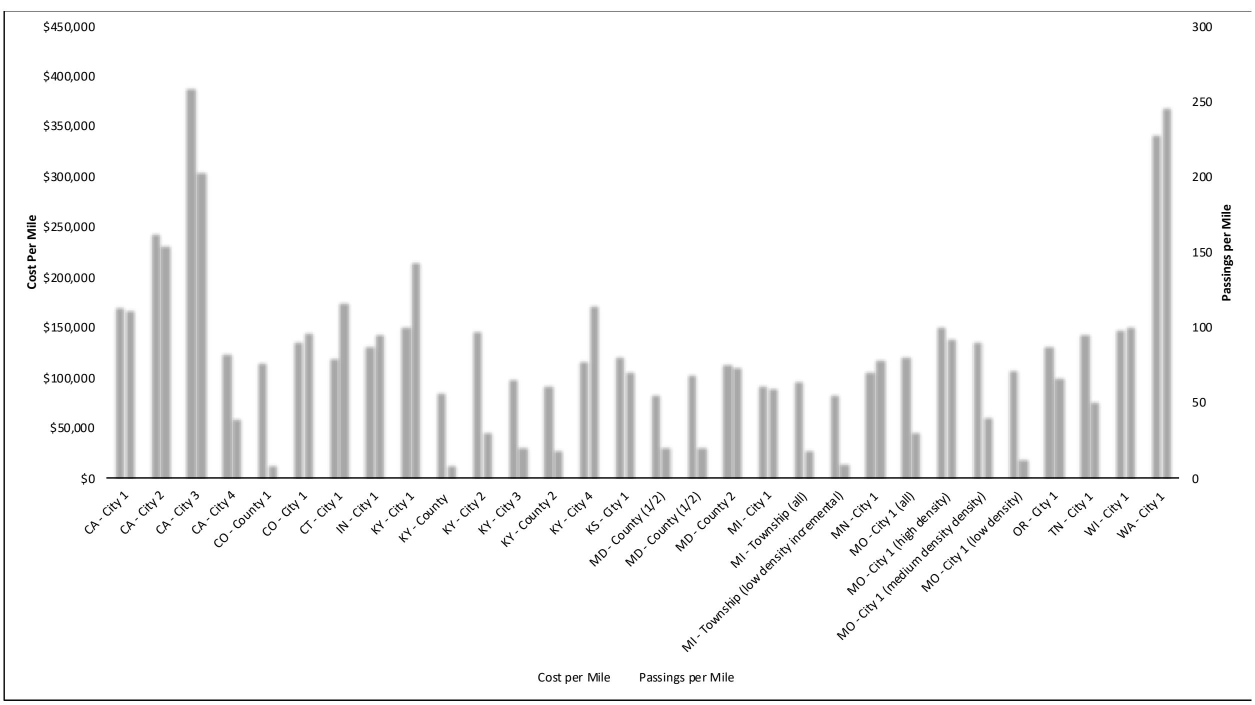


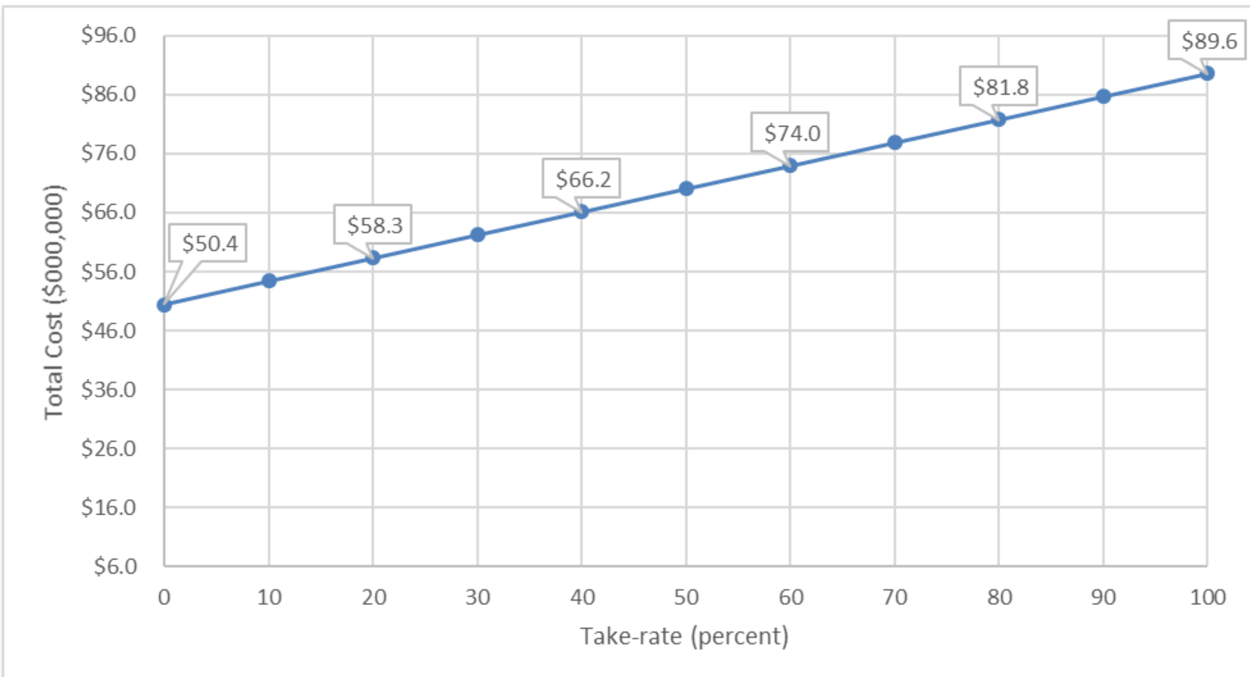
Figure 12: FTTP Key Cost Factors (Density and Construction Cost)



As indicated above, the take rate is the percentage of homes/businesses passed with fiber that will acquire service from the FTTP provider. The estimated 35 percent take rate is within the range that may exist in a market where both the cable and telephone companies also provide broadband service.

Figure 13 shows the total estimated cost by varying the expected take rate. Table 4 assumes a take rate of 35 percent.

Figure 13: Total Estimated Cost versus Take Rate



The cost is roughly linear by take rate, as the cost of adding additional subscribers is a fixed cost.

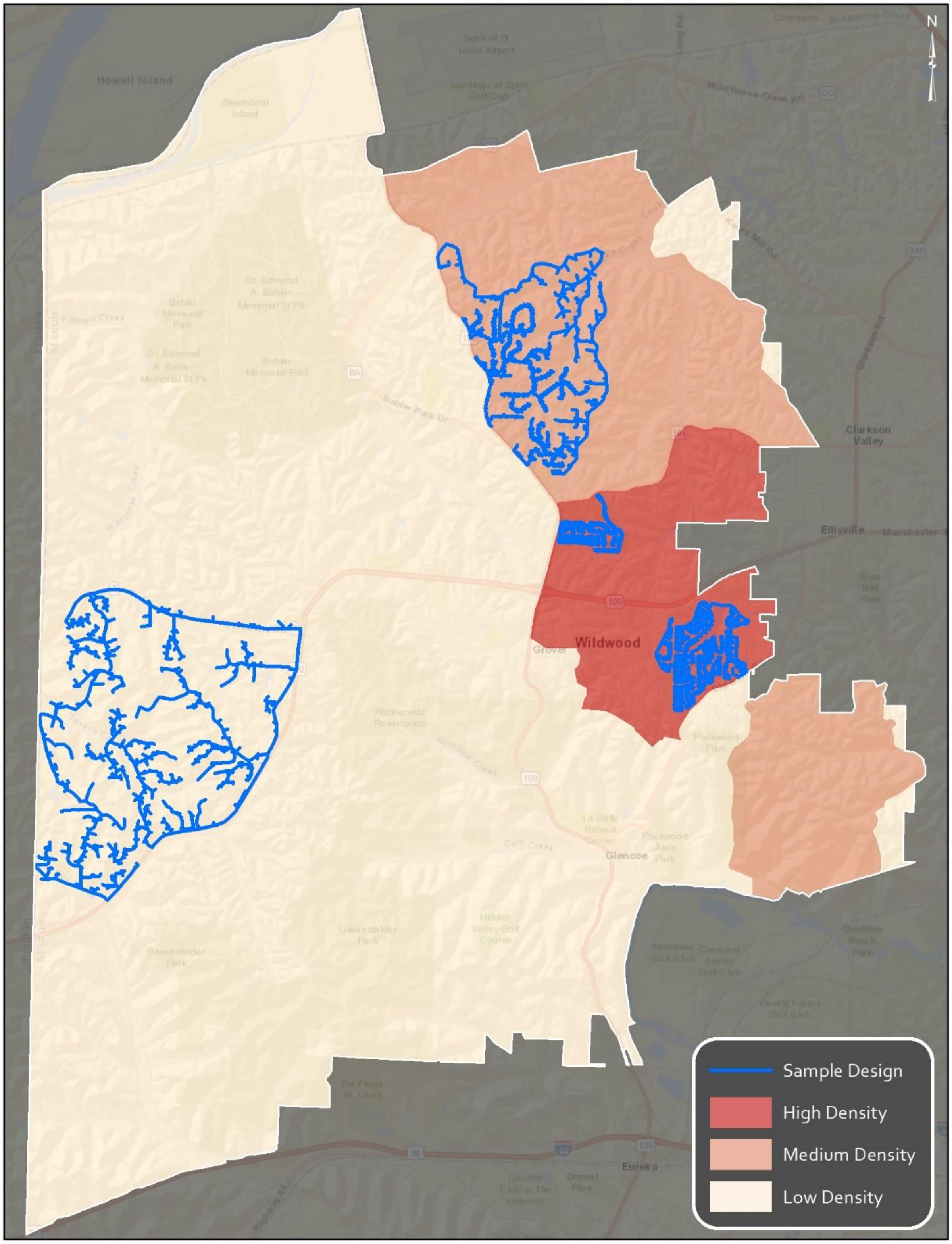
The total cost of operations will also vary with the business model chosen and the level of existing resources that can be leveraged by the City and any potential business partners.

3.4.2 OSP Cost Estimation Methodology

As with any utility, the design and associated costs for construction vary with the unique physical layout of the service area—no two streets are likely to have the exact same configuration of fiber optic cables, communications conduit, underground vaults, and utility pole attachments. Costs are further varied by soil conditions, such as the prevalence of subsurface hard rock; the condition of utility poles and feasibility of “aerial” construction involving the attachment of fiber infrastructure to utility poles; and crossings of bridges, railways, and highways.

To estimate costs, we extrapolated the costs for strategically selected sample designs based on street mileage and passings. Given the size of the City, we were able to develop an extensive sample design.

Figure 14: Map of the Sample Design



Our observations determined that the utilities are primarily aerial in the older portions of the City, and that newer developments are completely underground. We also anticipate that any new subdivisions will likely be constructed underground.

The assumptions, sample designs, and cost estimates were used to extrapolate a cost-per-passing for the OSP infrastructure. This number was then multiplied by the number of passings in each area based on the City's estimation of the population.

The actual cost to construct FTTP to every premises in the City could differ from the estimate due to changes in the assumptions underlying the model. For example, if make-ready and pole replacement costs are too high, the network would have to be constructed underground—which could significantly increase the cost of construction. Alternatively, if the City could partner with a local telecommunications provider and overlash to existing pole attachments, the cost of the build could be significantly lower. Further and more extensive analysis would be required to develop a more accurate cost estimate across the entire City.

3.4.3 OSP Costs

The estimated cost to construct the OSP portion of the proposed FTTP network is approximately $49.0 million, or $3,800 per passing.[8] As discussed above, the model assumes a mixture of aerial and underground fiber construction, depending on the construction of existing utilities in the area as well as the state of any utility poles, existing infrastructure, and construction within the communication space. Table 5 provides a breakdown of the estimated OSP costs. (Note that the costs have been rounded.)

[8] The passing count includes individual single-unit buildings and units in small multi-dwelling and multi-business buildings as single passings. It treats larger buildings as single passings.

Table 5: Estimated OSP Costs

Phase	Distribution Plant Mileage	Total Cost	Passings	Cost per Passing	Cost Per Plant Mile
Total	**403.0**	**$49,040,000**	**12,920**	**$3,800**	**$120,000**
High Density	63.0	$8,190,000	5,900	$1,390	$131,000
Medium Density	84.0	$10,077,000	3,540	$2,840	$120,000
Low Density	256.0	$26,458,000	3,470	$7,620	$103,000
Backbone	-	$4,315,000	-	N/A	N/A

3.4.3.1 Aerial and Underground Construction Approach

Costs for aerial and underground placement were estimated using available unit cost data for materials and estimates on the labor costs for placing, pulling, and boring fiber based on construction in comparable markets. The material costs were generally known, with the exception of unknown economies of scale and inflation rates, and barring any sort of phenomenon restricting material availability and costs. The labor costs associated with the placement of fiber were estimated based on similar construction projects.

Aerial construction entails the attachment of fiber infrastructure to existing utility poles, which could offer significant savings compared to all-underground construction, but increases uncertainty around cost and timeline. Costs related to pole remediation and make-ready construction can make aerial construction cost-prohibitive in comparison to underground construction.

We assume the installation of strand that the fiber will be lashed to in the communications space on the existing utility poles. Splice cases, subscriber taps, and drops will also be attached to the strand, which facilitates maintenance and customer installation.

While generally allowing for greater control over timelines and more predictable costs, underground construction is subject to uncertainty related to congestion of utilities in the PROW and the prevalence of subsurface hard rock—neither of which can be fully mitigated without physical excavation and/or testing.

While anomalies and unique challenges will arise regardless of the design or construction methodology, the relatively large scale of this project is likely to provide ample opportunity for variations in construction difficulty to yield relatively predictable results on average.

We assume underground construction will consist primarily of horizontal, directional drilling to minimize PROW impact and to provide greater flexibility to navigate around other utilities. The design model assumes a single 2-inch, flexible, High-Density Polyethylene (HDPE) conduit over underground distribution paths, and dual 2-inch conduits over underground backbone paths to provide scalability for future network growth.

3.4.3.2 OSP Cost Components

The cost components for OSP construction include the following tasks:

- ***Engineering*** – includes system level architecture planning, preliminary designs and field walk-outs to determine candidate fiber routing; development of detailed engineering prints and preparation of permit applications; and post-construction "as-built" revisions to engineering design materials.
- ***Quality Control / Quality Assurance*** – includes expert quality assurance field review of final construction for acceptance.
- ***General OSP Construction*** – consists of all labor and materials related to "typical" underground or aerial OSP construction, including conduit placement, utility pole make-ready construction, aerial strand installation, fiber installation, and surface restoration; includes all work area protection and traffic control measures inherent to all roadway construction activities.
- ***Special Crossings*** – consists of specialized engineering, permitting, and incremental construction (material and labor) costs associated with crossings of railroads, bridges, and interstate / controlled access highways.
- ***Backbone and Distribution Plant Splicing*** – includes all labor related to fiber splicing of outdoor fiber optic cables.
- ***Backbone Hub, Termination, and Testing*** – consists of the material and labor costs of placing hub shelters and enclosures, terminating backbone fiber cables within the hubs, and testing backbone cables.
- ***FTTP Service Drop and Lateral Installations –*** consists of all costs related to fiber service drop installation, including OSP construction on private property, building penetration, and inside plant construction to a typical backbone network service "demarcation" point; also includes all materials and labor related to the termination of fiber cables at the

demarcation point. A take-rate of 35 percent was assumed for standard fiber service drops.

3.4.4 Central Network Electronics Costs

Central network electronics will cost an estimated $2.3 million, or $175 per passing, based on an assumed take-rate of 35 percent.[9] (These costs may increase or decrease depending on take rate, and the costs may be phased in as subscribers are added to the network.) The central network electronics consist of the electronics to connect subscribers to the FTTP network at the core and cabinets. Table 6, below, lists the estimated costs for each segment.

Table 6: Estimated Central Network Electronics Costs

Network Segment	Subtotal	Passings	Cost per Passing
Core and Distribution Electronics (Sections 3.4.4.1 and 3.4.4.2)	$1.3 million	12,920	$100
FTTP Access Electronics (Section 3.4.4.1)	$1.0 million	12,920	$75
Central Network Electronics Total	**$2.3 million**	**12,920**	**$200**

3.4.4.1 Core Electronics

The core electronics connect the distribution electronics and connect the network to the internet. The core electronics consist of high performance routers, which handle all the routing on both the FTTP network and to the internet. The core routers should have modular chassis to provide high availability in terms of redundant components and the ability to "hot swap" line cards and modular in the event of an outage.[10] Modular routers also provide the ability to expand the routers as demand for additional bandwidth increases.

The cost estimate design envisions running networking protocols, such as hot standby routing protocol (HSRP), to ensure redundancy in the event of a router failure. Additional connections can be added as network bandwidth on the network increases. The core sites would also tie to the distribution electronics using 10 Gbps links. The links to the distribution electronics can also be increased with additional 10 Gbps and 40 Gbps line cards and optics as demand grows on the network. The core networks will also have 10 Gbps to ISPs that connect the FTTP network to the internet.

[9] The take rate affects the electronics and drop costs, but also may affect other parts of the network, as the City may make different design choices based on the expected take rate. A 35 percent take rate is typical of environments where a new provider joins the telephone and cable provider in a City. In CTC's financial analysis, we will examine how the feasibility of the project depends on a range of take rates.

[10] A "hot swappable" line card can be removed and reinserted without the entire device being powered down or rebooted. The control cards in the router should maintain all configurations and push them to a replaced line card without the need for reconfirmation.

The cost of the core routing equipment is $500,000. These costs do not include the service provider's OSS, such as provisioning platforms, fault and performance management systems, remote access, and other operational support systems for FTTP operations. The service providers may already have these systems in place.

3.4.4.2 Distribution Electronics

The distribution network electronics aggregate the traffic from the FDCs and send it to the core electronics to access the internet. The distribution electronics consist of high-performance aggregation switches, which consolidate the traffic from the many access electronics and send it to the core for route processing. The distribution switches are typically modular switch chassis that can accommodate line cards for aggregation. The switches should also be modular to provide redundancy in the same manner as the core switches.

The cost estimate assumes that the aggregation switches connect to the access network electronics with 10 Gbps links to each distribution switch. The aggregation switches would then connect to the core switches over single or multiple 10 Gbps links as needed to meet the demand of the FTTP users in each service area.

The cost of the distribution switching equipment is $500,000. These costs do not include any of the service provider's OSS or other management equipment.

3.4.4.3 Access Electronics

The access network electronics at the FDCs connect the subscribers' CPE to the FTTP network. We recommend deploying access network electronics that can support both GPON and AE subscribers to provide flexibility within the FDC service area. We also recommend deploying modular access network electronics for reliability and the ability to add line cards as more subscribers join in the service area. Modularity also helps reduce initial capital costs while the network is under construction or during the roll out of the network.

The cost of the access network electronics for the network is estimated at approximately $1.3 million. These costs are based on a take rate of 35 percent and include optical splitters at the FDCs for that take-rate.

3.4.5 Customer Premises Equipment and Service Drop Installation (Per Subscriber Costs)

CPE is the subscriber's interface to the FTTP network. For this cost estimate, we selected CPE that provide only Ethernet data services (however, there are a wide variety of CPE offering other data, voice, and video services). Using the assumed take rate of 35 percent, we estimated the cost for subscriber CPE will be approximately $2.9 million.

Each activated subscriber would also require a fiber drop cable installation and related electronics, which would cost roughly $2,850 per subscriber, or $12.9 million total—again, assuming a 35 percent take rate.

The drop installation cost is the biggest variable in the total cost of adding a subscriber. A short aerial drop can cost as little as $250 to install, whereas a long underground drop installation can cost upward of $5,000. We estimate an average of $2,220 per drop installation.

The other per-subscriber expenses include the cost of the optical network terminal (ONT) at the premises, a portion of the OLT costs at the hub, the labor to install and configure the electronics, and the incidental materials needed to perform the installation. The numbers provided in Table 7, below, are averages and will vary depending on the type of premises and the internal wiring available at each premises.

Table 7: Per Subscriber Cost Estimates

Construction and Electronics Required to Activate a Subscriber	Estimated Average Cost
Drop Installation and Materials	$2,220
Subscriber Electronics (ONT and OLT)	330
Electronics Installation	200
Installation Materials	100
Total	**$2,850**

3.4.1 Cost Estimate Assumptions

In developing the OSP cost estimate, unit cost estimates were created based on the existing construction conditions, labor market, current material costs, and project scope. Table 8 outlines the cost estimate assumptions that were used to generate the range of cost estimates. Additional details can be located in the attached cost estimate spreadsheet (Appendix E).

Table 8: Cost Estimate Assumptions

Description	Unit	Assumption
Total average cost per mile (Distribution Only)	$/mi	$120,000
Placement of 2-inch conduit using directional boring	$/ft	$11.00
Pull-box placement, 24"x36"x36" Tier 22	EA	$1,050
Aerial cable installation per foot	$/ft	$2.00
Traffic control and work area protection per foot	$/ft	$1.00
Tree Trimming	$/ft	$0.50
Make-ready per foot	$/ft	$8.66 to $11.05
288-count cable	$/ft	$2.05
Miscellaneous installation hardware	$/ft	$0.90

Appendix E is attached as a Microsoft Excel spreadsheet.

4 Approaches and Business Models

As part of its analysis CTC summarized the City's options for implementing the design described above. The City's options can be summarized in three basic approaches.

4.1 Overview of Models

The first approach involves the City building a FTTP network. (This network could be operated under one of four models, in decreasing order of complexity for the City: a full retail model, an open-access model, a privately-run open-access model, and a dark fiber model.)

The second approach involves the City building only a "middle-mile" network along main roads or other corridors and working with private providers and homeowners to create financing and business models for constructing the last-mile portion to premises.

The third approach involves the City providing incentives to private parties in exchange for those parties providing agreed-upon service coverage and perhaps fiber strands for City use. (Incentive approaches range from issuing an RFP offering incentives, to which Spectrum and perhaps others would be expected to respond, to expanding the placement of poles to aid the wireless ISPs operating in Wildwood. The FTTP approaches are presented in

Table 9; the middle-mile and incentive approaches are summarized in Table 10.

Table 9: FTTP Approaches

FTTP Approach	Capital Expense	Impact on Broadband Availability	Likelihood Financial Success	Likelihood of Meeting Service Goals
A: City Offers Retail Services In addition to the FTTP network, the City owns and operates the network electronics and runs a business providing retail services	$64.2 million citywide (or $31.4 million for low-density areas), at a 35 percent take-rate including drop costs	High	Low	High
B: City Enables Open Access Same as A, except the City does not provide retail services; rather, it enables open-access services to approved ISPs	$64.4 million citywide (or $31.6 million for low-density areas), at a 35 percent take-rate including drop costs (includes addition of management software)	High	Low	Moderate
C: City Enables Private Open Access Provider Same as B, except that a third-party owns and operates the electronics and enables open-access services to ISPs	$49.0 million citywide ($30.8 million, low-density only) assuming City does not pay drop costs	High	Low	Moderate
D: City Leases Dark FTTP The City only leases the dark FTTP to a private provider who owns and operates all electronics and provides retail service	$49.0 million citywide ($30.8 million, low-density only) assuming City does not pay drop costs	High	Low	Moderate

The middle-mile and incentive options are summarized in Table 10.

Table 10: Middle-Mile and Incentive Approaches

Approach		Capital Expense	Impact on Broadband Availability	Likelihood of Financial Success	Likelihood of Meeting Service Goals
Middle-Mile Fiber	**E. City Leases Dark Middle Mile** City provides access to middle-mile fiber to third parties. The third parties own and operate last mile infrastructure—OSP and electronics—and provide retail services	$4.3 million	Low to Moderate	Low to Moderate	Low to Moderate
Incentives	**F: City Offers Cash Incentives** The City issues an RFP offering funds for any ISP willing to provide coverage guarantees with broadband service. Spectrum would be expected to respond, others might	$2.5 million to $3.5 million (estimate based on discussions with Spectrum)	Moderate to High	Moderate	Moderate
	G. Expand Wireless Assets The City expands placement of poles and other assets for WISPs and streamlines permitting and other processes for underground fiber placement	TBD, but minimal	Low	High	Low
	H: Continue on Same Path The City supports pole additions as requested and streamlines permitting and other processes for underground fiber placement	TBD, but minimal	Low	High	Low

4.2 Advantages and Disadvantages of the Models

In consultation with the City we have determined that three of these (items E, F, and G above) are the most feasible: the City build and leases a dark fiber middle-mile network; the City provides cash incentives; or the City expands wireless assets. The advantages and disadvantages of these three approaches is summarized below; as noted earlier, a combination of all three of these approaches may ultimately be required. A table outlining advantages and disadvantages of all eight approaches is provided as Appendix B.

1: Middle Mile Option: Under the model in which the City owns and operates fiber middle-mile (and a third party owns and operates last mile infrastructure and provides services), the advantages are that it requires a much smaller City investment than building a full FTTP network, the City does not have to provide service, and the City would own the middle-mile infrastructure.

But the disadvantages are that the providers' payment to access the dark middle mile fiber is unlikely to cover cost of debt service and operating costs of the middle mile fiber. The model may not attract ISPs, at least not everywhere in the City. And ISPs are likely to build only in selected neighborhoods (and not provide ubiquitous coverage), given the high cost of deploying FTTP in the western portions of the City. Finally, and homeowner contributions would still be required. The City would also need to register with the Missouri Public Service Commission.

2: Cash Incentive Option: Under the option where the City provides cash incentives, the advantages are that it might be a relatively low cost compared to the middle-mile option, may meet core objectives, and the City would not need to provide retail service. The disadvantages are the potential legal restrictions; the City would need to consult with an attorney on whether the City could contribute but not own the asset. The City would then be reliant on the ISP to follow through on when and where to build, though contract terms could reduce this disadvantage. And finally, there would be no direct recovery of the investment. We note that Spectrum (formerly Charter) provided a proposal to Wildwood based on this approach in 2011.

3: Expand Wireless Assets Option: Under the option in which the City expands its placement of poles and other assets for WISPs and seeks to streamline permitting and other processes for underground fiber placement, the advantages are that it minimizes City's financial requirements and the City would not have to provide retail services. However, the disadvantages are that it would have only a minimal impact on the availability of broadband in the western portion of the City and would be very unlikely to meet all availability and performance objectives.

5 Funding and Financing Strategies

A key consideration for any broadband network deployment is how to finance upfront capital construction costs. These costs represent a large expenditure that is generally slow to yield a return; the lack of a quick return on investment (ROI) sheds some light on why the private sector is not clamoring to upgrade existing legacy networks with fiber infrastructure, or to build new FTTP networks, in many parts of the country.

5.1 Options for Bonds and Other Loans

The City can seek bonding, or borrow funds, to cover construction costs both to construct a network and in consideration of likely operations and maintenance (O&M) costs. Public bonds may also factor into a public–private partnership; that is because, even with a partner, the City will likely be required to finance some portion of a fiber network, and especially if it opts to retain ownership and control of the network. Public entities that have good credit ratings and a low cost for bond financing are at an advantage and are attractive to potential partners.

While not every partnership will require the City to pursue bonding, all potential private partners will likely request some contribution from the community. One partnership structure that may be particularly desirable to the City entails the public sector owning and operating the infrastructure while a private partner either lights the fiber and offers retail services over it or leases dark fiber to support a targeted wireless deployment. In this scenario, the City would likely need to bond to fund construction of the network.

We discuss here some of the common types of bonds that public entities typically rely on for capital projects, and the advantages and disadvantages of each. Please note that the following is a summary, does not include every financing mechanism available, and does not offer any legal or tax advice.

5.1.1 General Obligation Bonds

General obligation bonds are directly tied to the public entity's credit rating and ability to tax its citizens. This type of bond is not tied to revenue from any specific project but is connected instead to communitywide taxes and revenues that can be used to repay this debt.

General obligation bonds can be politically challenging because they generally require a public approval process. These bonds are usually issued for projects that will clearly serve the needs of the entire community, such as roadway improvements. While it is our opinion that a fiber enterprise serving the public clearly meets this condition, incumbent opposition is likely. If seeking this type of financing, the City will need to develop a clear vision for its messaging to convey to the community that it intends for the fiber network to enhance the lives of all residents. A model that opens access to the fiber to multiple providers may support general obligation bonding because it would enable new and existing providers to offer new services and give consumers a choice and alternatives.

It may be especially helpful if the City can work within existing initiatives and with other public, quasi-public, and private institutions to demonstrate how the fiber network can effectively benefit the entire community.

5.1.2 Revenue Bonds

Revenue bonds are directly tied to a specific revenue source to secure the bond and guarantee repayment of the debt. For example, the revenue stream from a public entity's electric, natural gas, or water utility may be used to secure a revenue bond.

Theoretically, any service that generates some sort of revenue that could be used to repay debt might potentially be used to secure a revenue bond; publicly owned transportation services or hospitals are two examples. But while the revenues generated from owning a fiber optic network and leasing it to providers could ostensibly be used to guarantee a revenue bond, this is typically not an accepted practice within the bonding community. Municipal broadband projects without a proven revenue stream are usually viewed as high-risk in the bonding community, and the projected revenues from the network will likely be viewed as too uncertain to support repayment of the loan. Given this, revenue bonds secured with projected fiber revenue are not a strong candidate for financing a fiber network.

5.2 Potential for Grant Funding

This section briefly analyzes Wildwood's potential eligibility for a selection of broadband funding programs. We found that it is unlikely that Wildwood will be eligible for any current funding programs.

At this time, the State of Missouri doesn't offer any broadband grant opportunities that apply to Wildwood. In July of 2018, the state created a Broadband Development Office[11] with the intention of helping rural areas find federal sources of funding to address the lack of broadband. Additionally, the state legislature has created a grant program designed specifically to address rural broadband needs.[12] Final rules and funding for this effort likely won't be available in the

[11] Also referred to as the 'Office of Broadband.' This is a joint venture between the state Department of Agriculture and Department of Economic Development that is meant to "…help communities navigate federal programs to bring broadband networks where only expensive or low quality internet access exists." See https://news.stlpublicradio.org/post/new-state-office-seeks-bring-high-speed-internet-rural-missouri#stream/0 and See https://ded.mo.gov/content/department-names-broadband-director. Accessed April 2019.

[12] SS HCS HB 1872 – MISSOURI RURAL BROADBAND DEVELOPMENT. See https://house.mo.gov/billtracking/bills181/sumpdf/HB1872T.pdf

next year[13] and given the focus on rural areas, this program is not likely to be helpful to Wildwood.

In terms of federal funding opportunities, most are aimed at unserved and underserved areas or economically distressed areas—which essentially means Wildwood would not be eligible, because it is considered served by broadband (defined in this context as 10 Mbps download, 1 Mbps upload) and is not economically distressed. Our review of potential federal funding opportunities included the current ReConnect opportunity through U.S. Department of Agriculture (USDA), the Department of Commerce's Economic Development Administration (EDA) Public Works and Economic Adjustment programs, the FCC Universal Service Administrative Company (USAC) Schools and Libraries Program (commonly called E-rate) and Healthcare Connect Fund (HCF), as well as the USDA Community Connect program. We provide a brief overview of each below and discussion on eligibility. We note that additional smaller opportunities may emerge in any given year.

As noted above, the majority of funding programs aimed at providing financial support for broadband are designed for communities that are economically distressed and/or are located in areas where available broadband services are less than 10 Mbps download and 1 Mbps upload speeds (10/1 Mbps). Demographic criteria relating to unemployment, population density, and per capita income preclude Wildwood from receiving assistance from federal programs supporting broadband expansion[14]. Other funding options, such as USACs E-rate and HCF programs, require Wildwood to act as a service provider and bid against other service providers in a competitive process[15] in order to realize funding. This would, of course, require Wildwood to first become a service provider.

5.3 Wildwood Is Not Eligible for Most Broadband Funding Opportunities at This Time

In this section we summarize existing funding programs, for your reference. We note at the outset that Wildwood is not eligible for these programs.

[13] Missouri still looking to expand rural broadband access. See https://www.missourinet.com/2018/12/31/missouri-still-looking-to-expand-rural-broadband-access/. Accessed April 2019.

[14] We also looked at Form 477 data reported to the FCC by providers. While this data is not considered fully reliable by most, it does indicate that Wildwood in general has more than 1 provider offering services that meet or exceed minimum requirements (defined as speeds at least 10/1 Mbps).

[15] While state law prohibits municipalities, generally, from selling or leasing telecommunications services to the public, education and healthcare uses are exempted from such prohibitions. See http://www.baller.com/wp-content/uploads/BallerStokesLideStateBarriers3-1-19.pdf accessed April 2019.

5.3.1 USDA ReConnect

The Consolidated Appropriations Act of 2018 (known colloquially as "the Omnibus") earmarked $600 million for a grant and loan pilot program administered by the U.S. Department of Agriculture's (USDA) Rural Utility Service (RUS) to encourage broadband infrastructure deployment in rural areas with services that are less than 10/1 Mbps speeds.[16] In addition to a large amount of financial and technical information, the program requires that applicants propose projects within a defined service area (proposed funded service area or 'PFSA') that lacks sufficient access to 10/1 Mbps services, and is not considered a prior funded service area (such as a CAF II, RUS broadband loans, RUS BIP grants, or areas that are considered 'State-funded').

Wildwood is not sufficiently rural to qualify for the program.

5.3.2 USDA Community Connect

USDA Community Connect is a modestly sized highly-competitive grant[17] program for local and tribal governments that targets broadband deployment to unserved (defined as speeds less than 10/1 Mbps), low-income rural communities with fewer than 20,000 residents. Grantees must ultimately offer service at the broadband grant speed (defined as 25/3 Mbps) to *all* households and community institutions in the PFSA, with free service for at least two years to a community center.

Wildwood is not sufficiently rural in population size to be eligible for the program as the applicant[18].

5.3.3 Economic Development Administration

The Department of Commerce's Economic Development Administration (EDA) has provided economic assistance 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 programs[19] if they are able to show a defined economic

[16] "Secretary Perdue Applauds Broadband Investment Included in Omnibus," *USDA*, https://www.usda.gov/media/press-releases/2018/03/23/secretary-perdue-applauds-broadband-investment-included-omnibus, accessed August 2018.

[17] This program also offers loans.

[18] Census data indicates that between the year 2000 and 2010, population grew approximately 8%. Between 2010 and 2017, population estimates are essentially identical to 2010 numbers (roughly 35,517 people live in Wildwood, MO). See https://www.census.gov/data/tables/2017/demo/popest/total-cities-and-towns.html accessed April 2019.

[19] EDA also awards funding under a Disaster Supplemental grant program. See https://www.eda.gov/funding-opportunities/ for more detail. Accessed April 2019. These grants are given on a case-by-case basis and are usually reserved for extreme circumstances and unforeseen events. If the Wildwood were to experience such an event, it may be able to use EDA funding to restore the availability of services that were incapacitated—but it would not be able to use those funds to expand the availability of broadband.

benefit[20]. The program awards grants of up to $3 million (and requires a 50 percent cash or in-kind match). Basic eligibility requirements include demonstration of economic distress through official unemployment data showing 1 percent higher rates than the national average over the most recent 24-month period or per capita income that is 80 percent or less than the national average as reported by most recent data. There are additional 'special need' categories, such as the imminent closure of a business in the region that will directly affect jobs, or the significant outmigration of population; however, these categories often require additional and significant detail to qualify the proposed project as eligible[21].

We reviewed applicable unemployment data and per capital income data and determined that Wildwood would not be able to demonstrate the economic distress required to be eligible for funding through EDA as both datapoints outperformed national averages (local unemployment is lower than the national average; per capita income is higher than the required eligibility threshold). Finally, research did not indicate that there were any potential imminent employment closures or loss of population in the most recent 24 months or a trend in population loss over the last 20 years[22] that would indicate imminent economic distress. Wildwood is not currently eligible to apply for this support mechanism.

5.3.4 USAC – E-rate

The federal Schools and Libraries universal service support mechanism (known as "E-rate") is administered through the Universal Service Administrative Company (USAC) under the authority of the Federal Communications Commission (FCC). The E-rate program provides discounts to schools and libraries ("Customers") for telecommunications and internet access.

In simple terms, E-rate is a discount program that funds defined eligible services to schools and libraries based on a combination of (1) degree of rurality and (2) local participation in the free and reduced school lunch program. If a school's monthly bill for internet services is $100, and the school has a calculated discount of 70 percent, the school pays $30 and E-rate pays $70. Applicants (schools or libraries) can receive up to a 90 percent discount on eligible services.

Wildwood – unless it started offering better than 10 Gbps services over fiber for almost no cost – would not be able to compete with services the schools[23] in the immediate area are already receiving. A review of publicly available data from USAC for funding requests made by the

[20] Typically, EDA looks for defined metrics related to job growth, such as jobs saved or added as a direct result of the proposed project effecting the marketplace.
[21] Ibid.
[22] Census data indicates that between the year 2000 and 2010, population grew approximately 8%. Between 2010 and 2017, population estimates are essentially identical to 2010 numbers (roughly 35,517 people live in Wildwood, MO). See https://www.census.gov/data/tables/2017/demo/popest/total-cities-and-towns.html accessed April 2019.
[23] There are no library sites within the limits of Wildwood.

Rockwood School District for the next E-rate funding cycle shows that the schools are well served and are not over-paying, relative to similarly sized districts, for the services they receive[24] (all sites receive 1/1 Gbps WAN services or better from Charter).

5.3.5 USAC – Healthcare Connect Fund

The Healthcare Connect Fund (HCF) is also administered through the Universal Service Administrative Company (USAC) under the Wireline Competition Bureau of the FCC. USAC oversees this opportunity as well as E-rate, and the two application processes and programs have significant similarities.

The HCF provides a 65 percent subsidy for broadband service to eligible healthcare providers and facilities. While the focus is on serving rural facilities, teaching hospitals and urban/suburban facilities are eligible if they are part of an in-state consortium that includes rural facilities. Keep in mind that the HCF is intended to provide Health Care Providers (HCP) access to broadband services, particularly in rural areas, and to encourage the formation of state and regional broadband networks linking HCPs. While the program is intended to benefit rural providers, consortia of urban and rural providers may also participate, so long as the majority of the members of the consortia (at least 51 percent) are rural.

To participate in HCF and provide services to HCPs benefiting from the subsidy, Wildwood would have to compete against other providers bidding for contracts with those HCPs utilizing the HCF mechanism for funding. There also is little control of this process for a provider as it relies on the stated needs of HCPs and therefore, little ability to plan or strategize until an RFP has been issued by an HCP.

[24] The Rockwood School District enjoys a 40% discount on Category 1 and Category 2 services. The 2019-2020 Form 471 Funding request for WAN services to all sites in the district totaled approximately $221,000 before the 40% discount from E-rate (which is approximately $88,000). Rockwood will pay approximately $133,000 out of pocket for services that have a minimum connection of 1 Gbps to most sites. Form 471 data is publicly available through the USAC E-rate Productivity Center, which requires a login to access. Retrieved April 2019.

6 Middle Mile and Dark FTTP Financial Analysis

This section investigates the costs of owning and operating a middle mile fiber network and a dark FTTP network. The analysis includes necessary financing, capital additions, test equipment, and network operations and maintenance expenses. Our analysis illuminates the total cost to finance, deploy, maintain, and operate the network. The costs in this model are comprehensive, including labor, replacement of test and other equipment, and fiber maintenance costs for the lifetime of the model.

6.1 Middle Mile Cost of Ownership

The cost to deploy a fiber network goes far beyond fiber implementation. Network deployment requires maintenance and technical operations, support personnel, and other functions. The model assumes a straight-line depreciation of assets, and that the fiber will have a 20-year life span and the management software and test equipment will have a 5-year life. We have not included any costs associated with the electronics to light the fiber, as these costs in this model are the responsibility of the internet service provider (ISP) or other entity.

In addition to the $4.32 million in the middle fiber, we have included $80,000 in test equipment and fiber management system software.

The resulting cost of ownership of the middle mile fiber estimate is $434,300 per year, which consists of:

- Debt service payment (P&I) of $336,300 per year,
- Operating & maintenance expenses of $82,000 per year, and
- Depreciation reserve (for the replacement of test equipment and software every 5 years) of $16,000 per year

6.1.1 Operations and Maintenance Expenses

Operations and maintenance assumptions include:

- Locates and ticket processing are estimated at $40 per month per mile of underground fiber, resulting in $11,100 once the middle mile fiber is fully deployed.
- Insurance is estimated at $5,000 in year 1, then $10,000 in year 2 and beyond.
- Fiber maintenance and repair fees are estimated at $375 per year per fiber route mile.
- Legal and other support is estimated at $20,000 in year one only.
- Contingency is estimated at $5,000 in year 1, then $10,000 in year 2 and beyond.

- GIS support for record keeping is estimated at $5,700 per year.

With the exception of GIS support, expenses are inflated by 2 percent per year. GOS support expenses are inflated by 3 percent per year (GIS support is primarily labor, while others are a mix of labor and materials). The summary of the O&M costs is shown in Table 11.

Table 11: Middle Mile Fiber Network Operating and Maintenance (O&M) Expenses

Expense	Year 1	Year 3	Year 5	Year 10
Locates & Ticket Processing	$2,800	$11,550	$12,010	$13,260
Insurance (liability)	5,000	10,400	10,820	11,950
Fiber Maintenance (breaks and other)	21,700	45,260	47,080	51,980
Legal & Other Support	20,000	-	-	-
Contingency	5,000	10,400	10,820	11,950
GIS Support	5,700	6,100	6,400	7,500
Total O&M Expenses	$60,200	$83,710	$87,130	$96,640

6.1.2 Financing Costs

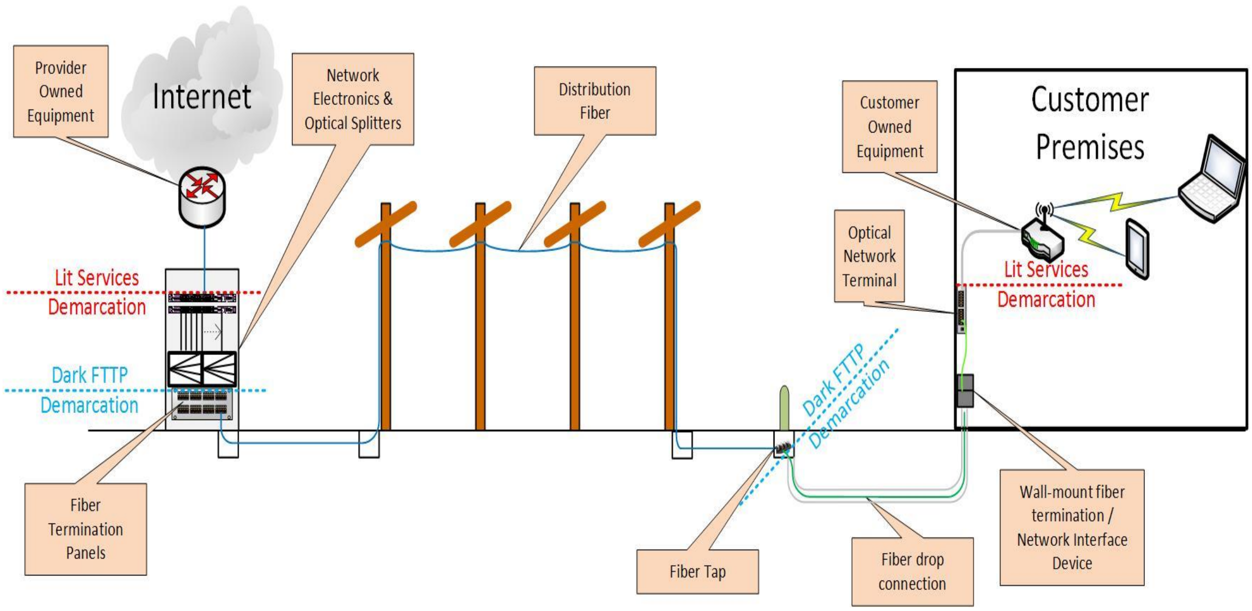
For the analysis we assume that the City will cover all its capital requirements with 20-year GO bonds totaling $4.42 million. We assume the bond rate will be 4 percent. The resulting principal and interest (P&I) payments will be the major factor in determining the City's long-term financial requirements.

We project that the bond issuance costs will be equal to 1 percent of the principal borrowed. For the bond, we assume neither a debt service nor interest reserve account are required. Principal repayment on the bonds will start in year two. This results in a year 1 interest payment of $176,680 in year 1 and an and P&I payment of $336,300 starting in year 2.

6.2 Dark FTTP Cost of Ownership

In a dark FTTP model the City would deploy fiber infrastructure for lease to a private partner but would not deploy the fiber drop cable that connects the customer's premises to the FTTP network or add any electronics. The private partner would be responsible for constructing the fiber drop cables and providing network electronics and customer premises equipment (CPE) to offer retail services. Because this model is based on the agreement between Huntsville (Ala.) Utilities and its private partner, Google Fiber, we refer to it as the Huntsville model.

Figure 15: Demarcation Between City and Partner Network Elements (Huntsville Model)



It should be noted that fiber drop costs, network electronics and CPE are significant additional expenses.

6.3 Dark FTTP Cost of Ownership

The financial analysis summary presented in this section represents a minimum requirement for the City to obtain a break-even cash flow each year. We have provided a complete financial model in Excel format (Appendix C) that can be leveraged to show the impact of changing assumptions.

The dark FTTP model is summarized by:

- Initial investment of $29.01 million to pass all residents in the low-density area of Wildwood. The investment cost includes test equipment and fiber management software, and Includes 55 percent of the middle-mile network
- Initial bonding of $31.33 million over three years. We assume 20-year GO bonds at 4 percent. We project that the bond issuance costs will be equal to 1 percent of the principal borrowed. For the bond, we assume neither a debt service nor interest reserve account are required. Principal repayment on the bonds will start in after the year of issuance. This results in a P&I payment of $2.39 million
- Operating & maintenance expense are estimated at $450,000 per year 9see Appendix D for details)

- Maintain a depreciation reserve of $29,360 per year for replenishments of test equipment and fiber management software

This results in a required fee of $69 per month per passing in order to maintain positive cash flow.

In our modeling, we compared a similar FTTP deployment in the city of Huntsville, Ala. In its contract with Google Fiber, Huntsville Utilities negotiated a monthly per-passing fee of $7.50. We include this reference to demonstrate what pricing is attractive enough to incent partnership, the financial implications of that pricing, as well as what Huntsville pricing would look like in relation to network deployment costs for the City. If the City were to charge similar lease fees as those paid by Google in Huntsville, it will result in cumulative cash deficits of almost $48 million after 20 years.

As indicated above, the required fee in order to maintain positive cash flow is $69.00 per passing per month, 9.2 times than those paid by Google in Huntsville. It is also important to note that the $9 per month per passing is for 100 percent pf all home and does not include drop cost or services fees for households requesting service.

Appendix A: Cooperative Model

An example of a model in which an ISP forms a cooperative with a neighborhood is provided as separate document.

Appendix B: Advantages and Disadvantages of All Models

A full table describing the advantages and disadvantages of all models is provide as a separate document.

Appendix C: Middle Mile Financial Model

The full working model is supplied as a separate document.

Appendix D: Dark FTTP Financial Model

The full working model is supplied as a separate document.

Appendix E: Fiber Cost Estimate

The full working model is supplied as a separate document.