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The Business Case for Government Fiber Optics in Holly Springs

Prepared for the Town of Holly Springs, North Carolina
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1. Executive Summary

This report presents the business case for a public investment in a fiber optic network to serve the Town of Holly Springs, its local schools, and public safety, and potentially to enable the private sector to serve local businesses and residences.

This strategy is designed to further the Town's plans to use advanced communications infrastructure to provide world-class government services, promote economic development, and to ensure that broadband infrastructure in Holly Springs evolves over time to meet the needs of its residents, businesses, and public institutions.

In terms of its existing internal communications capabilities, the Town has been making do with what it can afford. A key goal of this project is to dramatically enhance the Town's internal communications, such that the government is no longer constrained by bandwidth. The Information Technology Department seeks to not only meet the Town's needs, but also to enable network-based innovation and efficiencies that are inconceivable in the existing environment. To that end, the IT Department has planned a range of initiatives, from providing wireless access in parks to security surveillance over video for certain Town facilities, to dramatically enhancing network resiliency through redundant connections and reducing the Town's risk in that regard (which is something that the Town cannot afford to do with leased services).

This report analyzes the costs and benefits of such a strategy, and provides recommendations with respect to various options to leverage the potential of fiber optic infrastructure, including:

1. Using the fiber optics to deliver better, more cost-effective services to Town agencies, including Police and Fire Departments

2. Expanding the fiber optics to connect County facilities, such as schools, within Holly Springs' Town limits, and enabling private sector providers to provide communications services over the Town's fiber that reaches schools

3. Expanding the fiber optics to come within reasonable distance of key businesses and residential neighborhoods, such that private sector providers can elect to lease Town fiber and build their own "last mile" facilities to directly connect businesses and residences

Methodology

This report was researched and prepared in early 2013 by CTC Technology & Energy (CTC). Over the course of the engagement, CTC performed the following general tasks:

1. Met with key public stakeholders, including representatives of many Town agencies, the County schools, and neighboring jurisdictions

2. Met or spoke with private stakeholders, including local businesses, interested entrepreneurs, communications service providers, and North Carolina's Research and Education Network, NCREN

3. Met with Town stakeholders overseeing this project to present data, solicit input, and answer questions

4. Developed a preliminary engineering and financial analysis of requirements for deploying a fiber optic network to connect Town facilities

5. Developed recommendations regarding how the Town can use its potential fiber to potentially stimulate or catalyze broadband investment in Holly Springs

6. Developed recommendations regarding opportunities for Holly Springs to make incremental strategic investments in expanding broadband infrastructure as a means of enabling expansion of private sector broadband offerings and competition

Recommendation

Based on the research and findings in this report, CTC recommends that the Town proceed with its fiber construction plans to serve Town facilities. In addition, we recommend that the Town consider an overall strategy that includes certain initiatives to leverage the initial investment to meet the needs of Holly Springs businesses, residents, and service providers.

A Town-owned fiber infrastructure is the most cost-effective approach for meeting internal Town networking needs in the long-term. CTC estimates that the approximate cost to construct a Town-owned fiber backbone network would be $1.3 to $1.5 million. *Based on the Town's assumptions regarding financing rates and terms, we conclude that the Town will pay approximately the same or less each quarter to build and operate the fiber than to continue leasing services.*

In the "worst case" scenario, we estimate that the Town's fiber investment would cost just slightly more than current leased services over a 10-year loan repayment period; this scenario is based on the assumptions that construction costs will trend toward the higher end of the expected range and that the replaced costs are for only the minimum leased services required to meet current needs (with no future increases in capacity provided to meet growing demands). The Holly Springs IT Department has determined the bare minimum of network connectivity that the Town will require in the coming years, and has received pricing for those services from a private provider. The quote was approximately $159,000 per year, not including commodity Internet bandwidth. (Of that amount, $28,800 was to serve the new Police Department building with a 1 Gbps connection.)

Even in this case, the quarterly expenses during the 10-year period of loan repayment are just slightly greater than the estimated $159,000 per year for current leased services and those anticipated for the new Police Department and Sports Complex. In fact, the aggregate expenditure for leased services exceeds that of constructing and operating the fiber network after approximately 13 years. For all other scenarios examined, the total cumulative expenditures for leased services exceed that of fiber construction during a 10-year loan repayment period—and in most cases, quarterly expenses anticipated for the Town's fiber network are less than the costs associated with leased services.

It is important to note that this analysis is conservatively based on current lease levels—which are guaranteed to grow. In contrast to leased circuits, Town-owned fiber can be upgraded to higher capacity at no increase in recurring costs.

In other words, the Town's fiber offers a mechanism to mitigate the risk that its future needs will exceed the capacity of services it can afford, and contain the associated exposure to price increases. The Town's fiber will offer capabilities that leased circuits cannot, and will do so at a known cost that will remain relatively constant; if the Town chooses to continue leasing circuits, it will likely pay higher annual prices *ad infinitum*, and be forced to continue making do with less-than-adequate connections.

Building Fiber Will Deliver Enormous Government Benefits to Holly Springs and Savings over Time

As a starting point for our financial analysis, we estimated that the cost to construct the Town's proposed fiber network—including the backbone rings, northern extranet connection (to MCNC), and eight primary and secondary Town sites—would range from about $1.3 million to $1.5 million. These costs encompass conservative assumptions relating to labor and materials. In addition to construction costs, the Town would incur financing costs over a 10-year repayment period and pay ongoing fiber maintenance costs.

On the other side of the return-on-investment (ROI) equation is the Town's cost for leased communications services.

We believe it to be highly likely that the Town will need to scale to at least 1 Gbps circuits for each facility within a few years at most, even if it must pay for more expensive leased circuits to achieve that level of connectivity. If the Town were to purchase from its existing provider 1 Gbps circuits to each of the Town facilities, including the planned Police Department and Sports Complex (not including the schools), the annual cost to the Town would be about $259,000, not including commodity Internet bandwidth. Assuming those costs, the Town's projected savings over leased services during the 10-year loan repayment period would be about $922,000 to $1.1 million.

Another way of understanding the ROI for the Town-owned and operated fiber is to consider that the fiber will be capable of connections far greater than 1 Gbps,[1] and to calculate what comparable services would cost if the Town were able to purchase them from an existing provider. As is discussed elsewhere in this report, the level of security and reliability that wholly owned fiber delivers cannot be purchased at any price from the existing private sector. (We note, for example, that over the past year, a network failure on the part of a private provider took out Internet service for the entire Raleigh-Durham metro area, even though there were supposedly redundant services.) But for sake of argument, we look simply at cost-based analysis, with the assumption that the services would be comparable, however unlikely that assumption.

We do not have potential vendor pricing for 10 Gbps and 20 Gbps circuits (i.e., connections that would be comparable to the circuits that the Town would be able to deploy immediately upon building its own fiber) because those services are rarely affordable, and thus pricing is virtually nonexistent. Based on our experience in other markets, we feel confident that if the Town were able to secure those kinds of services, it would pay at least $10,000 to $15,000 per month per site for 10 Gbps service. Based on that pricing, the Town's projected savings over leased services during the 10-year loan repayment period would be about $3.6 million to $3.8 million, if 10 Gbps service was provided to just two "core" network locations (Town Hall and the Police Department) and given the construction costs contemplated here.

The range of cost savings based on these data is summarized in the following table:

[1] The Town's fiber network can achieve 10 Gbps connectivity over a given link, for example, with an inexpensive electronics upgrade (roughly $10,000); if pricing trends continue, 40 Gbps and 100 Gbps will cost roughly the same in a matter of a few years.

Table 1: Estimated Range of 10-Year Cost Savings for Town Fiber Construction

Compared to varying levels of service purchased from private sector:	Cost savings assuming lower range of construction costs:	Cost savings assuming higher range of construction costs:
Bare minimum to meet existing Town needs	$44,617	($178,461)
1 Gbps to each facility (minimum short-term need)	$1,144,738	$921,660
10 Gbps to two facilities and 1 Gbps to others	$3,811,275	$3,588,197

We also note that the Town will spend an amount equivalent to the network construction costs over some number of years whether it continues to lease circuits or it constructs its own network. The exact ROI will be determined through a range of variables, including the amount of bandwidth that the Town might lease. *The question for the Town is only whether it spends the money upfront and achieves long-term ownership and cost savings, or it spends the money over time on leased circuits.*

Building Fiber Can Also Have Long-term Ancillary Benefits for Education and Economic Development

Building fiber will allow Holly Springs to enable world-class services to Town schools and libraries by leasing capacity on the Town's fiber to private providers who wish to compete to provide better communications services to the schools and libraries.

And leasing fiber to private sector companies can also enable Holly Springs to improve the quality and price of communications services to some of its businesses, by enabling companies to reach key Holly Springs employers over Town fiber and thereby offer competitive services.

As part of the Town's Priority 1 and Priority 2 construction plans, the Town's fiber will reach key locations where there are target markets of larger businesses that are of real interest to private providers. Our recommendation is that the Town, given the abundance of fiber it is installing, should lease dark fiber to providers that meet certain credit and performance requirements. Leasing on a non-discriminatory basis would enable providers to compete over the fiber—and would likely create some modest revenue for the Town.

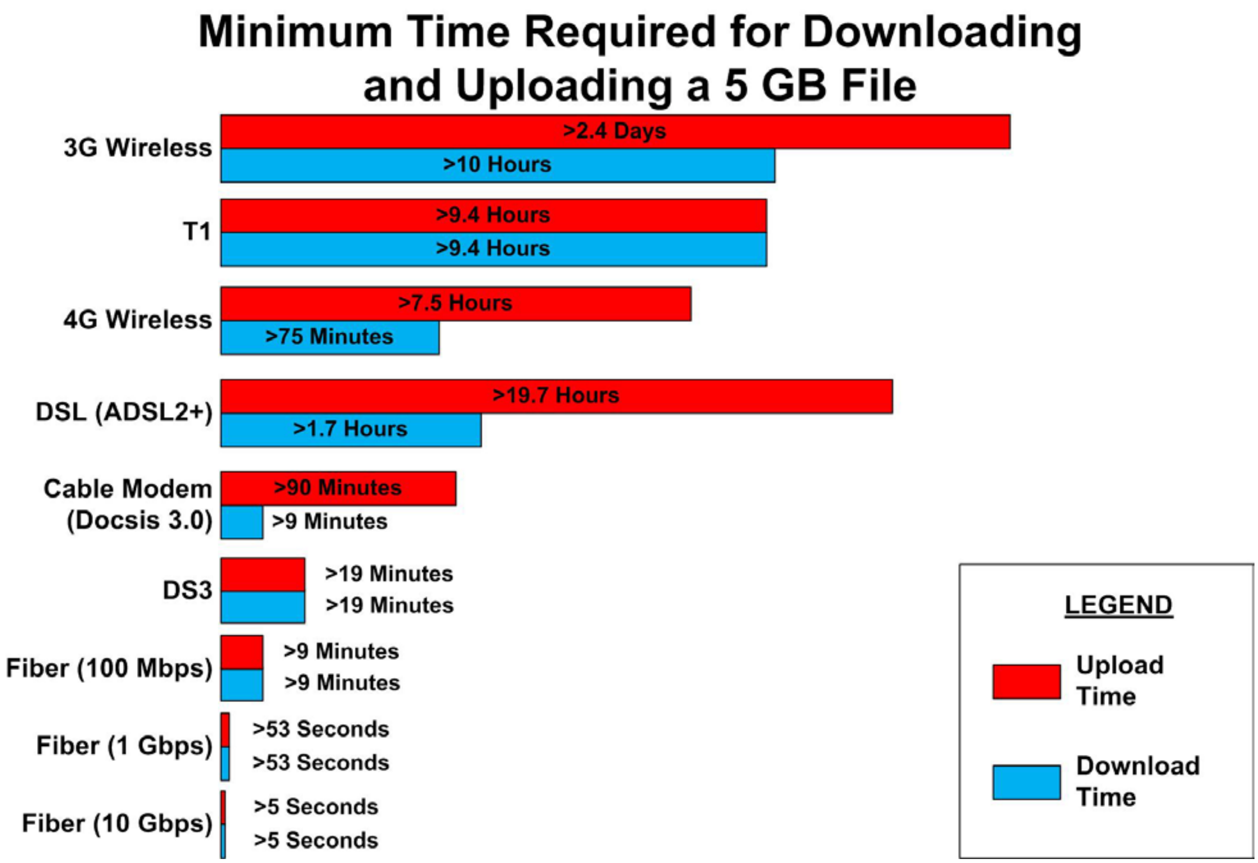
There is virtually no risk or cost to the Town in providing "dark" fiber in this way, and there is significant interest on the part of private providers to lease this fiber in order to better—and more competitively—serve the business and enterprise markets in Holly Springs.

Over time, Holly Springs' fiber network may serve as the basis for private investment in world-class broadband to all businesses and residences.

Fiber Is a Future-Proof Investment That Enables Enormous Growth and Innovation

The value of fiber for Holly Springs' public agencies is demonstrated by Figure 1 below, which illustrates the comparative upload (sending data up, to the Internet) and download (pulling data down, from the Internet) speeds of various technologies as they are typically offered today. Note that the faster speeds all require fiber optics and cannot be enabled over legacy technologies that are the usual last-mile medium of the phone and cable companies. In addition, it's important to note that, with fiber, the 10 Gbps speeds illustrated here represent a floor, not a ceiling, for fiber's ability to scale up—at modest—cost as the Town's needs increase. Put differently, it's highly likely (and not cost-prohibitive) that the Town could operate 20 Gbps and 100 Gbps circuits over its own fiber in the foreseeable future.

Figure 1: Comparative Speeds of Various Technologies



2. An Overview of Local Governments' Interests in Fiber Initiatives

Why Local Government Users Need Fiber

Reliable high-speed networks are critical to the changing needs of local governments, with a specific emphasis on law enforcement and public safety agencies. There are numerous applications for local officials to use in this area. In addition to the many wireless applications that can help emergency personnel cut precious seconds off of their response times, robust wireline networks play a critical role in public safety, due to their speed, bandwidth, and reliability. Criminal arraignments can be conducted using videoconferencing technologies, saving the government thousands and avoiding the dangerous task of transporting prisoners. Traffic systems, including signals wired with fiber optics, can be monitored and adjusted in real-time in response to events. Highway accidents, weather events, and other emergencies can be broadcast to thousands of users simultaneously through public alert systems via e-mail or text message. The improvement to efficiency in public safety created by high-speed network service is hard to overstate.

During large-scale regional emergencies, secure multi-party communications are often required, and wireless facilities may become overwhelmed and unusable. Many local jurisdictions nationwide have taken steps to address these needs. For example, the National Capital Region, comprising Washington, D.C. and the surrounding jurisdictions, built a fiber optic interoperability network known as NCRnet. Built for "security, reliability, and high bandwidth," NCRnet was created specifically to address the needs of first responders and emergency support personnel.[2] The high capacity and redundancy of the fiber network structure lends itself to reliable videoconferencing capacity, ensuring the ability for real-time coordination during a regional emergency.

The variety and scale of government applications demands the big bandwidth that fiber provides. As populations grow, institutional broadband needs will grow accordingly; and as data storage and applications move off of conventional hard drives and into the cloud, government institutions will become increasingly bandwidth hungry. These realities point to the need for future-proof institutional network infrastructure, which fiber provides.

Local Governments Have a 15-Year Success Record in Building and Operating Fiber for Government Use

Holly Springs' efforts to build fiber and conduit to meet public sector networking needs is part of a broader trend among local governments. Indeed, localities have exercised significant

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[2] http://www.broadband.gov/docs/ws_pshs/pshs_afflerbach_reference.pdf

leadership in broadband innovation in the United States. For more than 15 years, a significant minority of localities have chosen to build or purchase fiber for themselves.[3]

In this model, the locality negotiates, purchases, or constructs fiber optics to serve its own needs and those of its local community anchor institutions (CAIs)—connecting over fiber entities such as schools, libraries, public safety departments, and government buildings, and perhaps senior centers, public housing projects, or healthcare institutions. This is the model Holly Springs is contemplating.

Holly Springs is among many hundreds of communities that have implemented, or are considering, cautious fiber strategies. In North Carolina, these include Charlotte, Raleigh, Durham, Carrboro, and Chapel Hill. Outside North Carolina, these cities include San Antonio, New York City, Los Angeles, Seattle, San Francisco, Chicago, Washington, D.C., Boston, and hundreds of suburban and rural towns and counties.

We anticipate that this trend, which has continued unabated over the past decade and a half, is likely to continue into the future. The Broadband Technology Opportunities (BTOP) grant program under the federal Recovery Act has, in some parts of the country, accelerated this trend by enabling localities and regional consortia to build more fiber to public sector and other anchor institutions. And American communities are increasingly interested in this type of network to achieve self-reliance in communications.

[3] These internally focused projects contrast to those that are public-facing: networks built by public entities for the purpose of serving residential and business consumers where the private market has failed to deliver adequate service or has failed to deliver competition.

3. Building Fiber Will Deliver Enormous Government Benefits to Holly Springs

In almost any community, the local government is the largest user of broadband bandwidth, which has increasingly become essential to providing a range of public services and governing effectively. In Holly Springs, the Town's needs for bandwidth internally (connecting Town facilities to each other) and externally (connecting the Town to the Internet) have grown exponentially over the past few years, but the services (and prices) available have not met these needs.

In the sections that follow, we examine the potential return on investment (ROI) of the Town's proposed fiber network construction. We also explore why the Town's operations can benefit from fiber, and why the Town government is well-positioned to construct and operate the network.

The Cost Benefits of a Town-Owned Network

Comparing the cost between a leased service and a Town-owned and operated network is not trivial, as it requires making certain assumptions regarding future requirements and/or future costs of leased services. Fortunately, Town-owned infrastructure costs, including both hardware and physical fiber plant, remain relatively constant with respect to initial and ongoing expenses (though their capabilities increase with time).

What is also clear is that the cost of needed leased services will increase dramatically with time—because the Town's communications needs will grow dramatically (available connectivity options are not meeting even today's needs) and because there is little competition for such services.

The functional demands of public safety applications alone weigh strongly against the use of leased services, regardless of cost. Taking cost into account, however, a Town-owned fiber infrastructure is the most cost-effective approach for meeting internal Town networking needs in the long-term.

CTC estimates that the approximate cost to construct a Town-owned fiber backbone network would be $1.3 to $1.5 million. Assuming replacement of the Town's 2013 annual lease expenditures of $159,000, we estimate that the Town's fiber investment would cost about the same or less than its lease expenses in all but the worst-case scenario. (See the discussion and Table 3, below, for more details, including assumptions about financing and maintenance costs.)

It is important to note that this analysis is conservatively based on current lease levels and costs—which are guaranteed to grow. In contrast to leased circuits, Town-owned fiber can be upgraded to higher capacity at no increase in recurring costs. The Town's fiber offers capabilities that leased circuits cannot and enhances the Town's ability to innovate and grow with new applications. And, significantly, the Town's owned fiber does not entail recurring costs for capacity *ad infinitum* as do leased services.

Another way of understanding the value of Town-owned fiber is to compare its financed cost to the alternatives. Comparable functionality from leased services would cost far more than that amount. At least one carrier in the Holly Springs market may offer higher-end leased services to address capacity issues, but the lease costs are prohibitive. For example, in our experience, 10 Gbps circuits can range above $10,000 or $15,000 per month for each site.

The Functional and Technical Benefits of a Town-Owned Network

The majority of the Town's communications networking needs are currently met through leased circuits. This approach has some benefits: For example, it does not require internal staff to operate and maintain the network; its upfront costs are lower than constructing Town-owned fiber; and the time to deployment can be shorter. Leasing, however, has critical disadvantages that make it much less desirable than Town-owned and operated fiber, particularly with respect to public safety and emergency support services. Specifically:

- The Town does not have total control and management over the network
- The Town may not be able to evaluate the reliability or availability of a leased circuit because it has no knowledge of the private provider's proprietary network and its physical infrastructure
- Leased services are not independent of the networks used by the public and are therefore less secure and reliable
- The Town does not have control over network security between end points

Each of these items is addressed in detail below.

Town-Owned Fiber Facilitates Control and Management

A network built upon leased network services obtained from a service provider cannot provide the control and management that is available in a Town-owned and operated network.

Leased network services are in essence a "black box" in terms of control and management. The Town is forced to rely on the provider (usually the phone company) to maintain and operate the core equipment of a leased service (these tasks include configuring the equipment, monitoring the hardware and physical infrastructure, and performing routine maintenance).

Holly Springs' internal capacity requirements include video, voice, and data communications. Both voice and video services usually require dedicated bandwidth. Two-way voice and video services require dedicated bandwidth and very predictable transmission delay properties.

In other words, linking two-way radio communications systems or supporting videoconferencing over IP or using TDM connections requires the ability to manage bandwidth across the entire network. Although this functionality can be provisioned on the edge device when using a managed service provider for connectivity, if the Town owns and operates its own fiber network, it will have control and capability to increase bandwidth based on the Town's time frame (which will in turn allow the Town to properly plan for integration of new applications without an increase in cost for provisioning of new bandwidth). Further, it offers the ability to implement advanced Quality of Service mechanisms that are enforced on a network-wide, end-to-end basis.

Under the leased model, the Town must request (and pay for) the private company to make changes in the core of the network for a new application, increase bandwidth, or to implement new policies for enhanced Quality of Service.

Under the leased model, the Town is also not able to control who manages and maintains the core of the network. The knowledge, skill set, and security background of those operating the network is often beyond the control of the Town.

With a private fiber optic network, each piece of the communications network is controlled and managed by the Town. The Town may choose to operate the network on its own with its own staff, or it may outsource the operations to a contractor of its choosing. Either way, choices regarding the management of the network are in the hands of the Town—not the phone company.

Town-Owned Fiber Facilitates Availability and Reliability

The availability of a communications link is derived from the probability of a failure within the network between two points. In a leased circuit network, the end user is not aware of all of the potential risks to availability of the network. Several key factors that affect availability and cannot be determined by the Town include:

- Physical redundancy in the plant
- Physical redundancy in the building entrances
- Physical redundancy in the networking equipment

- Ensuring network equipment is properly configured and regularly tested to take advantage of hardware and link redundancy
- Redundancy for power and HVAC
- How many facilities the circuit crosses between endpoints
- Whether the plant is located underground or aerial
- Who has access to the core networking equipment and plant
- The core equipment's age and maintenance
- How the system is monitored and maintained
- The single points of failure in the communications link

Many of the factors can be approximated or relative numbers may be obtained from the leased circuit provider; however for critical government services such as public safety, the approximations and availability estimates from leased network services may not meet the availability requirements of a critical traffic network. In the case of physical architecture issues, such as the physical routes of cabling, approximations are not sufficient, and detailed maps are usually considered proprietary and confidential to a commercial provider.

In addition, lessees such as Holly Springs are subject to the lessor's schedule for repair and maintenance of the circuit. Although it may be possible to include provisions in the service level agreement (SLA) for special priority service restoration, it is possible that SLAs will not be adhered to during major disaster events. Further, there may be no way to ensure that a leased circuit for public safety is the first link to be repaired during a major disaster.

A similar problem can arise in both scheduled and unscheduled maintenance of a leased circuit. The timing of these maintenance downtimes may not correspond to available downtimes in a public safety network. In a Town-owned fiber network, maintenance downtimes can be coordinated to minimize downtime and the Town can prepare for an outage by adapting operational procedures.

SLAs often guarantee availability and repair time, but typically are not reliable in the event of a major disaster. In addition, service providers usually rely on cash rebates to compensate for network outages to the network—an unacceptable solution in the case of public safety, where cash cannot compensate for lost service.

Town-Owned Fiber Offers Independence from Public Networks

A privately owned communications network does not rely on physical infrastructure, equipment, or other resources that also carry public traffic for residents and businesses. Shared resources are used by a managed network service provider to reduce their cost by taking advantage of the statistical nature of communications traffic. In other words, commercial carriers intentionally oversubscribe their networks to minimize costs (maximize profits), because all of their customers are not likely (statistically speaking) to simultaneously use their services to full capacity all of the time. The advantage of an independent network is that increases in public traffic on the network or public network outages do not affect privately owned networks.

Additionally, the only way to ensure that there is adequate bandwidth is to overbuild a network to support maximum capacity demand, not average utilization (while absorbing the cost even if the bandwidth is not used). Some leased managed services will charge only for the bandwidth that is used—but capacity is limited. Typically, these services are only cost-effective when institutions have a specific understanding of their applications' bandwidth requirements. A Town-owned fiber network will provide a more reliable, higher capacity, flexible network infrastructure because it is designed to support a broad range of initiatives and to easily and seamlessly scale to meet new bandwidth requirements.

As is the case in many major public safety incidents, public networks such as the Public Switched Telephone Network (PSTN) and the Internet are often overloaded by the amount of traffic on the network. This can lead to busy signals on the PSTN and a lack of connectivity on the Internet. Privately owned networks typically do not experience the same traffic increases and can be designed to handle any expected traffic increase during a major incident.

Many public networks are in the planning and early implementation stages of providing priority and preemption capabilities for most managed service providers and will not be universally available, however in the event of a crisis, priority and preemption is critical for public safety networks.

A Town-owned fiber network can prioritize bandwidth both in the core and at the edge. This capability allows the Town to prioritize by location and to preempt all traffic other than public safety traffic, if necessary. More importantly, the Town-owned infrastructure can be allocated so that sensitive traffic always has dedicated capacity, because capacity can be readily scaled as needed for other applications.

Town-Owned Fiber Enables Control over Network Security

Implementation of network security on a leased circuit typically occurs at the edge of the network. Many leased networks use end-to-end encryption to securely transmit data over networks that share a core network with public users. Frequently, the provider of a leased circuit may dictate what types of end-to-end security are allowed on a leased circuit (IP managed services, for example).

On a Town-owned fiber network, the Town can control end-to-end security throughout the network infrastructure. The Town can offer layered that makes the network robust and secure.

In addition to data security, a Town-owned network allows the Town to manage physical security as well as network security. This includes:

- Access to facilities and networking rooms
- Passwords to edge equipment and firewalls
- Network access and authentication
- Monitoring of networking rooms, including security alarms, surveillance cameras, etc.
- Desktop security
- Equipment placement and provisioning

Additional Factors Accelerate ROI and Should Be Taken into Account

It is important to note that the return-on-investment (ROI) calculation presented below is the simplest way of evaluating investment payback. Per the Town's direction, we have focused solely on capital and operating expenses, and how long it would take to recoup them based on savings over the Town's likely spending on communications services. At the Town's request, we have not included potential fiber revenues in analyzing the return period for the fiber investment—though such revenue could dramatically improve the ROI over time.

In addition to these revenues, there is the truly hard-to-capture value that comes from having your own fiber, and no longer being restrained by scarce bandwidth. The Town would be able to meet its future needs as they emerge, and scale to greater speeds without needing to wait to be able to afford the additional bandwidth. Fiber offers a mechanism to mitigate the risk that future demands will exceed the capacity of affordable services, and contain the associated exposure to unknown future costs.

Among the many things possible in this area are potentially reduced future operating expenses for the IT and other Town departments as the result of the internal services enabled by a fiber network (e.g., virtual desktop, reduced number of servers managed centrally). These core efficiencies are difficult to quantify before the fact, at least without detailed analysis of the specific system migration plans and staffing costs, but are almost certain to emerge, and should be taken into account when considering the dramatic benefits that the new fiber will bring.

The Town's proposed fiber construction also includes both direct and redundant connections to MCNC, which is one of the premier research and education (R&E) networks in the country. These connections will provide at least two immediate forms of savings:

First, they will create options for dramatically reduced per-megabit pricing for Internet bandwidth relative to the Town's current expenditures; indeed, we anticipate an immediate per unit reduction in commodity Internet bandwidth of 70 percent to 80 percent. In the current lease scenario, the IT Department feels it cannot afford to purchase more than 50 Mbps of commodity Internet bandwidth. In an environment in which the Town owns its own fiber, however, the Town could get five to 20 times that amount of commodity Internet bandwidth for a relatively modest 30 percent increase in price—going from approximately $2,600 per month to $3,400 per month, and going from 50 Mbps under the lease pricing to 250 Mbps, burstable to 1 Gbps, in the new scenario.

Second, the connections to MCNC will provide high-bandwidth options for connecting to other communities over MCNC's state-of-the-art fiber network. Current connectivity with Wake County, for example, is supported over a relatively low-speed cable modem connection. That connection supports public safety applications, including access to the County's Sungard OSSI multi-jurisdictional public safety information sharing platform hosted by the County Sheriff's Office. The limited capacity of this connection led to the placement of a local server at Town Hall by the Wake County Sheriff's Office. While resolving the immediate need, a broader opportunity is missed due to lack of capacity, as the County would be able to leverage this server for regional redundancy if the link capacity were sufficient.

Notably, too, Raleigh is one of the many jurisdictions in the metro area that is currently building fiber to connect government facilities. (The others include Carrboro, Chapel Hill, and Durham.)

These additional factors—all of which involve efficiencies, savings, or revenues—should be considered in assessing the viability of a fiber project, in addition to a simple ROI calculation.

Fiber Network Cost Estimates Based on a Design Targeting Town Priorities

CTC worked with the Town's IT personnel to determine design priorities and develop a physical topology for the construction of a fiber optic network—primarily to serve as a basis for business case analysis calculations, but also as a key first step toward more detailed design efforts should the Town proceed with the construction.

The Town's objectives for a fiber network, as developed with Town staff and reflected by the resulting preliminary design, are listed as follows, approximately in order of priority:

1) Provide fiber connectivity to the Town facilities with the highest bandwidth connectivity needs to allow for the greatest reduction in leased service costs;

2) Provide connectivity to outside networks and Internet providers, including MCNC, to enable access to more cost-effective, higher speed Internet connections and for interconnection with regional governmental partners;

3) Maximize network resiliency for these same key Town facilities;

4) Provide connectivity to all other Town facilities for which leased service fees can be avoided;

5) Maximize opportunities to allow fiber construction to support economic development and potential fiber lease opportunities by optimizing routing to pass by or within close proximity to large businesses, business parks, and known commercial service provider points of presence; and

6) Provide connectivity to other non-commercial/government partner facilities, including the schools located within the Town.

The resulting network architecture, illustrated in Figure 2 and Appendix A, is comprised of several subparts, each addressing one or more of the stated objectives.

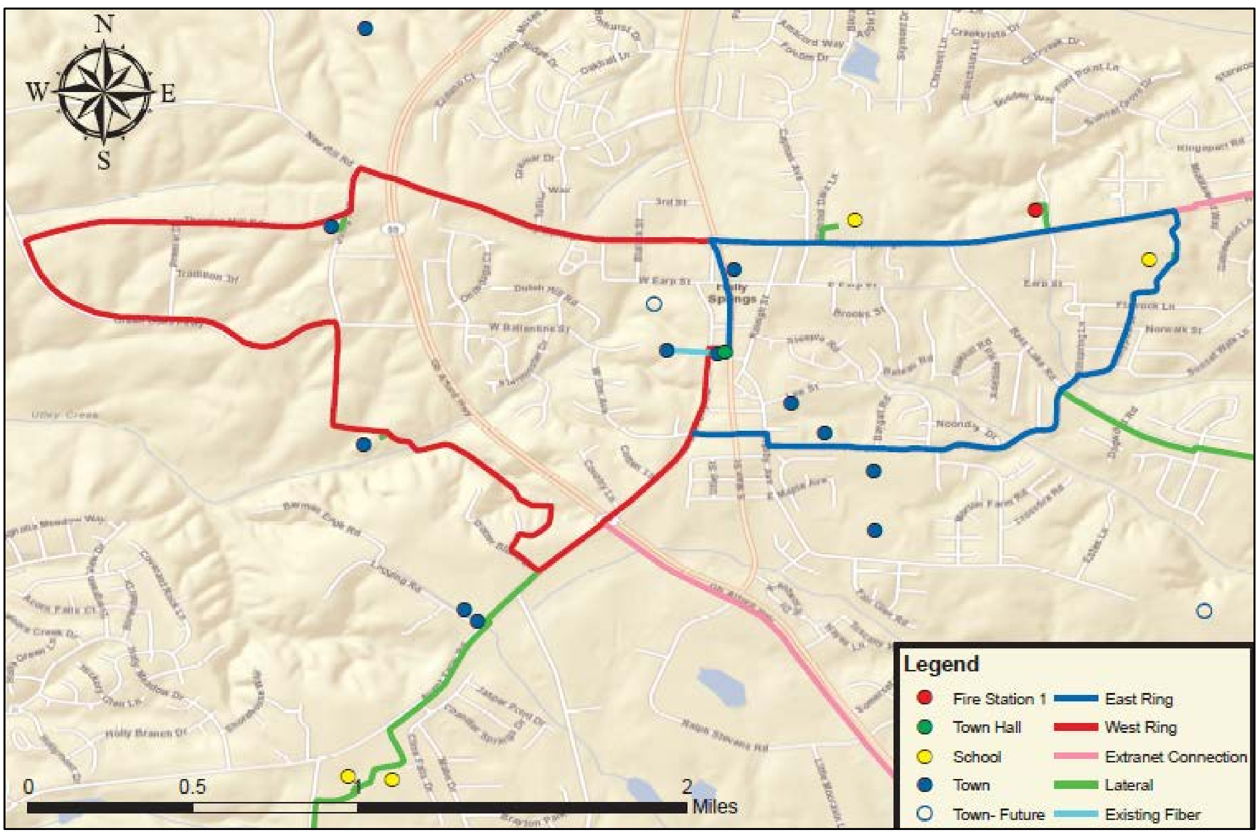
The East Ring and West Ring form a diversely routed backbone interconnecting all of the Town's high-priority sites: Town Hall, Fire Station 1, Public Works, Hunt Center, Wastewater Treatment Plant, and the future Police Department site. Both rings converge at Town Hall, and enable diverse backbone paths between the Town's high-priority sites.

This path diversity between sites allows the Town to activate connections with redundant electronics capable of maintaining connectivity even in the event a single path is disrupted due to a fiber break, effectively allowing the Town to support critical network services requiring upwards of 99.999-percent network availability (five minutes of outage or less per year), or better. This gold standard for network availability is only achievable with physical diversity of connectivity, because a single fiber break can require between several hours and several days to repair, and is commonly a requirement for communications supporting public safety services.

In addition to providing diverse connectivity to Public Works and the Wastewater Treatment Plant, the West Ring runs adjacent to the southern edge of the New Hill Shopping Center, and provides diverse routing past Novartis and the surrounding business park (along Thomas Mill Road and Green Oaks Parkway). This route diversity may allow for commercial carriers to leverage Town fiber to offer high-availability services over redundant links to the businesses in this area. This is likely a requirement for Novartis in its capacity as a critical federal infrastructure in the public health sector; it may also be a high priority for many businesses (either already in this area or that are seeking to locate in Holly Springs) for which Internet connectivity supports time-sensitive, revenue generating activities.

Lateral routes from this backbone provide connectivity to secondary Town sites, as well as five School facilities. Additionally, two distinct routes to external network points-of-presence (including MCNC) are provided both to the north (along Ten-Ten Road) and south (in the Fuquay-Varina area) of the Town.

Figure 2: Candidate Fiber Network Physical Topology



Other design and construction attributes impacting the cost estimate include the following:

- ***Fiber strand count*** – The number of individual fiber strands provided in a single cable correlates to the capacity of the cable. Due to the vast effective bandwidth of fiber, it is feasible to scale the rate of data transmission carried by even a single fiber strand to meet all of the Town's needs indefinitely; however, the cost of network electronics increases exponentially with this capacity. Given that, the material cost of fiber strands represents a very minor component of the overall cost of fiber construction (about $0.01 per strand per foot, compared to $15 to $20 per foot for the total cost of typical construction); it is thus prudent to install a cable of sufficient size to meet any conceivable requirements to ensure these needs can be met with electronics configurations that are as low-cost as possible. In fact, with sufficient fiber strands, the Town can increase network capacity many orders of magnitude above current levels with little or no change to its network electronics. While we anticipate no portion of the network requiring more than a few dozen strands, cost estimates are based on the installation of a 288-count cable in all portions of the network. This will ensure sufficient capacity for nearly any conceivable expansion of Town needs, fiber leasing, or even future support of business or residential services.

- ***Conduit size and quantity*** – The network design anticipates completely underground construction of the fiber in conduit. While it is possible to install fiber cable directly underground, this complicates installation and makes repairs difficult to implement without creating permanent impairments to the communications path. Instead, the cost estimates are based on the installation of flexible plastic conduit that provides a path into which fiber cable can be installed, allowing for cable slack to be pulled to accommodate repairs, or for new cable to be installed to expand capacity. The vast majority of the construction cost is due to this underground conduit placement, and within limits, adding additional conduit increases costs only marginally, primarily for the incremental material. As such, the cost estimates are based on the installation of two 1.25-inch or 2-inch conduits, which will provide a primary path for Town purposes, as well as: 1) spare capacity for leasing conduit space in the future, 2) a secondary conduit for more quickly effecting repairs that require large segments of cable to be replaced; and 3) to facilitate more cost-effective and less time-consuming addition of new lateral connections to the backbone by providing a parallel path for pulling cable along existing fiber paths to existing splice enclosures. Depending on material prices, 2-inch conduit is preferable along backbone routes, as it can accommodate one or more additional large-strand-count fiber cables in each.

- ***Handhole placement and size*** – Handholes are enclosures installed underground in which conduit terminates for the purpose of providing access to conduit for installing cable, as well as to house cable splice enclosures and cable slack loops required for future repairs. Handholes generally must be placed at intersections of multiple conduit paths, or where the conduit path makes a sharp change in direction. Handholes provide important access points to underground conduit infrastructure, enabling expansion of the conduit infrastructure (i.e., installation of a lateral connection to a new network location) without disrupting conduit or installed cables. While cable can be pulled upwards of several thousand feet at a time, cost estimates for the Town network assume installation of handholes every 600 to 700 feet on average, ensuring that the infrastructure supports cost-effective expansion to new sites, including access to Town businesses that might be targets of commercial network operators seeking to lease Town fiber (or conduit space).

- ***Rights-of-way restoration and fees*** – The network cost estimates assume that the Town will pay no encroachment fees for construction along State roads or for boring under the State bypass. In addition, and more significantly in terms of cost savings, the estimates assume that the Town's Public Works Department will perform all asphalt and concrete restoration, even if a third-party contractor conducts the utility test pitting for the network. While we have not evaluated the capacity of existing Public Works staff to handle this workload, we calculate that by leveraging its own resources for this work, the Town might reduce its construction costs by about 10 percent.

The network design targets four main divisions of defined priorities, potentially representing different construction phases in the event the construction is implemented in a phased approach. These phases and their corresponding construction cost estimate ranges are summarized in Table 2. A total of seven Town sites are encompassed by Priority 1 and Priority 2, not including the future Police Department site that is situated along the East Ring. The lower and upper range cost estimates vary primarily based on the anticipated labor and material costs, and should reflect the range within which most bid pricing could be expected for turnkey fiber construction.

Table 2: Summary of Network Construction Costs by Phase

Phase / Priority Level	Lower-end Construction Cost Estimate	Upper-end Construction Cost Estimate	Scope Summary
1	$1,183,000	$1,363,615	East and West backbone rings, interconnection to primary Town sites, and northern extranet connection (MCNC and Level 3 connectivity)
2	$120,330	$137,787	Adds secondary Town sites
Priority 1 and 2 Subtotal*	**$1,303,330**	**$1,501,403**	
3	$140,419	$159,449	Adds School sites
4	$425,242	$487,877	Adds southern extranet connection
Total*	**$1,868,992**	**$2,148,729**	

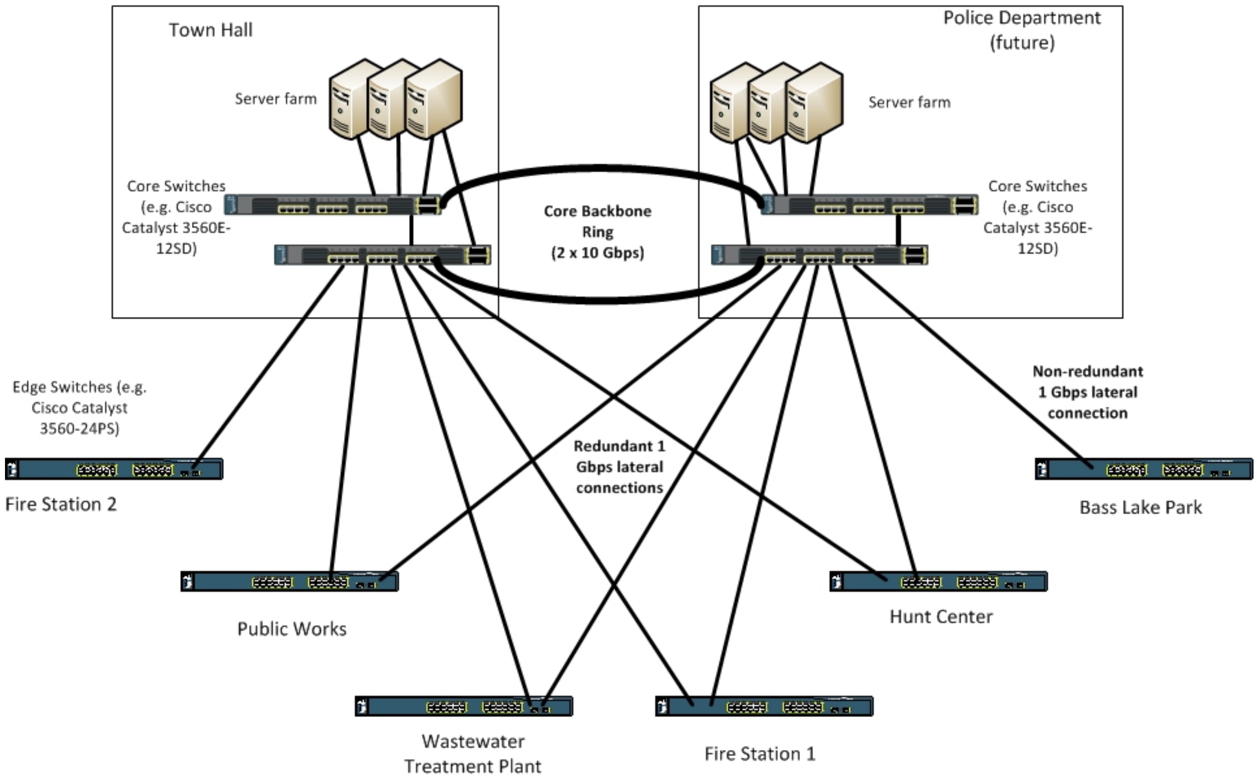
*Note: Totals may not sum properly due to rounding.

We note that the above cost estimates represent relatively conservative estimates assuming most, if not all, labor, services, and material are contracted and provided on a turnkey basis.

A wide range of logical topologies are feasible given the physical architecture of the proposed network. Depending on splicing configurations, connections can be established with or without route diversity over backbone rings, and provide dedicated paths between any sites without the need for “patching” between intermediate sites. The cost estimates are based on a flexible approach to splicing and fiber termination, providing a minimum of 24 strands spliced to provide a contiguous backbone ring between core locations (e.g., Town Hall and Fire Station 1 and/or the new Police Department), as well as a minimum of six strands from each other site to each of the two core sites leveraging diverse paths to the degree possible.

An example of one candidate logical topology facilitated by this proposed architecture is illustrated in Figure 3 based on the use of existing or comparable network equipment with little or no modular upgrades to support use of the fiber architecture.

Figure 3: Example Logical Topology of Network Connectivity



Building and Operating Holly Springs' Fiber Network Will Cost About the Same or Less than Leased Services

Based on our cost estimates and the engineering data and financing assumptions provided by the Town, there exists a strong business case for a public investment in a fiber optic network to serve the government of the Town of Holly Springs.

In our analysis, building and operating the Priority 1 and Priority 2 fiber[4] (connecting the Town facilities and building in additional capacity for economic development) will cost approximately the same or less each quarter than leasing comparable or less-capable services. The actual results will depend on the interplay of two primary factors:

1. The first factor is the actual cost of construction. As discussed, we present here two construction cost scenarios, one at the low end of what we believe is likely, and one

[4] For purposes of our calculations, we labeled the backbone rings and eight primary and secondary Town sites as "Priority 1" and "Priority 2" (which, combined, deliver connectivity to the Internet, connect the key sites, and provide for economic development growth over time), the five schools as "Priority 3," and the southern extranet connection as "Priority 4."

at the high end. These costs encompass a range of conservative assumptions relating to labor and materials.

a. At the low end, we assume total construction costs for the Priority 1 and Priority 2 sites to be $1,303,330.

b. At the high end, we assume total construction costs for the Priority 1 and Priority 2 sites to be $1,501,403.[5]

2. The second factor to be considered in calculating ROI is the savings that will be realized once the Town has its own fiber and need no longer pay for services from a private sector company. In this area, we present three scenarios for savings:[6]

   a. Savings over the bare minimum services that the Town is likely to need to support its functions in the next few years. This number— approximately $159,000 per year—assumes the minimum circuits that the IT Department believes will enable basic functionality in the near term.

   b. Savings over the services that we believe the Town is likely to require within two to three years. Assuming 1 Gbps service among Town facilities and based on list pricing, this would be about $259,000 per year.

   c. Savings over enhanced services comparable to what the Town can deliver over fiber and that would provide to Holly Springs the functional benefits and efficiencies described above. This number assumes 1 Gbps service among most Town facilities, enhanced by two 10 Gbps circuits for core sites. This would cost, based on our experience in other markets, about $502,000. (Pricing does not currently seem to be available in the Holly Springs market.)

On the cost side of the equation, we have also included estimated expenses for financing and maintenance. The Town's projected financing (10 years at 2 percent, with repayment beginning in the year following construction) adds about $118,000 to $136,000 to the total cost. We estimated annual fiber maintenance at $13,400, based on the size of the network.

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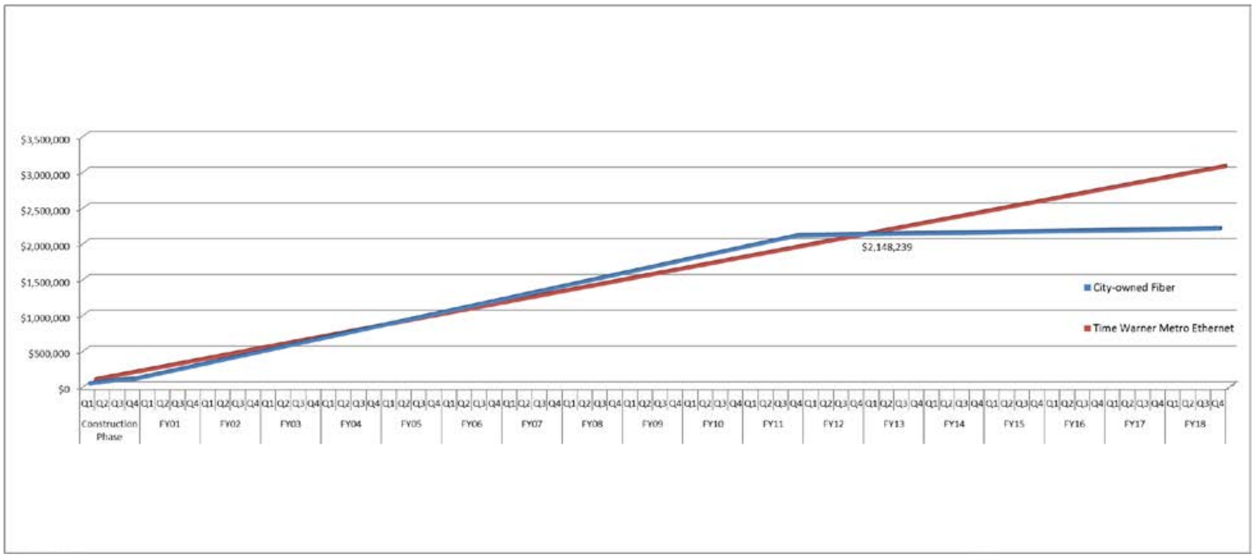
[5] These construction cost projections are based on preliminary site surveys conducted by the Town's contractor, Templar Inc., and provided to CTC. We note that these numbers have not been fully vetted, and that until engineering is undertaken, it is not possible to project a definitive number. For this reason, we have presented here a range of potential costs that lean toward the conservative side.

[6] In the first year of each scenario, we include $10,000 as an estimated Time Warner charge for constructing fiber to the new Police Department site. If the Town's fiber network were complete prior to the planned move-in date for the Police Department, this cost would be saved—though eliminating that amount would not materially impact the ROI period.

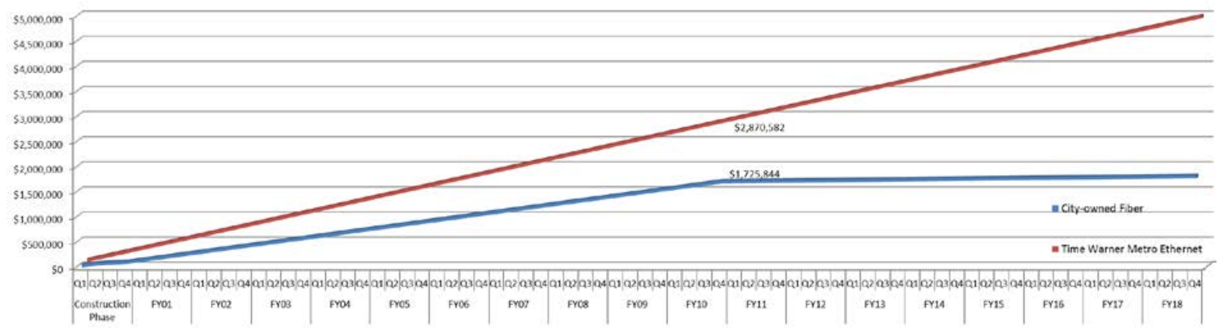
In only the worst-case scenario, assuming the high end of our construction cost estimates and replacing only bare-minimum services (rather than the full range of services the Town could use), would the cost of Town-owned and operated fiber exceed the cost of leased services—and then only for a relatively short period of time during loan repayment. Long term, after the loan repayment, the Town-owned fiber will cost less each quarter. This worst-case scenario is illustrated below, comparing cumulative costs for constructing and maintaining the fiber network to the cumulative costs of leased services.

Figure 4: Cumulative Payments, Fiber Construction (High Estimate) vs. Minimal Leased Services



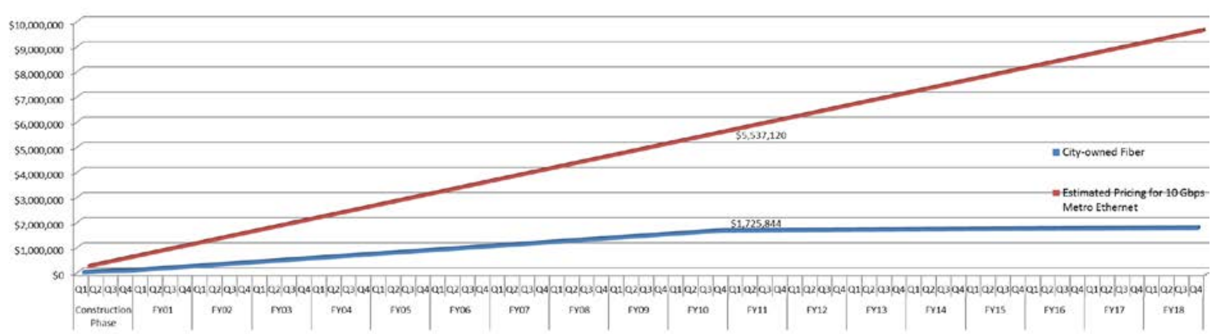
In all other scenarios, the Town's quarterly and cumulative costs for constructing and operating its own fiber are less than the costs for comparable leased services. In an alternative scenario, for example, we assume that the Town's spending on services would increase to approximately $259,000 per year to enable the Town to purchase gigabit services (which we believe is merited almost immediately). Based on the savings from that likely spending, and on low-end construction costs, the cumulative cost differential is an estimated $1.1 million by the end of year 10.

Figure 5: Cumulative Payments, Fiber Construction (Low Estimate) vs. Gigabit Services



We also determined cost savings for the fiber relative to the Town purchasing all the capacity it needs (thus comparing "apples to apples"—Town-owned fiber to comparably capable leased services). Assuming the Town will need at least two 10 Gbps circuits, which we believe will be required to achieve the kinds of efficiencies that it would like to deliver to all government users (i.e., highly capable, efficient, cost-saving applications like server virtualization), the cost savings would reach an estimated $3.6 million to $3.8 million—and would increase as the Town adds more 10 Gbps circuits.

Figure 6: Cumulative Payments, Fiber Construction (Low Estimate) vs. 10 Gigabit Service[7]



[7] Estimated pricing for 10 Gbps is based on our experience in other markets; pricing does not currently seem to be available in the Holly Springs market.

The range of potential cost savings based on the data described above is summarized in the following table:

Table 3: Estimated Range of 10-Year Cost Savings for Town Fiber Construction

Compared to varying levels of service purchased from private sector:	Cost savings assuming lower range of construction costs:	Cost savings assuming higher range of construction costs:
Bare minimum to meet existing Town needs	$44,617	($178,461)
1 Gbps to each facility (minimum short-term need)	$1,144,738	$921,660
10 Gbps to two facilities and 1 Gbps to others	$3,811,275	$3,588,197

In short, the Town's payback period is longer if it is willing to live with barely adequate service; the payback period accelerates dramatically as the Town takes advantage of available technologies and increases its capacity to a level that meets its needs.

4. Building Fiber Will Allow Holly Springs to Enable World-Class Services to Schools, Libraries, and Other Anchors as Appropriate

High capacity over fiber is crucial for community anchor institutions such as those in Holly Springs. Nationally, the need for bandwidth by community anchor institutions (CAI) such as public safety facilities, schools, libraries, and hospitals is growing dramatically and is fundamental to state and local interests. The Federal Communications Commission's (FCC) National Broadband Plan establishes as one of the nation's key goals that "[e]very community should have affordable access to at least 1 gigabit per second broadband service to anchor institutions such as schools, hospitals, and government buildings."[8] Such speeds are increasingly needed to support the growing demand for high-speed Internet access in education, public libraries, and medicine.

The section below discusses the strategy and cost under which Holly Springs can expand its fiber to enable service by the private sector to schools within the Town limits; the following section discusses the many applications that schools use (and will use in the future) that require higher bandwidth. We also include here a discussion of the broadband needs of libraries—a reflection both of the important role that libraries play as a provider of broadband connections in many communities, and that the Town could potentially build fiber to the county's Holly Springs Community Library branch, in the future, for a relatively low incremental cost.

The Vision and Cost for Providing Fiber to Schools

There are five public schools within the Town. These are county facilities, and the county pays for their communications services, but the parameters of this project included determining what it would entail to extend the Town's fiber there. Based on our network financial analysis, we estimate that it would cost the Town about $150,000 to $170,000 to connect the five school sites.

We have not recommended a specific business model, but we think it is safe to assume that the existence of new fiber connections to the schools would presumably open a better competitive market for the schools, and enable more providers to compete to provide service, to the benefit of the students at these schools.

Our assumption that private providers would be interested in leasing Town fiber to serve the schools is based on our experience in many other jurisdictions: The public school market is lucrative because it is so substantially subsidized by the federal E-rate program. Thus, Town dark fiber could be a mechanism for improving the service and prices available to schools.

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[8] National Broadband Plan: Connecting America, Goal 4.
http://www.broadband.gov/plan/goals-action-items.html

Why Schools Need Fiber

The U.S. Department of Commerce has found that schools require connections of 50 to 100 Mbps per 1,000 students.[9] Education technologists recommend even greater capacity; in an environment where students are bringing up to three devices each to school, some recommend that schools provide 300 to 600 Mbps *per classroom,* which delivers a few megabits per student to support video learning.[10]

The State Educational Technology Directors Association (SETDA) recommends that by the 2014–15 school year, each school have at least 100 Mbps Internet per 1,000 students and staff (service to the public *Internet*) and at least 1 Gbps for each 1,000 students and staff connecting the schools to each other and to their district building (*intranet* service).

These recommendations increase in the 2017–18 school year to 1 Gbps for every 1,000 students and teachers for an external connections and 10 Gbps for internal network connections, "in anticipation of future technologies not yet conceived:"[11]

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[9] Federal Communications Commission, Eighth Broadband Progress Report, In the Matter of Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act, August 14, 2012, GN Docket No. 11-121, at 133.

[10] Tanya Roscorla, "5 Ways to Prepare Schools for Bring Your Own Device," Center for Digital Education, December 10, 2012, http://www.centerdigitaled.com/news/5-Ways-to-Prepare-Schools-for-Bring-Your-Own-Device.html.

[11] Ian Quillen, "Bandwidth Demands Rise as Schools Move to Common Core," Education Week: Digital Directions, October 17, 2012, October 17, 2012, Vol. 6. at 19-20. http://www.edweek.org/dd/articles/2012/10/17/01bandwidth.h06.html.

Fox, *et al.,* 2012, "The Broadband Imperative: Recommendations to Address K–12 Education Infrastructure Needs," Washington D.C.: State Educational Technology Directors Association (SETDA). http://www.setda.org/c/document_library/get_file?folderId=353&name=DLFE-1515.pdf. S*ee also* Center for Digital Education, "Preparing for the Common Core State Standards: School districts face an opportunity to reinvest in network infrastructure," at 5. http://images.erepublic.com/documents/CDE12+STRATEGY+Comcast_V.pdf.

Table 4: Recommended Bandwidth for Schools

Broadband Access for Teaching, Learning and School Operations	2014-2015	2017-2018
An external Internet connection to the Internet Service Provider (ISP)	At least 100 Mbps per 100 students/ staff	At least 1 Gbps per 100 students/ staff
Internal wide area network (WAN) connections from the district to each school and among schools within the district	At least 1 Gbps per 1,000 students/ staff	At least 10 Gbps per 1,000 students/ staff

Source: State Educational Technology Directors Association

A significant number of the nation's schools suffer from inadequate Internet access. Insufficient bandwidth precludes creative and expansive online learning, such as video conferencing or collaborative work. Such schools are restricting classroom use of broadband applications like streaming video to preserve bandwidth. As the Benton Foundation explains:

> Distance learning over broadband is a distant dream. Online curricula is offline. Teachers are insufficiently trained to use technology in their classrooms, so that whatever technology is available to them languishes. Students are taught the basic 3 Rs, as required by the No Child Left Behind Act, but not the digital skills that will enable them to translate those 3 Rs into success in today's Information Age.[12]

"The content-rich world in which we live requires bandwidth to view it."[13] Yet, according to the 2008 America's Digital Schools report, 37 percent of school districts anticipate a problem obtaining sufficient bandwidth and the majority have already implemented policies to conserve bandwidth by limiting student Internet use.[14] Although a 2010 FCC survey of e-Rate funded schools found the majority of respondents had some level of Internet access, nearly 80 percent

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[12] Jonathan Rintels, "An Action Plan for America: Using Technology and Innovation to Address Our Nation's Critical Challenges," The Benton Foundation, 2008, at 20. http://www.benton.org/initiatives/broadband_benefits/action_plan.

[13] Edwin Wargo, "2008 Digital Schools Report and Bandwidth," *The Brute Thing*, May 16, 2008. http://edtecheconomics.blogspot.com/2008/05/ed-tech-trends-report.html.

[14] Meris Stansbury, "Researchers Identify Key Ed-Tech Trends," *eSchoolNews*, May 15, 2008. http://www.eschoolnews.com/2008/05/15/researchers-identify-key-ed-tech-trends/. (Summarizing Thomas W. Greaves and Jeanne Hayes, "America's Digital Schools Report 2008: The Six Trends to Watch.")

of respondents reported insufficient bandwidth for educational needs.[15] Despite these problems, Internet proficiency is assumed at the college level, leaving many children at an educational disadvantage. These problems will only grow as more schools adopt more bandwidth-intensive practices.

Electronic Textbooks

In no more than a few years more, hard-copy text books will cease to be printed in favor of electronic textbooks. This process is underway in Korea with a fixed deadline. The U.S. Federal Communications Commission (FCC) has challenged the private sector to enable this process by 2015.[16] At a recent conference, FCC Chairman Julius Genachowski urged the nation to "step up [its] efforts to realize the promise of this new technology in the U.S."[17] States around the country are seizing this challenge.

In September 2012, the California state Senate approved SB 1052 and SB 1053, requiring the University of California, the California State University, the California Community Colleges, and other private institutions to find or develop open education resources for students. The legislation is intended to reduce textbook costs for students, saving students at participating universities as much as $1,500 annually. The bills are currently awaiting consideration by the California State Assembly.[18] Such initiatives would not be possible without sufficient bandwidth to support online viewing.

Online Testing

A growing number of states are beginning to administer tests to their students online. SETDA reports that at least 33 states are already delivering at least one test via technology. Moreover, the Department of Education is advocating for a greater use of online testing

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[15] Fox, *et al.,* 2012, "The Broadband Imperative: Recommendations to Address K–12 Education Infrastructure Needs," Washington D.C.: State Educational Technology Directors Association (SETDA), at 2. http://www.setda.org/c/document_library/get_file?folderId=353&name=DLFE-1515.pdf.

[16] "FCC Chairman Genachowski Joins Secretary of Education Duncan to Unveil New 'Digital Textbook Playbook,' A Roadmap for Educators to Accelerate the Transition to Digital Textbooks," News Release, Federal Communications Commission. http://transition.fcc.gov/Daily_Releases/Daily_Business/2012/db0201/DOC-312244A1.pdf.

[17] Katie Ash, March 29, 2012, "U.S. Officials Tackle National Adoption of Digital Textbooks," *Education Week* (Blog), March 29, 2012. http://blogs.edweek.org/edweek/DigitalEducation/2012/03/fcc_lead_and_doe_discuss_digit.html.

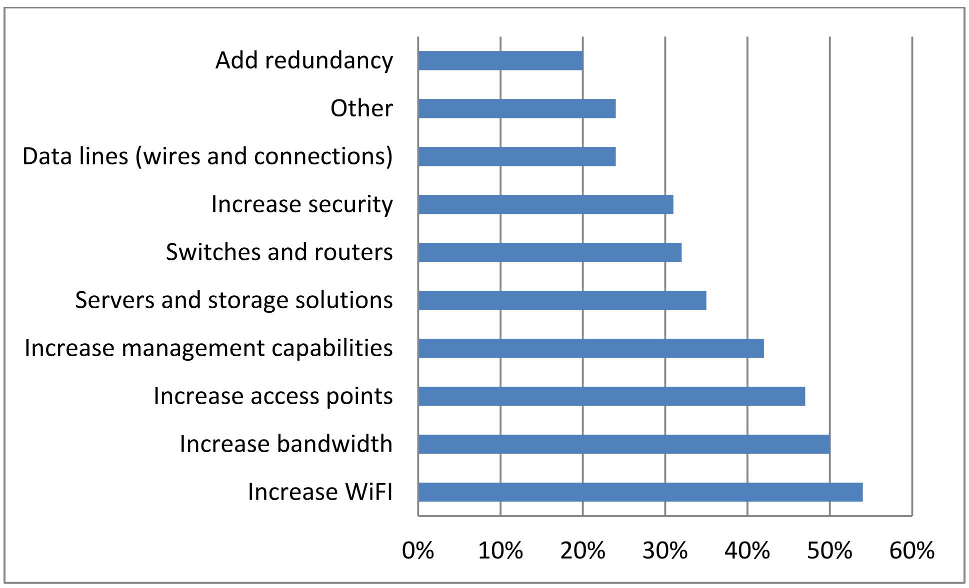
[18] Levon Massian, June 3, 2012, "State Senate Advances Bills that would Create Free Online Textbook Library," *The Daily Californian,* June 1, 2012. http://www.dailycal.org/2012/06/01/state-senate-advances-bills-that-would-create-free-online-textbook-library/.

through the Common Core State Standards initiative, which requires schools in 46 states and the District of Columbia to "administer 'next generation' assessments almost exclusively online."[19]

The new assessments for the "Smarter Balanced" and "Partnership for the Assessment of College and Career Readiness" (PARCC) consortia will be conducted electronically by 2014. Moreover, national guidelines require that once such online assessments are implemented, all students in a grade must take the tests (which will include high-definition videos and sound files) simultaneously,[20] leading to greater network traffic during testing.

In fact, the Center for Digital Education explains, "adherence to Common Core guidelines will force school districts across the nation to rethink the way they handle networking and computing in a number of mission-critical areas."[21] (See Figure 7.) Because digital testing entails large numbers of students working online simultaneously, it is a function that simply cannot be accommodated, even in a small school, over copper-based Internet access.

Figure 7: Networking Upgrades Needed for Online Assessments[22]



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[19] Ian Quillen, "Bandwidth Demands Rise as Schools Move to Common Core," Education Week: Digital Directions, October 17, 2012, Vol. 6. at 19-20. http://www.edweek.org/dd/articles/2012/10/17/01bandwidth.h06.html.

[20] Center for Digital Education, "Preparing for the Common Core State Standards: School districts face an opportunity to reinvest in network infrastructure," at 2. http://images.erepublic.com/documents/CDE12+STRATEGY+Comcast_V.pdf

[21] *Id.*

[22] Center for Digital Education, "Preparing for the Common Core State Standards: School districts face an opportunity to reinvest in network infrastructure," at 4 (http://images.erepublic.com/documents/CDE12+STRATEGY+Comcast_V.pdf)

One-to-One Computer Programs

American schools are migrating to one-to-one computer programs (also known as "ubiquitous computing"), whereby each student and teacher has one Internet-connected wireless computing device for use both in the classroom and at home. A 2006 survey found that 31 percent of superintendents are implementing ubiquitous computing in at least one grade, up from an historical average of 4 percent. Moreover, over 75 percent of superintendents recognized the potential benefits of one-to-one computing, agreeing with the statement that "ubiquitous technology can reduce the time, distance, and cost of delivering information directly to students and that teachers can spend substantially more one-on-one time with each student and personalize the education experience to each student's needs."[23]

By 2007, 78.7 percent of U.S. school districts reported moderate to significant improvement in one-to-one computing programs,[24] with potentially significant benefits for student learning. A 2006 report by America's Digital Schools found that one-to-one computing programs correlated with increased student retention and attendance, improved writing skills, and reduced disciplinary problems.[25] As Michael Davino, Superintendent of Schools in Springfield, New Jersey explains, "[a] wireless laptop program provides up-to-date information, access to virtual experiences, instant feedback, individualized attention for all learning styles, student independence, and constant practice. And it's highly adaptable to individual, small group, or whole class instruction."[26] To accommodate such programs, SETDA recommends that a school upgrade its network to a 50 Kbps/ student/staff broadband connection.[27]

Bring Your Own Device (BYOD) Initiatives

Schools are also launching "bring your own device" (BYOD) initiatives. While this leverages limited school infrastructure (by requiring students to provide their own), it raises a number of information technology challenges, including "information security and privacy, support costs, network capacity and bandwidth."[28] Of particular concern, BYOD initiatives are very bandwidth

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[23] "America's Digital Schools 2006: A Five-Year Forecast," The Greaves Group and The Hayes Connection, at 15, 18. http://www.ads2006.net/ads2006/pdf/ADS2006KF.pdf.

[24] Meris Stansbury, "Researchers Identify Key Ed-Tech Trends," eSchoolNews, May 15, 2008. http://www.eschoolnews.com/2008/05/15/researchers-identify-key-ed-tech-trends/.

[25] "America's Digital Schools 2006: A Five-Year Forecast," The Greaves Group and The Hayes Connection, at 15. http://www.ads2006.net/ads2006/pdf/ADS2006KF.pdf.

[26] *Id.* at 18.

[27] Fox, *et al.,* 2012, "The Broadband Imperative: Recommendations to Address K–12 Education Infrastructure Needs," Washington D.C.: State Educational Technology Directors Association (SETDA), at 4. http://www.setda.org/c/document_library/get_file?folderId=353&name=DLFE-1515.pdf.

[28] Bob Violino, Aug. 21, 2012, Community College Times, "BYOD: Bring your own devices to campus" (http://www.communitycollegetimes.com/Pages/Technology/BYOD-Bring-your-own-devices-to-campus.aspx).

intensive. A recent mobile learning report found that about half of high school students and 40 percent of middle school students have a smartphone or tablet. This represents a 400 percent increase from 2007.[29] Assuming similar growth over the next five years, student use of mobile devices will increase the demand on K–12 networks.

Bailey Mitchell, chief technology and information officer of Georgia's Forsyth County Schools, witnessed the impact of such growth on the school's network, explaining that the County did "not have adequate infrastructure to enable an environment where potentially every other or every student has a device." There, the number of devices increased from 10,000 to 19,000 in a single year. The growth exceeded network capacity and "student instruction was interrupted." This failure led to a three-fold expansion of network capacity (1.3 Gbps to the Internet and 2 Gbps to wide area networks). Mitchell explains, "We've been able to justify that expense because when the network blips, it's such an impact on instruction that it's absolutely unacceptable." He cautions that IT directors will need to anticipate such needs when students are allowed to use their devices throughout the day.[30]

Expanded Course Offerings

Many schools are using the Internet to expand course offerings. For instance, in Greenville, South Carolina, students are enrolling in an online Latin course taught by a teacher at another school in the district. Elsewhere, students can use the Internet to take higher level or better-quality courses than those available at their home schools.[31] The Greaves Group has found that many schools are even offering core courses over the Internet, with vocational technology (91 percent) leading, followed by science (78 percent) and social studies (76 percent). Online learning is often used for advanced-placement courses, including art and music (38 percent), math (35 percent), and science (31 percent), which may not have sufficient student enrollment to support a live course.[32] Online education enrollment has grown exponentially. In fact, the Innosight Institute reports that in 2000, roughly 45,000 K–12 students had taken an online course. By 2009, more than 3 million K–12 students had done so. Innosight

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[29] Tanya Roscorla, Dec. 10, 2012, "5 Ways to Prepare Schools for Bring Your Own Device," Center for Digital Education, December 10, 2012. http://www.centerdigitaled.com/news/5-Ways-to-Prepare-Schools-for-Bring-Your-Own-Device.html.

[30] Tanya Roscorla, "Bring Your Own Device Prompts School Infrastructure Investments," Center for Digital Education, March 13, 2012. http://www.centerdigitaled.com/classtech/BYOD-Forsyth-Infrastructure.html.

[31] Jonathan Rintels, "An Action Plan for America: Using Technology and Innovation to Address Our Nation's Critical Challenges," The Benton Foundation, 2008, at 21. http://www.benton.org/initiatives/broadband_benefits/action_plan.

[32] "America's Digital Schools 2006: A Five-Year Forecast," The Greaves Group and The Hayes Connection, at 19. http://www.ads2006.net/ads2006/pdf/ADS2006KF.pdf.

predicts that 50 percent of high school courses will be delivered partially online by 2019.[33] Beyond K–12, online learning is growing in favor because it saves students time and money.[34]

The Internet helps break down the walls of the classroom, allowing students to participate in virtual fieldtrips and better visualize their lessons. Students are going online and "touring the Smithsonian National Air and Space Museum, experiencing a tribal dance in Africa, or scouring the depths of the Pacific Ocean in a submarine." Users are exploring the digital archives at the Library of Congress and collaborating with students, professors and government officials in other states and around the world.[35] The State Educational Technology Directors Association envisions a classroom environment where "Internet-based educational technologies and practices" are fully "integrated into the curriculum." In such a scenario, students "access rich, multimedia-enhanced educational content from the Internet" on personal laptops, post both audio and video content to school learning management systems, access e-textbooks and assignments online, collaborate with other students both at their own school and around the world, participate in fieldtrips to distant locations, and complete online assessments. Such technology-rich experiences require greater bandwidth in the classrooms. In fact, SETDA asserts that this whole-curricula approach requires schools to provide a 100 Kbps per student/staff broadband connection.[36]

Benefits of Broadband Applications in Schools

Research by the International Society for Technology in Education and the Consortium for School Networking confirms that broadband applications in the schools have many benefits. In particular, technology has:

- Led to measurable improvements in school performance (as measured on the Adequate Yearly Progress Tests under the No Child Left Behind Act of 2001).

- Improved attendance, decreased dropout rates, increased graduation rates, and allowed increased parental involvement.

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[33] Michael Horn and Heather Staker, Jan. 2011, "The Rise of K–12 Blended Learning," Innosight Institute, January 27, 2011. http://www.innosightinstitute.org/education-blog/the-rise-of-k-12-blended-learning/

[34] Collette Boothe, "The Need for Data," Center for Digital Education, Jan. 8, 2009. http://www.centerdigitaled.com/edtech/The-Need-for-Data.html.

[35] Jonathan Rintels, "An Action Plan for America: Using Technology and Innovation to Address Our Nation's Critical Challenges," The Benton Foundation, 2008, at 21. http://www.benton.org/initiatives/broadband_benefits/action_plan.

[36] Fox, *et al.,* 2012, "The Broadband Imperative: Recommendations to Address K–12 Education Infrastructure Needs," Washington D.C.: State Educational Technology Directors Association (SETDA), at 4. http://www.setda.org/c/document_library/get_file?folderId=353&name=DLFE-1515.pdf.

- Improved school efficiency and productivity.
- Helped teachers satisfy professional requirements by helping develop lesson plans and providing continuing education opportunities.
- Enhanced students' problem-solving and independent-thinking skills.
- Enabled schools to meet the needs of special education children.
- Increased equity and access in education by creating learning opportunities for geographically isolated students.
- Improved workforce skills.[37]

Case studies bear out these benefits. For instance, elementary school students in the "Enhancing Missouri's Instructional Networked Teaching Strategies" (eMINTS) program consistently scored higher on standardized achievement tests than students who did not have access to the same technology. Participants' classrooms are equipped with a teacher's desktop computer and laptop computer, a scanner, a color printer, a digital camera, an interactive white board, a digital projector, and one computer for every two students. In New York, middle and high school students enrolled in the "Points of View media project" used broadband to access museums and historical collections, streaming video and video conferencing, and primary documents to explore the Theodore Roosevelt era. Seventy-five percent of program participants reported that they learned more than they would have from a traditional class.[38]

Why Libraries Need Fiber

In the libraries sector, TechSoup, a non-profit that provides technical assistance to libraries with the support of the Gates Foundation, notes that the amount of bandwidth required depends on the number of users and computers at a library facility.[39] As a TechSoup/Colorado

[37] "Why Technology in Schools?" Ed Tech Action Network. http://www.edtechactionnetwork.org/why-technology-in-schools.

[38] "Ed Tech and Student Achievement," Ed Tech Action Network. http://www.edtechactionnetwork.org/student_achieve.html.

[39] "Bandwidth Management," TechSoup for Libraries. http://www.techsoupforlibraries.org/planning-for-success/networking-and-security/bandwidth-management; see also Kieran Hixon, "Broadband Basics for Public Libraries," TechSoup and Colorado State Library, Presentation, January 15, 2013, http://www.techsoupforlibraries.org/blog/broadband-basics-webinar-follow-up; http://ipac.umd.edu/survey/analysis/broadband-public-libaries; http://plinternetsurvey.org/sites/default/files/publications/BroadbandBrief2012.pdf; http://www.webjunction.org/documents/illinois/Broadband_Calculator.html (a broadband bandwidth calculator for libraries that uses speed of website loading as a guide to bandwidth needs).

State Library graphic illustrates (see below), a T-1 used by three library patrons simultaneously will enable website loading in five seconds and a book download in 15 seconds.[40] While not optimal, these speeds may be acceptable. Times will multiply, however, as the number of simultaneous users multiply. As a result, a library serving 30 simultaneous users would require at least 45 Mbps to enable website loading in five seconds and a book download in 15 seconds. Video applications will require three times that bandwidth.

Figure 8: Download Speeds for Libraries[41]

Download Speeds

Internet Connection Speed by Mbps based on 1 computer connected	www Website (320 KB)	Book (1 MB)	Song (4 MB)	Movie (6 GB)
>50	.003 seconds	.01 seconds	.03 seconds	8 minutes
25-50	.06 seconds	.2 seconds	.6 seconds	16 minutes
10-24	.09 seconds	.3 seconds	1.3 seconds	33 minutes
6-9	.3 seconds	.8 seconds	3.2 seconds	1.5 hours
3-5	.4 seconds	1.3 seconds	5.3 seconds	2.25 hours
1.5-2	.8 seconds	2.7 seconds	10.7 seconds	4.5 hours
<1.5	3.2 seconds	10.4 seconds	41.7 seconds	9 hours

However
The more computers per connection, the slower that connection becomes:

	www Website (320 KB)	Book (1 MB)	Song (4 MB)	Movie (6 GB)
3 computers* on one T1 (1.544 Mbps) = 512 Kbps	5 seconds	15 seconds	1 minute	26 hours
12 computers* on one T1 (1.544 Mbps) = 128 Kbps	20 seconds	1 minute	4 minutes & 10 seconds	106 hours
30 computers* on one T1 (1.544 Mbps) = 56 Kbps	45 seconds	2 minutes & 22 seconds	9 minutes & 31 seconds	244 hours

*For connection purposes, a computer includes desktops, laptops, tablets, and all devices on the connection via wired or wireless access.

For more information: www.broadbandmap.gov

Source: TechSoup / Colorado State Library

[40] "Bandwidth Management," TechSoup for Libraries. http://www.techsoupforlibraries.org/planning-for-success/networking-and-security/bandwidth-management.

[41] Kieran Hixon, "Broadband Basics for Public Libraries," TechSoup and Colorado State Library, Presentation, January 15, 2013. http://www.techsoupforlibraries.org/blog/broadband-basics-webinar-follow-up

Libraries have long served as "a premier Internet access provider in the continually evolving online culture."[42] In fact, a 2008 study found public libraries provided the only free Internet access in 72.5 percent of U.S. communities nationwide. This number rose to 82 percent in rural communities.[43] A 2012 study reaffirms the role of libraries as the sole public provider of free Internet access in the majority (64.5 percent) of American communities.[44]

Public libraries serve a variety of functions. They offer desktop workstations for Internet use, technical training, and access to locally relevant content. Public library Internet access is used for an array of reasons—job seeking, educational research, travelers looking to keep in touch with their families, and emergency information. Libraries play a key role in providing access, assistance and training through e-government sites and services. Public libraries also provide a safety net during disasters when Internet access may be limited elsewhere.[45] In light of this wide array of services, "the role of the public library as a stable Internet provider cannot be overestimated."[46]

Public libraries, however, are facing significant capacity constraints. Bandwidth requirements are growing as public use expands and matures, but libraries are unable to keep up. As Bertot, McClure, and Jaeger report:

> Libraries may be struggling to meet demands as a result of a combination of factors such as the limits on physical space in libraries, the increasing complexity of Internet content, the continual costs of Internet access and computer maintenance, the inherent limitations of the telecommunications grid, and the rising demands for bandwidth, processing speed, and numbers of workstations, among other factors.[47]

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[42] Marijke Visser and Mary Alice Ball, Dec. 2010, "The Middle-mile: The Role of the Public Library in Ensuring Access to Broadband," Information Technology and Libraries, at 193. http://www.ala.org/lita/ital/sites/ala.org.lita.ital/files/content/29/4/visser.pdf.

[43] *Id.* at 191.

[44] Information Policy and Access Center (IPAC), 2012, "Public Libraries and Broadband." http://www.plinternetsurvey.org/analysis/public-libraries-and-broadband.

[45] John Carlo Bertot, Charles R. McClure, and Paul T. Jaeger, 2008, "The Impacts of Free Public Internet Access on Public Library Patrons and Communities," *Library Quarterly* 78, no. 3, at 286. http://mcclure.ii.fsu.edu/publications/2008/The%20impacts%20of%20free%20public%20Internet%20access%20on%20public%20library%20patrons%20and%20communities.pdf

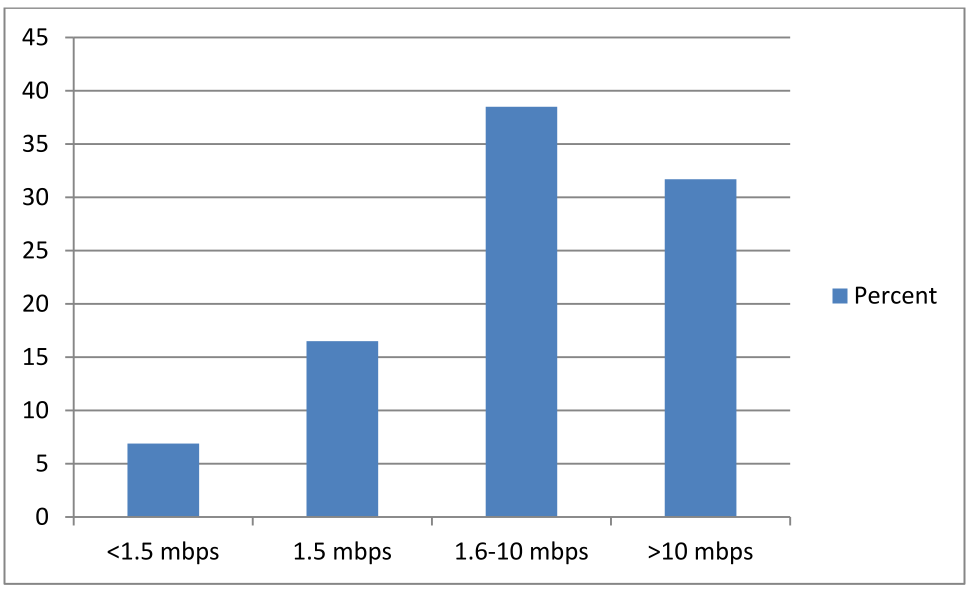
[46] Marijke Visser and Mary Alice Ball, Dec. 2010, "The Middle-mile: The Role of the Public Library in Ensuring Access to Broadband," Information Technology and Libraries, at 192.

[47] John Carlo Bertot, Charles R. McClure, and Paul T. Jaeger, 2008, "The Impacts of Free Public Internet Access on Public Library Patrons and Communities," *Library Quarterly* 78, no. 3, at 297.

In recent years, libraries have expanded wireless access to allow for a larger number of users at limited workstations. While this allows more users to get online, it also creates additional traffic on limited bandwidth.[48]

Libraries are seeking ways to add bandwidth as applications become more intensive (e.g., streaming video, online communications, social networking tools), yet this growing need is seldom accompanied by a corresponding increase in budget or capacity. The Information Policy and Access Center (iPAC) reports that libraries have steadily increased their bandwidth capacity in recent years. While only 12.3 percent of public libraries reported speeds greater than 10 mbps in 2008-2009, 31.7 percent of public libraries have reported speeds at this level in 2011-2012 (see Figure 9).[49] While bandwidth has increased in recent years, however, this growth has been outpaced by the increase in bandwidth-requiring applications. Consequently, despite supposed high-speed connections, users may experience “slow connectivity and near dial-up speeds.”[50]

Figure 9: Public Library Internet Connectivity Speeds (2011–2012)[51]



Data from the Public Libraries and the Internet studies reveal a “‘disconnect’ between what their communities expect and the levels of Internet access that they are able to provide to their

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[48] *Id.* at 292.

[49] “Public Libraries and Broadband,” *Public Library Funding and Technology Survey,* Information Policy and Access Center, 2012. http://ipac.umd.edu/sites/default/files/publications/BroadbandBrief2012_0.pdf.

[50] “Broadband and Public Libraries,” Information Policy and Access Center (IPAC), 2012. http://www.plinternetsurvey.org/analysis/public-libraries-and-broadband.

[51] “Public Libraries and Broadband,” *Public Library Funding and Technology Survey,* Information Policy and Access Center, 2012. http://ipac.umd.edu/sites/default/files/publications/BroadbandBrief2012_0.pdf.

communities."[52] In fact, a 2012 study found that 41.1 percent of public libraries report that their connection speeds are insufficient to meet patron needs some or all of the time.[53] While this is an improvement from nearly 58 percent reporting inadequate speeds in a similar 2007 survey,[54] it reveals that additional bandwidth is needed. The data suggests that libraries have reached an "infrastructure plateau for provision of and access to Internet services."[55] This problem is only compounded by the economic downturn, as more people depend on libraries for free Internet access. As a consequence, infrastructure limits are being hit precisely at a time when consumer demand for library services is increasing.

While libraries have long served the role of "community guarantor of free public Internet access,"[56] they cannot meet these needs without public support. As Visser and Ball acknowledge, "[o]vercoming the challenges successfully will require support on the local, state, and federal level."[57] Indeed, "[w]hat else can the federal government fund that simultaneously serves so many educational, economic, employment, communication, government, and emergency preparedness functions?"[58]

While slightly more than half (58.3 percent) of public libraries reported in 2010-2011 that their broadband connection meets patron needs, more libraries are expected to report insufficient connections in coming years unless funding to improve broadband infrastructure is increased. Indeed, "[a]s more people rely on public libraries for Internet access, and as more of these people use a greater range of high bandwidth education, government, and entertainment content, the bandwidth capacity of libraries becomes an increasingly significant issue."[59]

Many libraries are seeking to expand their use and meet access demands by establishing Wi-Fi networks. However, the Information Policy and Access Center (iPAC) reports that in the vast majority of libraries with wireless access (82.3 percent), wireless users are sharing the same bandwidth and connection with existing workstations. As a consequence, libraries are

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[52] John Carlo Bertot, Charles R. McClure, and Paul T. Jaeger, 2008, "The Impacts of Free Public Internet Access on Public Library Patrons and Communities," *Library Quarterly* 78, no. 3, at 287.

[53] "Broadband and Public Libraries," Information Policy and Access Center (IPAC), 2012. http://www.plinternetsurvey.org/analysis/public-libraries-and-broadband.

[54] Marijke Visser and Mary Alice Ball, Dec. 2010, "The Middle-mile: The Role of the Public Library in Ensuring Access to Broadband," Information Technology and Libraries, at 191.

[55] John Carlo Bertot, Charles R. McClure, and Paul T. Jaeger, 2008, "The Impacts of Free Public Internet Access on Public Library Patrons and Communities," *Library Quarterly* 78, no. 3, at 297.

[56] *Id.* at 299.

[57] Marijke Visser and Mary Alice Ball, Dec. 2010, "The Middle-mile: The Role of the Public Library in Ensuring Access to Broadband," Information Technology and Libraries, at 191-92.

[58] John Carlo Bertot, Charles R. McClure, and Paul T. Jaeger, 2008, "The Impacts of Free Public Internet Access on Public Library Patrons and Communities," *Library Quarterly* 78, no. 3, at 300.

[59] "Survey: Broadband and Public Libraries," Information Policy and Access Center (IPAC), 2012. http://ipac.umd.edu/survey/analysis/broadband-public-libaries.

increasing "connection capacity at the expense of connection quality." This growth results in more users drawing on limited bandwidth. iPAC explains:

> As an example, take a common scenario: a public library has 15 public access workstations in constant use; it offers Wi-Fi that supports another 10–15 simultaneous connections, typically in use; the library has a T-1 connection (1.5 Mbps or megabits per second leased line broadband service); and the Wi-Fi and public access workstations share the same connection. With up to 30 devices sharing the same 1.5 Mbps connection, the connection speed at the device level is the equivalent of dial-up service, severely affecting the quality of the user experience.[60]

It is unsustainable for libraries to increase the number of workstations and use of their Wi-Fi networks without a concomitant increase in connection speed. Yet, this is precisely what is occurring. In fact, though 74.3 percent of libraries reported that they did not increase their connection speed from 2011–2012, 60.1 percent reported an increase in the use of their public access workstations and 74.9 percent reported an increase in the use of their Wi-Fi network. "If these trends continue, we can expect the demands on public library networks to exceed capacity in the near future, especially at urban public libraries."[61]

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[60] *Ibid.*
[61] *Ibid.*

5. Providing Private Sector Use of Its Fiber Can Enable Holly Springs to Facilitate World-Class Services to Some Businesses and, Thereby, Economic Development

We recommend the strategy of maximizing the Town's new fiber infrastructure by making it available, under defined terms, to the private sector to encourage competition, economic development, and last-mile construction (i.e., further connections from the Town's backbone to homes and businesses).

The Vision and Cost for Providing Fiber to Private Entities That Will Serve Holly Springs Businesses

We suggest that the Town make available spare conduit and fiber capacity for use by the private sector at competitive rates.

Such an arrangement would ideally result not only in a modest revenue stream to the Town, but would also enable competitive providers to compete more aggressively in the Holly Springs market, whether they are new entrants to the market or already established in Holly Springs.

This strategy is also low risk for Holly Springs. The ongoing efforts to expand Holly Springs' fiber footprint are fully justified by the need to meet internal communications needs; it is an added economic bonus to open the fiber/conduit infrastructure to private companies.

The Town has already undertaken some conversations with private sector providers such as Level 3, which has demonstrated some preliminary interest in leasing Town fiber in order to serve business customers within Holly Springs. This example is an excellent illustration of how Town fiber can enable a range of private sector companies and entrepreneurs to compete in the Holly Springs market.

In the course of this project, CTC analysts spoke with a range of communications providers about their interest in using the Town's fiber to extend their capacity to serve customers in Holly Springs. Among others, planners for Level 3 signaled interest; Level 3 has a track record of taking advantage of such opportunities in other communities.

To enhance these opportunities, we recommend that the Town consult with private sector providers when constructing or enhancing conduit or fiber routes. If a route is of interest to a provider, the cost of construction can be shared or offset by purchase or lease fees from a private sector provider, and the size and quantity of infrastructure can be adjusted to meet the provider's need.

The Town may also wish to offer preferred pricing on conduit or fiber to providers that commit to building out unserved areas, low-income neighborhoods, economic development zones, or other high-priority areas.

The risk to the Town is relatively low because if there are few or no takers, the cost is marginal—the cost only of planning and marketing efforts. And if there are takers, then the Town is using its infrastructure to open up and enable a competitive market where none currently exists.

Once the fiber build is complete, we recommend that the Town undertake a request for information (RFI) process to identify potential private sector partners. This strategy will enable the Town to determine and select the model that is most likely not only to deliver some modest revenues, but also to facilitate the Town's public policy purposes (e.g., economic development, open and competitive markets, enabling new and better services). The RFI should specify the amount and nature of the asset available for lease (fiber and conduit) but offer the bidders flexibility to propose their own business and compensation models for the partnership with Holly Springs—thus enabling the bidders to propose the model they see as most viable.

For example, a provider might propose to lease all of the Town's excess fiber and re-lease it; alternatively, a provider might propose to serve as an independent broker for the Town's dark fiber on a commission basis; as another alternative, a new competitor might propose to lease Holly Springs' dark fiber to enable it to enter the market, or an existing provider might want access to the fiber to supplement and provide redundancy for its existing network and services.

High Speed Broadband to Businesses Can Create Economic Activity and Development

The literature on broadband and economic development suggests a causal relationship. High-speed broadband is an economic enabler for businesses. From the standpoint of most businesses, broadband has ceased to be a luxury and has become crucial to business functionality.

According to a 2011 survey of building owners and property managers, broadband access is one of the most important decision factors for commercial real estate siting—after price, parking, and location. Similarly, a national survey found that 77 percent of economic development professionals believe that to attract a new business, a community must have broadband of at least 100 Mbps; in other words, they believe that economic development without broadband is essentially inconceivable.

The high speeds that fiber provides can facilitate economic development by:

- Enabling job creation and the enhanced, multiplied economic activity that accompanies it

- Supporting businesses with very high bandwidth needs, such as digital media and software development
- Attracting and retaining businesses of all sizes
- Enabling workforce education
- Enabling telework and distributed work
- Stimulating economic activity
- Promoting major development initiatives such as revitalization zones

A number of studies show a significant positive effect on economic growth by the increase of broadband speeds.[62]

Indeed, the U.S. Ignite Partnership grew out of a White House Office of Science and Technology Policy roundtable discussion in January 2011 on how to develop applications that would maximize the benefit of fiber connectivity across the country. The public and private participants in U.S. Ignite are now working "to catalyze approximately 60 advanced, next-gen applications over the next five years in six areas of national priority: education and workforce development, advanced manufacturing, health, transportation, public safety, and clean energy."[63]

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[62] Press Release: "New study quantifies the impact of broadband speed on GDP," Ericsson, September 27, 2011. (http://www.ericsson.com/news/1550083).

Sharon E. Gillett, Dr. William H. Lehr, et al., "Measuring the Economic Impact of Broadband Deployment," Final Report Prepared for the U.S. Department of Commerce, Economic Development Administration, National Technical Assistance, Training, Research, and Evaluation Project #99-07-13829, February, 2006, (http://cfp.mit.edu/publications/CFP_Papers/Measuring_bb_econ_impact-final.pdf).

Jed Kolko and Davin Reed, "Does Broadband Boost Local Economic Development," Public Policy Institute of California, January 2010, p. 28. (http://www.ppic.org/content/pubs/report/r_110jkr.PDF).

[63] "What is U.S. Ignite?," U.S. Ignite website. http://us-ignite.org/what-is-us-ignite/. One fascinating fact about U.S. Ignite is that it seeks to enable private, commercial development of new, high-bandwidth applications, but most of the network infrastructure it makes available for that development is public—municipal fiber networks that connect many thousands of homes and provide a test-bed for advance application creation.

6. Over Time, Holly Springs' Fiber Network Can Serve as the Basis for Private Investment in World-Class Broadband to Residences

A wide range of American communities are making their core fiber rings available to the private sector in the hopes that private investment will build from public "middle mile" fiber out to the "last mile" to residential premises. The idea is that, by making middle-mile capacity available where it does not otherwise exist, and at very reasonable cost, a community reduces the barriers to investment for entrepreneurial companies (and non-profits) that want to build last-mile capacity to the home. In this model, those companies' lease arrangements would lead to not only revenues, but also stimulate private investment and the extension of broadband service to members of the community that otherwise would not have it, or would not have the benefits of competition.

This model is currently being tested in a range of communities, including among the NC NGN communities of Raleigh, Durham, Carrboro, Chapel Hill, Winston-Salem, and Cary.

We believe that the model, over time, may prove to be of use in Holly Springs as well and that the Holly Springs fiber ring is well positioned to serve as the backbone for a future private fiber-to-the-premises network. This potential is built into the existing project.

The Vision and Cost for Building a Fiber Ring That Can Serve in the Future as the Backbone of a Privately Provided Fiber Network to Holly Springs' Residences

A growing body of evidence suggests that localities can successfully implement this strategy given the proper market conditions. The Recovery Act grants made by the U.S. Department of Commerce actually require this strategy: Grant recipients must commit to nondiscriminatory, open access policies that make access available to third-party service providers.

Because many of the Recovery Act infrastructure grants incorporate this business model, significant data will emerge over the next few years as to the scope of the ROI of this model. Preliminary indications from many of these projects are very good. In both metropolitan and rural areas, grant recipients are engaged in negotiations with last mile providers who seek access to the new middle mile fiber that will make it possible for them to affordably reach areas for last mile service.

Holly Springs' Fiber Design Will Ensure Reliability and Marketability

Holly Springs' intended fiber design focuses on building the fiber in "rings." This ring architecture will result in significant operational benefits in that it will offer a level of redundancy, reliability, and resilience that existing carrier infrastructure does not have. These benefits would accrue for the Town's internal communications services and would also make the Town's fiber more marketable to private sector providers who seek to enter or expand service in Holly Springs.

As an example, redundant fiber routes would allow the system to continue to operate at full functionality even in the event of a fiber cut (i.e., if a single fiber route is cut, the network is disabled—but if the fiber is in a ring, the network traffic can reverse course at the point a single route is cut, and go around the ring to reach its destination).

Connecting the Town's fiber and conduit routes into rings would also increase the capacity of the links, making it possible to operate more advanced services in the future. And the rings will increase the value of the existing network with respect to potential leasing of the fiber.

Figure 10 below presents a high-level overview of a redundant fiber network. Figure 11 illustrates the single points of failure in a fiber route, and the multiple paths enabled by fiber rings connecting to the existing fiber.

Figure 10: High-Level Diagram of Redundant Fiber Network

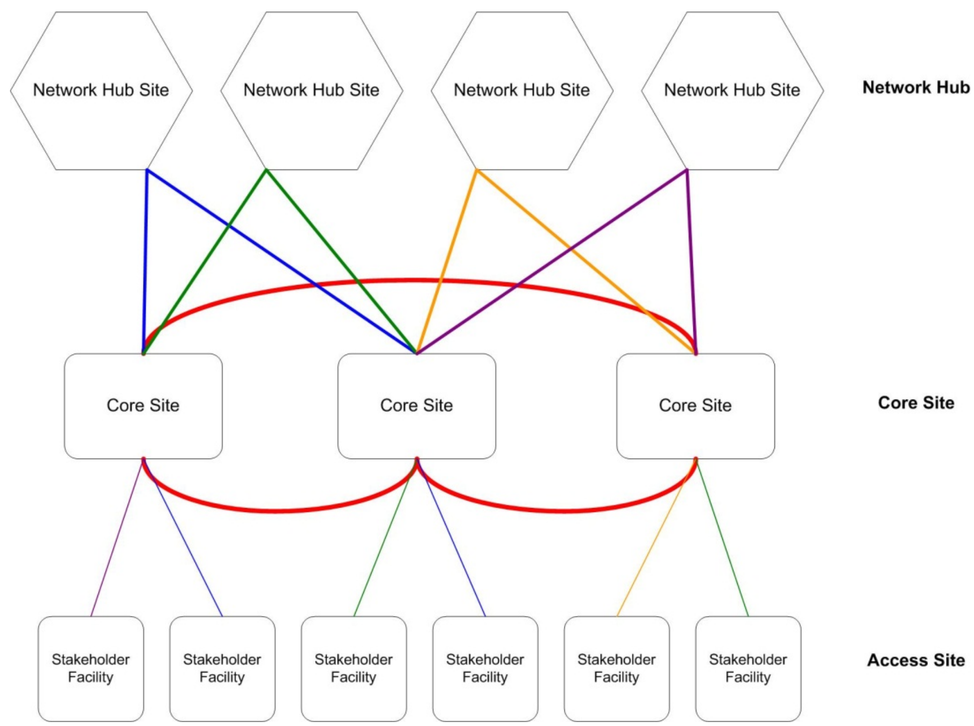
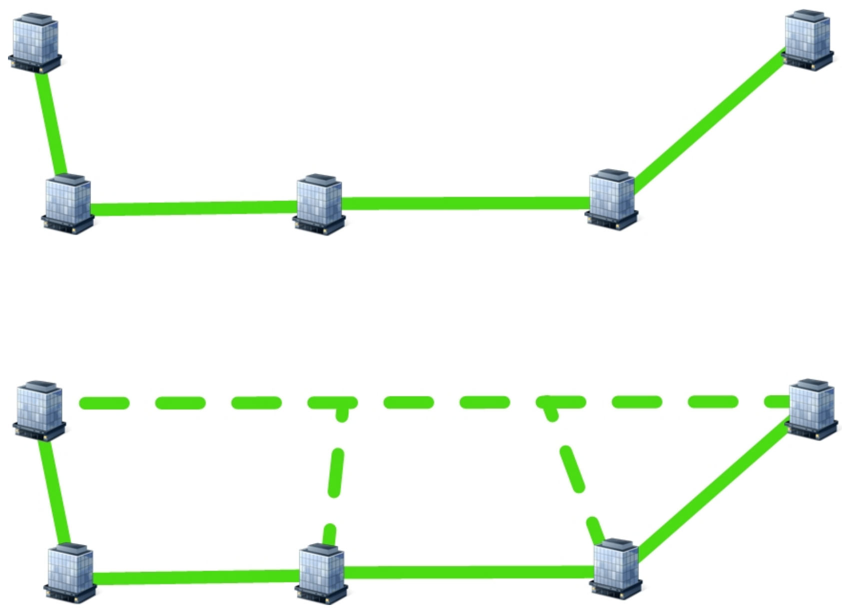


Figure 11: Multiple Survivable Paths from Redundant Fiber Connections



The backbone rings will have several potential roles:

- Increasing the robustness and capacity of Town communications
- Providing a robust backbone for other institutional users, such as the Wake County schools located in Holly Springs
- Creating dual routes from any location on or near the backbone to key IT and communications resources, such as a potential future peering locations or connections to NCREN and other national backbone networks
- Developing a core route for future expansion, including lease to private sector networking companies or establishing a backbone for a potential, future private sector, Town-wide, fiber-to-the-premises network

7. Fiber Represents the Preferred Medium for the Broadband Future

Fiber represents an infrastructure asset with a lifetime of decades that is almost endlessly upgradeable and capable of supporting any number of public or private sector communications initiatives.[64]

The key advantage fiber holds over other technologies is that it is future-proof. It enables not just today's high-bandwidth applications, but all applications in the foreseeable future, and can deliver a range of well-documented benefits to Town users.

Other Technologies Are Not Capable of Speeds Enabled by Fiber

Fiber technology offers speeds and capacity that are several orders of magnitude removed from the other technologies that are considered to "compete" with it—as a technical matter and as a matter of physics, those technologies cannot compete with fiber:

A T-1 circuit, for example, is frequently the only "high" bandwidth option available to a government facility over copper (and then at considerable cost); it offers 1.54 Mbps, or one 600th of the speed that fiber can deliver using existing, affordable, off-the-shelf technologies (Gigabit Ethernet, 1,000 times one megabit). These speeds will grow dramatically as new technologies become available. The speeds possible over copper, coax, and wireless speeds will also grow, but as a matter of physics, cannot keep up with fiber's ability to scale.

Gigabit over fiber offers more than 25 times the maximum capacity of advanced cable networks,[65] more than 75 times the capacity of advanced copper/phone networks,[66] and 250 times the capacity of the fastest, most sophisticated commercial wireless services currently available to government users on smart phones and tablets.[67]

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[64] All broadband is not created equal, however. Fiber-to-the-premises (FTTP) is currently the most flexible and future-proof architecture of broadband—a fat pipe all the way into the home or business—but in the near future, it will only be available for a privileged few located in the limited areas of private-sector or municipal deployment. (Our competitor cities in Europe and Asia are increasingly adopting FTTP as the inevitable, essential broadband medium.)

[65] Assuming average downstream speeds of approximately 38 Mbps. Note that cable modem networks are usually engineered to enable far slower upstream speeds.

[66] Based on maximum downstream speeds on a VDSL network of approximately 13 Mbps with a maximum distance of 5,000 feet between the customer premises and provider Central Office. Note that DSL networks are usually engineered to enable far slower upstream speeds.

[67] Assuming average downstream speeds of 4 Mbps, currently available only in limited markets. Note that wireless networks are usually engineered to enable far slower upstream speeds.

Fiber Holds Advantage over Copper/Coaxial Technologies

Copper wire has been widely used for carrying voice, video, and data since the days of the telegraph. Progress in telecommunications technology and the growth in popularity of the Internet were characterized by a transition to digital modes of communications and higher demands for communications capacity. As a result, copper telecommunications networks were retrofitted for transferring data as well, with an ongoing shift in the network architectures to support the growing demands.

Copper cabling is predominantly found in two forms: coaxial (coax) cables and twisted-pair cables. Coax cables were originally used for carrying video signals within cable television systems and radio frequency (RF) signals to and from antennas within wireless systems. Twisted-pair copper wire was developed from the invention of the telegraph, and was later used in the traditional telephone industry. Due to rising demands for Internet connectivity, cable TV companies and traditional phone companies adapted their infrastructure with new technologies, including cable modems and digital subscriber line (DSL), to begin offering higher speed data services than simple telephone lines could support.

Coax cables, on the other hand, have one central conductor surrounded by a conductive shield that blocks electromagnetic interference (EMI) from outside sources. Insulating layers separate and protect each conductive component.

All copper cables use electrical signals to transfer information between users. Optical fibers use light rays to transfer the same information through their glass cores. The core is usually made out of specialized glass with low optical attenuation. The cladding, coating, and housing serve to protect the optical core and minimize the optical loss of the core.

Optical fibers and copper cables have different physical compositions, which give the optical fibers inherent advantages over their copper counterparts. For a given expenditure in communications hardware, fiber optics can reliably carry many times more capacity over many times greater distances than copper wires of any type—far superior in both regards.

The biggest advantage that fiber has over copper is the exponentially greater bandwidth that it can provide. This bandwidth is only restricted by the electronics at either end of the cable; modern fiber equipment is capable of speeds on the order of terabits per second over a single "strand." In addition, not only do fibers provide more bandwidth, they are able to do so over longer distances as compared to copper cables without necessitating regeneration or amplification, both of which can reduce signal reliability and capacity while increasing costs.

Bandwidth limits on copper cables are directly related to the underlying physical properties of copper. Copper conducts electrical signals at various frequencies, and higher data rates over copper require higher frequencies of operation. Twisted pair wire is limited to a few hundred megahertz in usable bandwidth (at most), with dramatic signal loss increasing with distance at higher frequencies. This physical limitation is why DSL service is only available within a close proximity to the telephone central office. Coaxial cable has a frequency bandwidth of approximately one gigahertz, or more; therefore its capacity is greater than that of twisted pair. Despite its higher capacity, coaxial cable does experience signal attenuation at higher frequencies similar to twisted pair. In other words, coaxial cable is incrementally more capable than twisted-pair wire, though it is still not comparable to the exponentially greater upper limits of fiber.

Within a fiber optic strand, an optical communications signal (essentially a ray of light) behaves according to a principle referred to as “Total Internal Reflection” that guides it through the optical cable. Optical cables do not use electrical conduction, and thus do not require a metallic conductor, such as copper, as their propagation medium. Further, technological innovations have allowed for the manufacturing of very high quality, low impurity glass that can provide extremely low losses within a wide range of frequencies, or wavelengths, of transmitted optical signals, enabling long range transmissions. Compared to a signal loss on the order of tens of decibels (dB) over hundreds of feet of coaxial cable, a fiber optic cable can carry a signal of equivalent capacity over several miles with only a few tenths of a dB in signal loss.

Even with technological advances, copper cables will not be able to live up to customer requirements. This is why communications carriers and cable operators are deploying fiber to replace large portions of their copper networks, and on an increasingly larger scale. Fiber optics is one of the few technologies that can legitimately be referred to as “future-proof,” meaning that they will be able to provide customers with larger, better and faster service offerings as demand grows.

Fiber is able to provide better signals over longer distances. This does not hold true for copper cables since copper is susceptible to cross talk, more rapid signal attenuation, and interference that degrade the signal quality. Longer cables result in greater losses at any bandwidth or frequency of operation. To compensate for this, electrical signals need to be amplified or regenerated every few thousand feet using repeaters and amplifiers, whereas fiber optic signals can travel hundreds of miles without regeneration. This reduces the complexity and expense of operation and maintenance of networks comprised of fiber.

Optical fibers do not conduct electricity and are immune to other electromagnetic interferences. These properties allow optical fibers to be deployed where conductive materials would be hazardous, such as near power lines or within electric substations. Moreover, the cables do not corrode in the way that metallic components can over time, due to weather and environmental conditions, further reducing maintenance costs.

Copper cables transfer data in the form of electrical signals. This makes the data less secure, since it is more readily possible to physically “tap” in to the cables, especially twisted pair, and observe the data. Optical fibers are much more difficult to tap without breaking the connection, making the data they carry more secure.

Fiber Holds Advantage over Wireless Technologies

Fiber and wireless are frequently posited as competing technologies, a common—but inaccurate—perception. Neither can supplant nor compete with the other; rather, ***these technologies inherently enhance and complement each other***. Wireless delivers mobility and fiber delivers capacity and speed. In addition, wireless needs fiber: for purposes of reliability and speed, a wireless network requires a robust fiber optic core backbone that connects it to core resources, to the Internet, and to other public networks. High wireless performance depends on backhaul over a core fiber network and, correspondingly, a wireless network will deliver poor performance if backhaul is inadequate, regardless of the quality of the wireless network itself.

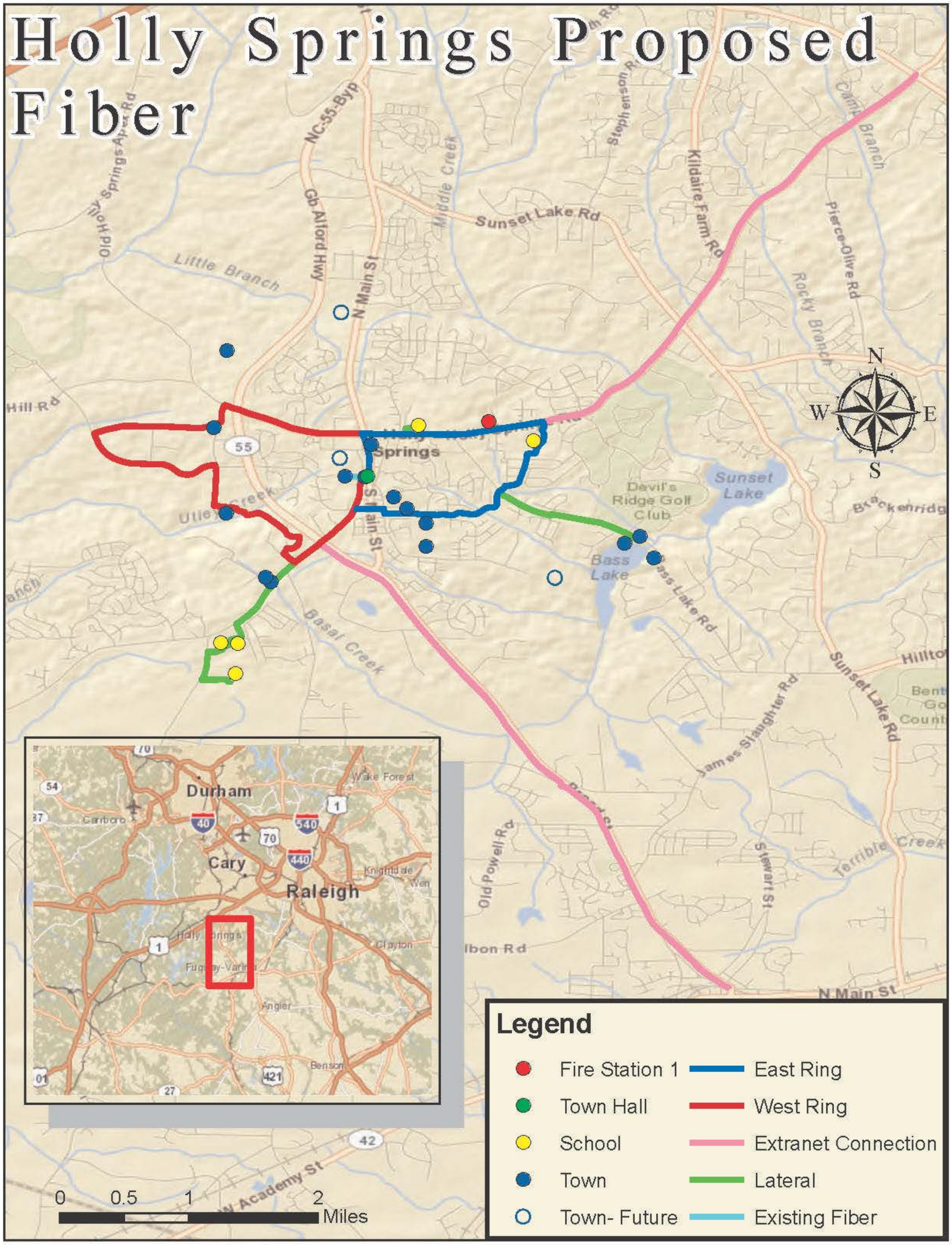
Each network technology has its own distinct advantages and challenges, but fiber is a more flexible, future-proof, and capable technology—and a far less risky investment.

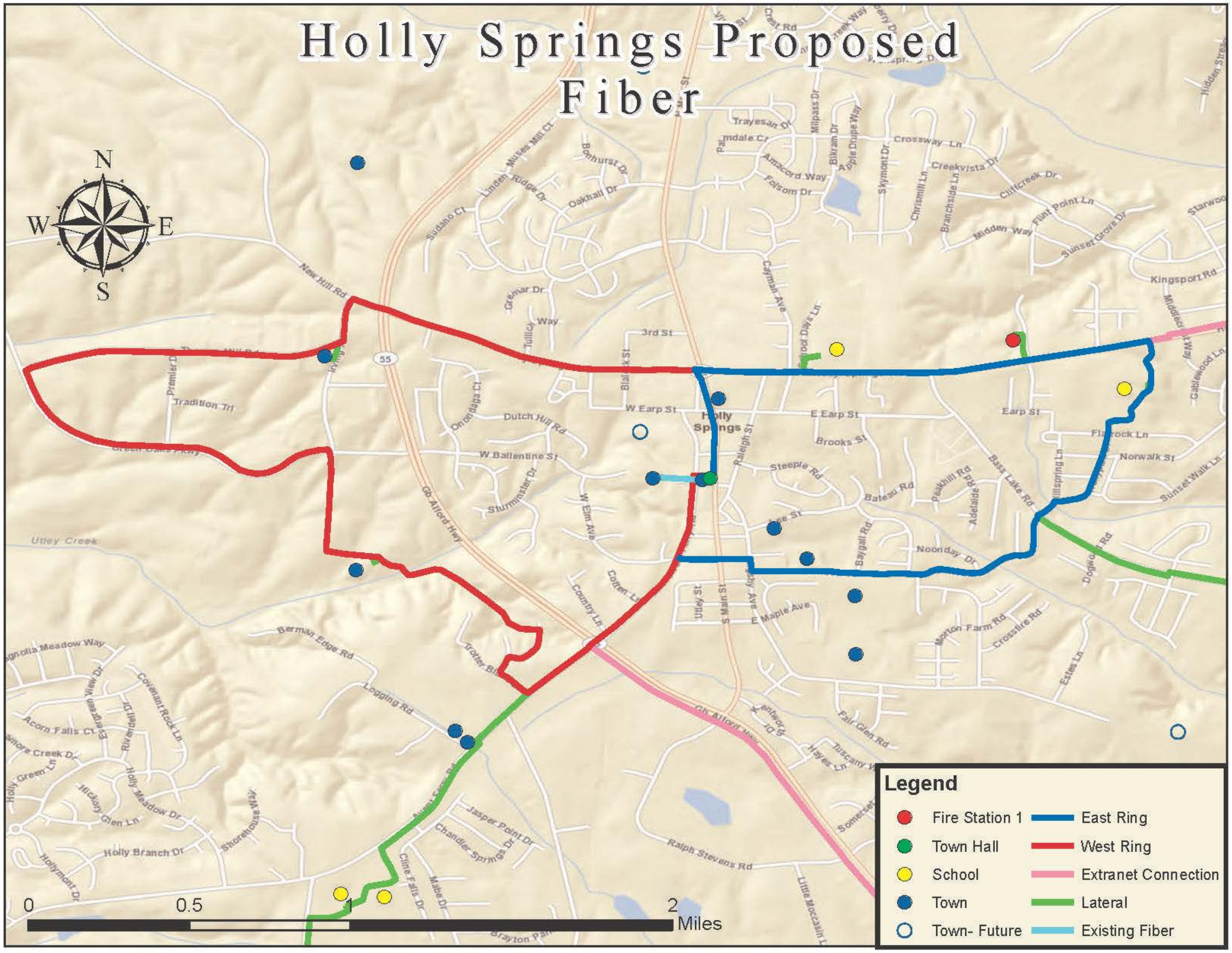
Wireless networks provide mobility and flexibility. Wireless holds a benefit with respect to speed to deployment and flexibility. However, there are significant challenges in providing effective wireless service. Design limitations such as power levels, spectrum availability, and required data capacity require that individual antennas or base stations serve limited areas, such as one mile or less. The challenge of deploying and managing wireless is also complicated if unlicensed frequencies are used for such technologies as WiFi. Further, when a wireless provider needs to migrate to a more advanced technology platform, it may need to re-engineer and redesign its entire system.

Fiber networks hold the advantage in capacity, robustness, and security. Fiber provides almost unlimited capacity. Each single fiber optic strand is theoretically able to duplicate the entire electromagnetic spectrum available to all wireless users. In a practical sense, the capacity limit is imposed by the capability of the electronics connected to the fiber. Further, capacity is constantly increasing as technology improves. Fiber has a life of decades, assuming adequate maintenance, and it can cost-effectively and simply be scaled to dramatically higher speeds as new electronics become available.

There are significant challenges in fiber optic network technology, especially in the high cost of initial construction—particularly for underground installation or where extensive make-ready is required for aerial installation.

Appendix A: Proposed Fiber Maps


Holly Springs Proposed Fiber
Legend
Fire Station 1
Town Hall
School
Town
Town- Future
East Ring
West Ring
Extranet Connection
Lateral
Existing Fiber
0
0.5
1
2
Miles
N
S
E
W
Durham
Cary
Raleigh
Sunset Lake Rd
Kildaire Farm Rd
N Main St
S Main St
Gb Alford Hwy
NC-55-Byp
Little Branch
Utley Creek
Basal Creek
Devil's Ridge Golf Club
Sunset Lake
Bass Lake
Bass Lake Rd
James Slaughter Rd
Old Powell Rd
Stewart St
Terrible Creek
Pierce-Olive Rd
Rocky Branch
Middle Creek
W Academy St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