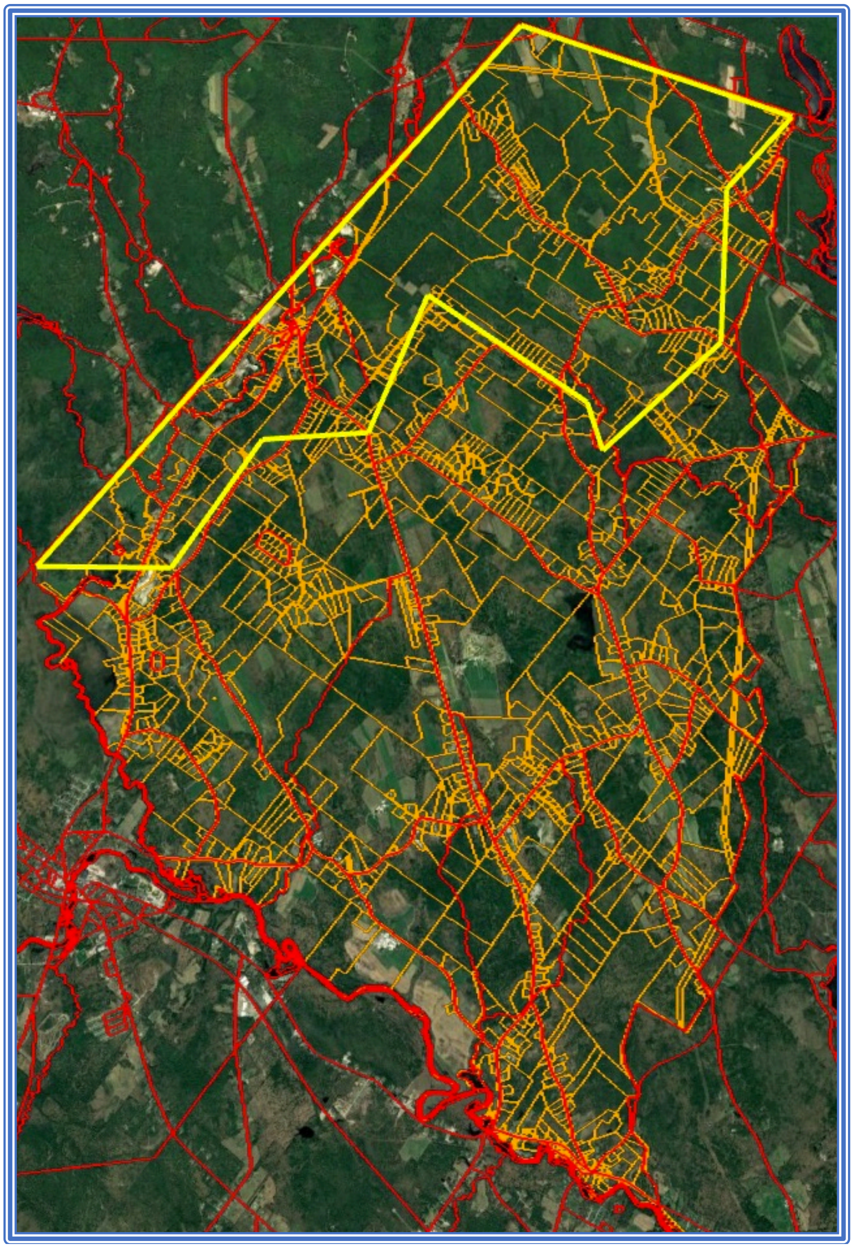
Town of Minot, Maine
Broadband Report



Prepared by

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November 22, 2019

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1 Executive Summary

Casco Bay Advisors, LLC (Casco Bay) is pleased to present this Broadband Report (Report) to the Town of Minot (Town), examining existing high-speed broadband assets within the Town limits, where gaps in coverage may exist and potential solutions to fill those gaps.

The intent of this report is not to analyze Internet usage trends, determine how much bandwidth will be required in the future, or explain why the Internet is important to the Study Area. As a society, we already understand that the Internet is pervasive and integrated into all facets of everyday life, and that we all must have unrestricted access to the Internet in order to participate in the increasingly global economy, especially in the areas of healthcare, education, entertainment, financial services, consumer goods and services, and global commerce. Rather, this report presents a foundational understanding of the different Internet access technologies, the existing broadband infrastructure supporting the community, and the gaps that exist in coverage and/or service capacity. With this baseline in hand, we review and present high-level costs to ensure a solid foundation to help inform the Town's broadband vision and goals and provide recommendations for next steps.

We applaud the Town for taking this initiative to better understand their current resources and to set the stage for ensuring the entire community is well positioned to take advantage of the introduction of new Internet enabled services.

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2 Internet Access and Broadband Definition

The terms "Internet access" and "broadband" are often used interchangeably. There is frequently confusion between the two, especially as the definitions evolve with technology changes.

Internet access connects individual computer terminals, computers, mobile devices, and computer networks to the Internet, enabling users to access Internet services such as email, applications and information delivered via the World Wide Web. Internet service providers (ISPs) offer Internet access through various technologies that offer a wide range of data signaling rates (speeds).

Consumer use of the Internet first became popular through dial-up Internet access in the 1990s. By the first decade of the 21st century, many consumers in developed nations used faster, broadband Internet access technologies.

Broadband is a generic term representing any wide-bandwidth data transmission method with the ability to transport multiple signals and traffic types simultaneously. This data can be transmitted using coaxial cable, optical fiber, radio or twisted pair copper. In the context of Internet access, broadband is used much more loosely to mean any high-speed Internet access that is always on and faster than traditional dial-up access. Different governing authorities have developed inconsistent definitions of what constitutes broadband service based on access speed.

In January 2015, the Federal Communications Commission (FCC) voted to define broadband as Internet service with at least 25 Mbps (megabits per second) download and 3 Mbps upload. Their definition affects policy decisions and the FCC's annual assessment of whether broadband is being deployed to all Americans quickly enough. In Maine, the ConnectMaine Authority Board[1] currently defines effective broadband network capacity as speeds equal to or greater than 25Mbps/3Mbps, and anything less as "unserved."

For those rural and high-cost areas served by Consolidated Communications, Inc. (CCI) where CCI has accepted subsidies through the Connect America Fund – Phase II (CAF-II), the FCC has adopted a minimum speed standard of 10Mbps/1Mbps.

[1] In recognition of the critical importance of modern technology for education, health care, and business success in Maine, the Legislature created the ConnectME Authority (Authority) in 2006 as an independent state agency to develop and implement broadband strategy for Maine. The Authority is governed by a board which is comprised of members appointed by the Governor or specifically identified and designated by statute.

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3 Internet Access Technology Overview

In this section, we present an overview of different Internet access technology, including digital subscriber line, cable modem, fixed wireless, 4G/LTE Advanced, 5G, satellite, and Fiber-to-the-Premise.

3.1 DSL

Digital subscriber line (DSL) is a technology most frequently used by traditional telephone system operators such as Consolidated Communications, Inc. (CCI) and FirstLight (formerly Oxford Networks) to deliver advanced services *(high-speed data and potentially video)* over twisted pair copper telephone wires. This technology has lower data carrying capacity than the hybrid fiber coaxial network deployed by cable system operators like Charter Communications (Spectrum). Data speeds are range-limited by the length of the copper cable serving the premise, the wire gauge of the copper conductors and the condition of the copper.

DSL service can be delivered simultaneously with wired telephone service on the same telephone line. This is possible because DSL uses higher frequency bands for data transmission than are required for the voice service transmission. On the customer premises, a DSL filter on each non-DSL outlet blocks any high-frequency interference to enable simultaneous use of the voice and DSL services.

The bit rate of consumer DSL services can range from 256 Kbps *(kilobits per second)* to over 100 Mbps in the direction of the service provider to the customer (downstream), depending on the DSL technology, line conditions, and the length of the copper loop. Until recently, the most commonly installed DSL technology for Internet access has been asymmetric digital subscriber line (ADSL). With ADSL, the data throughput in the upstream direction *(the direction from the consumer to the service provider)* is lower, hence the designation of asymmetric service.

At the central office, a digital subscriber line access multiplexer (DSLAM) terminates the DSL circuits and aggregates them, where they are handed off to other networking transport equipment. The DSLAM terminates all connections and recovers the original digital information. For locations beyond the maximum distance from the central office for the particular type of DSL technology deployed (7,000 – 12,000 feet), DSLAMs can be deployed in the field in outside plant cabinets *(remote terminals)* and connected to the central office by fiber optic cables. A shorter distance from the subscriber premise to the DSLAM results in greater bandwidth *(speed and/or capacity)* for the connected users.

The customer end of the connection consists of a terminal adaptor or "DSL modem." This converts data between the digital signals used by computers and the voltage signal of a suitable frequency range which is then applied to the phone line.

There are additional formats of DSL technologies that can enhance the capacity of the network. ADSL2+ extends the capability of basic ADSL by doubling the number of downstream channels,

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increasing the frequency from 1.1 Mhz to 2.2 Mhz. The data rates can be as high as 24 Mbps downstream and up to 1.4 Mbps upstream, depending on the distance from the DSLAM to the subscriber's premises. Like the previous standards, ADSL2+ will degrade from its peak bit rate after a certain distance.

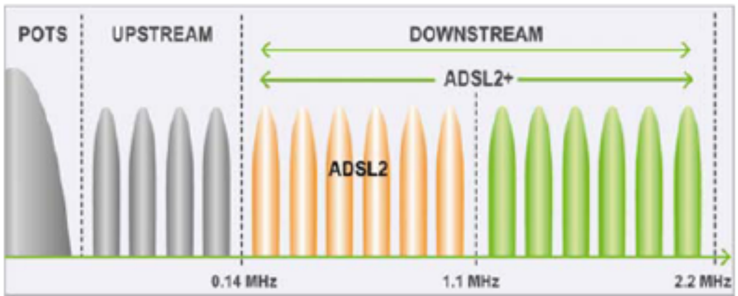

Figure 1: ADSL2+ Frequency Utilization

ADSL2+ allows port bonding, where multiple ports are physically provisioned to the end user and the total bandwidth is equal to the sum of all provisioned ports. When two lines capable of 24 Mbps are bonded, the end result is a connection capable of 48 Mbps download and twice the original upload speed.

Very-high-bit-rate digital subscriber line 2 (VDSL2+) permits the transmission of asymmetric and symmetric aggregate data rates up to 200 Mbps downstream and upstream on twisted pairs using a bandwidth up to 30 Mhz. It deteriorates quickly from a theoretical maximum of 250 Mbps at the source to 100 Mbps at 1,600 feet and 50 Mbps at 3,300 feet but degrades at a much slower rate from there. Starting from one mile, its performance is similar to ADSL2+. Bonding may be used to combine multiple wire pairs to increase available capacity or extend the copper network's reach.

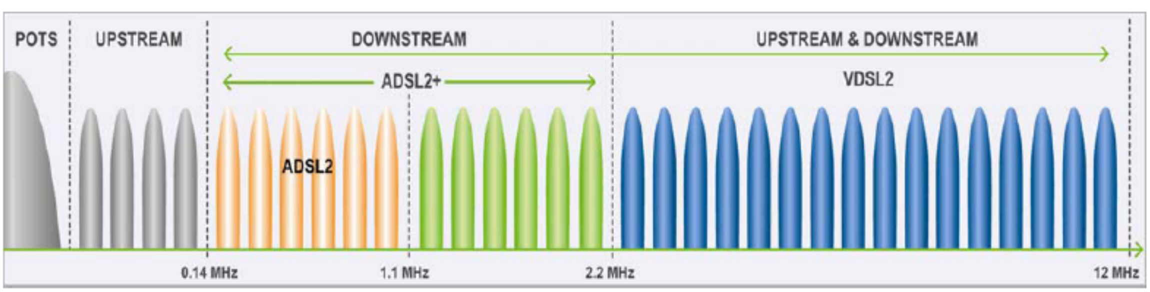

Figure 2: VDSL2+ Frequency Utilization

All new DSL deployments for CCI utilize VDSL2+ equipment. The current infrastructure for CCI and FirstLight in the Town of Minot is limited to ADSL service.

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3.2 Cable Modem

Cable modem Internet access is provided over a hybrid fiber coaxial (HFC) broadband network. It has been employed globally by cable television operators since the early 1990s and is the network architecture utilized by Spectrum. In an HFC cable system, the television channels are sent from the cable system's distribution facility, the headend, to local communities through optical fiber trunk lines. The fiber-optic trunk lines provide adequate bandwidth to allow future expansion for bandwidth-intensive services. At the local community, an optical node translates the signal from a light beam to an electrical signal and sends it over coaxial cable lines for distribution to potential subscribers.

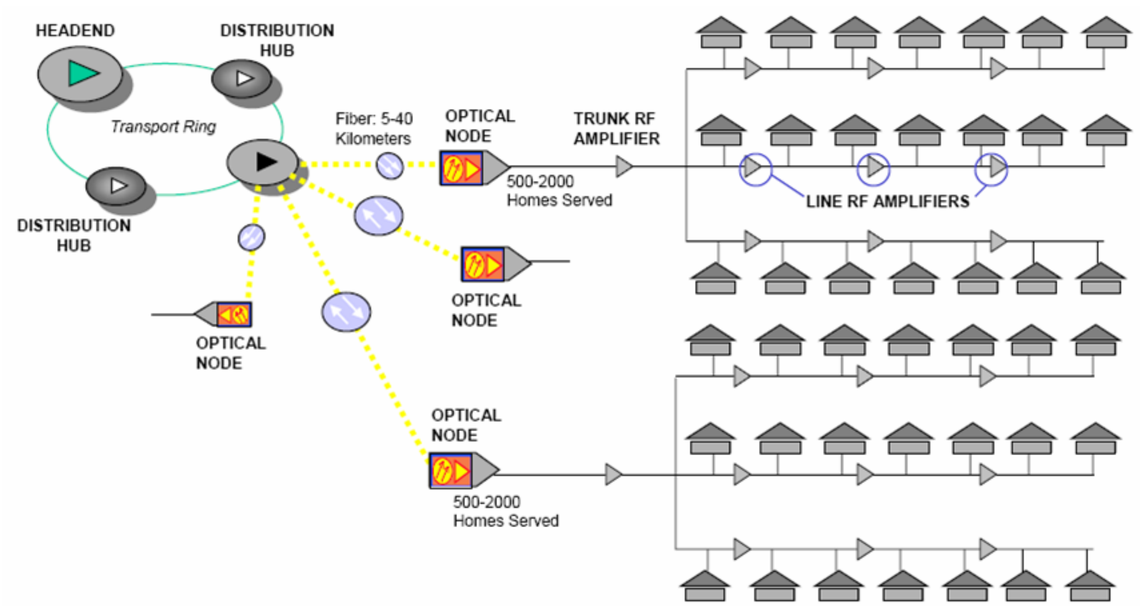

Figure 3: Hybrid Fiber/Coax Network Architecture Diagram

The coaxial portion of the network connects 25–2,000 homes in a tree-and-branch configuration off the node. RF amplifiers are used at intervals to overcome cable attenuation and passive losses of the electrical signals caused by splitting or "tapping" the coaxial cable.

The HFC broadband network is typically operated bi-directionally, meaning that signals are carried in both directions on the same network from the headend/hub office to the home, and from the home to the headend/hub office. The forward-path or downstream signals carry information such as video content, voice and data. The return-path or upstream signals carry information such as video control signals to order a movie or Internet data to send an email. The forward-path and the return-path are carried over the same coaxial cable in both directions between the optical node and the home.

Data Over Cable Service Interface Specification (DOCSIS) is an international telecommunications standard that permits the addition of high-bandwidth data transfer to an existing cable TV (CATV) system. DOCSIS 3.1 has been deployed by Spectrum to provide Internet access over their existing HFC

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infrastructure. The DOCSIS 3.1 standard is capable of supporting Internet speeds of up to 10 Gbps *(gigabits per second),* but most providers are currently offering speeds of 1 Gbps or less service for residential users.

3.3 Fixed Wireless

Fixed wireless broadband is the operation of wireless devices or systems used to connect two fixed locations *(e.g., building to building or tower to building*) with a radio or other wireless link. Fixed wireless data (FWD) links are often a cost-effective alternative to leasing fiber or installing cables between the buildings. The point-to-point signal transmissions occur through the air over a terrestrial microwave platform. The advantages of fixed wireless include the ability to connect with users in remote areas without the need for laying new cables and the capacity for broad bandwidth that is not impeded by fiber or cable capacities. Fixed wireless services typically use a directional radio antenna on each end of the signal. These antennas are generally larger than those seen in Wi-Fi setups and are designed for outdoor use. They are typically designed to be used in the unlicensed Industrial, Scientific, and Medical (ISM) radio frequency bands (900 MHz, 1.8 GHz, 2.4 GHz and 5 GHz). However, in many commercial installations licensed frequencies may be used to ensure quality of service (QoS) or to provide higher connection speeds.

To receive this type of Internet connection, consumers mount a small dish to the roof of their home or office and point it to the transmitter. Line-of-sight is usually necessary for Wireless Internet Service Providers (WISPs) operating in the 2.4 and 5 GHz bands. The 900 MHz band offers better non-line-of-sight (NLOS) performance. Providers of unlicensed fixed wireless broadband services typically provide equipment to customers and install a small antenna or dish somewhere on the roof. This equipment is usually deployed and maintained by the company providing that service.

3.4 4G/LTE Advanced Broadband

4G/LTE Advanced is wireless technology being deployed by cellular telephone providers such as AT&T, Verizon Wireless, US Cellular, Sprint and T-Mobile for traditional mobile phone and data services. The latest standard incorporates two new technologies - Carrier Aggregation, and Multiple Input Multiple Output (MIMO), in order to provide speeds in excess of 100 Mbps, and eventually up to 1 Gbps and beyond. While standard data connections use one antenna and one signal at any given time, 4G LTE Advanced has the capability of utilizing multiple signals and multiple antennas.

Mobile LTE wireless service uses MIMO technology to combine multiple antennas on both the transmitter and the receiver. A 2×2 MIMO configuration has two antennas on the transmitter and two on the receiver, but the technology is not limited to 2x2. More antennas could theoretically operate at faster speeds as the data streams can travel more efficiently. The signal is then combined with "carrier aggregation," which allows a device to receive multiple 4G signals at once. The received signals don't have to be on the same frequency; one could receive an 1800 MHz and an 800 MHz signal at the same

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time, which is not possible with standard 4G. Up to five different 20 MHz signals can be combined to create a data pipe of up to 100 MHz of bandwidth.

3.5 5G Wireless[2]

Fifth-generation wireless (5G) is the latest iteration of cellular technology, engineered to greatly increase the speed and responsiveness of wireless networks. With 5G, data transmitted over wireless broadband connections could travel at rates as high as 20 Gbps by some estimates -- exceeding wireline network speeds -- as well as offer latency of 1 millisecond or lower for uses that require real-time feedback. 5G will also enable a sharp increase in the amount of data transmitted over wireless systems due to more available bandwidth and advanced antenna technology.

In addition to improvements in speed, capacity and latency, 5G offers network management features, among them network slicing, which allows mobile operators to create multiple virtual networks within a single physical 5G network. This capability will enable wireless network connections to support specific uses or business cases and could be sold on an as-a-service basis. A self-driving car, for example, would require a network slice that offers extremely fast, low-latency connections so a vehicle could navigate in real time. A home appliance, however, could be connected via a lower-power, slower connection because high performance isn't crucial.

5G networks and services will be deployed in stages over the next several years to accommodate the increasing reliance on mobile and internet-enabled devices. Overall, 5G is expected to generate a variety of new applications, uses and business cases as the technology is rolled out.

How 5G works - Wireless networks are composed of cell sites divided into sectors that send data through radio waves. Fourth generation (4G) Long-Term Evolution (LTE) wireless technology provides the foundation for 5G. Unlike 4G, which requires large, high-power cell towers to radiate signals over longer distances, 5G wireless signals will be transmitted via large numbers of small cell stations located in places like light poles or building roofs. The use of multiple small cells is necessary because the millimeter wave spectrum -- the band of spectrum between 30 GHz and 300 GHz that most 5G implementations rely on to generate high speeds -- can only travel over short distances and is subject to interference from weather and physical obstacles, like buildings.

Previous generations of wireless technology have used lower-frequency bands of spectrum. To offset millimeter wave challenges relating to distance and interference, the wireless industry is also considering the use of lower-frequency spectrum for 5G networks so network operators could use spectrum they already own to build out their new networks. Lower-frequency spectrum reaches greater distances but has lower speed and capacity than millimeter wave.

[2] https://searchnetworking.techtarget.com/definition/5G

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3.6 Satellite

Satellite Internet is available to virtually the entire lower 48 states, with some coverage in Alaska, Hawaii and Puerto Rico. The satellites are positioned more than 22,000 miles above the equator. These satellites are geostationary, which means they are always above a specific point on the earth as it rotates. The first Internet satellites successfully brought the Internet to a larger audience, but the rates were incredibly slow. Modern satellites use more advanced technology to transmit information which provides faster Internet access, but this is still much slower than landline-based Internet and terrestrial wireless Internet services.

When a consumer subscribes to satellite Internet, the company installs household equipment, which consists of an antenna dish and a modem. The antenna is located outside of the house and is generally two or three feet in diameter. The antenna must have an unobstructed view of the sky, called the line-of-sight, in order to communicate with the satellite. The antenna is connected to a modem, which connects to a computer with an Ethernet cable.

To manage bandwidth quality for all users, each plan comes with a cap on the data you can transmit or consume per month. The amount of data allotted depends on the subscriber's plan. Plans typically range from 5 GB to 50 GB of data transmission per month with use limits prescribed. If you exceed the allotted data amount, Internet speeds will be throttled back until the next month. However, some companies allow subscribers to pay for more data capacity once the threshold is met, resetting normal operation levels.

Looking forward, at least a dozen companies, including Boeing, Amazon, SpaceX, OneWEb and Telesat are deploying, or planning to deploy thousands of Low Earth Orbit (LEO) satellites in massive constellations to provide Internet service to unserved and underserved regions of the world. The benefit of LEO satellites includes greater bandwidth and less latency, with the reported potential of displacing traditional land-line based Internet service. SpaceX and others have begun deploying LEO satellites and are in the process of testing the service to demonstrate their viability.

Satellite industry proponents say that now, unlike decades ago when Teledesic and the earlier iteration of Iridium failed to develop successful businesses, technology advancements are enabling satellite service to be offered more affordably and efficiently.

3.7 Fiber-to-the-Home (FTTH)

Fiber-to-the-Home (FTTH) or Fiber-to-the-Premise (FTTP) is a network utilizing fiber optic cables directly to the home or business and is capable of offering virtually unlimited symmetrical bandwidth. Most FTTP networks can offer 1 Gbps of bandwidth in both download and upload directions, with some providers offering 2 Gbps and even 10 Gbps service capacity. The majority of new networks being deployed utilize this type of technology.

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FTTH networks can be configured and operated in a number of different ways. These include:

- As a single service provider in a closed network environment;
- As an open access dark fiber configuration where, competing providers can lease the fiber and place their own optical/electronics to complete the service;
- As an open access dark fiber configuration where the network owner provides the optical/electronics and leases the service to competing providers; and,
- As a Software Defined Network, where competing providers interconnect with the network and users select their provider in a virtual manner.

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4 Mapping of Existing Infrastructure and Capabilities

4.1 Data Collection Efforts

To kick off our mapping initiative, we solicited industry standard GIS-based maps from all known service providers with assets deployed in Minot. Two (2) providers declined to provide the requested mapping - Consolidated Communications (CCI) and Charter (Spectrum), one (1) provider (FirstLight) provided digital maps of their fiber optic infrastructure.

As background, CCI and FirstLight are each the incumbent telephone service provider in separate sections of the Town. The FirstLight service territory is bounded by the yellow polygon highlighted in each of the maps in this report. Spectrum is the sole cable TV and cable modem Internet provider, primarily limited to the southern portion of the Town.

In order to incorporate the assets of those who declined or were unresponsive to our request, we performed a field audit to identify fiber optic cabling owned by CCI, determine the extent of the Spectrum network and to identify any other fiber optic cabling not previously identified by those who were responsive to our request. As a result, we are highly confident we have identified all of the high-speed broadband assets deployed within the Town limits.

Following are maps for each providers asset and a discussion regarding the capability of those assets.

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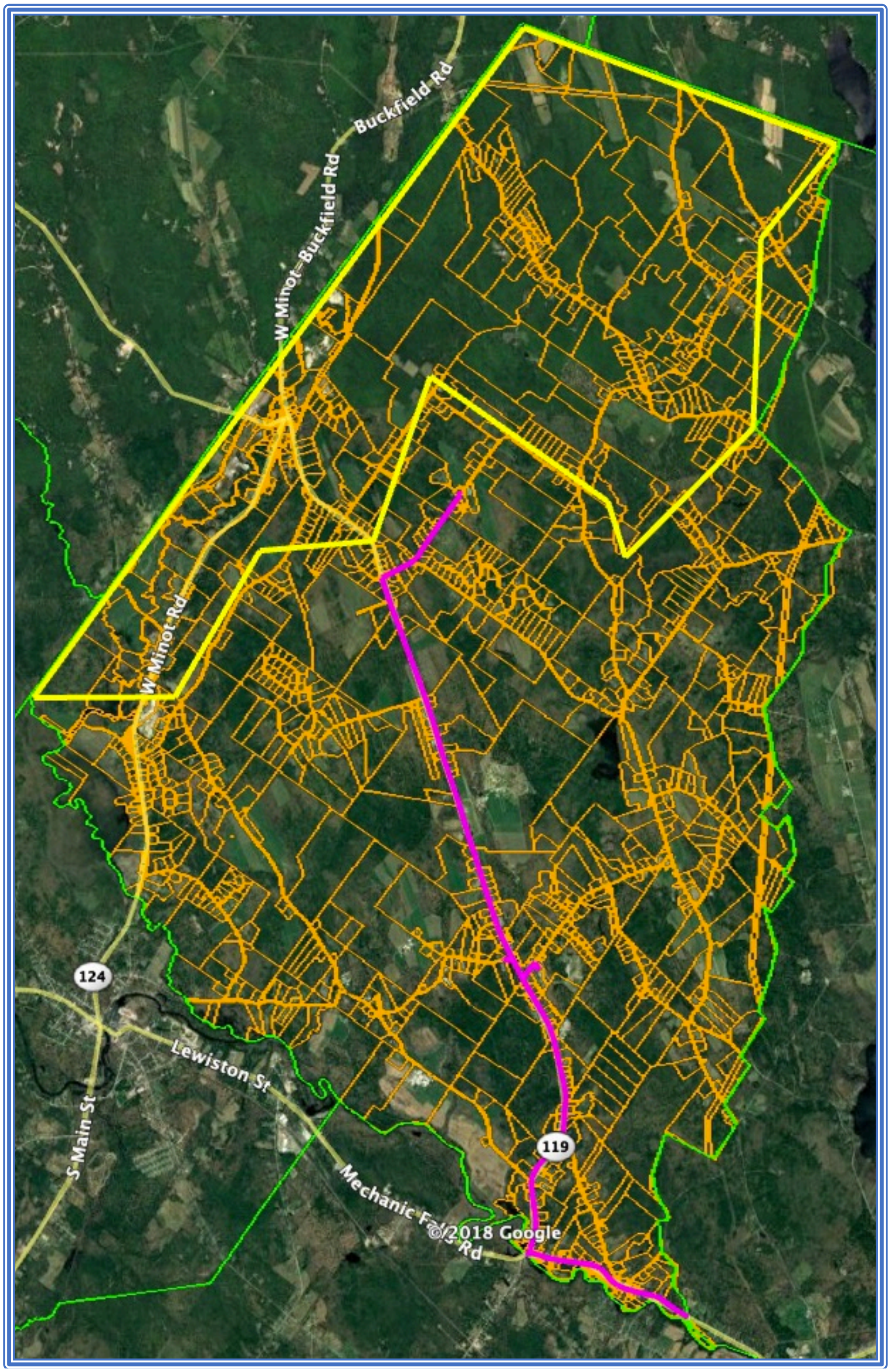
4.2 Consolidated Communications (CCI)



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As the incumbent local telephone company in the southern portion of the Town, Consolidated Communications (CCI) has a twisted-pair copper network connecting virtually every potential residential and business subscriber within their serving area of the Town. We did not attempt to map these copper assets, which are utilized for voice and lower speed DSL-based broadband services. The map above illustrates the location of CCI's fiber optic network based upon our field survey. CCI is capable of providing any type of service along their fiber optic network up to 10Gbps or greater, but the infrastructure was not designed or engineered to provide Fiber-to-the-Home broadband service.

The ConnectMaine Authority reports that a minimum 25Mbps/3Mbps service can be provided to all but one address within CCIs operating territory. We have confirmed with CCI that no subscribers can be served with 25Mbps/3Mbps, rather the highest speeds available to a limited number of potential subscribers is offered at 25Mbps/2Mbps, which is below the State of Maine minimum standard.

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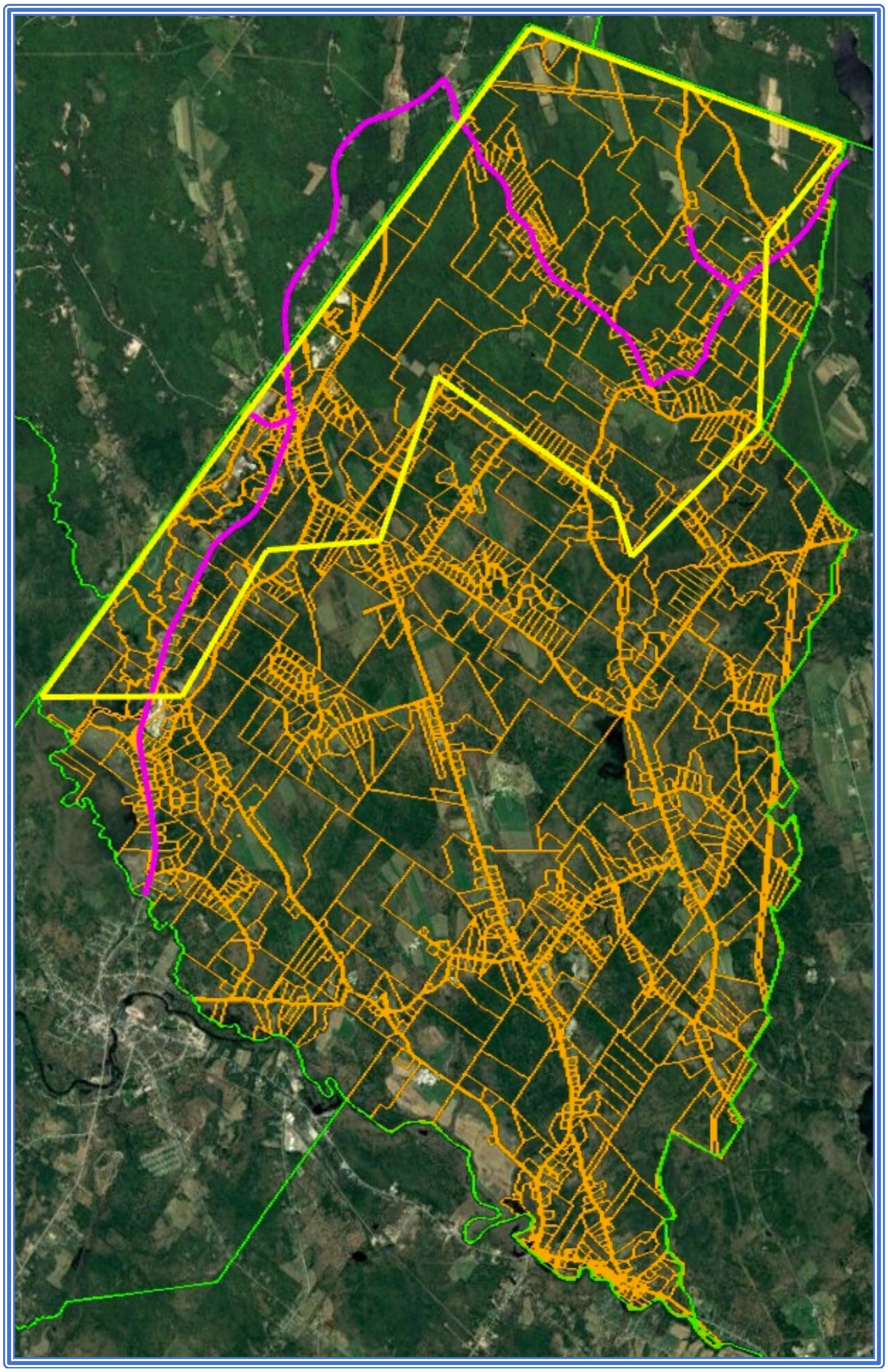
4.3 FirstLight (formerly known as Oxford Networks)



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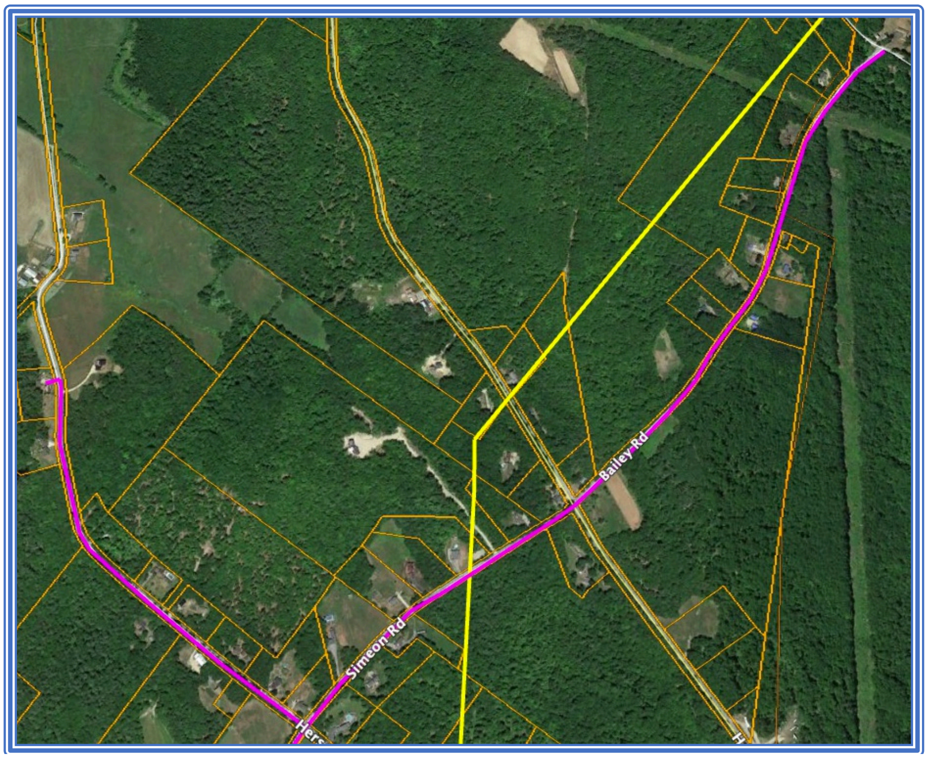
As the incumbent local telephone company in the northern portion of the Town, FirstLight has a twisted-pair copper network connecting virtually every potential residential and business subscriber within their portion of the Town. We did not attempt to map these copper assets, which are utilized for voice and lower speed DSL-based broadband services. The map above illustrates the location of FirstLight's fiber optic network based upon our field survey. FirstLight is capable of providing any type of service along their fiber optic network up to 10Gbps or greater, but the majority of their infrastructure was not designed or engineered to provide Fiber-to-the-Home broadband service, with the exception of the portions of Bailey Road, Simeon Road and Hersey Hill Road highlighted below.



According to FirstLight officials, this fiber cable was installed to serve a wireless tower near the end of Hersey Hill Road and was engineered with extra fiber capacity and drop terminals in order to be capable of providing FTTH service to subscribers along the route at some point in the future. In order for this route to be usable for FTTH service, additional fiber optic capacity must be deployed to connect back to their central office facilities in the Lewiston/Auburn area.

While the ConnectMaine Authority reports that only 2 addresses within the FirstLight service territory are not capable of providing a minimum 25Mbps/3Mbps service, FirstLight has acknowledged the ConnectMaine Authority mapping is not correct and that the majority of the potential subscribers within their service territory _cannot_ currently be served with a minimum 25Mbps/3Mbps service.

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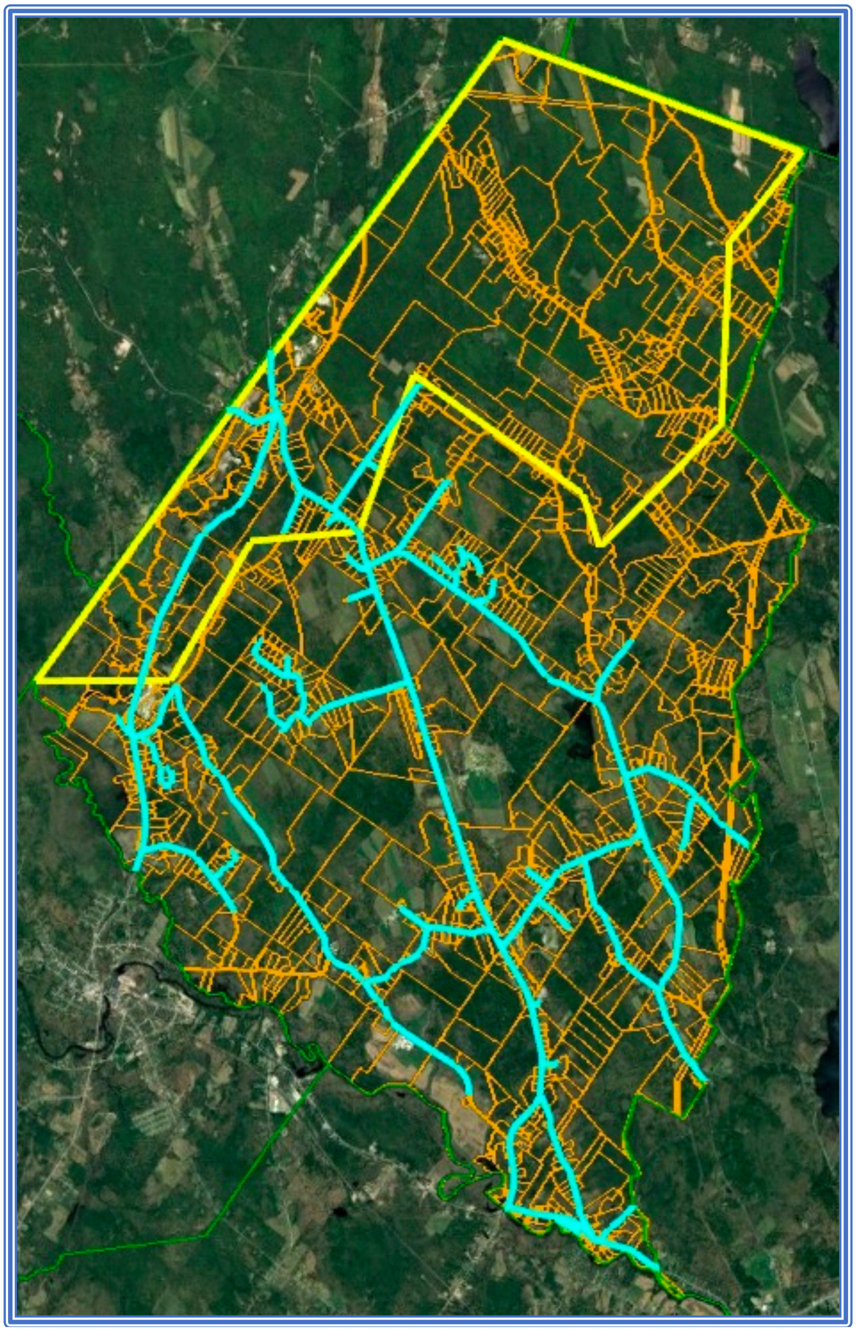
4.4 Charter (Spectrum)



Charter (Spectrum) has deployed their hybrid fiber coaxial network along the cyan colored roads highlighted in the map above. Spectrums entry-level broadband service is a minimum 100Mbps/10Mbps, with the capability of increasing the speed to 1Gbps. By our count, Spectrum is currently capable of serving 742 of the potential 1,092, or 68% of the potential subscriber locations within the Town.

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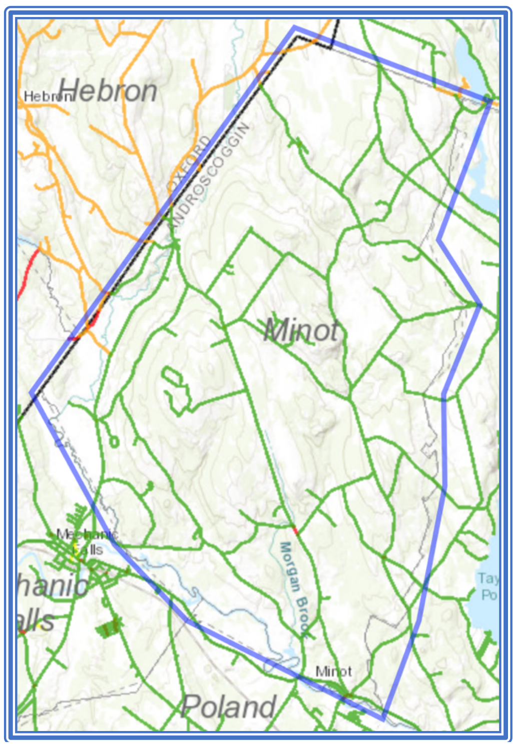
5 Infrastructure Gap Analysis

5.1 DSL - Minimum 25Mbps/3Mbps

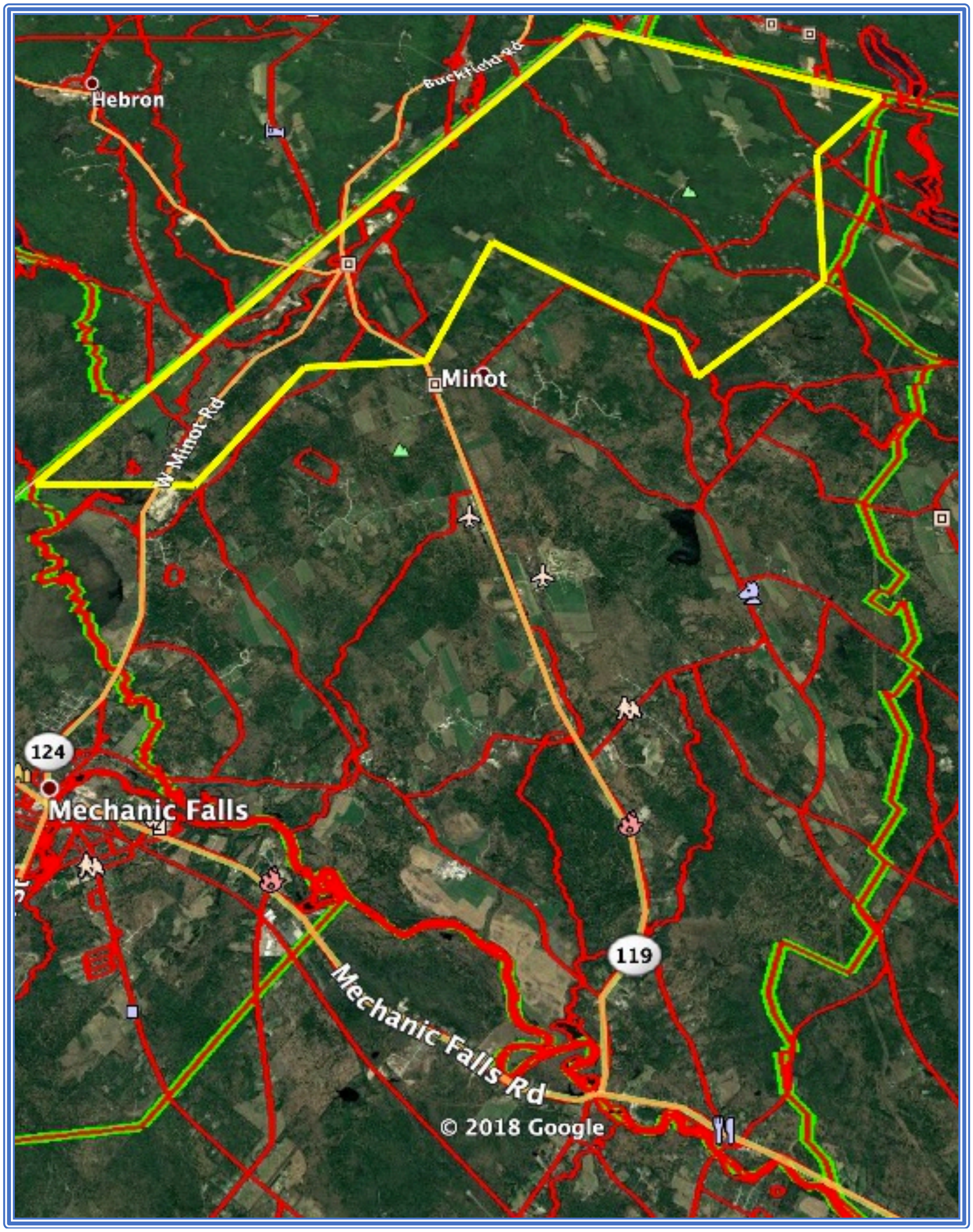
The ConnectMaine Authority considers subscribers unable to receive a minimum 25Mbps/3Mbps service as "unserved" and eligible for grant programs. As reported previously in this report, while the ConnectMaine data shows just a few road segments as unserved (see map below), FirstLight reports the majority of their service territory is not capable of receiving DSL service with a minimum 25Mbps/3Mbps speeds. On the other hand, ConnectMaine reports that only one address within CCI service territory along Wilson Hill Road is unable to receive a minimum 25Mbps/3Mbps service. CCI reports that the maximum DSL speed available to a very limited number of locations within their service territory is 25Mbps/2Mbps. As a result, we believe all roads not served by Spectrum are eligible for ConnectMaine implementation grant funding.



It is important to note that the ConnectMaine Authority mapping is based upon census block data as submitted by the service providers using a process defined by the FCC. That process considers any census block containing just a single subscriber capable of receiving a minimum 25mbps/3Mbps as fully served. As such, the mapping provided by the ConnectMaine Authority may dramatically overstate availability and understate those areas considered unserved. Without access to the service providers operation systems, cable plant records and deployed equipment types, it is impossible to determine the actual extent of areas unserved by a minimum 25Mbps/3Mbps service.

5.2 Census Block Mapping

The map below illustrates the census blocks within the Town.



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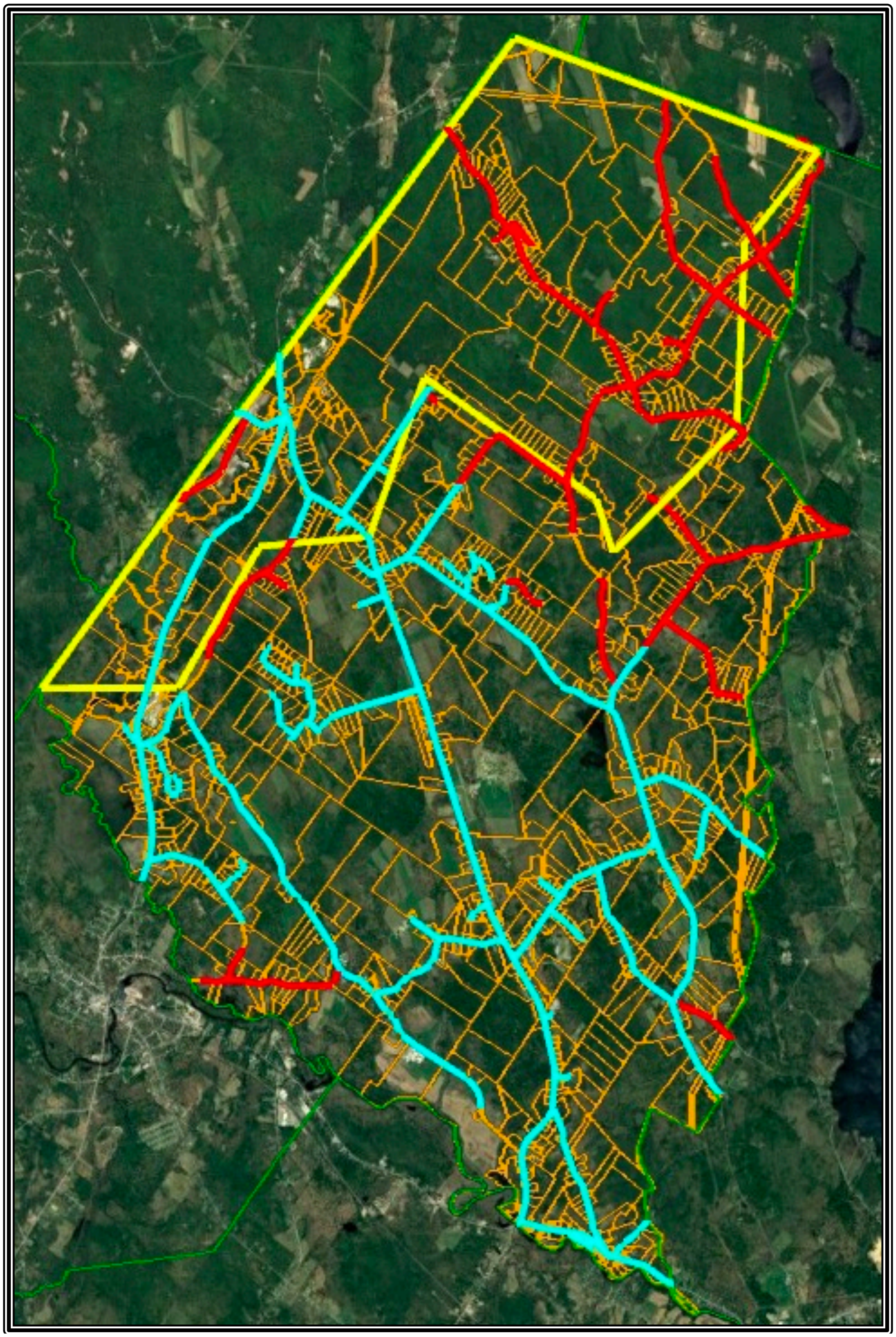
5.3 Cable Modem Internet - Minimum 100Mbps/10Mbps



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The map above illustrates the areas served by Spectrum with a minimum 100Mbps/10Mbps service in the color **cyan** and the roads unserved by Spectrum in the color **red**. The table below itemizes the un-cabled road segments and measures the mileage and quantity of potential subscribers along each road segment. Where logical, the road segments are organized by groups as a specific road segment may require another road segment to be built in order to establish continuity and connectivity.

Charter (Spectrum) Un-Cabled Roads				
Road Segment	**Group**	**Mileage**	**Potential Subscribers**	**Average per mile**
Jeffrey Rd	A	0.20	7	
Millett Rd	A	1.10	13	
Group Subtotal	**A**	**1.30**	**20**	**15.4**
Goodwin Rd - River Rd	B	1.10	18	
Grange Ave	B	0.28	4	
Group Subtotal	**B**	**1.38**	**22**	**15.9**
Brighton Hill Rd (South)	C	0.37	5	
Hadfield Rd	C	0.88	18	
Marston Hill Rd	C	1.77	30	
York Rd	C	0.66	13	
Group Subtotal	**C**	**3.68**	**66**	**17.9**
Bailey Rd	D	0.78	11	
Brighton Hill Rd	D	3.33	75	
Death Valley Rd (South)	D	0.81	8	
Harris Rd	D	1.00	17	
Hersey Hill Rd	D	2.00	25	
Hersey Hill School Rd	D	0.99	16	
Holbrook Rd	D	1.15	10	
Mountain View Rd	D	0.21	10	
Mountain View Rd (Entrance)	D	0.05	0	
Old Buckfield Rd	D	0.28	3	
Pleasant Dr	D	0.28	8	
Simeon Rd	D	0.42	8	
Strawberry Ln	D	0.14	3	
Sunset Dr	D	0.19	6	
Wilson Hill Rd	D	0.29	5	
Group Subtotal	**D**	**11.92**	**205**	**17.2**
Death Valley Rd (North)		1.27	16	12.6
E Garfield Rd		0.50	7	14.0
E Oxford Rd		0.80	7	8.8
Highland Dr		0.34	5	14.7
Jarvi Rd		0.10	2	20.0
Total of all Road Segments		**21.29**	**350**	**16.4**

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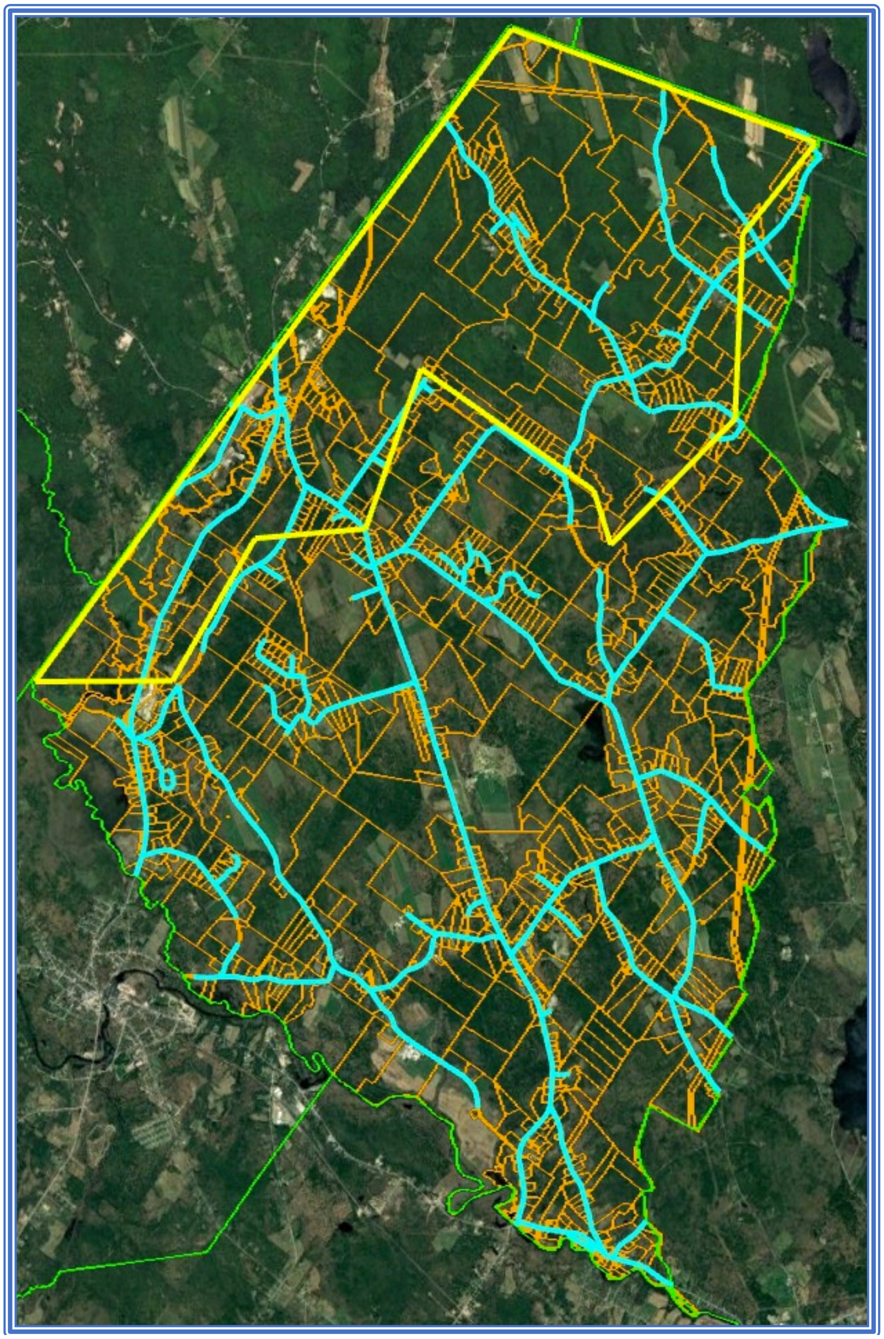
5.4 Fiber-to-the-Home - Minimum 100Mbps/100Mbps

Based upon our analysis and investigation, there are no households in the Town of Minot currently able to receive a consumer-grade FTTH service. The map below illustrates the roads unserved by a symmetrical 100Mbps FTTH service.



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6 Network Designs

6.1 Minimum 25Mbps/3Mbps - DSL

6.1.1 FirstLight Service Territory

FirstLight has suggested they are not interested in upgrading DSL service in their operating territory and are focusing all of their attention on upgrades to FTTH service. As of this writing, FirstLight has no plans to deploy FTTH service in the Town of Minot, but that could change as they complete upgrades in more densely populated and economic areas, or if pubic subsidies are made available. As a result, we are not including a network design for upgraded DSL service.

6.1.2 CCI Service Territory

With the few areas of CCI service territory not currently served by a minimum 100Mbps/10Mbps cable modem service, it does not appear to be a viable option to upgrade DSL service capability and reach. Further, CCI has indicated they have no plans to upgrade their DSL service in the Town. A more viable approach would be to extend cable modem service to those currently un-cabled roads. As a result, we are not including a network design for upgraded DSL service.

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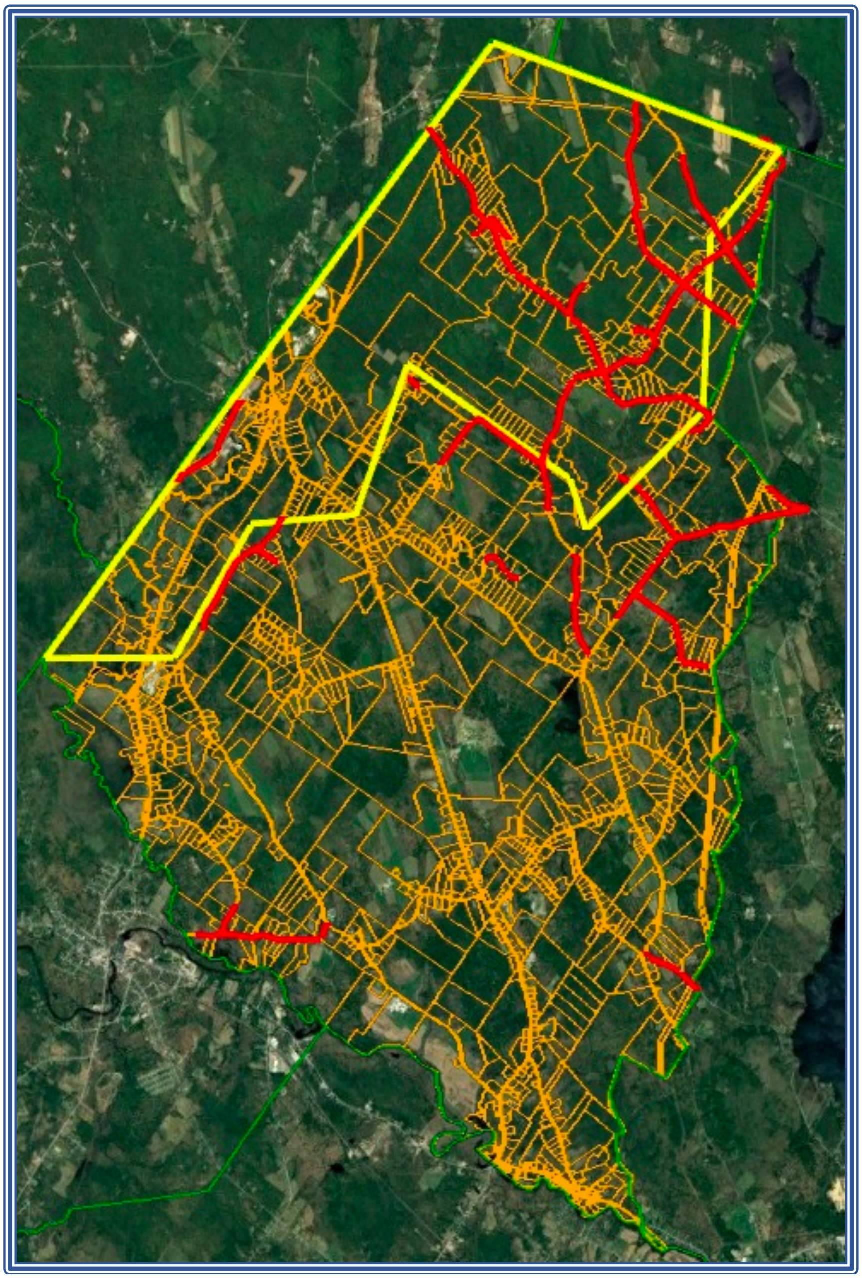
6.2 Minimum 100Mbps/10Mbps - Cable Modem

With 68% of potential subscribers already served by a minimum 100Mbps/10Mbps cable modem service, extension of that capability to the remaining un-cabled roads as illustrated in the map below would be a viable solution. Further, with an average of 16.4 potential subscribers per mile served by these line extensions compared to the average of 19.4 potential subscribers per mile served by the existing Spectrum network, we believe Spectrum would be willing to fund at least 75% of the cost to serve all of the remaining potential subscribers in the community.



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6.3 Minimum 100Mbps/100Mbps - FTTH

By virtue of the fact that there is not currently any FTTH service within the Town, the gap area illustrated in Section 5.3 above represents the design for a FTTH solution. There are a number of different design/operating options for a FTTH solution that should be considered.

Single Provider FTTH network - This is a network built and operated with a single provider only. The single provider could be the Town of Minot itself, or another service provider who partners with the Town. Service provider partners could potentially be any service provider, including the incumbent telephone providers currently operating within the Town.

Non-Discriminatory Open-Access FTTH network - A non-discriminatory open-access fiber network is an all-fiber network constructed and operated in a manner that allows multiple service providers to utilize the network under the same pricing, terms and conditions as any other service provider. In other words, it provides a level playing field and encourages and facilitates competition between an unlimited number of competitors. There are two types of open-access networks:

> **An Open-Access *Lit* Fiber network** - is a network where an Internet Service Provider (ISP) would interconnect their network to the common equipment in the centrally located Point of Presence (POP) and lease the fiber and the optical/electronics at the subscriber premise to deliver the service.
>
> **An Open-Access *Dark* Fiber network** - is a network where the ISP leases a fiber from the POP to the subscriber and places their own equipment in the POP and their own optical/electronics interface at the subscriber premise to deliver the service.

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7 Cost Estimates and Public-Private Partnership Strategies

There are a number of variables that impact the construction cost and operation of extending the existing cable modem infrastructure or a fiber network that can only be determined with confidence by producing a detailed engineering plan and financial proforma, which is outside the scope of this Study. However, using various industry metrics and leveraging our experience building and operating fiber networks and negotiating with service providers, we can provide a high-level estimate of such costs. The table below summarizes the high-level estimated costs for the various options, with each option discussed below the table.

Cost Options						
	Cable Modem Extension	Single Provider FTTH	Single Provider FTTH	Single Provider FTTH	Open Access Lit FTTH	Open Access Dark FTTH
Ownership	Spectrum	Incumbent Phone	3rd Party	Municipal	Municipal	Municipal
Road Miles	21.29	59.47	59.47	59.47	59.47	59.47
Potential Subscribers	350	1092	1092	1092	1092	1092
Estimated Cost per mile	$35,000	$30,000	$55,000	$55,000	$50,000	$50,000
Take rate	80%	40%	40%	40%	40%	40%
Subscriber Drop Cost	$0	$1,000	$1,000	$1,000	$1,000	$500
Total Estimated Capital Cost	**$745,150**	**$2,220,900**	**$3,707,650**	**$3,707,650**	**$3,410,300**	**$3,191,900**
Estimated Municipal Subsidy	25%	50%	33%	100%	100%	100%
Estimated Municipal Subsidy %	**$186,288**	**$1,110,450**	**$1,223,525**	**$3,707,650**	**$3,410,300**	**$3,191,900**

7.1 Cable Modem Extension with Spectrum

Extending the Spectrum network to reach all potential subscribers is the lowest estimated capital cost and the least risk for the Town. We believe all of the line extensions will qualify under the ConnectMaine Authority implementation grant program and the subsidy amount per potential subscriber would compete well for the funds available. Spectrum's minimum offered speed is 100Mbps/10Mbps and reportedly will soon be increased to a minimum 300Mbps/50Mbps, similar to their upgrades in other parts of the country.

The estimated cost per mile for Spectrum is based upon a similar project for the Town of Mount Desert we negotiated in 2017. The estimated subsidy percentage is lower than what was required in Mount Desert because the potential subscribers per mile is greater. Given the lack of competitive options, we believe the percentage of potential subscribers who sign up for service (take rate) will be very high and comparable to what we see in other similarly situated jurisdictions where Spectrum provides service.

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7.2 Single Provider FTTH with Incumbent Phone Companies

With this option, both FirstLight and CCI would over-build their networks with FTTH. The estimated cost per mile will be lower than the Spectrum option since both FirstLight and CCI are joint owners of the utility poles and already have cabling attached enabling both companies to simply over-lash the new fiber optic cable over the existing copper infrastructure. As a result, they would not have the considerable expense associated with the utility pole make-ready process.

Since both would be competing in a portion of their service area with Spectrum, who can be a formidable competitor, the overall take-rate is estimated to be half of the take-rate predicted with the Spectrum solution. We also believe the required subsidy percentage will be double that of the Spectrum solution since CCI is already receiving considerable revenue from many of these subscribers which may not be included in their economic investment analysis.

We do not believe the ConnectMaine Authority will fund this entire subsidy amount. As a result, municipal funding or other sources will need to be considered.

7.3 Single Provider FTTH with 3rd Party Service Provider

If the Town decides to pursue a FTTH solution and the incumbent providers and/or the Town are not interested in partnering, there are a number of 3rd Party service providers who may have an interest. Those providers would include: GWI, Pioneer Broadband, Premium Choice Broadband, Axiom Technologies, OTELCO, LCI and Matrix Communications.

In this scenario, the estimated construction costs are significantly higher as these service providers currently have no infrastructure in the area from which to extend or leverage. The estimated subsidy percentage is lower than with the incumbent telephone companies and higher than the Spectrum solution, primarily due to the fact that all revenue generated would be new revenue for these service providers compared to the replacement revenue for the incumbents.

We do not believe the ConnectMaine Authority will fund this entire subsidy amount. As a result, municipal funding or other sources will need to be considered.

7.4 Single Provider FTTH with Municipal Ownership and Operation

This solution is the most expensive, carries the most risk for the Town and is very similar to the FTTH network for the Town of Islesboro, where we acted as the Owners Project Manager on behalf of the town. This scenario is similar to partnering with a 3rd Party service provider in terms of the estimated costs per mile and take-rate. The difference would be the network would be entirely owned by the Town and the Town would be fully responsible for the maintenance and operation of the network. In

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the case of Islesboro, the Town contracts with GWI for the operation and routine maintenance and contracts with the contractor who built the network for major maintenance and restoration activities.

While this solution carries the greatest burden in terms of costs and risks, it provides the Town with complete control for the quality and performance of the service provided, and the Town would no longer be subject to large companies from away who do not share the same interests.

We do not believe the ConnectMaine Authority will fund this entire subsidy amount. As a result, municipal funding or other sources will need to be considered.

7.5 Open-Access Lit FTTH with Municipal Ownership and Operation

As discussed previously, an **Open-Access FTTH network** is a non-discriminatory open-access fiber network constructed and operated in a manner that allows multiple service providers to utilize the network under the same pricing, terms and conditions as any other service provider. In other words, it provides a level playing field and encourages and facilitates competition between an unlimited number of competitors. This solution envisions an **Open-Access *Lit* Fiber network** where the Internet Service Providers (ISPs) would interconnect their network to the common equipment in the centrally located Point of Presence (POP) and lease the fiber and the optical/electronics at the subscriber premise to deliver the service.

The estimated cost per mile would be slightly less than the single provider FTTH solutions where a 3rd Party or the Town would own the network because the cost to connect back to the Internet would be the responsibility of each service provider who leases capacity on the network. This is the only difference in terms of costs. Like the Single Provider FTTH with Municipal Ownership option, the Town would be fully responsible for the maintenance and operation of the network.

While not mentioned previously, the Town should be aware that CCI and Spectrum currently have a policy of not utilizing open-access networks and will likely continue to maintain their separate networks.

7.6 Open-Access Dark FTTH with Municipal Ownership and Operation

This option is an **Open-Access *Dark* Fiber network** where the ISPs lease a fiber from the POP to the subscriber and place their own equipment in the POP and their own optical/electronics interface at the subscriber premise to deliver the service.

The overall estimated cost for this solution is lower than an open-access lit fiber network because no optical electronics are required to be provided in the POP or at the customer premise, which is the responsibility of the ISP. Like the Single Provider FTTH with Municipal

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Ownership option, the Town would be fully responsible for the maintenance and operation of the network.

7.7 Cost Options and Public-Private Partnership Strategy Summary

There is no right or wrong choice as to which solution the Town chooses to pursue, rather each solution should be contrasted with the vision and goals of the Town, the available funding sources, and the capacity and commitment of the Town to provide management and oversight.

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8 Recommendations for Next Steps

Casco Bay recommends the Town aggressively and timely pursue the following initiatives as many service providers are looking for expansion areas and communities willing to partner. ConnectMaine anticipates funding rounds in March and May of 2020, the Mills administration is pursuing a bipartisan approach to additional state funding and our federal delegation continues to pursue funding from Congress and the FCC. As such, time is of the essence. Our recommendations are itemized below.

- The Minot Broadband Committee and Select Board should quickly develop the Town's broadband infrastructure vision and goals.

- Since the Spectrum Cable Modem Extension solution is the lowest cost, least risk, quickest to deploy and likely eligible for full funding by the ConnectME Authority, the report should be shared with Spectrum at the earliest opportunity.

- Simultaneously, we recommend sharing the report with FirstLight, CCI and all of the potential 3rd Party service providers to gauge their interest in serving the Town. For those interested, negotiations should be pursued on a timely basis.

- If a public-private partnership can be negotiated that achieves the goals and vision of the Town, submit grant applications to fund the public portion of the funding requirement.

Casco Bay Advisors maintains collaborative and independent working relationships with all of the service providers, network construction contractors and with the state-based institutions that can assist with funding models including the ConnectMaine Authority and the Finance Authority of Maine. We would be happy to assist the Town of Minot execute upon its broadband vision and leverage our 35 years' experience and success with other Maine municipalities.

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