Town of Bar Harbor

Broadband Plan and Network Designs

Submitted to:

The Town of Bar Harbor

Prepared by:

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Note:

Cost information included in the following report is an estimate based on recent quotes, historical data, certain assumptions about the project scope and approach, the regulatory environment and market conditions at a fixed point in time. Given these variables, we recommend updating the estimate as time passes, and allocating sufficient contingency to allow for inevitable but unpredictable changes in the cost environment if the project moves forward.

TILSON

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Executive Summary

The Town of Bar Harbor engaged Tilson to evaluate current broadband availability in the Town for several different constituencies. Town officials' goal through the engagement was to obtain options for improving broadband access at different levels throughout the Town. These levels ranged from a discrete few buildings in the village, to larger areas in the region, to the Town at large. Town officials expressed a desire for Tilson to plan a municipally owned fiber optic network to connect Community Anchor Institutions (CAIs) throughout the Town. The Town's two primary articulated goals in the engagement are to provide broadband service to downtown commercial interests with a more cost effective, Town-owned network, and to make this connectivity an aspect of Town life that retains more residents year-round and attracts new residents to live in the Town as well. As part of this vision, stake holders expressed a goal of encouraging college-age Bar Harbor residents to remain in the community as well. Like most communities in the U.S., Bar Harbor receives internet service from an incumbent local exchange carrier (FairPoint) and a cable company (Time Warner Cable). Tilson explored the feasibility of deploying last mile fiber in a phased approach throughout the town. As a secondary exercise, Tilson explored the feasibility of a 4G LTE wireless broadband solution to businesses and residents. This solution would offer service packages and prices comparable to those enjoyed by cable customers. Due to comparable pricing, higher risk, and lack of a significant improvement in service, Tilson recommends against pursuing a 4G LTE wireless solution. Tilson believes that a fiber-based solution is the only technology capable of meeting the Town's goals of creating an economically distinct broadband service, retaining substantial operating control, offering low cost, world-class bandwidth.

The key findings of the report are as follows:

1. Stakeholders in the Town of Bar Harbor feel that their current Internet capabilities are inadequate to meet changing business demands. There are onerous cost burdens associated with subscribing to the services one of the incumbent carriers for the Town, residents, and businesses alike. Such ongoing costs are significant, and can be avoided with the right broadband investment initially, creating a solution where the Town is not dependent upon a powerful carrier with prohibitive prices.

2. The following are the Town-identified constituencies. Tilson has developed four different designs and networks of varying scopes in answering the needs of these constituencies with varying capital costs associated with each.

   Town-identified Constituencies:

   -Unserved/Underserved
   -Hotels/Motels/Campgrounds
   -Remote workers
   -Hi Tech startups
   -Cafes (Internet)

-Library
-Visitors/tourists
-Businesses
-Connections to other towns/public services (i.e. Police)

3. The Town believes that a municipally owned fiber connection may result in lower, long term costs to the consumer than a commercially owned network. Tilson's asset inventory of the area found that there is a significant amount of fiber in Bar Harbor. While Tilson believes that this has the physical capacity to provide last mile connectivity, it is not economically available for use by small businesses and residents. However. For the Town-identified Municipal Phase II buildings, the majority of these locations are part of the Town's water and sewer infrastructure. Many are remote and would require extended fiber laterals to reach.

   In terms of wireless assets, despite the existence of five cellular towers in the greater Bar Harbor region in the vicinity of the Town and Mount Desert Island, there are significant coverage gaps in the Village area of Bar Harbor, as well as to the south of the Village. The reason for these gaps despite the tower assets already in the region is due to the mountainous terrain, which hinders radio frequency communications.

4. Tilson envisions four different phases of varying costs in its fiber design for the Town. "Municipal Phase I" includes the primary municipal buildings, with a modest incremental increase for "Municipal Phase II" additional buildings, which consist of Town Water and Wastewater Division buildings. The next increment in the fiber design contemplated would serve residential and commercial customers on the main and side roads in the Bar Harbor Downtown Village in a "Residential/Commercial Phase I" buildout, with the final potential buildout (Residential/Commercial Phase II) representing all residential and commercial premises of the main and side roads in the areas outside of the Downtown Village. Tilson recommends a multistep approach to proceeding with a solution. First, determine the baseline of support from both seasonal and year round residents. The Town can utilize several methods for assessing this level of support. Those methods include a pre-subscription campaign, marketing campaign, and resident survey. Second, select and carefully defined business model which includes financial analysis to determine take rate thresholds and pricing. Third, conduct a detailed engineering study to finalize the capital cost estimate.

   Tilson conducted a high level design for a 4G LTE solution that could provide broadband throughout the Town. A network deployment that utilizes 10 small cell antennas and one to three macrosites would provide 4G LTE residential and small business broadband solution throughout the Town. This solution presumes a carrier tenant with spectrum rights to provide service over the infrastructure. However, this solution does not provide a significantly different option in terms of price, speed, or reliability from cable. Therefore, Tilson recommends against deploying this technology with municipal financing. The only exception to this recommendation are for discrete areas of Bar Harbor that do not have access to Time Warner Cable.

   Tilson estimates that the total capital cost to connect the primary town buildings (Municipal Phase I) is $2.2 million. The total capital cost to add the Phase II municipal buildings is

approximately $300,000. The differential is due to the fact that most of the additional Town water and wastewater division locations would be served by the Phase I backbone. Thus the total capital cost for Phases I and II would be approximately $2.5 million. Tilson estimates that the capital cost for Residential/Commercial Phase I buildout, connecting residences and businesses of the Downtown Village, is $4.2 million. The Residential/Commercial Phase II build adds about $8.4 million to the capital costs. Tilson estimates that the total capital cost of all phases in this fiber buildout designed is just over $15 million. This figure includes the cost of serving every premise in the Town and is the cost for "lit" universal service, assuming all aerial drops. Note that the Res./Comm Phase I and Phase II builds assume the existence of the Municipal Phase I and II builds. The municipal core network serves as a backbone to end customers in this model, so any subsequent fiber build to residential customers/premises depends on the existence of this initial fiber backbone.

There are however, a number of different permutations that these capital costs can have depending on the type of model the Town selects.

5. The marginal operating costs for each of the four fiber buildouts is estimated below.

Municipal Network Phase 1	$123,233
Municipal Network Phase 2	$7,025
Res/Comm Phase 1	$276,713
Res/Comm Phase 2	$517,680
Total	**$924,650**

Many operating costs are fixed regardless of how many users are on network. This creates attractive economies of scale for the networks that serve residential and commercial customers in addition to business customers.

6. Tilson studied a number of different permutations of various types of business model structures available to the Town to choose from. Among these were the Town-owned utility network, public-private partnership network, and fully municipally owned network. Each of these have advantages and disadvantages related to ownership, operation, funding, revenue, operational risk and costs, and open or closed access status. There are essentially two options if the town decides to use bond capital. First, it can own the network and partner with an outside internet service provider. Second, the town can both own and operate the network as a municipal ISP.

7. Finally, Tilson's review of the economic analysis associated with an investment in broadband showed significant potential positive effects on the Town's economic activity, including GDP, job creation, wages, tax revenues, and consumer surplus—the measure of consumer wellbeing.

8. Given the Town's objectives of obtaining low cost, highly reliable, and future proof bandwidth for municipal, small business, and residential uses, Tilson recommends that the Town pursue a fiber-based solution and one of the two Town-led business models. A municipal subsidy results in lower broadband costs to the user compared to a privately funded model. Tilson recommends

that the Town pursue a municipally financed and controlled solution that delivers the fastest possible bandwidth at the lowest prices.

9. Other Towns in the region are pursuing similar processes. Tilson recommends that Bar Harbor partner with neighboring communities to the greatest extent possible. This will have minimal impact on capital costs but will reduce ongoing operational costs and minimize the risk of operational losses in the long term.

10. The Town's immediate next step is to decide upon the desirable business models and to approach the private marketplace for partners and general contractor vendors to implement solutions.

    By doing an incremental buildout in the four phases explored in this plan, the Town can build its subscriber base with each additional increment. In this way, the Town can reduce operational risk by securing revenue before capital is invested.

Defining Broadband

It is important to note that the term "broadband" does not refer to any technology in particular. Rather it refers to data transmission through a medium in excess of certain threshold. From an information technology perspective, it represents the amount of data that a consumer can download or upload from the Internet in a given second. This is the measurement known as bandwidth. Greater bandwidth is analogous to a faster connection. Connection speeds are generally measured in kilobits per second (Kbps), megabits per second (Mbps) or gigabits per second (Gbps).[1]

In the U.S., broadband standards are defined by the Federal Communications Commission (FCC), which regulates interstate and international communications by radio, television, wire, satellite and cable. The FCC uses a tiered approach to define broadband based on download and upload speeds for wireline and wireless technologies:

FCC Speed Tiers

FCC Speed Tier	Download Speeds	Upload Speeds
1st Generation Data	200 Kbps to 768 Kbps	200 Kbps to 768 Kbps
Tier 1	768 Kbps to 1.5 Mbps	768 Kbps to 1.5 Mbps
Tier 2	1.5 Mbps to 3 Mbps	1.5 Mbps to 3 Mbps
Tier 3	3 Mbps to 6 Mbps	3 Mbps to 6 Mbps
Tier 4	6 Mbps to 10 Mbps	6 Mbps to 10 Mbps
Tier 5	10 Mbps to 25 Mbps	10 Mbps to 25 Mbps
Tier 6	25 Mbps to 100 Mbps	25 Mbps to 100 Mbps
Tier 7	> 100 Mbps	> 100 Mbps

[1] 1 Gbps = 1000 Mbps = 1,000,000 Kbps.

Until very recently, the FCC defined broadband as 4 Mbps downstream and 1mbps upstream. As shown in the table above, that standard translates to a minimum Tier 3 download and Tier 1 upload connection to qualify as broadband service. In July of 2014, the FCC announced that it planned to increase the download threshold to 25 mbps. On January 29th, 2015 the FCC formally redefined broadband as 25 mbps download and 3 mbps upload. This redefinition has the potential to dramatically increase the number of communities in the U.S. eligible for subsidy.

The rapid advancement of delivered data speeds in the U.S. caused the change in the definition of broadband. In 2000, only 4.4 percent of American households had a broadband connection (as defined prior to January 29, 2015) in their homes. By 2010, that number had jumped to 68 percent. Moreover, since 2010, average delivered speeds in the U.S. have doubled overall, and today roughly 94 percent of Americans have access to wireline or wireless broadband speeds of at least 10 Mbps downstream. As a result, the FCC raised the minimum threshold.[2] This evolving baseline reflects a growing need for higher bandwidth as Americans increasingly use the internet and communications technologies in all aspects of their lives.

In terms of functionality, the following table shows download speeds[3] required for a range of common internet-based activities:

	Basic Use (Email, Web Surfing Basic Video)	**Moderate Use (Basic use plus high demand functions i.e. gaming, conferencing, HD video)**	**Heavy Use (Basic use plus multiple high demand functions)**
1 user on 1 device (laptop, tablet, gaming console)	1 – 2mbps	1 – 2mbps	6 – 15 mbps
2 users on 2 devices at a time	1 – 2mbps	1 – 2mbps	6 – 15 mbps
3 users on 3 devices at a time	1 – 2mbps	2 – 5 mbps	15 mbps or more
4 users or devices at a time	2 – 5 mbps	6 – 15 mbps	15 mbps or more

Figure 1: Minimum Download Speed for Common Activities

[2] Pg. 4. *Four Years of Broadband Growth*, June 2013. The White House Office of Science and Technology Policy & The National Economic Council. http://www.fcc.gov/document/fcc-finds-us-broadband-deployment-not-keeping-pace

[3] FCC, Household Broadband Guide.

Download and upload speeds depend on the type of communications technology service providers utilize. There are a number of different technologies currently available to residential and business users, which offer varying bandwidth capabilities:[4]

Technological Speed Capabilities

Technology	Download & Upload Speeds
Dial-up	Up to 56 Kbps
2G Mobile	Up to 100 Kbps
3G Mobile	384 Kbps – 2 Mbps
4G Mobile[5]	2 Mbps – 18 Mbps
Satellite[6]	200 Kbps – 2 Mbps
DSL	768 Kbps – 7 Mbps
Traditional Cable	1 Mbps – 10 Mbps
DOCSIS 3.0 Cable	1 Mbps – 150 Mbps
Fixed Wireless[7]	1 Mbps – 1.5 Gbps
T-1	1.5 Mbps
Fiber Optic	Up to 1,000 Gbps. Effectively infinite

The speeds shown above are averages achieved for each technology. Higher speeds are possible for certain technologies depending on network layout and user saturation. If a user is located close to a network node, which houses the networking equipment that sends the network signal, and overall network use at that point in time is low, he will obtain higher connection speeds. DSL subscribers commonly experience this phenomenon. If a DSL subscriber is located close to the service provider's (Verizon for example) remote terminals he can achieve download speeds as high as 15 Mbps.[8] However, as one moves farther away from the remote terminal, download and upload speeds decrease. Outside of one mile from a central office, it is very difficult to achieve a broadband connection over DSL.

Current State of Broadband in Bar Harbor

Stakeholders in the Town of Bar Harbor initially expressed an ultimate goal universal coverage for all constituencies. Specifically, the Town identified the following as groups with distinct broadband needs that could be addressed with a solution.

-Unserved
-Underserved
-Hotels/Motels/Campgrounds

[4] Pg. 5. The ConnectME Authority. 2012. *Developing Broadband in Maine: Strategic Plan.* Available at http://www.maine.gov/connectme/grants/ntia/planning.shtml.
[5] AT&T Wireless currently has the highest tested capacity at 18 Mbps.
[6] Current satellite service may achieve broadband level speeds, but the excessive latency or delay precludes the use of many broadband applications.
[7] The Rhode Island company Towerstream offers up to 1.5Gbps.

-Remote workers
-Hi Tech startups
-Cafes (Internet)
-Library
-Visitors/tourists
-Businesses
-Connections to other towns/public services (i.e. Police)

At the present time, the Town is considering a phased approach, with a first phase that focuses on the Municipal Buildings, and then the Downtown Core initially, before building out to the more outlying areas over time.

Each of these constituencies possesses different types of Internet usage and the types of technologies which would normally serve each area. Figure 2 below contains a summary of these:

Figure 2

Constituency	Typical Internet Usage	Existing Technologies
Municipal Buildings	File sharing, record keeping, office uses	Fiber Optics
Downtown Core	Transactions, cloud computing, visitor connectivity	Fiber Optics + WiFi
Park Lands	Mobile usage	Cellular Data (LTE)
Commercial Corridors	Transactions, software as a service, data needs	Fiber Optics and/or LTE
Low Density Residential	Content consumption, internet browsing	LTE or existing copper

Business/Community Need

As part of the Municipal buildings constituency, local businesses in the Town of Bar Harbor feel that their current Internet capabilities are inadequate to meet changing business demands. The owner of a local shared office space supporting local companies emphasized that as time goes on, businesses need higher speed Internet in order to keep pace with the changing economy. Toward this end, the owner of this shared space sought the fastest Internet connection available to support companies housed in this space. As such, high speed Internet has become as important as access to parking and being within walking distance of the downtown for people who work in the Town. This growth in demand is due to

several factors including greater prevalence of video content, prevalence of high definition digital imagery, and increased reliance on cloud-based computing. Businesses need more bandwidth to perform their traditional services.

Speeds/Pricing

The following are the speeds and pricing quoted for local business and town officials by the local carriers.

Business[8]

Speed (Download/Upload)	Price/Month	Contract Term	Carrier
35 Mbps/5 Mbps	$190	1 year	Time Warner
50 Mbps/5 Mbps	$450*	1 year	Time Warner
50 Mbps/50 Mbps	$180**	3 year	GWI
25 Mbps/10 Mbps	$89/month	No Term	RedZone
10 Mbps/1 Mbps	$25/month	No Term	RedZone

*The $450/month is the highest-priced service available to small business owners in the local market.
**The $180/month business rate may only be available to properties along the Maine 3 Ring Binder fiber route.

Residential[9]

Time Warner Cable

Speed (Download/Upload)	Price/month	Contract Term
50 Mbps/5 Mbps	$65	1 year
30 Mbps/5 Mbps	$55	1 year
20 Mbps/2 Mbps	$45	1 year
15 Mbps/1 Mbps	$35	1 year

GWI (DSL)[10]

Speed (Download/Upload)	Price	Contract Term

[8] Source: Interview with local business; www.broadbandnow.com/Maine/Bar-Harbor
[9] Source: www.timewarnercable.com
[10] Source: www.gwi.net/residential/high-speed-internet-service-in-maine

20 Mbps/1 Mbps	$50/month	Unspecified
7 Mbps/1 Mbps	$47/month	Unspecified

RedZone

Speed (Download/Upload)	**Price**	**Contract Term**
25 Mbps/10 Mbps	$89/month	No Term
10 Mbps/1 Mbps	$25/month	No Term

Town of Mount Desert Optical Service Cost

The Town of Mount Desert pays approximately $40,000 annually for connectivity between buildings, consisting of fiber running to its Town Office. They push Internet out to the other buildings via Virtual Private Network (VPN). The previous year the cost of this service was about $22,000. For the Town of Mount Desert, the primary cost is the fiber rental to the town office. The monthly charges to the other sites in Town are around $280- $320 per month. The town office has a 50 mbps symmetrical fiber connection. All other locations are connected via the provider's managed VPN. They are 35 down and 5 up with the exception of the two fire departments which are 15 down and two up. Mount Desert investigated fiber for all locations about 2 years ago and it was about another 11 to 12 thousand dollars annually above and beyond what they are paying currently. Current cost is approximately $42,000 annually.

The solution currently employed by the Town of Mount Desert is an example of a local town's expensive connectivity solution for a small connection of a few buildings, as well as the dramatic escalation in costs from year to year. By identifying existing infrastructure assets in the area as well as designing a network that utilizes this infrastructure, the goal is to provide a broadband future that avoids the onerous cost burdens associated with subscribing to the services one of the incumbent carriers. Such ongoing costs are significant, and can be avoided with the right broadband investment initially, creating a solution where the town is not dependent upon a powerful carrier with prohibitive prices. In addition, the lack of symmetric performance of some of the Town's circuits would inevitably hinder the Town's ability to centralize resources such as workstation backups, phone services, and surveillance cameras.

Asset Inventory

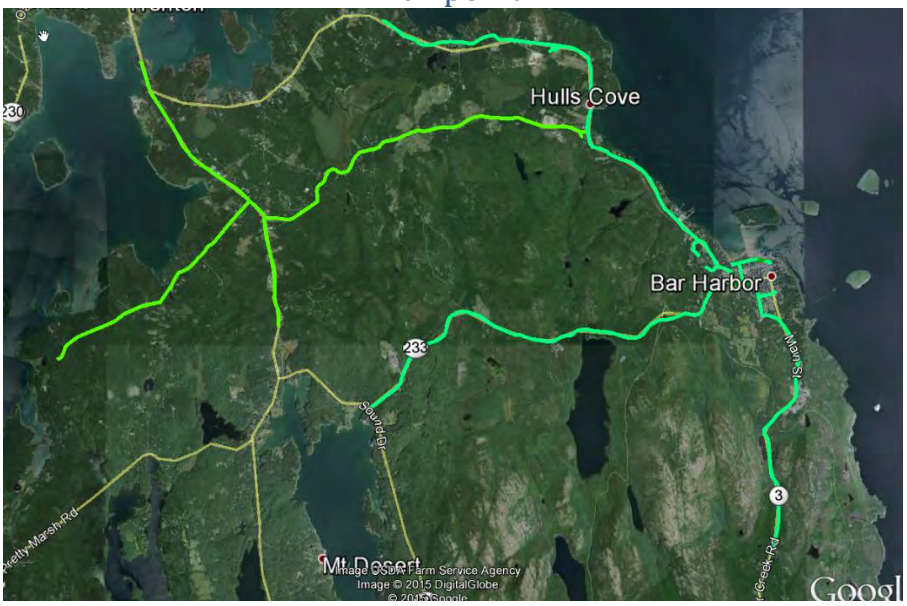
Existing Fiber

The first step in planning for the Town of Bar Harbor's broadband future is to understand the existing infrastructure present within the Town. It is critical to understand that the existence of infrastructure does not necessarily entail access. While Tilson found fiber throughout Bar Harbor, much of this fiber is inaccessible due to subscription costs or the owner's corporate policy.

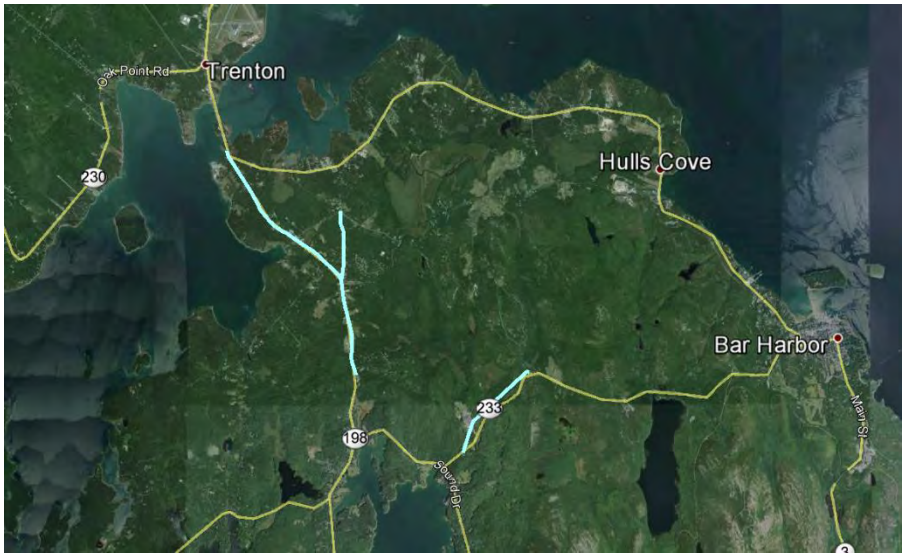
The mere presence of fiber in an area does not necessarily mean that this fiber is available. In the case of the Town of Bar Harbor, there is even evidence to suggest that the existing fiber is not available, as an inspection of fiber running along Route 233, for example, showed a dearth of slack loops or splice cases that would be necessary for fiber drops to premises. Many of the buildings in the downtown area have fiber on the premise, but no provider offering service over the circuit. With the caveat that much of the existing fiber is difficult or impossible to access, Tilson's inspection found four providers with varying footprints in the Town:

Time Warner

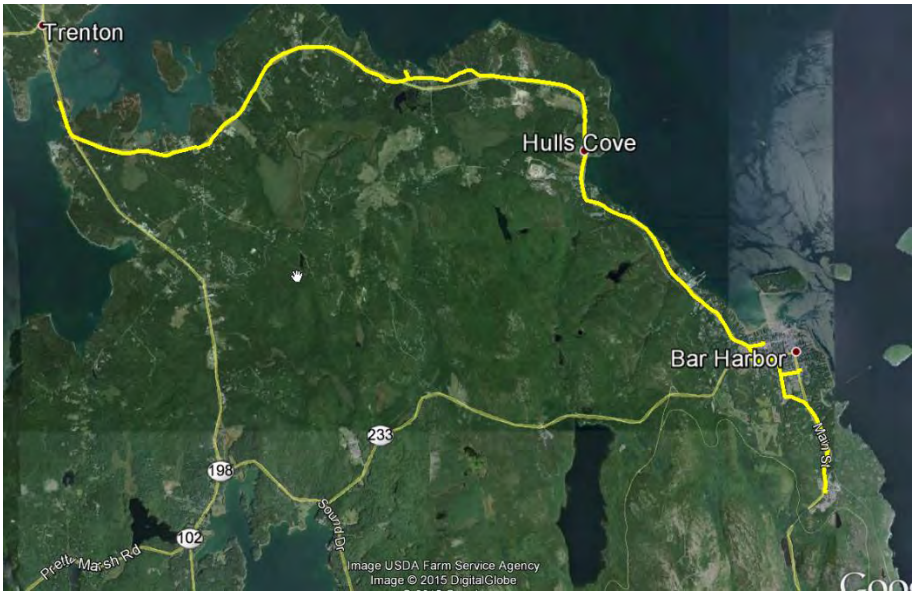
Fairpoint



Emera



Maine Fiber Company (3 Ring Binder Route)



Once again it is important to emphasize that while there are significant fiber assets in the Town of Bar Harbor via Fairpoint and Time Warner, only the assets along the Three Ring Binder fiber route could be available for lease by the Town.

As a requirement of the report, the Town sought a fiber network design that connected two sets of municipal buildings. The first set consist of government, public safety, educational, and municipal sewer infrastructure facilities. Most of these facilities are currently wired with Time Warner Cable fiber. Time Warner offers a suite of business class offerings over the infrastructure but the Town is exploring options for accessing different services.

These four providers serve the Municipal Phase I locations listed below.

Municipal Phase I Locations and Fiber Providers

Location	Address	Fiber Access
Town Office	93 Cottage St	TW, FP, MFC
Port Security/Harbor	21 Ells Pier	None unless buried conduit
Public Safety	37 Firefly St.	TW
WW Treatment Plant	136 Ledgelawn Ave.	TW
(Old) Highway Garage	135 Ledgelawn Ave.	TW

Solid Waste/Transfer	9 White Spruce	TW (offices have TW fiber there, but the transfer station does not)
Town Hill FD	1328 Rte. 102	TW, FP, Emera
Duck Brook	226 Duck Brook	TW and FP nearby on Rt. 233
Ireson Hill	329 Route 3	TW (FP & MFC nearby)
Hulls Cove Treatment Plant	37 Wilcomb Lane	TW (Wilcomb Ln.) and FP on Crooked Rd.
MDI High School	1081 Eagle Lake Rd.	Emera directly; TW and FP nearby Rt. 233 but the school lacks access
Connor-Emerson	3 Eagle Lake Rd.	TW, FP, MFC
Jesup Library	34 Mt. Desert St.	TW, with FP and MFC on Ledgelawn Ave.
Comfort Station	30 Park Street	TW nearby

The figure below maps the existing fiber infrastructure in the Town against the Municipal Phase I locations. There is a significant amount of fiber in Bar Harbor and Tilson believes that it has the capacity to provide last mile connectivity to business and municipal clients. However, the Town believes that a municipally owned fiber connection may result in lower long term operating costs than a commercially owned network.

Overlay of Current Fiber Assets and Municipal Phase I Buildings

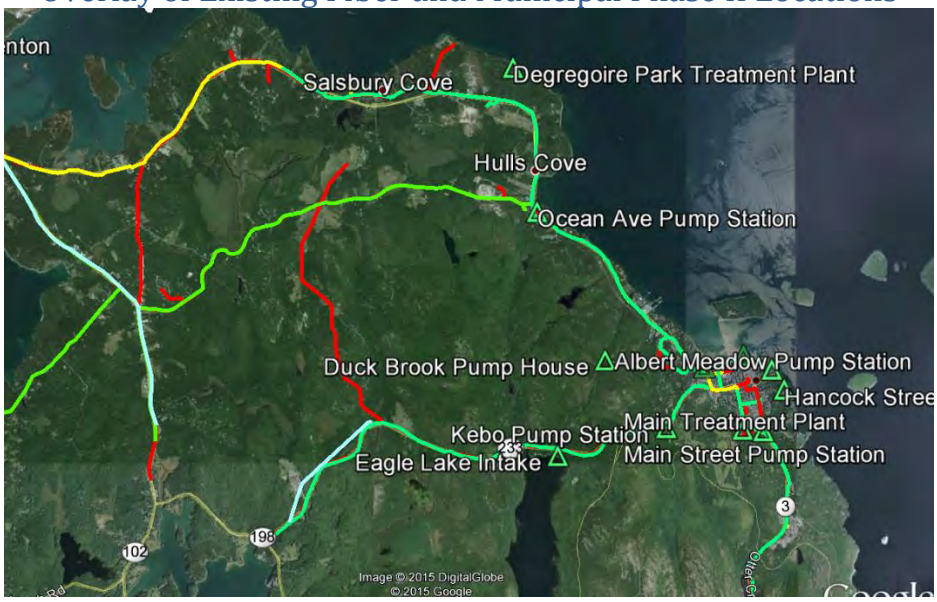
The second set of municipally owned facilities is outlined below. These are secondary priorities to the first set, and the majority of these locations are part of the Town's water and sewer infrastructure. Many are remote and require extended fiber laterals to reach. The Town believes that the water and wastewater supervisory control and data administration capabilities are not up to date. Tilson's asset inventory confirmed that these systems are completely underserved by fiber, and the Municipal Phase II design solution would remedy the deficiencies in the automated command and control functions of these buildings.

Municipal Phase II Locations and Fiber Providers

Location	Address	Fiber Access
Eagle Lake Intake	422 Eagle Lake Road	TW and FP, but no splice points/slack loops
Kebo Pump Station	138 Eagle Lake Road	TW, FP
Albert Meadow Pump Station	30 Albert Meadow Road	None
Degregoire Park Treatment Plant	57 Degregoire Park Road	None
Eddie Brook Pump Station	138 West Street	TW; FP and MFC nearby
Hancock Street Pump Station	5 Devilstone Way	None
Hulls Cove Pump Station	1 State Hwy 3	TW
Main St. Pump Station	1 Cromwell Harbor Road	TW, FP, MFC
Ocean Ave. Pump Station	27 Ocean Ave.	TW directly; FP and MFC nearby
Rodick Street Pump Station	49 West Street	None directly; buried FP nearby; TW nearby as well

The figure below shows the overlay of the existing fiber map and these locations.

Overlay of Existing Fiber and Municipal Phase II Locations



Network Design

Fiber Capital Cost Estimate

Tilson conducted an inventory of the fiber assets in the Town of Bar Harbor, employing a walk-through survey method and utilizing GPS for all of the Town-identified locations for both Municipal Phase I priority locations and Municipal Phase II priority. In this process, 22 miles of fiber was priced and the network was engineered to be as efficient as possible in minimizing the number of splice points necessary. Toward this end, Tilson's engineers created a design that isolated each fiber connection back to the central office so as to avoid additional splice points. This called for the capacity of a 144 strand or greater fiber cable.

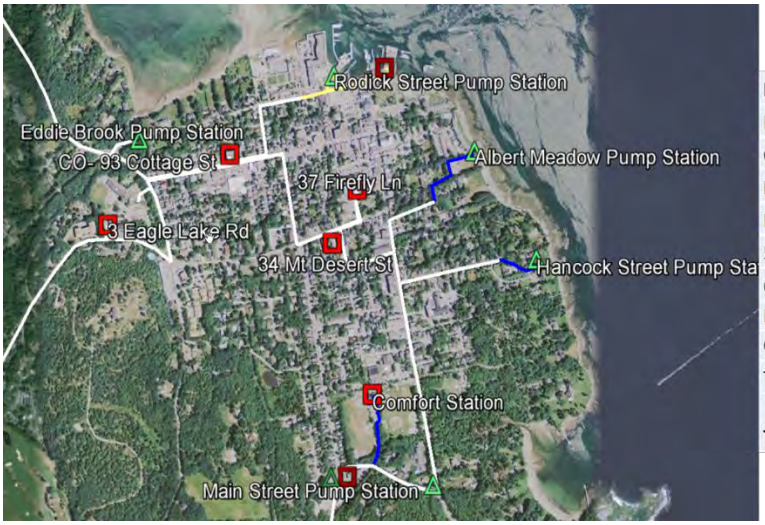
The figure below shows the major fiber routes (in blue) necessary to serve the "Municipal Phase I" locations of priority as identified by the Town which are denoted by red square placemarks. The fiber connecting these locations comprises a proposed fiber backbone for the Town, from which additional fiber could be added for different Town locations or constituencies in subsequent phases.

Town of Bar Harbor Network Design – Municipal Phase I Buildings

Line Item	Est. Cost
Materials Including Fiber	$184,361
Construction (aerial and underground)	$368,568
Electronics and Shelter	$264,237
Make Ready	$415,730
5.5% Sales Tax (materials)	$24,673
6.0% Service Provier Tax (labor)	$47,058
Professional Services	$369,665
Contingency	$560,896
Total	**$2,235,188**

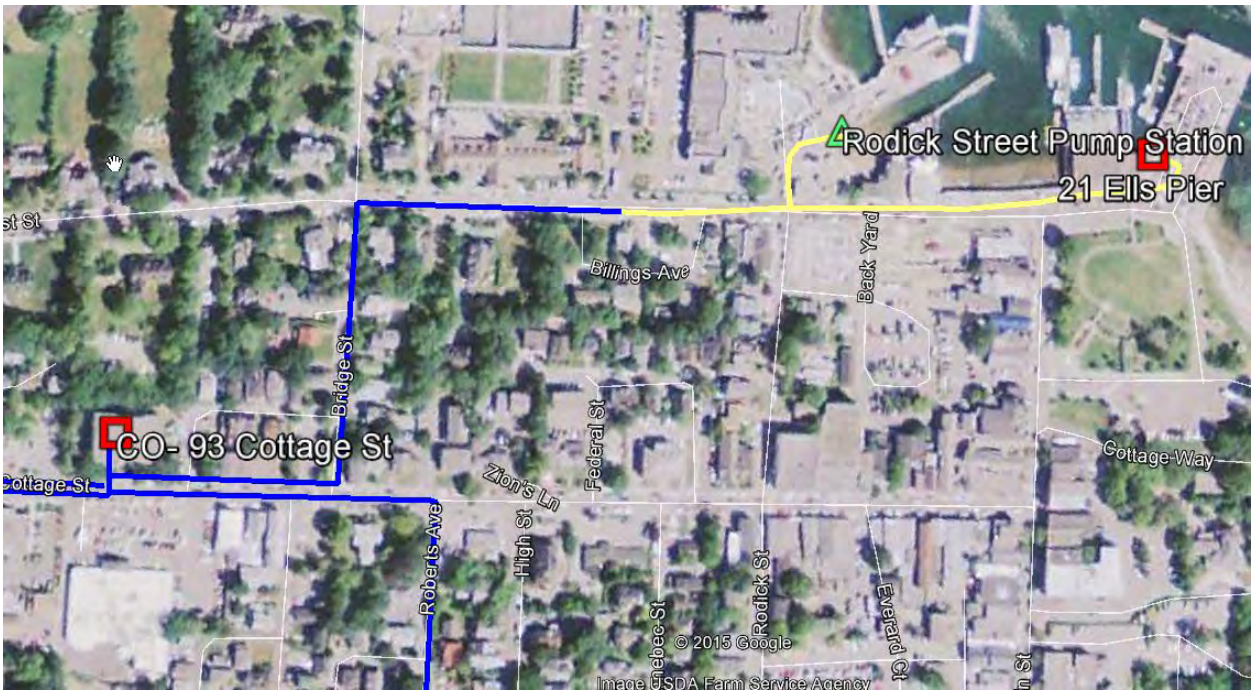
The diagram below depicts the Bar Harbor downtown fiber design. The red squares illustrate the Municipal Phase I locations, with Municipal Phase II locations indicated by the green triangles. Aerial fiber is indicated in blue, with the yellow and white lines indicating areas where the aerial fiber ends and where conduit would be necessary to reach certain sites, such as the Albert Meadow Pump Station (Phase II), Hancock Street Pump Station (Phase II), and Comfort Station (Phase I).

Town of Bar Harbor Network Design – Municipal Phases I and II (Downtown Village)



Line Item	Est. Cost- Ph 1	Est. Cost- Ph 2
Materials Including Fiber	$184,361	$25,218
Construction (aerial & underground)	$368,568	$86,276
Electronics and Shelter	$264,237	$8,542
Make Ready	$415,730	$36,381
5.5% Sales Tax (materials)	$24,673	$1,857
6.0% Service Provier Tax (labor)	$47,058	$7,359
Professional Services	$369,665	$56,093
Contingency	$560,896	$74,378
Total	$2,235,188	$296,104
Total (Phase I + Phase II)		**$2,531,292**

Important to note in terms of gauging cost, the Yellow line (enlarged below) depicts a new conduit system that would need to be run to feed the Rodick Street Pump Station (Municipal Design - Phase II) and the Port Security/Harbormaster building (Municipal Design - Phase I) unless the town has rights to it. The estimated cost of running conduit to the pier is $42,500.



Other significant cost considerations that were built into the cost estimates for this fiber design include $80,000 for connecting the building entrances—this was derived from all of the municipal buildings list (Municipal Phase I)—this figure represents the estimated a level of effort to service these locations.

Additional cost factors built into the capital cost estimate for the Municipal Phase I fiber design include the Town's ability to put its own poles in, and for approximately half of the poles, this will be necessary.The following are the capital cost estimates for the Municipal Phase I buildings by line item.[11]

There are however, a number of different permutations that these capital costs can have depending on the type of model the Town selects.

- The Town could have the Internet service provider (ISP) pay for its own electronics. This represents over $3.0M in savings to the Town in the full build scenario.

[11] Walker & Associates, Inc., pricing source.

- Further, the Town could have a private entity own the aerial drops and the Town could elect simply to own the fiber backbone. This represents over $1.6M in avoided costs in the full build.

These are just two potential cost avoiding measures that network operators commonly employ. It is relatively uncommon for publicly funded networks to own their own head end electronics. Usually ISPs prefer to fund their own equipment purchases. One exception is the planned Islesboro Maine network. On Islesboro the Town feels that municipal subsidy of all capital purchases is necessary to create a sound business model. By the same token, carriers often share some of the costs of running a drop from the backbone to the premise with the home owner. For example, GWI operates Rockport's Phase 1 network and charges new customers a fixed fee of $300 to connect.

The table below shows the financial impact of pursuing one or both of these cost saving measures. A third cost saving measure is to minimize buried connections. However, this analysis did not believe that this project would require significant buried cable. These measures can trim capital costs by almost $300,000 for the municipal phases and over $4 million for the full buildout. This is equal to approximately 10% and 33% of the maximum capital costs for both solutions respectively.

Capital Cost Scenarios – Municipal Phase I &II

	Scenario			
	Build Everything	No Electronics	No Drops	No Electronics or Drops
Make Ready	452,111	452,111	452,111	452,111
Fiber Costs	52,674	52,674	52,674	52,674
Other Materials	156,906	156,906	156,906	156,906
Drop Materials	5,210	5,210	0	0
Labor Backbone	447,044	447,044	447,044	447,044
Drop Labor	7,800	7,800	0	0
Electronics	272,779	0	272,779	0
5.5% Sales Tax (materials)	26,816	11,813	26,530	11,527
6.0% Service Provider Tax (labor)	54,417	54,417	53,949	53,949
Contingency	635,275	635,275	635,275	635,275
Professional Services	425,758	425,758	425,758	425,758
Total	2,536,791	2,249,009	2,523,026	2,235,244

Capital Cost Scenarios – Full Build Out

	Scenario			
	Build Everything	No Electronics	No Drops	No Electronics or Drops
Make Ready	1,729,327	1,729,327	1,729,327	1,729,327
Fiber Costs	209,266	209,266	209,266	209,266
Other Materials	752,012	752,012	752,012	752,012
Drop Materials	450,710	450,710	0	0
Labor Backbone	2,316,170	2,316,170	2,316,170	2,316,170
Drop Labor	507,800	507,800	0	0
Electronics	2,772,779	0	2,772,779	0
5.5% Sales Tax (materials)	230,162	77,659	205,373	52,870
6.0% Service Provider Tax (labor)	273,198	273,198	242,730	242,730
Contingency	3,790,804	3,790,804	3,790,804	3,790,804
Professional Services	2,096,184	2,096,184	2,096,184	2,096,184
Total	15,128,412	12,203,130	14,114,645	11,189,363

Each of the items listed above is comprised of the following detailed information:

Fiber Cable and Materials represents the cost of the fiber (144 strand), messenger strand, inner duct for buried conduit, fiber enclosures, a central cabinet, and pole replacements estimated.

Construction (Aerial and Underground) represents the labor costs of placing strand, lashing fiber, preparation of splice cases, the $42,500 conduit system for the pier, cost of servicing 15 building entrances, splicing and poles.

Electronics and Shelter represent the cost of a central office for equipment and the electronics costs associated with a fiber build.

Make Ready capital costs consist primarily of application fees for telephone and electric companies, tree trimming, and potential pole replacements.

Professional Services costs consist of engineering and drafting costs of professional engineer work for the initial design.

5.5% Sales Tax represents the state sales tax on materials.

6.0% Service Provider Tax represents the state tax on telecommunications services effective January 1, 2016 (up from 5.0% previously).

Contingency (35%) represents the standard cost contingency built into the capital cost estimate as a matter of practice.

Tilson budgeted for 50 pole replacements. We estimate that potentially 8% of poles will need to be changed due to age, quality, or lack of space for new telecom tenants. Telecommunications carriers must maintain a minimum height of 18 feet above the right of way to permit traffic to pass on main roads, and a 15 foot minimum on unpaved roads. If a new construction project shifts the telecommunications equipment below this threshold then a taller pole will need to be installed.

Distances used for the cost estimation were based on formulas in which map distance as well as fiber sag and slack were factored into the assessment.

Capital Cost Estimate – Municipal Phase II

Make Ready	36,381
Fiber Costs	1,471
Other Materials	19,747
Drop Materials	4,000
Labor Backbone	86,276
Drop Labor	0
Electronics	8,542
5.5% Sales Tax (materials)	1,857
6.0% Service Provider Tax (labor)	7,359
Contingency	74,378
Professional Services	56,093
Total	296,104

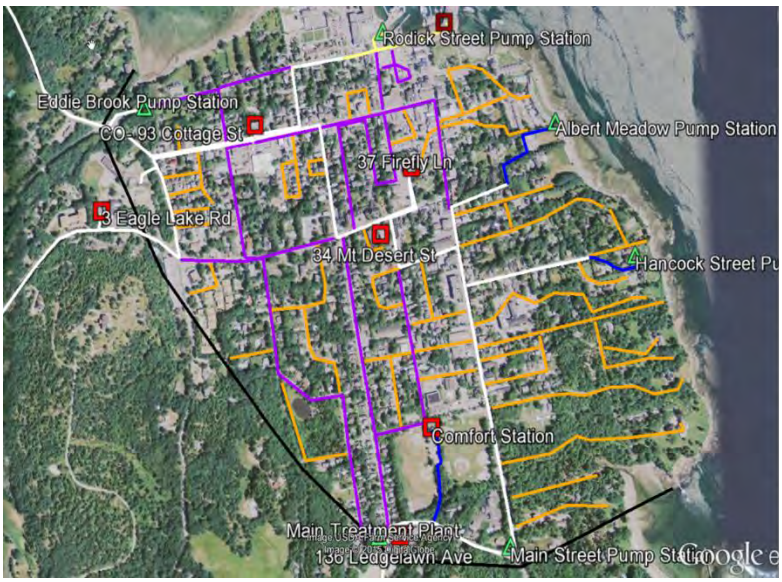
The estimated capital cost for Municipal Phase II is significantly less than Phase I given that most of the Phase II locations would be able to be served by drops from the Phase I fiber backbone

For the Phase II cost estimate, hand holes were included instead of the entrance costs in Phase I as the Phase II sites are direct buried. Another significant cost factor would be the 3,000 feet of inner duct materials because of the remote location of certain named sites--for example, Albert Meadow Pump Station (Phase II) would require buried inner duct of 800 feet. In addition, the Hancock St. Pump station (Phase II) is in the Town right of way, but buried. Also of note is that Eddie Brook Pump Station could easily be included into Phase I.

Incremental Buildout

Tilson also conducted a high-level engineering and cost estimate for an additional, more comprehensive fiber buildout beyond Municipal Phase I and Municipal Phase II, consisting of two different Residential/Commercial Phases—the first, a network of the main and side roads in the Bar Harbor village as shown below. The purple lines represent coverage of the downtown main roads serving residents and businesses in the Town with feeder cables, and the orange lines representing distribution fiber cables to all other Town premises and locations. The terms, “feeder” and “distribution” cable are used in a typical fiber optical network, with feeder cable referring to cable, which extends from the central office along a primary route or from a main feeder cable along a secondary route to a distribution point. These feeder cables provide connections to a number of distribution cables, which extend from the feeder cables into specific areas for the purpose of providing service to those areas. The blue and white lines represent the fiber backbone design for Municipal Phases I and II respectively, as already discussed.

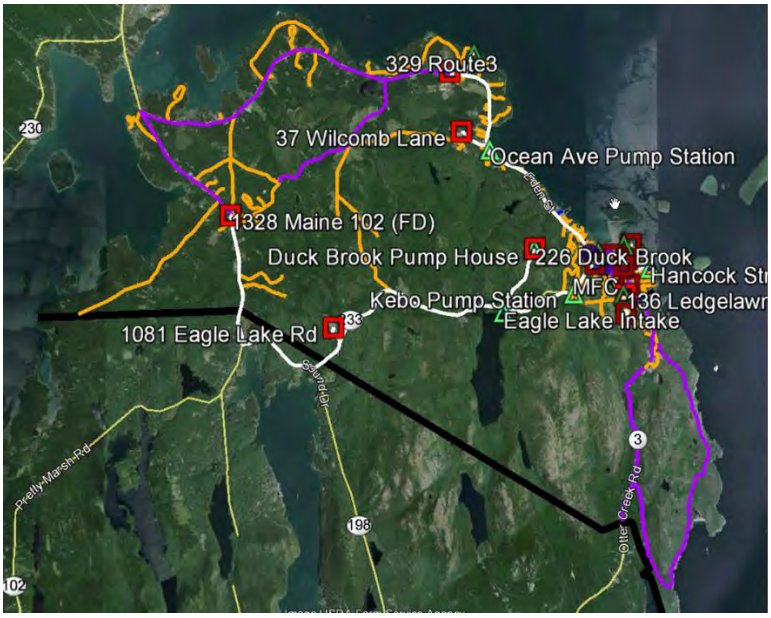
Residential/Commercial Phase I Downtown (Main and Side Roads)



Line Item	Est. Cost
Materials Including Fiber	$480,280
Construction (aerial & underground)	$972,225
Electronics and Shelter	$825,000
Make Ready	$244,187
5.5% Sales Tax (materials)	$71,790
6.0% Service Provier Tax (labor)	$72,985
Professional Services	$583,548
Contingency	$927,217
Total	**$4,177,232**

The second residential and commercial phase contemplated in the figure below illustrates the feeder and distribution cable for areas outside of the Bar Harbor downtown. In the diagram below, the purple lines indicate feeder cables serving residential and commercial customers for all of the main roads in the areas outside the downtown, with the orange lines representing side roads.

Residential/Commercial Phase II Fiber Design



Line Item	Est. Cost
Materials Including Fiber	$789,421
Construction (aerial and underground)	$1,535,020
Electronics and Shelter	$1,675,000
Make Ready	$1,131,262
5.5% Sales Tax (materials)	$135,543
6.0% Service Provier Tax (labor)	$159,977
Professional Services	$1,086,878
Contingency	$1,900,359
Total	**$8,413,460**

*NOTE: Tilson was made aware that the route along the Ocean Drive portion of the Park Loop Road (in purple, lower right corner of the above map) does not have utility poles. The exact location and route distance of underground utilities would be identified in an engineered network design. This would occur in a subsequent phase before putting the network out to bid.

Cost Estimate Detail – Res./Comm. Phases I and II

The biggest cost considerations for the Res./Comm. Phase I buildout for Make Ready consist of Tree Trimming costs ($191,000), and potential pole replacements ($45,000), with approximately $7,500 in application fee costs for telephone and electric company. The table below details these costs in descending order.

Make Ready Item	Cost
Tree Trimming	$191,000
Potential Pole Replacements	$45,000
Application Fees (Electric and Telco)	$7,500

In terms of costs associated with fiber and materials, this phase would require additional fiber strands, in particular 24, 48, and 144, and 288 fiber count, which comprise nearly $50,000 in costs. In addition, a very significant additional cost of the Res./Comm. Phase I buildout arises from Fiber Network Interface Devices (NID) ($100,000), which are the equivalent of Optical Network Terminals (ONT) for fiber to the premise installations, but which are specific to dark fiber. Additional costs include 200 foot fiber drops ($75,000), an enclosure ($78,500), inner duct ($35,000), splice cases ($32,195), Multiservice Terminals (four ports) (MST-4) at both 100 feet and 250 Feet ($32,400), 35-foot, class 5 thickness, pole replacements ($40,000), and Messenger Strand ($15,646), which is strung along poles to support the fiber. The table below details the materials costs in descending order.

Materials Cost Item	Cost
Fiber Network Interface Devices (NID)	$100,000
Enclosure	$78,500
200-foot fiber drops	$75,000
Fiber Strands (24, 48, 144, 288)	$50,000
35/5 Pole Replacements	$40,000
Inner Duct	$35,000
MST-4 at 100 and 250 feet	$32,400
Splice Cases	$32,200
Messenger Strand	$15,650

As for construction costs, the most significant items are the necessary conduit system ($200,000), aerial fiber installation drop ($200,000), splicing ($150,000), splice case preparation ($102,376), and trenching for inner duct ($150,000). The bulk of the remaining costs are comprised by tree trimming ($75,000), lashing of fiber ($42,000), placing of strands ($30,000), and installing fiber in the inner duct ($10,000) and pole replacement ($12,000). The table below breaks these costs down in descending order.

Construction Cost Item	Cost
Installation of drops	$200,000
Conduit System	$200,000
Splicing	$150,000
Trenching for Inner Duct	$150,000
Splice Case Prep	$102,380
Tree Trimming	$75,000
Lashing of Fiber	$42,000
Placing of Strands	$30,000
Pole Replacement	$12,000
Install. Fiber Inner Duct	$10,000

A very significant cost for the Res./Comm. Phase I buildout is that attributable to engineering and drafting costs ($583,548), representing the initial, once-off formal design engineering.

The final significant cost considerations for Phase I are the State of Maine sales tax on materials ($114,012), and the 25% contingency built into the total capital cost estimate ($600,000).

Res./Comm. Phase I Total Capital Costs

Make Ready	244,187
Fiber Costs	48,465
Other Materials	252,815
Drop Materials	179,000
Labor Backbone	772,225
Drop Labor	200,000
Electronics	825,000
5.5% Sales Tax (materials)	71,790
6.0% Service Provider Tax (labor)	72,985
Contingency	1,086,834
Professional Services	583,548
Total	4,336,849

Res./Comm. Phase II

The biggest cost considerations for the Res./Comm. Phase II buildout for Make Ready consist of Tree Trimming costs ($978,500), and potential pole replacements ($15,000), with approximately $38,944 in application fee costs for telephone and electric company. The table below breaks these costs down in descending order.

Make Ready Item	Cost
Tree Trimming	$978,500
Application Fees (Electric and Telco)	$38,944
Potential Pole Replacements	$15,000

In terms of costs associated with fiber and materials procurement, this phase would require additional fiber strands, in particular 12, 24, 48, 72 and 144, count, which comprise nearly $108,000 in costs—70% of which would be attributable to the 48 and 144 fiber. In addition, a very significant additional cost of the Phase II buildout arises from fiber NID ($150,000), 200 foot fiber drops ($75,000), an enclosure ($150,000), inner duct ($10,500), splice cases ($32,195), MST-4 at both 100 feet and 250 feet ($32,400), 35-foot, class-5 pole replacements ($40,000), and messenger strand ($63,723). The table below details these costs in descending order.

Materials Cost Item	Cost
Fiber Network Interface Device	$150,000
Enclosure	$150,000
Fiber Strands (12, 24, 48, 72, 144)	$108,000

200-foot fiber drops	$75,000
Messenger Strand	$63,723
MST-4 at 100 and 250 feet	$32,400
Splice Cases	$32,195
Inner Duct	$10,500

As for construction costs, the most significant items are the necessary conduit system ($200,000), installation drops ($300,000), splicing ($200,000), splice case preparation ($194,300), trenching for inner duct ($150,000), and direct bury for the inner duct ($100,000). The bulk of the remaining costs are comprised of tree trimming (150,000), lashing of fiber ($140,800), placing of strands ($120,550), installing fiber in the inner duct ($10,000), and pole replacements ($30,000). The table below details these costs in descending order.

Construction Cost Item	**Cost**
Installation of drops	$300,000
Conduit System	$200,000
Splicing	$200,000
Splice Case Prep	$194,300
Trenching for Inner Duct	$150,000
Tree Trimming	$150,000
Lashing of Fiber	$140,800
Placing of Strands	$120,550
Pole	$30,000
Install. Fiber Inner Duct	$10,000

The following chart details each of the significant capital cost items for the Residential/Commercial Phase II fiber network build:

Res./Comm. Phase II Total Capital Costs

Make Ready	1,033,029
Fiber Costs	108,128
Other Materials	342,290
Drop Materials	266,500
Labor Backbone	1,096,902
Drop Labor	300,000
Electronics	1,675,000
5.5% Sales Tax (materials)	131,555
6.0% Service Provider Tax (labor)	145,796
Contingency	2,068,696
Professional Services	1,086,878
Total	8,254,774

Operating Cost Estimates

Fiber Network

The costs associated with operating telecommunications networks depend on many factors. These include the number of customers, population density, business model of the operator, capital costs of the owner, and the preference for unionized vs. non-unionized labor. The following estimates represent Tilson's best attempt to estimate what a stand-alone network would cost to run in Bar Harbor absent any other consideration. The estimates below represent the incremental costs of running each phase of the network. Tilson estimates that a Town-wide network would cost approximately $1.0M to run annually. The table below shows the marginal operating cost of each design stage.

Incremental Operating Costs	Municipal Network		Residential / Commercial	
	Phase I	Phase II	Phase I	Phase II
Pole Attachment Fees	$16,300	$1,000	$9,550	$48,925
Maintenance & Repair	$45,433	$6,025	$88,034	167,564
Bandwidth	$0	$0	$36,000	$0
Fixed G&A	$61,500	$0	$21,000	$37,000
Variable G&A	$0	$0	$122,129	$264,191
Total	**$123,233**	**$7,025**	**$276,713**	**$517,680**

Some network phases do not result in substantial increases in marginal costs. For example, expanding to the second phase of the municipal network does not require any additional bandwidth or fixed general and administrative expense beyond what is already paid for in the first municipal phase. Similarly, Tilson

believes that a full town FTTH network built as part of the Residential / Commercial Phase II will not require substantially more backhaul bandwidth than the Phase I build.

The following table shows the same results as above, but aggregated as opposed to incremental. Both phases of the municipal network would cost approximately $170,000 to operate annually. The municipal networks plus the first phase of the residential commercial network would cost approximately $450,000 to operate. The full build would cost approximately $1.0 million to operate annually. These estimates are based on recent quotes and comparable projects. They are highly variable and would likely change based on the business model of the operating entity. For example, our model estimated an annual Variable G&A (general and administrative expenses, e.g. billing, customer support) expenditure of $220 per customer.

Aggregate Operating Costs	Municipal Network		Residential / Commercial	
	Phase I	Phase II	Phase I	Phase II
Pole Attachment Fees	$16,300	$17,300	$26,850	$75,775
Maintenance & Repair	$45,433	$51,457	$139,491	$307,055
Bandwidth	$0	$0	$36,000	$36,000
Fixed G&A	$61,500	$61,500	$82,500	$119,500
Total Fixed Costs	$123,233	$130,257	$284,841	$538,330
Variable G&A	$0	$0	$122,129	$386,320
Total	**$123,233**	**$130,257**	**$406,970**	**$924,650**

Potential Network Revenue

Tilson prepared a high level financial model to assess the potential revenue from a fiber-based solution using the operating cost figures provided above. Our analysis shows that the network has the potential to cover costs very soon after the start of commercial operations. However, this cost does not include debt service or other costs of capital. Tilson does not believe that the network can generate enough revenue to cover operating costs as well as capital costs. Therefore, the network will require a source of capital that is not dependent upon the network's financial performance. This may include municipal capital or philanthropic capital.

Our analysis assumed commercial and residential pricing similar to comparable networks in the country and a starting market share equal to 30%, which is commonly observed in fiber to the home builds. Under these assumptions, Tilson estimates that the Residential/Commercial Phase I network alone can generate up to $600,000 in revenue. The full Residential/Commercial network can generate up to $1.15 million in revenue. These scenarios assume residential pricing of $85 per month and commercial pricing of $200/month. The Phase I solution becomes profitable in the third year of operations and the Phase II solution becomes profitable in the second year of operations due to the favorable economies of scale. These financial projections are intended to be business model agnostic. The findings apply both to a business model where the municipality or a private party operates the network. The limited upside potential of each opportunity suggests that this investment will not be a revenue source for the Town in the near term.

Another source of potential revenue not included in the analysis is dark fiber lease revenue. Customers that might lease dark fiber from the Town of Bar Harbor's municipal network could include other municipalities that use the Town's dark fiber to connect to the mainland, service providers, and large private customers (e.g. businesses). Dark fiber market pricing is based on term, volume (fiber route miles), and scarcity. Tilson has provided a sample of dark fiber pricing for middle mile, open access networks in Appendix B.

Scenario - Municipal Network Plus Phase 1 Residential/Commercial					
Year	2017	2018	2019	2020	2021
	1	2	3	4	5
Revenue	420,677	497,163	573,650	573,650	573,650
Fixed Costs	284,841	284,841	284,841	284,841	284,841
Variable Costs	177,063	209,257	241,450	241,450	241,450
Net Margin	(41,227)	3,066	47,359	47,359	47,359
Residential Customers	652.67	771.33	890.00	890.00	890.00
Business Customers	152.17	179.83	207.50	207.50	207.50

Full Build Scenario - Municipal Network Plus Phase 1 and 2 Residential/Commercial					
Year	2015	2016	2017	2018	2019
	1	2	3	4	5
Revenue	841353	994327	1147300	1147300	1147300
Fixed Costs	538330	538330	538330	538330	538330
Variable Costs	354127	418513	482900	482900	482900
Net Margin	-51103	37483	126070	126070	126070
Residential Customers	1305	1543	1780	1780	1780
Business Customers	304	360	415	415	415

Assumptions

Potential Customers	Village Build	Full Build
Residential	1780	3560[12]
Business	415	830[13]

[12] From Census.gov: Population Estimates July 1, 2013 (Housing Units, April 1, 2010). http://www.census.gov/quickfacts/table/PST045214/00,2300902865.

[13] From Census.gov (All Firms, 2007). http://www.census.gov/quickfacts/table/PST045214/00,2300902865. The 415 businesses in the Village build is Tilson's estimate ratio that half of these businesses were in the Village versus the Town at large.

Gig Service Pricing (Monthly)		
Residential	$85	$85
Commercial	$200	$200
Fixed Costs	$320,841	$574,330
Annual Variable Costs per User	$220	$220
Take Rate Limit	50%	
Initial Take Rate	30%	
Years to Limit	3	
Annual Increase	7%	

This model does not include any carrier services such as wholesale, backhaul, and cellular products. These products would have minimal marginal costs once the network is built and the business entity formed. While the market for such products is likely small for a place such as Bar Harbor which is not on any major fiber route, there is likely an opportunity to serve major bio-medical facilities such as Jackson Labs, cellular towers throughout the island, and a potential future small cell roll out.

Business Models

Tilson examined several municipalities' experiences in studying the various permutations of business models available for addressing the Town's service needs, both immediately, and moving forward. Among the examples surveyed, several threshold areas such as network funding, structures, ownership, operation, tax payment, risk, revenue, and fiber use were explored in an effort to learn about the successes and shortcomings of each structure in an effort to recommend a structure which aligns best with the Town of Bar Harbor's goals.

FastRoads, (Keene, NH)

Ownership/Operation

The FastRoads network in Keene, New Hampshire is owned and operated by a single-member LLC, FastRoads, LLC, in which the Monadnock Economic Development Corporation (MEDC), which is a private non-profit economic development entity, is the sole member.[14] MEDC works closely with the Town of Keene, and they are a quasi-public 501(c)(3) organization. In this example, MEDC was approached by the Town to oversee the construction of the network and to be the recipient of grant money used to fund construction of the network. When MEDC assumed this role, it hired the executive director and technical engineer for FastRoads and oversaw contracts.

Funding

[14] Information for this section was gathered from phone interview with FastRoads personnel.

The funding for FastRoads came primarily from a National Telecommunications and Information Administration (NTIA) Broadband Technology Opportunities Program (BTOP) grant (70%). The remainder was borrowed by FastRoads and guaranteed by the MEDC. In addition, some private investment money in the form of royalty financing was secured as well. The New Hampshire Business Finance Authority provided additional funding and an Economic Development Administration grant from another part of the state rounded out the funding totaling $2.4 Million.

Operating Costs
In terms of costs associated with the network, the City of Keene charges FastRoads, LLC to use the city's conduit (lease) and the city taxes FastRoads in addition to this lease charge.

Operating Risk
MEDC assumes the operational risk from managing the network as the sole shareholder in FastRoads LLC.

Revenue
Service providers pay a portion of their revenue to the network in exchange for use of the network. The amount or percentage of this revenue is based on the type of service, with lower percentages paid by service providers who use the network for limited hours (i.e. a computer backup service), and larger percentages paid by ISP's which use the network heavily during daytime hours. Revenue from the project goes to FastRoads, LLC and this revenue is currently applied against expenses. At present time, revenue is offsetting expenses at a breakeven level and in the event of any shortfall, these are made up by MEDC.

Access
The FastRoads fiber network is an open network, so anyone able to find an ISP connect agreement can use the network.

Note
Since its development, the FastRoads network has struggled to make its payments.

Leverett, MA

Ownership/Operation
In the case of Leverett, the Town owns this town-wide fiber-to-the-home (FTTH) network and the town-created Municipal Light Plant (MLP) entity (with a separate budget) is the custodian of the network. This network is operated by an entity called Crocker Communications. While Crocker as service provider collects service costs, MLP also performs a range of responsibilities in terms of network operations, and MLP assumes the financial risk of operations.

Funding

The Leverett, Massachusetts network is an example of a FTTH municipal network which was constructed with funding from tax-backed municipal bonds. While the Leverett network does rely on subscriber revenue, it is only to the extent necessary to pay for ongoing maintenance costs.[15]

Operating Costs
MLP assumes the financial risk of operations for this town-owned network.

Operating Risk
The town-created MLP, which has a separate budget both performs a number of network operations responsibilities and also assumes the financial risk of operations as well.

Revenue
As referenced above, the Leverett network relies on subscriber revenue, but only to offset ongoing maintenance costs.

Access
Leverett has reserved the right to limit access to the network to Leverett residents and businesses only. As such, it is not an open access network, in contrast to most municipally-owned networks. The reasoning behind the closed nature of the network is that it allows for one Internet Service Provider (ISP) chosen by the Town itself to provide services to subscribers.

Chattanooga, TN

Ownership/Operation
Chattanooga's FTTH broadband fiber network is a model of a successful municipally owned and operated fiber network, with the Chattanooga Electric Power Board (EPB) performing the range of network operations responsibilities and assuming the financial risk of operations as well.

Funding
The city of Chattanooga, Tennessee, undertook to improve broadband access for its citizens through its municipally-owned power utility, the Chattanooga Electric Power Board (EPB). One of the primary advantages of this structure for Chattanooga was that it significantly reduced the cost of constructing the network through lower make ready expenditures. Similar to the previous municipalities mentioned in this section, Chattanooga also used municipal bonds to provide funding for constructing its 170,000-service location, 8,000 mile network. The total project cost of the EPB network was approximately $340 million, with $111 million funded through a federal American Recovery and Reinvestment Act (ARRA) grant from the Department of Energy. The remaining cost of the network was funded through the City's passing of a $229 million municipal bond to provide matching funds. The structure of the loan involved

[15]There are a number of municipal networks for which construction of these networks was funded by revenue-backed bonds. Networks built by revenue bonds are susceptible to financial pressure if these municipalities fail to gain enough subscribers. Failure to make debt payments resulting from undersubscription is a leading cause of failure among municipally owned networks.

EPB's electric division lending EPB's cable/internet division sufficient funds, with the loan being repaid using revenue generated from network subscriptions.[16]

Operating Costs
These are assumed by the EPB, as it serves as the network ISP.

Operating Risk
The operating risk for the network is also assumed by EPB as the network ISP.

Revenue
The revenue for the Chattanooga network comes from subscribers to the network.

Access
Only Chattanooga EPB operates over their network. Access is closed to other competition.

Burlington Telecom

Ownership/Operation
Burlington Telecom is a department of the City of Burlington, Vermont and is 100% municipally owned and operated.

Funding
Originally funded through a capital lease, this network was refinanced in an effort to expand the money available.

Operating Costs
While the original intent of the City was for network operations to be funded not by general revenue (taxpayer dollars) but instead by project revenue, Burlington Telecom ran out of money and used $17 million from the City Treasury department to support network operations.

Operating Risk
Burlington Telecom shouldered the operating risk associated with the network.

Revenue
Burlington Telecom then failed to repay the loan from the City Treasury. Burlington Telecom has settled a suit levied against it by its commercial lender, CitiLeasing. Burlington Telecom assumed additional debt to retire the settlement liability. The telco is still making payments against this loan.[17]

Access
The Burlington Telecom network is an open access network.

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[16] Information regarding EPB's network was obtained in a phone interview with Danna Bailey, EPB's Vice President of Corporate Communications (baileydk@epb.net).
[17] Information gathered from interview with Chris Campbell, former director of the Vermont Telecommunications Authority.

CityNet (Santa Monica, CA)

Ownership/Operation
CityNet is currently a 10Gbps network in the city of Santa Monica, California, spawned by the City's need to reduce its data access costs.[18] After forming a task force evaluating several different approaches, Santa Monica decided to pursue an institutional fiber network in 1998. The first step in developing its fiber network was for Santa Monica to lease an institutional fiber network from the local cable TV operator. That network connected 43 city buildings as well as school and college facilities.

Funding
When it leased the institutional network, the City funded the network construction but shared the operations and maintenance costs with the local school district and college. The operational cost savings derived from this shared cost approach reduced the combined telecom costs by $500,000 per year shortly after the network went live in 2002. From here, the City utilized the savings to build its own 10 Gbps municipal fiber network, from which it began leasing its excess dark fiber to local businesses. Because of low monthly fees, these businesses were willing to fund the cost of building fiber from the backbone to their buildings. In this manner, Santa Monica's network was extended at no cost to the city. In 2009, the city made an additional investment in the network in an effort to provide lower cost bandwidth to small businesses in the area. It did this by leasing a fiber connection to a major colocation center in Los Angeles, 15 miles away and getting transport from a service provider.

Operating Costs/Risk
As noted above, initially the operations and maintenance costs were shared by Santa Monica with the local school district and college.

Revenue
City Net's revenue is $300,000 per year, which is adequate to fund network operations and maintenance while also supporting a network of 27 WiFi hot spots throughout Santa Monica. The city used its nearly $200,000 in remaining capital funds as a revolving capital improvement project account. This account funds construction for network expansion, which is repaid by customers as the network continues to expand to their premises.

Access
While the city provides internet access directly, it also makes the network available to third-party providers on an open-access basis.

Note
CityNet's requirement that customers pay for their own connections slows the growth of the network, but short of receiving a stimulus grant, CityNet will continue a policy of expanding based on demand alone.

[18] http://www.bbpmag.com/MuniPortal/EditorsChoice/0511editorschoice.php

South Portland, ME

Ownership/Operation
The City of South Portland is working with the ISP GWI, and GWI will own and operate the fiber network.

Funding
GWI constructed this 1 Gbps fiber to the home (FTTH) network connected to the Maine Three Ring Binder.[19] The project construction cost was approximately $170,000, with $150,000 of this cost covered by a one-time, $150,000 lease payment to connect City-owned facilities to the network. The remaining $20,000 was invested by the ISP.[20] Customers would be signed up for the service during the construction phase with installation fees waived for early sign-ups.

Operating Costs/Risk
The operating costs and operating risk of the network will be assumed by GWI as the network owner.

Revenue
The City's arrangement with the ISP will allow it to drop a $2,000/month lease cost which it had for its previous fiber network provider, and after installation, the City and the ISP will share in five percent of the revenue of business and residential customers who sign up for the network.[21]

Access
The ISP which owns this network is providing the fiber on an open-access basis, thus opening the door to competition from other service providers.[22]

Rockport, ME

Ownership/Operation
Owned by the Town of Rockport, GWI operates the network, contracting with customers for the actual service.[23]

Funding
For the Town of Rockport, Maine's 1.6 mile fiber project, cost of installing the network was estimated at $60,000, half of which came from the University of Maine's Networkmaine program and private

[19] http://www.pressherald.com/2014/09/22/super-fast-internet-coming-to-parts-of-south-portland/
[20] Id.
[21] http://bangordailynews.com/2014/09/22/business/gwi-beats-out-maine-fiber-co-for-south-portland-municipal-fiber-contract/)
[22] Id.
[23] http://www.wcsh6.com/story/news/local/2014/08/11/rockport-builds-municipal-owned-internet/13922981/.

investment from local business, and half of which came from a Town of Rockport tax increment financing (TIF) tool.[24]

Operating Costs/Risk
Similar to the City of South Portland, Rockport's network is one in which the municipality only funds the capital investment for the fiber and does not fund the capital investment for the equipment. In addition, the Town does not have any significant operating expense or responsibility. Instead ISP's are responsible for providing and operating the network's equipment.

Revenue
The revenue model employed in Rockport is the subscriber-based revenue model, with a percentage of monthly subscriber costs for the network going to the Town to pay off the original investment.

Access
The Rockport network is an open access network.

E-Rate Subsidies and Dark Fiber

In September 2010, an FCC order made non-regulated non-profit and public networks eligible for the E-rate subsidy under the Universal Service Fund.[25] Under the program, eligible schools, school districts and libraries may apply individually or as part of a consortium. There are two categories of funding under the program: services to a school or library (telecommunications, telecommunications services and Internet access), and services that deliver Internet access within schools and libraries (internal connections, basic maintenance of internal connections, and managed broadband services). Awards of support are contingent upon the level of poverty and whether the school or library is in an urban or rural area, with discounts ranging from 20-90 percent of costs of eligible services. The annual cap of program funding available is $3.9 billion.[26]

Recently, The FCC has expanded the E-Rate program with a stated objective to get fiber to every school in the country. As such, the FCC has expanded the program to pay for leased dark fiber. The E-Rate program only pays for projects related to schools and libraries, and schools have the ability under the program to undertake self-construction.

For states that provide 10% of cost of E-Rate services being purchased, the FCC will match this. However, the FCC will not contribute more than 10% if state does more than 10%.

For the Town of Bar Harbor, if Jesup Library, MDI High School, and Connor-Emerson can qualify, an E-rate award could provide a source of guaranteed revenue for the Town depending on whether and how much subsidy these institutions qualify for. The Universal Service Administrative Company (USAC)

[24] http://www.muninetworks.org/content/rockport-builds-maine%E2%80%99s-first-municipal-network.
[25] Hovis, Joanne, "Building the Business Case for Government Fiber Networks: There *Is* Life After I-Nets and Stimulus," (http://ctcnet.us/GovernmentFiberNetworksAfterBTOP.pdf) 2012.
[26] https://www.fcc.gov/encyclopedia/e-rate-schools-libraries-usf-program

website provides a discount matrix, which depends on percentage of students in a particular school participating in the National School Lunch Program (NSLP) and whether the school or library is in an urban or rural location.[27] For schools that either do not participate or do not use NSLP participation numbers, there are alternative discount mechanisms available.[28] In order to access these funds, the Town much first become a telecommunications carrier. While these sources are not necessarily helpful for financing a buildout, they can serve as potential resources in the future. If the Town elects to pursue one of the two recommended models.

Economic Impact of Broadband Investment

Recent studies regarding the economic impact of broadband investment have revealed a connection between increased broadband availability and economic performance. Research by Professor Sudip Bhattacharjee, Associate Professor at the University of Connecticut School of Business evaluated this connection.[29]

The research, based on five years of data from 169 towns in the state of Connecticut from 2009-2013, used the following methodology: It took raw data regarding demographics, occupation, broadband, and housing from various public sources (CERC (Ct. Economic Resources Center)), DOL, and FCC), identified key variable economic benefits assessing the impact of broadband, including per capita income, median housing price, and the number of business units to estimate the economic benefit for Connecticut towns and grouped and ranked the towns based on the benefit achieved.

The research summarized the impact of broadband, finding that five years after each 1 Mbps increase in internet speed (up to 60 Mbps) resulted in the following average economic gains:

Factor	Result
Unemployment Rate	Drops by .08%
Bachelor Degree Rate	Increases by .42%
Median Household Income	Increases by $570
Average Home Value	Increases by $3,200
Assisted Housing Unit	Decreases by 200

In the research, the average economic benefit by town cluster was as follows: impact of broadband was highest in industrial areas and major population centers, followed by small towns, office centers and commercial areas, and the impact was the lowest in rural communities, traditional towns, and residential and industrial mixed areas.[30]

[27] http://www.usac.org/_res/documents/sl/pdf/samples/Discount-Matrix.pdf
[28] http://www.usac.org/sl/applicants/step04/alternative-discounts.aspx
[29] Bhattacharjee, Sudip, Presentation: "The Economic Impact of Gig Networks", Yale School of Management. May 4, 2015.
[30] Id. at slide 12.

Take Rate

Take rate is defined as the percentage of potential subscribers who are offered service who actually do subscribe. The following are some examples of take rate figures and timelines for some of the municipal networks currently in existence:

MUNICIPALITY	TAKE RATE	TIME TO ACHIEVE
Leverett, MA	85%	1 Year
Kansas City (Google Fiber)	75%	2 Years
Chattanooga, TN	11% (Year 1); 35% (Year 5)	5 Years to 35%
Verizon FiOS	35%	3 Years on average

Benefits of Broadband for Each Constituency

At the start of its engagement with Tilson, the Town identified the following list of Bar Harbor constituencies to be served:

-Unserved
-Underserved
-Hotels/Motels/Campgrounds
-Remote workers
-Hi Tech startups
-Cafes (Internet)
-Library
-Visitors/tourists
-Businesses
-Connections to other towns/public services (i.e. Police)

The following section examines each of these named constituencies, and provides a review of the impact that a significant broadband investment could have on them.

Municipal Buildings/Public Services

Government entities typically are large users of internet, often leasing the right to use such bandwidth at rates that can often represent significant profits for phone companies and similar providers. Municipalities use their connectivity to support internal operations, public safety, and many other applications.[31]

[31] Hovis, Joanne, "Building the Business Case for Government Fiber Networks: There *Is* Life After I-Nets and Stimulus," (http://ctcnet.us/GovernmentFiberNetworksAfterBTOP.pdf) 2012.

For the Town of Bar Harbor to operate, it must pay the incumbent providers of its connectivity, representing a significant cost to the Town. Just as the genesis for Santa Monica's gigabit network was the goal of reducing such costs, the Town of Bar Harbor has expressed an interest in reducing its costs and not being subject to the expenses of incumbent providers. When Santa Monica constructed its network, it shared the operations and maintenance costs with the local school district and college. The operational cost savings derived from this approach reduced the combined telecom costs by $500,000 per year shortly after the network went live in 2002. By reducing these connectivity costs so dramatically, a phased expansion was enabled. In short order Santa Monica was able to build its own 10 Gbps municipal fiber network, lease its excess dark fiber to local businesses, and this in turn, due to low monthly fees, incented these businesses were to fund the cost of building fiber from the backbone to their buildings. As time went by, the continued savings provided by the network allowed the city to make an additional investment in the network for small businesses in the area, leasing a fiber connection to a major colocation center in Los Angeles, 15 miles away and getting transport from a service provider. Today CityNet has enough revenue from its network to support operations and maintenance while also supporting an extensive WiFi network throughout the City.

The growth of governmental bandwidth needs is another consideration that the municipal constituency must weigh as it considers broadband expansion. Capacity requirements for governmental operations have grown at an exponential rate over the past 15 years, and the broadband capacity for most community anchors need more capacity than they currently have.[32] Investing in a Town owned broadband network will allow the Town and community anchors to adapt to future innovation, scale up to meet these needs at a far lower price than purchasing circuits from an incumbent provider. Further, by investing in broadband infrastructure, the Town is not constrained by older infrastructure, and does not have to pay for the incumbent to build fiber to it and pay for service on top this fiber.[33]

Furthermore, a government-owned fiber network represents the potential to create a source of revenue, through the provision of reasonably priced dark or lit fiber to non-profit, community organizations and facilities such as the library, and connecting with nearby towns and their public services. Just as most towns do, the Town of Bar Harbor has a number of important community anchor institutions (CAI's). Typically, CAI's are significant consumers of connectivity, and often serve residents who lack broadband service in their homes.

The Greater Downtown Community/Businesses

When municipalities save money that they would otherwise spend on leasing fiber from a large private carrier, the money saved remains in the community and can be spent on other government services. In addition, locally-employed network operators will spend money at local establishments. This economic scenario is termed "the multiplier effect," and represents the notion that local money saved and earned by Town officials and employees respectively leads to that money being spent within the community. Another aspect of increased connectivity for businesses will be a major source of improvement to internet cafes in the Town as well. With increased connectivity in these businesses, as well as the increased availability and investment in broadband will have on the many public spaces in the

[32] Id. at pg. 3.
[33] Id. at pg. 4.

Downtown Village, residents and visitors alike will spend more time in each of these areas, and when people spend more time spent in these areas, the surrounding businesses will see greater amounts of traffic and spending.

Another recent study by the Public Policy Institute of California (PPIC) assessed the connection between policies raising broadband availability and local economic development.[34] Their analysis concluded that there is indeed a positive relationship between broadband expansion and economic growth, with the relationship being stronger in the IT industry and in areas with lower population density. While the study concluded that economic benefits to residents were limited and that the prevalence of telecommuting and home based work as well as average wage and employment were unaffected by broadband expansion, the conclusion further stated that while broadband could not definitively be said to cause the economic growth, that the evidence "leans in the direction of a causal relationship".[35]

Unserved/Underserved

For these areas, a wireless or cellular broadband solution would likely be the best option offering the best and most cost-effective connectivity solution unless the Town decides to pursue one of the more extensive incremental fiber buildouts described above. Alternatively, a mix of wireless and wireline technology could present the most comprehensive yet cost-effective solution for the Town.

In terms of the impact on these areas, the potential to retain and attract more young residents as well as the potential telemedicine applications and capabilities enabled by a broadband investment would be the most significant.

When high school students leave the Bar Harbor area for college, most enjoy the high-speed broadband provided their institutions. When they return to Bar Harbor for the summer, many if not most are unable to use the Internet in their homes, reducing their incentive to spend time off at home and preventing them from conveniently connecting. In addition, the connectivity challenge has far reaching effects for this young population. Maine in general, and rural areas in particular have had an increasingly difficult time retaining young residents entering the workforce as these students view both the lack of job opportunities as well as the inability to work remotely from home as reasons to remain or move to more urban areas after college, despite the lure of Bar Harbor's natural beauty and family in the area.

In addition, the decrease in young workers in many rural parts of Maine has only added to the average age in these towns, and this population has increasing medical needs. For many elderly living on their own in these underserved or unserved areas, the need to conveniently access medicine without leaving the home is not just a luxury, but a necessity. An investment in broadband would allow for this population access to healthcare from the comfort of their own homes.

[34] Kolko, Jed, "Does Broadband Boost Local Economic Development?" Public Policy Institute of California. January 2010.
[35] Id. at pg. 2.

By providing a broadband solution for these unserved and underserved areas, high school students and recent college graduates living in these areas will see more potential for remaining or returning to Bar Harbor as they enter the workforce, while allowing them more options to craft their own Internet-dependent work and businesses from their hometowns. For most of Maine's recent college graduates, leaving Maine and family after college is less of a desire and more of an economic necessity. An investment in community broadband could reverse that trend in Bar Harbor.

Hotels/Tourism

Tourism, and with it, lodging in the Town of Bar Harbor are vitally important to the Bar Harbor economy. As such, creating hotel experiences positively impacting guest loyalty and visit frequency are a priority for hotels in the Town.

A recent survey of the hotel industry conducted by J.D. Power (2010 North America Hotel Guest Satisfaction Survey) indicated that wireless Internet access was one of the top five hotel amenities according to guests.[36] In addition 80 percent of travel managers indicated that Wi-Fi performance was a "deal maker/breaker" in choosing a hotel.[37]

In addition to the current customer expectation for Wi-Fi as part of their lodging experience, the consumption habits of guests using this Wi-Fi is also rapidly changing, with web browsing decreasing and real-time entertainment (streaming) increasing significantly. With 80% of hotels only offering speeds less than 6 Mbps, most hotels are not equipped to support usage and data transfer that most hotel guests would experience at their residences.[38] In this regard, the increased speed that would be provided by a broadband investment would be a significant incentive for area hotels to lease from the Town. In such a way, the hotel/motel Town constituency of Bar Harbor could be significantly benefited by a broadband investment as a way to serve customers. Increased broadband's impact on hotels/ motels, and campgrounds will allow tourists to take their vacations, while also allowing them the Internet consumption options as they would have at home, potentially extending vacations, while having the option to telecommute if necessary.

Remote Workers (Telecommuting)/Hi-Tech Startups

The ability of broadband Internet to offer speeds significantly faster than other forms of "narrowband access" is what makes it particularly suitable for use in business applications. An examination of the impact of broadband access on telecommuting suggests that as rural areas develop and improve their broadband access, the gap between urban and rural areas in remote working will lessen as well.[39] Despite reaching a conclusion that telecommuting did not raise individual earnings significantly,

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[36] Lock, Howard and Reberger, Christopher, "Hotel Guests Say Broadband is Important: Can you Meet Their Expectations?" White paper, Cisco Internet Business Solutions Group, July 2011, page 2.
[37] Id.
[38] Id. at pg. 3.
[39] Song, Moohoun, Orazem, Peter F., and Singh, Rajesh, "Broadband Access, Telecommuting, and the Urban-Rural Digital Divide", Iowa State University, Office of Social and Economic Trend Analysis, Technical Report, March 1, 2006.

researchers at the University of Iowa's Office of Social and Economic Trend Analysis suggested that the presence of broadband created a significant impact on the incentives to work from home.[40]

An investment in broadband for the Town of Bar Harbor will create an incentive to both retain workers who already work from home, and attract new residents. For those in Town already telecommuting, increased broadband will both help them to better perform the business applications necessary to their work with increased speed, while lowering the cost for those already paying for high speed access from incumbent providers.

Economic Impact of Bar Harbor Network

Broadband investment can have a dramatic effect on economic development in rural communities. Among other effects, broadband enhances efficiency and productivity of firms, facilitates commerce, attracts jobs, increases consumer options, and saves residents money.

In the absence of conducting an extensive survey of spending trends in the Town of Bar Harbor over the past ten years, it is impossible to precisely estimate the economic product of Bar Harbor alone. Tilson used the economic data of Bangor, Maine as a corollary. Bangor shares many of the same characteristics of Bar Harbor.

Tilson employed the "value transfer method" in its analysis. This approach borrows from the research contained in peer reviewed studies of the economic impact of broadband and applying local data to the same models. Tilson first gathered census data for the Town of Bar Harbor and the Bureau of Economic Analysis data for Bangor to establish the economic baseline. Those estimates were then run through economic models that forecast the impact of new broadband infrastructure on gross domestic product (GDP), job creation, and enhancing consumer well-being the Town of Bar Harbor. Tilson believes that developing universally-available, world class broadband infrastructure in the Town of Bar Harbor has the potential to increase GDP growth by 11% by 2020.

This estimate represents $17.8 million in additional goods and services over the course of the next five years. This figure is open to debate, however, a large increase in broadband penetration usually results in a significant increase in output. In a study of 22 Organization for Economic Cooperation and Development (OECD) member countries, Koutroumpis et al. (2009) found that an increase in broadband penetration of 10 percent added 0.25 percent to GDP growth on average.[41] In a similar study, Czernich et al. (2009) found that an increase in broadband penetration of 10 percent added 0.73 percent to GDP growth on average.[42]

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[40] Id. at pg. 20.

[41] Koutroumpis, P. 2009. The Economic Impact of Broadband on Growth: A Simultaneous Approach. *Telecommunications Policy.* Vol: 33, Pages 471-485.

[42] Czernich, N., Falck, O., Kretschmer, T & Woessman, L. 2009. Broadband Infrastructure and Economic Growth. *The Economic Journal.* Vol: 121, Pages: 505-532.

Impact on GDP

Tilson's economic modeling examined the effect of an investment in broadband on the Town of Bar Harbor's baseline GDP through three different increases of speed: 1) An increase of 1.5 times the current speeds; 2) a doubling of speed; and 3) a quadrupling of speed. By 2020, the investment in the Town of Bar Harbor's broadband network (through Phase II of the buildout) would equate to an increase in GDP of $1.33 million over the baseline for the 50% speed increase; $2.7 million if Internet speeds were to double, and an additional $5.4 million in additional GDP over baseline by 2020 if Internet speeds were to quadruple.

Put into terms of capital cost input versus GDP increase, for the Municipal Phase I and II combined capital cost of approximately $2.44 million, this capital cost would be nearly recouped in terms of the region's GDP increase by 2019 ($2.1 million) in a scenario where Internet speeds were to double.

If the Town were to invest in the Res./Comm. Phase I buildout in addition to Municipal Phases I and II, this would represent a capital cost of just about $6.9 million. A quadrupling of Town Internet speeds would represent an increase in baseline GDP of more than two-thirds of this initial investment by 2019, and would nearly equal the capital cost investment with a $6.6 million increase over baseline GDP by 2021 if Internet speeds were to quadruple.

If the Town were to invest in a full broadband buildout contemplated by Residential/Commerical Phase II on top of Res./Comm. Phase I and Municipal Phases I and II, two-thirds of this capital investment ($10.4 of $15.4 million) would be recouped by an increase of GDP over the baseline of nearly the same amount by 2024, assuming a quadrupling of Internet speeds.

In terms of the wireless buildout capital costs, assuming both the construction of a new tower and colocation on the five existing area towers, as well as 10 small cells, the total capital cost of this wireless investment would be $740,000. If the Town were to only pursue this solution, these costs could be nearly offset by additional GDP over the baseline GDP by 2016 in a doubling of internet speed, or by 2018 if only a 1.5 times increase in speed.

Impact on Job Creation, Wages, and Tax Revenues

Assessing the impact of an investment in broadband on job creation in the area, the gains over the next few years are modest, with 85 jobs created by 2020 assuming a quadrupling in Internet speeds. More significantly, an increase in wages with a 1.5 times increase in Internet speeds leads to over $775,000 in wages by 2020, a $1.56 million increase in wages with a doubling in Internet speeds, and a $3.14 million increase in wages with a quadrupling of Internet speeds over the next five years. These increases equate to $131,700 in additional sales taxes, over $106,000 in increased property taxes, and just over $75,000 in increased state income taxes for a total of over 313,000 in additional total state and local tax revenue by 2020. The ten year totals of wages at the three levels of increased Internet speed are about $10.7 million at a 1.5 increase in speed, $21.5 million at a doubling of speeds, and $43.4 million with a quadrupling of speeds over the ten years through 2027.

Once again framing the analysis of job and wages gains within the context of capital costs expended to build the various incremental build outs for the Town, this could mean the following:

A Municipal Phase I capital expenditure of $2.3 million would lead to nearly $1.6 million increase in wages by 2020 assuming a doubling of Internet speeds.

The increase in total wages by 2027 ($10.7 million) would be greater than two-thirds the total anticipated capital cost of all phases. ($15 million).

The increase in total state and local tax revenues over the ten year period ($4.3 million through 2027) is double the anticipated capital cost expenditure for the Municipal Phases I and II broadband buildout for the Town of Bar Harbor, two-thirds of the capital cost of Res./Comm. Phase I + Municipal Phases I and II. In terms of total wages increase by 2027, for a 1.5 times increase in speed following a broadband investment, total wages would increase by $10.7 million, greater than two-thirds the total capital cost of the fiber buildout for all phases of the project. Over that same span of time, if a quadrupling of Internet speeds is achieved by the network, the increase in wages would be $43.4 million.

Impact on Consumer Surplus

Broadband investments improve consumer wellbeing. Consumers are not necessarily better off just because economic output increases. An increase in GDP just means that they are spending more. That being said, broadband access empowers consumers to both pay less for goods than they otherwise would have purchased and to purchase goods and services that were not available before. An example of this is with regard to streaming video, which enables almost limitless viewing for little to no cost. Without this streaming capability, consumers would pay more to rent films and/or subscribe to satellite television. In the economic lexicon this phenomenon is known as “consumer surplus”.

For the purposes of this exercise, consumer surplus is defined as the amount that consumers benefit from purchasing a product for a price that is less than what they would be willing to pay. In a study of 40 million U.S. households with access to broadband, Greenstein and McDevitt (2009) found that broadband access increased consumer surplus by between $120 and $167.50 per household, per year.[43] Tilson’s economic analysis shows that a total increase in surplus over the next ten years of between $5.1 and $7.2 million.

Conclusions

A significant amount of transport fiber and cellular communications assets exist in Bar Harbor. However, businesses, local government, and residences describe an inability to subscribe to services that meet their needs. Our analysis indicated some areas in Town unable to obtain any service. The challenge for Bar Harbor is accessing FCC-defined broadband speeds at the price point of local stakeholders. In order

[43] Greenstein, S. and McDevitt, R. 2009. The Broadband Bonus: Accounting for Broadband Internet Impact on U.S. GDP. NBER Working Paper No. 14758.

to accomplish this goal, the Town wishes to consider last mile broadband infrastructure investments. The Town specifically requested a network design that connected all of the municipal facilities. All of the Town's facilities can be networked with a municipally controlled network for a capital cost of $2.5M. Additionally the Town wished to assess the feasibility of fiber to the home solution in the Village area as well as universally throughout the Town. Tilson estimates that the total capital cost to implement a universal FTTH for the entire Town is $15.1M. The economic benefits of such an investment potentially outweigh the capital investment over the lifetime of the project.

Capital Costs of the Various Network Options

Capital Expense	Municipal Network Phase I	Municipal Network Phases I + II Buildings	Res./Comm. Phase I (Village/ Downtown)	Res./Comm. Phase I + II (Village + Outlying Areas)	Total (Municipal Phase I + Muni. Phase II + Res./Comm. Phase I + Res./Comm. Phase II
Fiber/Materials	184,361	214,790	480,280	1,197,198	1,411,988
Construction Labor	368,568	454,844	972,225	2,369,127	2,823,971
Electronics and Shelter	264,237	272,779	825,000	2,500,000	2,772,779
Make Ready	415,730	452,111	244,187	1,277,216	1,729,327
5.5% Sales Tax (materials)	24,673	26,816	71,790	203,346	230,162
6.0% Service Provider Tax (lab	47,058	54,417	72,985	218,781	273,198
Professional Services	369,665	425,758	583,548	1,670,426	2,096,184
Contingency	560,896	635,275	1,086,834	3,155,530	3,790,805
Total	2,235,188	2,536,791	4,336,849	12,591,623	15,128,414

Business Model Options

There are a number of different business model structures available to the Town as it decides how it would like to proceed. The various types of models have been detailed and there are successful and unsuccessful examples of each type. The following table provides a summary of each permutation of business model available, and the differing structures of each as the Town makes an informed choice moving forward.

Type	Electric Company	Municipally Owned	Public-Private Partnership
Examples	Leverett MA, Chattanooga (EPB), Lafayette LA,	Burlington Telecom	Santa Monica (CityNet) Rockport South Portland FastRoads

Network Ownership	Town-owned Utility	Municipality	Municipality or Non-Profit 501(c)(3) or ISP
Network Operation	Town-owned Utility	Municipality	Muncipality, Non-Profit, or ISP
Funding	Municipal Bonds	Capital Lease	NTIA/BTOP/EDA grants; Private investment; Municipality
Operating Costs	Town-owned Utility	Project Revenue (subscriber)	501(c)(3); Municipality shared with local institutions; ISP
Operating Risk	Town-owned Utility	Municipality	Municipality or 501(c)(3)
Revenue	Subscriber Revenue	Subscriber Revenue	ISP service providers pay LLC; Subscriber revenue shared between ISP and Municipality
Access	Limited to town residents and businesses	Open	Open

Recommendations

1) **Pursue a Fiber Based Residential Solution.** Based on the Town's vision for itself, Tilson believes that a fiber-based solution can meet those goals for high speed, low cost, reliable, and future-proof bandwidth. Tilson believes that a 4G LTE solution will not meet these requirements and will not provide a substantial advantage in terms of cost or bandwidth relative to cable offerings.

2) **Determine Scope of Project.** Tilson believes that the Town has several options for their next steps. The first option is to do nothing and accept the broadband status quo. The second option is to pursue the municipal network build in either Phase I or both Phases. This will involve determination of an operating model for the network and sponsoring a request for proposals (RFP) for a general contractor to build the network. The third option is to pursue a residential and commercial solution. This involves selecting the scope of the network and an operating model. Once the model is selected, the Town can sponsor a request for information (RFI) or RFP to select a partner. Note that the third option may incorporate the second option.

3) **Partner with Surrounding Municipalities.** Many municipalities in the region have expressed interest in similar solutions. The Town of Mt. Desert is undergoing a very similar broadband planning process and may wish to partner on a design.

4) **Finalize Financing.** Tilson believes that it will be difficult to attract subsidy to Bar Harbor because the Town is well served compared to many municipalities in the state and within the

US. If the Town pursues a solution, financing will come from either private impact investors or municipal capital.

Appendix A – Wireless Assets in Bar Harbor

The table below shows FCC data regarding the local towers in Bar Harbor and the nearby areas.[44] The FCC tracks all towers utilized for cellular communications. There are five cellular towers in the Bar Harbor region. In the Town of Bar Harbor itself, there are two towers, one owned by U.S. cellular at a height of 52 feet above ground, and the other owned by Verizon on State Highway 3 at a height of 124 feet. There are also cellular assets in the surrounding towns of Mount Desert, Trenton, and Lamoine, which could supplement the coverage area served by these towers.

Local Cellular Assets Serving Bar Harbor Region

Registration Number	Status	Owner Name	Address	Latitude/Longitude	Overall Height Above Ground (AGL)
1251251	Constructed	U.S Cellular	5 Norman Drive, Bar Harbor, ME	44-23-30.6N 068-13-21.4W	52 Feet (15.8 meters)
1273997	Constructed	Portland Cellular Partnership (Verizon)	854 State Hwy. 3, Bar Harbor, ME	44-25-56.7N 068-18-40.4W	124 Feet (37.8 meters)
1288640	Constructed	Global Tower (American Tower)	Huckleberry Lane, Mt. Desert, ME	44-22-13.2N 068-19-59.7W	130 Feet (39.6 meters)
1272447	Constructed	AT&T Mobility Spectrum	331 Oak Point Road Trenton, ME	44-26-27.9N 068-24-36.9W	159 Feet (48.5 meters)
1272306	Constructed	Portland Cellular Partnership (Verizon)	212 Lamoine Beach Rd., Lamoine, ME	44-28-10.8N 068-19-36.4W	150 Feet (45.7 meters)

Assuming five LTE base stations at 700MHz, 20w of output, and varying heights based on the five towers in the Bar Harbor region, Tilson's wireless engineer estimated a hypothetical coverage area depicted in the heat map below. These are common specifications for cellular services. Speeds of this technology will vary depending on many factors, including but not limited to local clutter and interference, and antenna height.

Capital Costs for LTE Wireless Solution

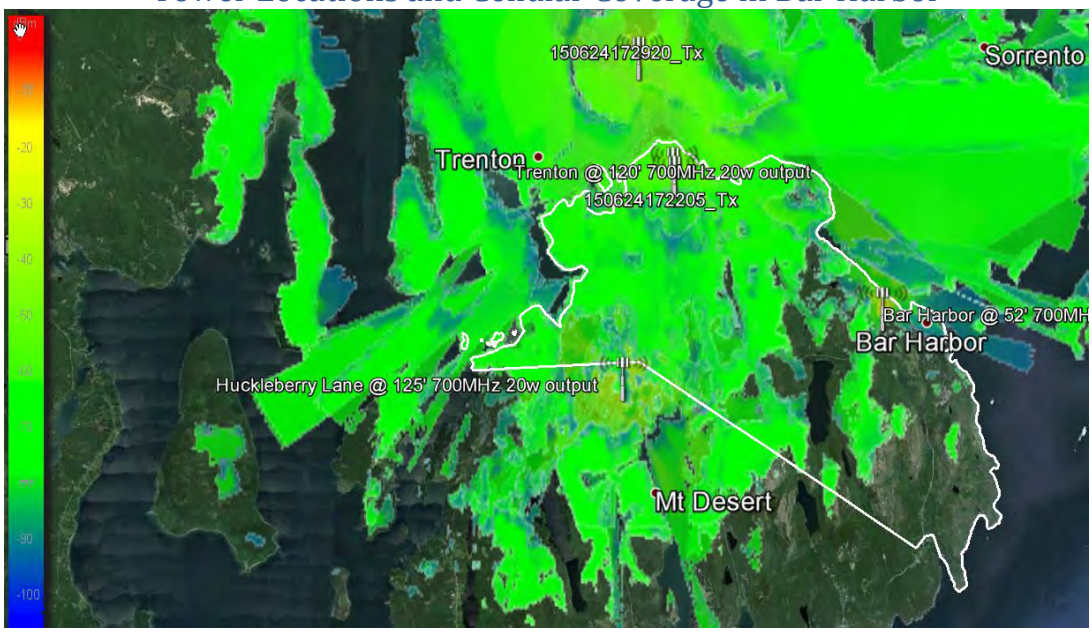
A 4G LTE wireless solution offers a significantly less expensive residential and commercial broadband solution than fiber. This solution does not provide the reliability, consistency, speed, or durability features that the Town desires. It offers a compelling solution for last mile connections to homes that are not served by Time Warner. Tilson estimates that the total capital cost of a wireless buildout is approximately $250,000 to $350,000 depending on whether the solution is a colocation, new tower build, or set of micro or macrocells. However, where wireless infrastructure is typically replaced every five years on average, fiber optic infrastructure typically lasts between 20 and 30 years. Given this, if the Town were to pursue the most modest fiber design build outlined in this report (Municipal Phase I) at an initial capital cost of approximately $2.3 million, this is a one-time cost over the next 20-30 years. Over

[44] Federal Communications Commission. Antenna Structure Registration Database. Accessed on June 26, 2015.

Appendix A (Cont'd)

that same span, a $350,000 LTE wireless build would need to be replaced five to six different times, which would cost over $2 million, for a significantly slower, less reliable solution which is weather and environmentally sensitive. In comparison, the one-time fiber build cost with unlimited bandwidth and unaffected by environmental factors would cost the Town a similar amount over that same period, while providing the economic benefits of increased revenue, GDP, and job and wage increases as well.

Tower Locations and Cellular Coverage in Bar Harbor



The map above shows the locations of these tower assets as well as the approximate cellular data coverage in the region. There are significant coverage gaps in the Village area of Bar Harbor, as well as to the south of the Village. The reason for these gaps despite the tower assets already in the region is due to a combination of mountainous terrain and interference over water. In addition, due to the fact that cellular data signals degrade over water on account of reflection, it is unlikely that the tower assets that are not on Mount Desert Island will provide significant additional coverage.

Additional Wireless Assets

There are additional cellular data assets in Town including a low-lying antenna on the roof of the Criterion Theater, and the Public Safety Tower (Verizon). The Public Safety Tower is not available for use, but Tilson believes that the Town could make an addition to the existing infrastructure should the Town desire to do so. The existence of these wireless assets is important to note because these are additional options for citing wireless communications equipment in the Town.

Appendix B – Dark Fiber Lease Rates

Maine Fiber Company (3 Ring Binder)

Dark Fiber Lease Rates for Mileage Commitments

For commitments made on or after January 1, 2014:

Total Strand mile commitment	Core Network Rates	Portland to Brunswick (1)	Orono to Bangor	Ellsworth to Bar Harbor	Portland to South Berwick	Commitment Term Options
10,000 + (2)	$10.00	$25.00	$22.00	$22.00	$22.00	5-20 years
5,000 to 9,999 (2)	$12.00	$25.00	$25.00	$25.00	$22.00	5-20 years
500 to 5,000 (3)	$14.00	$25.00	$25.00	$25.00	$22.00	5-20 years
Less than 500 (3)	$16.00	$25.00	$25.00	$25.00	$22.00	5-20 years
Any Strand Amount	$25.00	$25.00	$25.00	$25.00	$25.00	Less Than 5 years

(1) Two (2) strand minimum from end to end with limited on/off capabilities.

(2) Strand miles can be deployed anywhere on the network, flexibly over time, with maximum density of 20% of bundle capacity (above 20% revocable based on demand)

(3) Strand miles are licensed from point to point with maximum density of 20% of bundle capacity (above 20% revocable based on demand)

Vermont Telecommunications Authority Pricing Schedule

	15+ year term	10 year term	5 year term	3 year term
	All rates shown in $/month			
Per strand mile	$17.00	$19.00	$22.00	$27.00
>100 strand miles	$17.00	$17.00	$20.00	$25.00
>500 strand miles	$13.00	$15.00	$18.00	$23.00
>1,000 strand miles	$9.00	$11.00	$14.00	$19.00