Wireless Expertise, LLC

WIMA project report: Review of wireless coverage options and proposed new wireless communications facilities

March 9, 2022 for the Cape Elizabeth Ordinance Committee

Introduction

The Town of Cape Elizabeth has retained Wireless Expertise, LLC to perform a Wireless Infrastructure Augmentation Study (Wima). Steven Webster, the Principal Engineer for this consulting firm, met with Town Planner Maureen O'Meara and with the Ordinance Committee in an interview November 17, 2021, and then in meetings on January 12 and February 9, 2022. Interim reports were generated for the January 12 and February 9 Ordinance Committee meetings. This is the final report to be presented to the Ordinance Committee during its meeting on March 23, 2022.

Methodology

Wireless carriers use licensed frequency bands to transmit and receive LTE signals to and from users of the network. The FCC has sold licenses in two bands for 4G/LTE service, the low-band which is from 600 to 900 MHz (just above where terrestrial UHF TV is broadcast) and the mid-band which is from 1700 to 2600 MHz, which is at the high end of the UHF band with propagation properties similar to microwave radio. 5G service added high-band frequency bands, which are above 6 GHz and provide significant capacity increases over the low and mid band frequencies but at a cost of considerable losses when trying to penetrate signals through foliage (trees), making them impractical for residential wireless service in a heavily wooded town like Cape Elizabeth. As a rule of thumb, the higher the frequency, the shorter the range, due to higher losses bending around obstacles (hills and buildings) and foliage (tree) scattering and absorption losses.

I was hoping to use the 600 - 900 MHz low-band spectrum to model all four of the existing wireless carriers, but only AT&T, Verizon and US Cellular have licensed spectrum in those bands. T-Mobile/Sprint only has spectrum from 1700 - 2600 MHz (mid bands). The other three carriers also have licensed spectrum the low bands, but the majority of all carriers' bandwidth and capacity are in the mid bands, which is where high bandwidth services are being optimized for, so it is wisest to model and design coverage using the mid bands.

I analyzed the predicted coverage from the four wireless carriers (Verizon, AT&T, US Cellular and T-Mobile/Sprint) in the 1.7 to 2.5 GHz "mid band" that wireless carriers have most of their spectrum holdings and have prioritized 5G deployments.

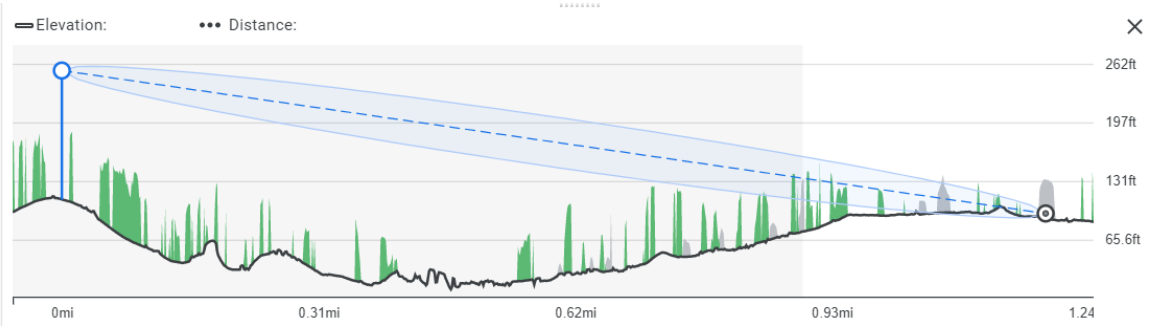
The coverage analysis requires a sophisticated computer CAD capability to predict radio coverage. The CAD tool needs to be able to use high resolution and up to date terrain and land cover data. I used Google Network Planner to model the coverage from the towers in Cape Elizabeth. Google Network Planner runs in the cloud on massively parallel computing platforms that provide quick, but sophisticated radio coverage models and it uses Google's high resolution geo database that has a 1 meter (3'x3') resolution and includes the heights of not only the terrain, but what is on the terrain (trees and buildings).

Coverage Limiting Factors

The reasons for the limited wireless coverage in Cape Elizabeth are as follows:

- Distance – The tower overlay districts are on the western side of Cape Elizabeth but most of the population and residences are on the eastern side of town.
- Hills – UHF signals are impacted by terrain obstacles.
- Trees – Trees are significant absorbers and scatterers of UHF wireless signals. This limits the ability to cover distant residences through trees, requiring wireless sites that are close to or in residential areas.

Below is an example of a wireless path profile from the tower on 14 Strout Road to the Cape Elizabeth Town Hall



This plot shows the tower on the left and the Cape Elizabeth Town Hall as the gray building on the right. The signal path passes over the roof of the Pond Cove Elementary School and the Thomas Memorial Library as well as through the tops of some trees that are across Scott Dyer Road from the school. This plot is to demonstrate the level of detail that is used to predict radio coverage as well as to show that foliage is a major factor in wireless coverage.

Task 1

FROM RFP and contract: The consultant will prepare an analysis of existing wireless infrastructure coverage levels in the Town of Cape Elizabeth. The analysis will identify “dead spots” and areas with service deficiencies. To identify deficiencies, standard service levels will be proposed by the consultant that are adequate for modern households and commercial businesses.

Predictions of Existing Wireless Network Coverage

I analyzed the predicted coverage from the four wireless carriers (Verizon, AT&T, US Cellular and T-Mobile/Sprint) in the 1.7 to 2.5 GHz "mid band" that wireless carriers have most of their spectrum holdings and have prioritized 5G deployments.

The coverage analysis requires a sophisticated computer CAD capability to predict radio coverage. The CAD tool needs to be able to use high resolution and up to date terrain and land cover data. I used Google Network Planner to model the coverage from the towers in Cape Elizabeth. Google Network Planner runs in the cloud on massively parallel computing platforms that provide quick, but sophisticated radio coverage models and it uses Google’s high resolution geo database that has a 1

meter (3'x3') resolution and includes the heights of not only the terrain, but what is on the terrain (trees and buildings).

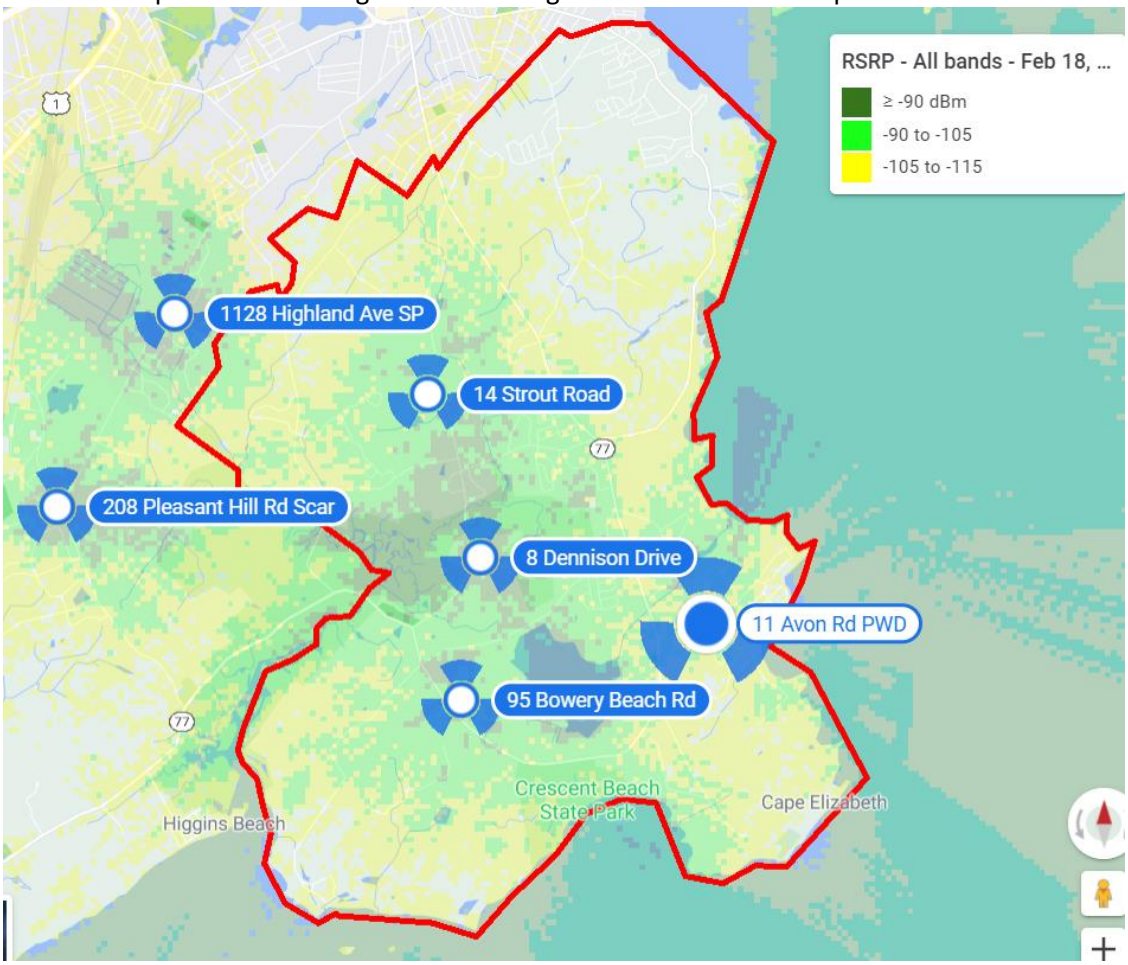
Existing Towers modeled

Here's the summary of the available wireless tower sites in Cape Elizabeth and bordering towns. The information includes address, coordinates (latitude and longitude in WGS-84) and height:

- 180' self-support at Transfer Station, 8 Dennison Drive, Cape Elizabeth
  43.5858, -70.2431
- Portland Water District 80' water tower at 11 Avon Road, Cape Elizabeth
  43.5798, -70.2148
- 180' pole at 95 Bowery Beach Rd. 43.5729, -70.2455
- 180' guyed tower at 14 Strout Road. 4 carriers already on tower 135' to 175'
  43.6006, -70.2497
- 150' guyed tower at 1128 Highland Ave, South Portland. 43.6079, -70.2814
- 100' tower at 208 Pleasant Hill Rd in Scarborough. 43.5904, -70.2961

I assumed that all wireless carriers could or would collocate on all of the available towers in the area and I located antennas at the 80% height level on towers for the wireless coverage simulation in order to accommodate for multiple antennas needed at various levels down from the top of the tower.

Below is the predicted coverage of the existing wireless facilities in Cape Elizabeth:



Task 2

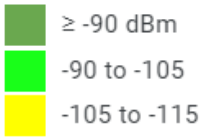
FROM RFP and contract: Based on information from private service providers and general knowledge of the consultant, the consultant will advise on expected service levels offered by the market.

In order to determine if there are coverage gaps, it's important to define what "coverage" is. Currently, all commercial wireless networks use 4G/LTE technology. The legacy 2G and 3G networks have either been shut down or are going through the shut down process. LTE and it's "5G" successor are both built on the same wireless technology referred to as "OFDMA." For the reason, LTE coverage criteria carry forward to 5G and use a similar signal strength measurement called RSRP.

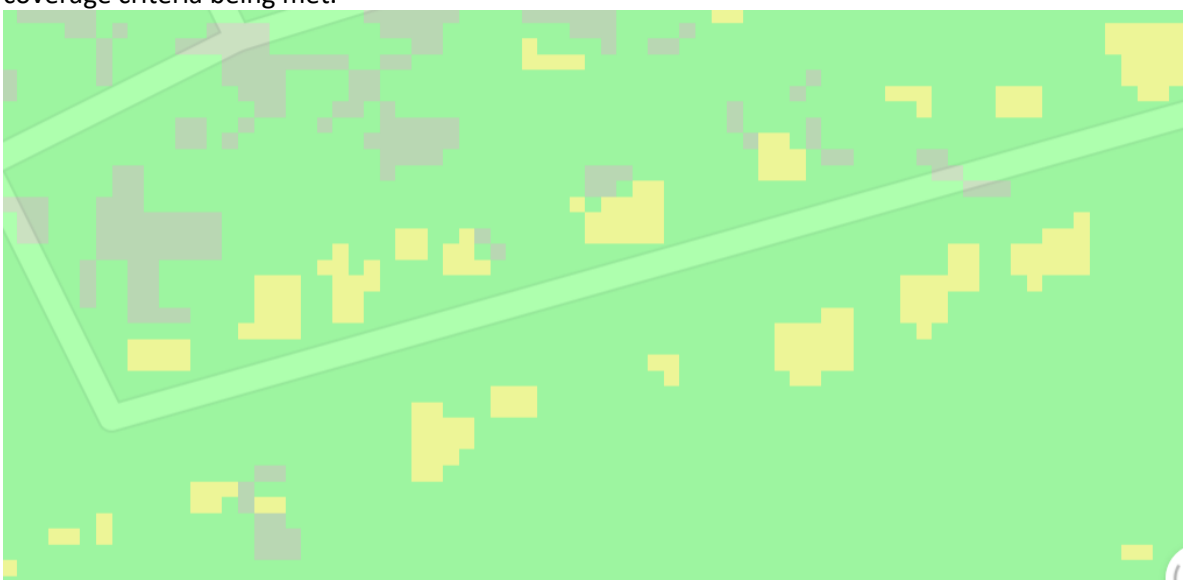
When designing LTE coverage, the following typical thresholds for RSRP (LTE signal strength) are used:

- The minimum usable LTE coverage level is -115 dBm.
- The typical minimum service level is -105 dBm, which makes for reliable text, call and data sessions.
- Typical residential structures lose 10 to 20 dB of signal level indoors vs. outdoors, so residential indoor service tends to require a minimum of -90 dBm of RSRP on street coverage

The plot on the first page of this report as well as the remaining coverage plots use the following RSRP signal level legend:



When examining coverage to individual residences, the wireless coverage prediction tool is aware of the building envelopes for the buildings in Cape Elizabeth, including residential structure. An example plot below shows signal levels consistently above -105 dBm RSRP in a residential area with predicted signal levels above -115 dBm within the residences (shown in yellow). This shows the minimum residential coverage criteria being met.



Below is an example of a portion of a building that might not have complete wireless coverage. It shows predicted coverage below -115 dBm RSRP at the northern portion of the building.

With the proposed design that will be outlined in this report, a handful of buildings in Cape Elizabeth like this may experience spotty indoor coverage.

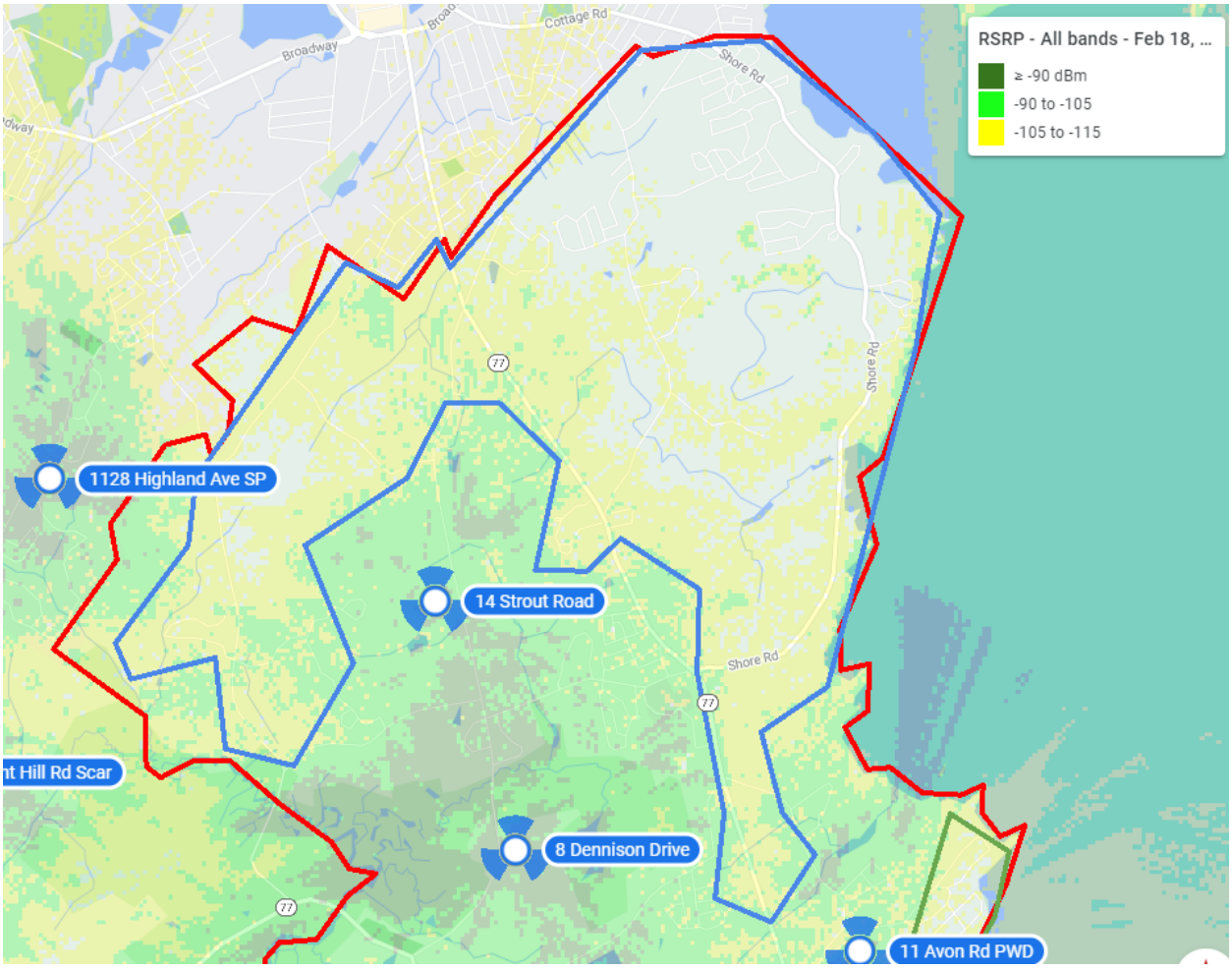
Where coverage is needed

As can be seen in the above map, there are three areas in Cape Elizabeth that require wireless coverage enhancements:

- Sawyer Road, Spurwink Road, Mitchell Road and Shore road areas (the light blue boundary)
- Broad Cove and Hunts Point (the dark green boundary)
- The Sprague properties (the orange boundary).

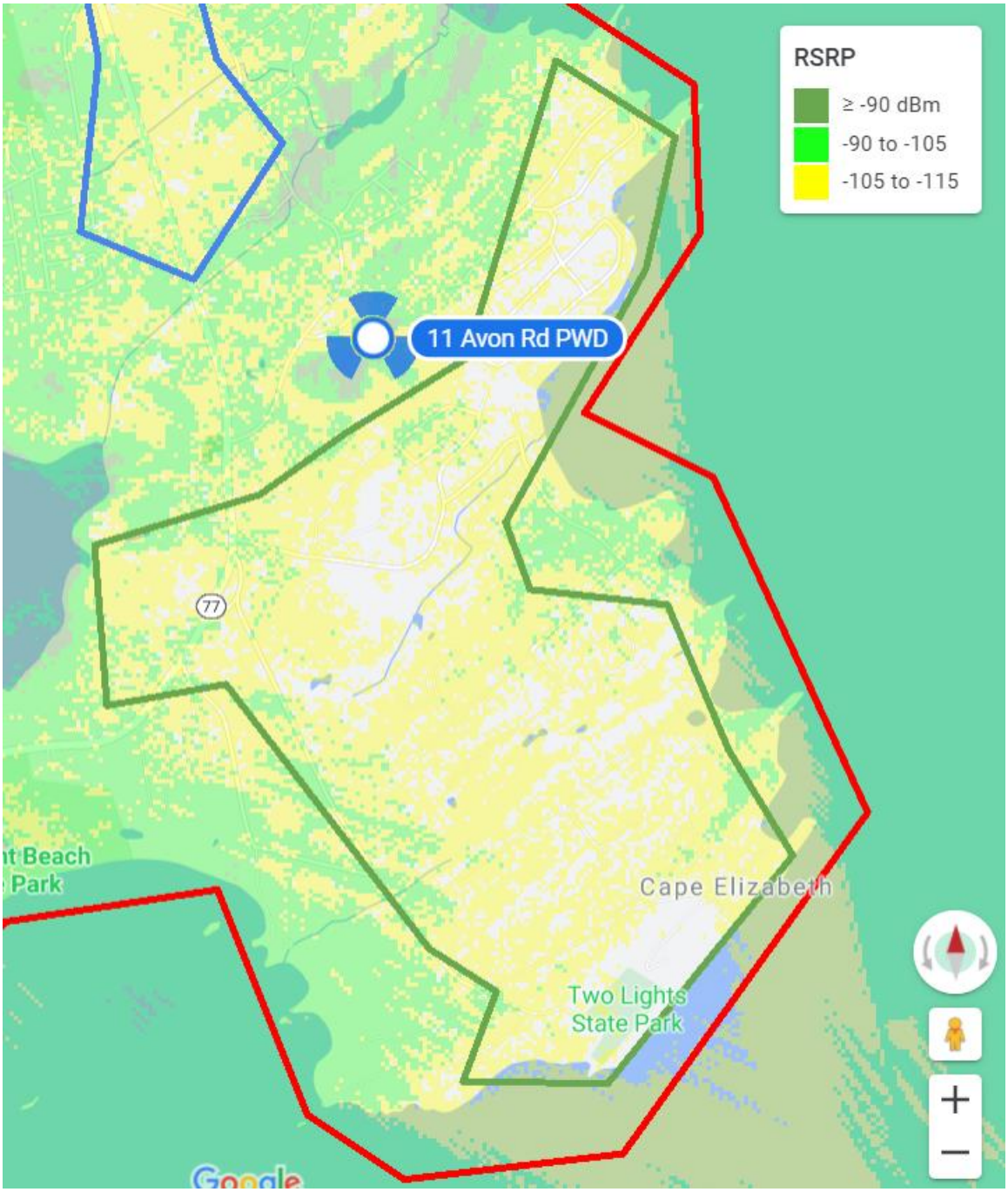
Below are zoomed in coverage map details for the three areas that require wireless service:

Mitchell Road and Shore Road area



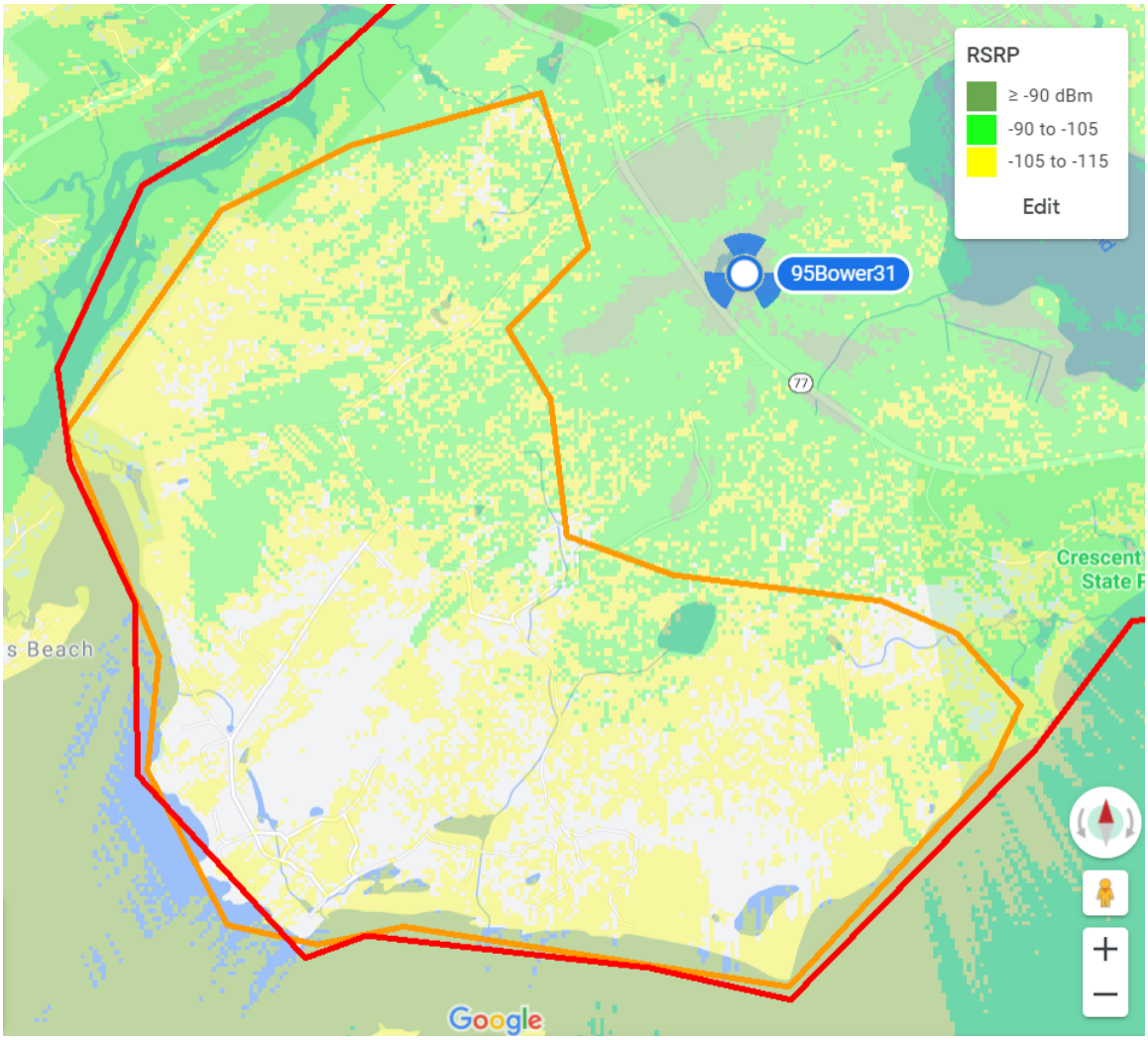
The main roads to cover are SR-77 from the South Portland town line, Sawyer & Eastman Roads (left side of map), Mitchell Road (upper portion) as well Shore Road (eastern portion). The residential neighborhoods that these roads serve also need to be covered.

Broad Cove and Hunts Point



This includes Two Lights Road from SR-77 to the ocean, Broad Cove Road, Hunts Point Road, Hannaford Cove Road and Two Lights Road as well as the residential areas that border these roads.

The Sprague properties



This is mostly rural farmland and a series of homes along the coastline that is located south of SR-77, west of Crescent Beach SP and east of the Spurwink River. This is mostly large private land holdings, so permitting and budgeting will likely be different from the other two areas, which are more populated and accessible to the public.

Task 3

FROM RFP and contract: The consultant will develop alternatives for Town Council consideration in which the town can proactively and financially partner with a wireless provider(s) to augment service levels above what would otherwise be available through market expansion.

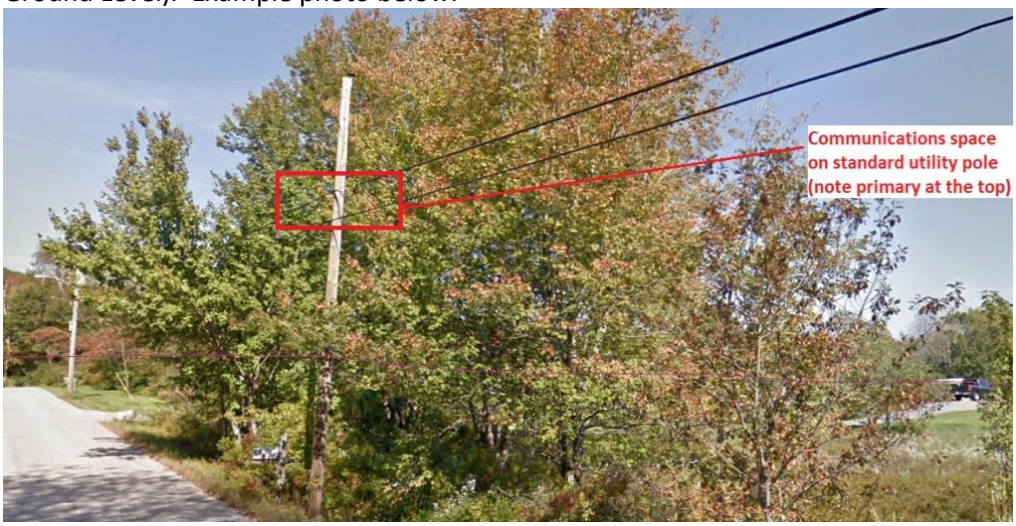
Proposed Wireless Augmentation Plan

Siting wireless facilities in residential areas can easily bring up aesthetic concerns, which is why this report proposes to enhance wireless service in Cape Elizabeth by using existing power poles with a few strategically located short (50' to 80' AGL) monopoles on strategic Cape Elizabeth town properties. This report outlines the design proposal using small wireless base stations located on CMP/Frontier utility poles connected by a fiber optic cable broadband network. 5G service requires fiber optic cable connectivity to base stations, which is why the fiber proposal is part of this study on what is required to provide universal residential wireless service within the town limits of Cape Elizabeth.

Proposed support structures

Most of the proposed antenna structures are collocations on existing or replacement power poles that are owned by CMP and/or Frontier. There are two basic types of power poles and one type of low-profile monopole that are being proposed for collocation:

1. Existing power poles with primary (high voltage) power cables running along the top of the pole. These types of poles are proposed to have the antennas in the communications space on the pole (where telephone, cable TV and fiber optic cables are run), approximately 25' AGL (Above Ground Level). Example photo below:



2. Existing power poles that don't have primary (high voltage) power cables. These are sometimes referred to as drop poles used to support long secondary (residential) power and/or telephone/cable service. Poles only used to support street lamps are also selected for this purpose. These can be used to support antennas at the top of the pole (45' AGL minimum) or can be extended if the antennas need to be raised. Antennas can be hidden in an RF-transparent tubular shroud. Example photo below of a "drop" pole (no antennas):

50’ or 80’ monopoles, which would be newly added antenna support structures that look like a tall flagpole or metal light pole. The antennas at the top of the pole can be shrouded (hidden). Example photo below:

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This report shows potential pole collocations of small cell wireless facilities to improve wireless coverage in residential areas of Cape Elizabeth.

I extensively used Google Earth and Google Street View to find suitable locations for possible wireless facilities and I modeled their coverage, along with the existing tower sites and neighbor proposed pole attachment sites. The coverage modeling uses Google Network Planner software that uses very high resolution terrain and land use data including heights and footprints of trees and buildings. This produces accurate simulations in wooded towns like Cape Elizabeth.

One of the challenges that I had, even in areas that had overhead utilities, the tree cover tended to reduce the usable coverage of these poles, which requires considerable optimization and some difficult decisions with regard to coverage placement.

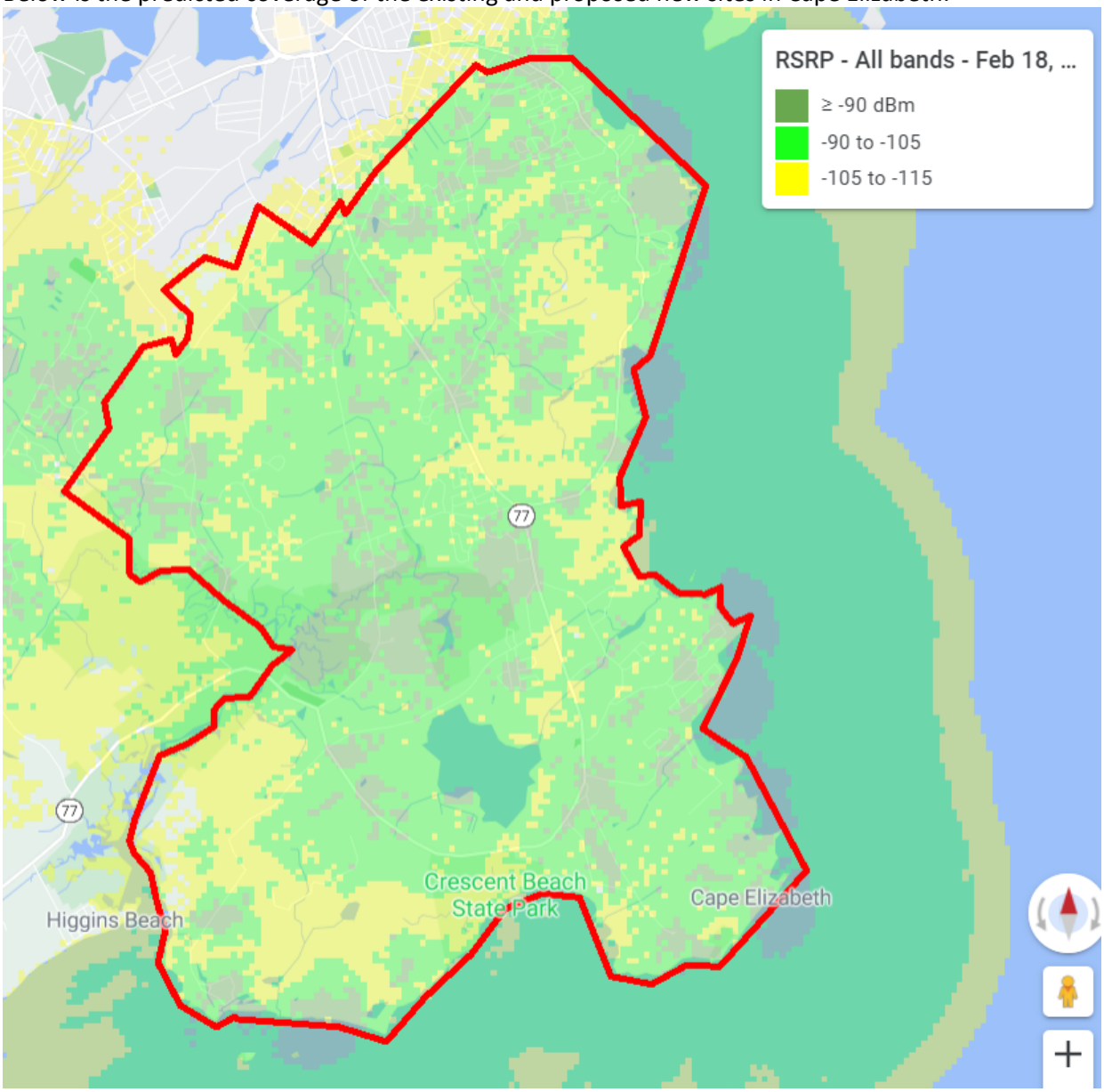
This coverage augmentation design was done in two phases. The first phase prioritized wireless facilities that covered as many residences and buildings as possible. The resulted in an interim report with a number of proposed wireless facilities that covered most, but not all of the buildings in Cape Elizabeth. That report was discussed during the February 9, 2022 Ordinance Committee meeting and this consultant was instructed to add additional wireless facilities to ensure coverage to nearly all of the buildings in Cape Elizabeth along with sufficient outdoor coverage within the town limits of Cape Elizabeth.

The following pages describe the proposed wireless facilities and their parameters. The proposed sites are described in the following search areas:

- Sawyer Road and Spurwink Road (including Eastman Road)
- Mitchell Road
- Shore Road
- Broad Cove and Hunts Point
- The Sprague Properties

Starting at the top of the following page is the map showing the predicted coverage in Cape Elizabeth from all of the proposed and existing wireless facilities. This town-level plot doesn't show the locations of each existing and proposed sites, which are shown later in this report in detailed coverage maps showing the predicted coverage for each neighborhood. This plot is followed by a table showing the proposed new sites to be added to improve coverage in Cape Elizabeth. Included in this table are the results of a coverage demographic study included in this table that shows how many people each current and proposed site will cover. This is helpful in prioritizing sites and areas for wireless development.

Below is the predicted coverage of the existing and proposed new sites in Cape Elizabeth:



Most of the areas shown as yellow coverage (between -115 and -105 dBm RSRP) are undeveloped areas (parks and open space).

Opening the provided Google Earth KMZ files of the predicted coverage plots that are included in this report will allow the reader to obtain a more detailed view of the predicted coverage, sites and their locations.

Table showing the location proposed antenna height and support structure of each proposed site

Site Name	Population covered	Latitude	Longitude	Antenna height (feet)	Search Area	Structure type
14 Ledgewood Lane	90.5	43.5772	-70.2105	25	Broad Cove	Existing power pole
39 Trundy Road	122.1	43.5831	-70.2091	25	Broad Cove	Existing power pole
69 Hannaford Cove Rd	53.8	43.5685	-70.2031	25	Broad Cove	Existing power pole
Broad Cove and Ledgewood	118.7	43.57489	-70.2118	25	Broad Cove	Existing power pole
Dyer Lane and Two Lights Rd	81.9	43.56361	-70.201	25	Broad Cove	Existing power pole
Hannaford Cove Rd and Captain Elliot	78.4	43.56616	-70.2074	45	Broad Cove	Existing power pole
Pilot Point Rd and Katahdin Rd	91.7	43.57925	-70.209	25	Broad Cove	Existing power pole
Reef Road and Oak Knoll	89.4	43.58641	-70.2053	25	Broad Cove	Existing power pole
Running Tide Rd	122.4	43.57132	-70.2031	45	Broad Cove	New 50' pole
SR-77 and Two Lights Road	565.8	43.57243	-70.2201	75	Broad Cove	New 80' pole
Surfside and Waumbeck	109.8	43.58095	-70.2062	25	Broad Cove	Existing power pole
Tower Drive and Two Lights Rd	109.7	43.56063	-70.2101	25	Broad Cove	Existing power pole
10 Woodcrest Road	110.4	43.62694	-70.2287	25	Mitchell Road	Existing power pole
133 Oakhurst Road	125.3	43.62485	-70.2305	45	Mitchell Road	New 50' pole
134 SR77	61.8	43.61	-70.2396	45	Mitchell Road	Existing power pole
168 Mitchell Road	216.9	43.62958	-70.2349	25	Mitchell Road	Existing power pole
27 Kildeer Rd	170.4	43.6202	-70.24	45	Mitchell Road	Existing power pole
41 Cranbrook Drive	16.6	43.60914	-70.2275	25	Mitchell Road	Existing power pole
505 Mitchell Road	42.0	43.60812	-70.2341	25	Mitchell Road	Existing power pole
61 Stonybrook Road	123.5	43.62833	-70.2267	45	Mitchell Road	Existing power pole
Cranbrook and Belfield	28.9	43.61058	-70.2239	25	Mitchell Road	Existing power pole
End of Cranbrook Drive	35.0	43.60519	-70.2279	25	Mitchell Road	Existing power pole
Hobstone Road and Hidden Creek Dr	18.8	43.61091	-70.2351	45	Mitchell Road	New 50' pole

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Site Name	Population covered	Latitude	Longitude	Antenna height (feet)	Search Area	Structure type
Locksley Rd and Bridal Path Way	100.3	43.62191	-70.2228	45	Mitchell Road	Existing power pole
Lydon and Campion	242.3	43.62414	-70.2365	45	Mitchell Road	Existing power pole
Mitchell and Cape Woods	78.0	43.62618	-70.2333	25	Mitchell Road	Existing power pole
Mitchell and Columbus drop pole	153.5	43.62079	-70.234	45	Mitchell Road	Existing power pole
Mitchell and Hobstone	17.0	43.61085	-70.232	45	Mitchell Road	Existing power pole
Mitchell and Meadowview	154.7	43.61619	-70.2318	45	Mitchell Road	Existing power pole
Mitchell and SR77	182.4	43.60573	-70.2357	45	Mitchell Road	Existing power pole
Mitchell Road and Belfield Road	66.8	43.61327	-70.2304	25	Mitchell Road	Existing power pole
Oakhurst and Rocky Knoll	191.2	43.62662	-70.2245	45	Mitchell Road	Existing power pole
SR77 and Canterbury Way	84.6	43.61565	-70.2451	45	Mitchell Road	Existing power pole
Stonebridge and Cranbrook	8.1	43.60701	-70.2272	25	Mitchell Road	Existing power pole
Stonebridge Road end	34.4	43.60764	-70.2246	25	Mitchell Road	Existing power pole
Stonegate Rd and Granite Ridge Rd	58.6	43.61938	-70.2279	45	Mitchell Road	New 50' pole
Woodland and Cottage Farms	279.7	43.63104	-70.2307	25	Mitchell Road	Existing power pole
Jewett Road and Vernon Road	166.9	43.58258	-70.2292	25	Outside of search zones	Existing power pole
1072 Shore Road	49.9	43.613	-70.2139	25	Shore Road	Existing power pole
1117 Shore Road	91.8	43.6073	-70.2167	45	Shore Road	Existing power pole
1160 Shore Road	81.8	43.6019	-70.2172	45	Shore Road	Existing power pole
1203 Shore Road	44.7	43.5972	-70.2223	25	Shore Road	Existing power pole
Cape Elizabeth HS	468.0	43.59144	-70.2282	75	Shore Road	New 80' pole
Ft Williams old fire Station	554.8	43.6233	-70.212	75	Shore Road	New 80' pole
Shore Rd Cape Cottage CEFD Station	690.4	43.63356	-70.2266	45	Shore Road	New 50' pole
Shore Road and Oakhurst	186.8	43.62915	-70.2211	25	Shore Road	Existing power pole
61 Charles E Jordan Rd	4.2	43.56249	-70.2633	25	Sprague	Existing power pole

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Site Name	Population covered	Latitude	Longitude	Antenna height (feet)	Search Area	Structure type
Bacchus Road	9.9	43.55475	-70.2527	45	Sprague	New 50' pole
Breakwater Farm Road end	3.4	43.55817	-70.241	45	Sprague	New 50' pole
Japanese Pond Rd	8.6	43.55616	-70.2639	25	Sprague	Existing power pole
1131 Sawyer Road	92.9	43.6064	-70.2677	45	Spurwink and Sawyer	Existing power pole
1200 Sawyer Rd	23.3	43.59657	-70.2665	45	Spurwink and Sawyer	Existing power pole
170 Spurwink Ave	388.4	43.61505	-70.2484	45	Spurwink and Sawyer	Existing power pole
46 Eastman Rd	55.5	43.60944	-70.2552	25	Spurwink and Sawyer	Existing power pole
84 Eastman Road	91.1	43.61207	-70.2592	25	Spurwink and Sawyer	Existing power pole
Cole Field Rd and Prout Place	45.9	43.59861	-70.2721	25	Spurwink and Sawyer	Existing power pole
Park Circle	38.7	43.5972	-70.2741	45	Spurwink and Sawyer	New 50' pole
Sawyer and Cole Field	74.7	43.60047	-70.266	25	Spurwink and Sawyer	Existing power pole
Sawyer Road and Salt Marsh Way	62.8	43.59229	-70.2642	45	Spurwink and Sawyer	Existing power pole
Spurwink and Aster	301.1	43.62102	-70.2456	25	Spurwink and Sawyer	Existing power pole
Spurwink and Pleasant	51.4	43.61095	-70.2493	45	Spurwink and Sawyer	Existing power pole

The total Cape Elizabeth population covered by the existing tower sites as well as these added sites is the 2020 census population for Cape Elizabeth (9535), which is more than twice the population covered by the existing sites (only 4699 residents according to Google Network Planner demographics analysis).

Sites and coverage predictions in Cape Elizabeth neighborhoods

North end of both Mitchell Road and Shore Road areas

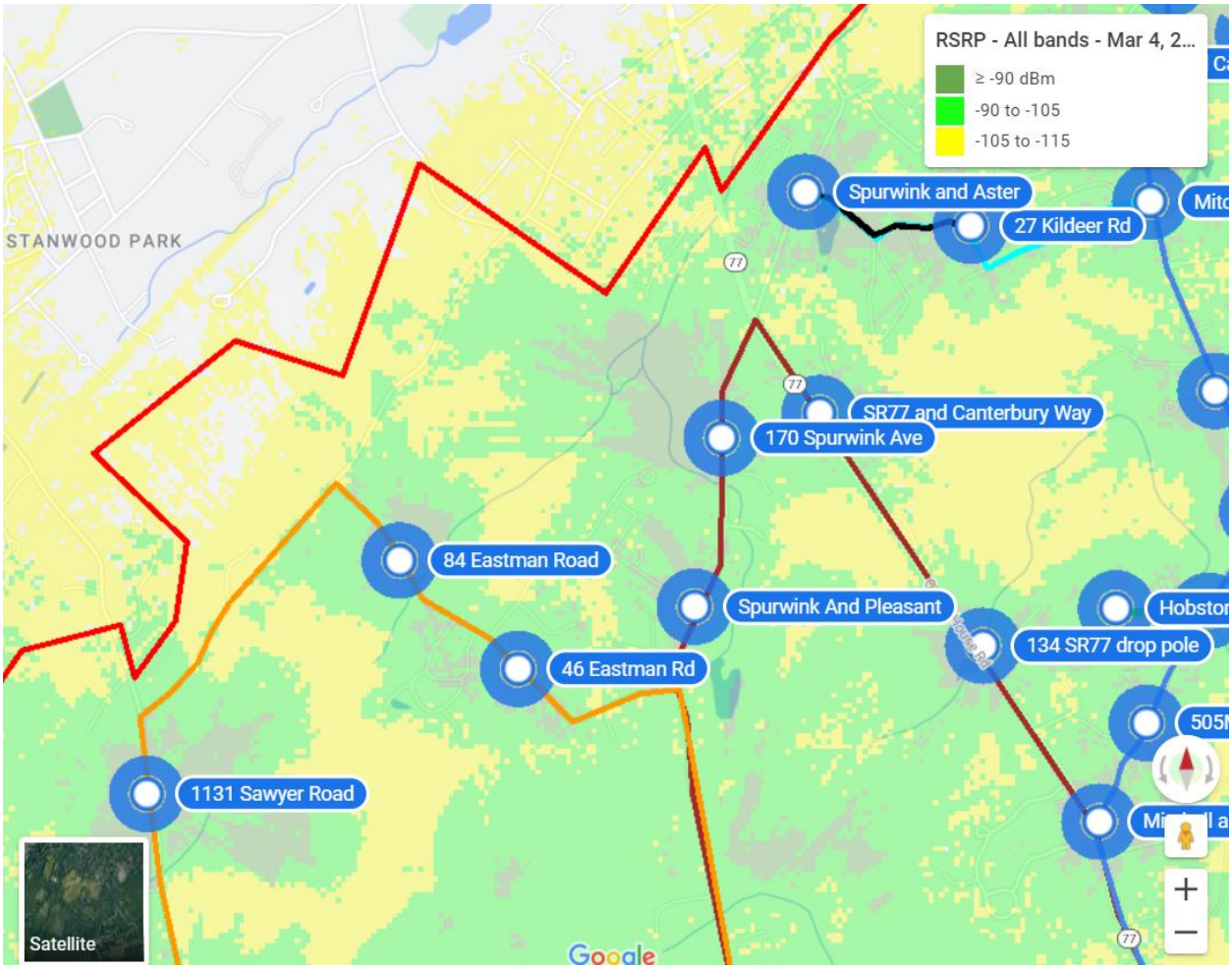
With the exception of the red line showing the town border of Cape Elizabeth, the colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The blue loop is the northern half of the Mitchell Road and Shore Road loop. The orange, brown, yellow, black and light blue lines represent short fiber connections to proposed sites that aren't on the main fiber routes.

These fiber routes are described in further detail at the end of this report.

Remaining part of Mitchell Road and Shore Road areas:

The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The blue loop is the middle portion of the Mitchell Road and Shore Road loop. The orange, violet, brown, yellow, black, green and light blue lines represent short fiber connections to proposed sites that aren't on the main fiber routes.

Spurwink Road area including western portion of Mitchell Road area:



The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The blue loop is the western portion of the Mitchell Road and Shore Road loop. The dark brown loop in the middle is the northern portion of the main fiber loop, the orange loop on the left is the northern portion of the Sawyer/Spurwink Roads loop. The black and light blue lines at the top represent short fiber connections to proposed sites that aren't on the main fiber routes.

Sawyer Road area:

The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The blue loop on the right is the western portion of the Mitchell Road and Shore Road loop. The dark brown loop in the middle is the northwestern portion of the main fiber loop, the orange loop in the middle is the entire Sawyer/Spurwink Roads loop.

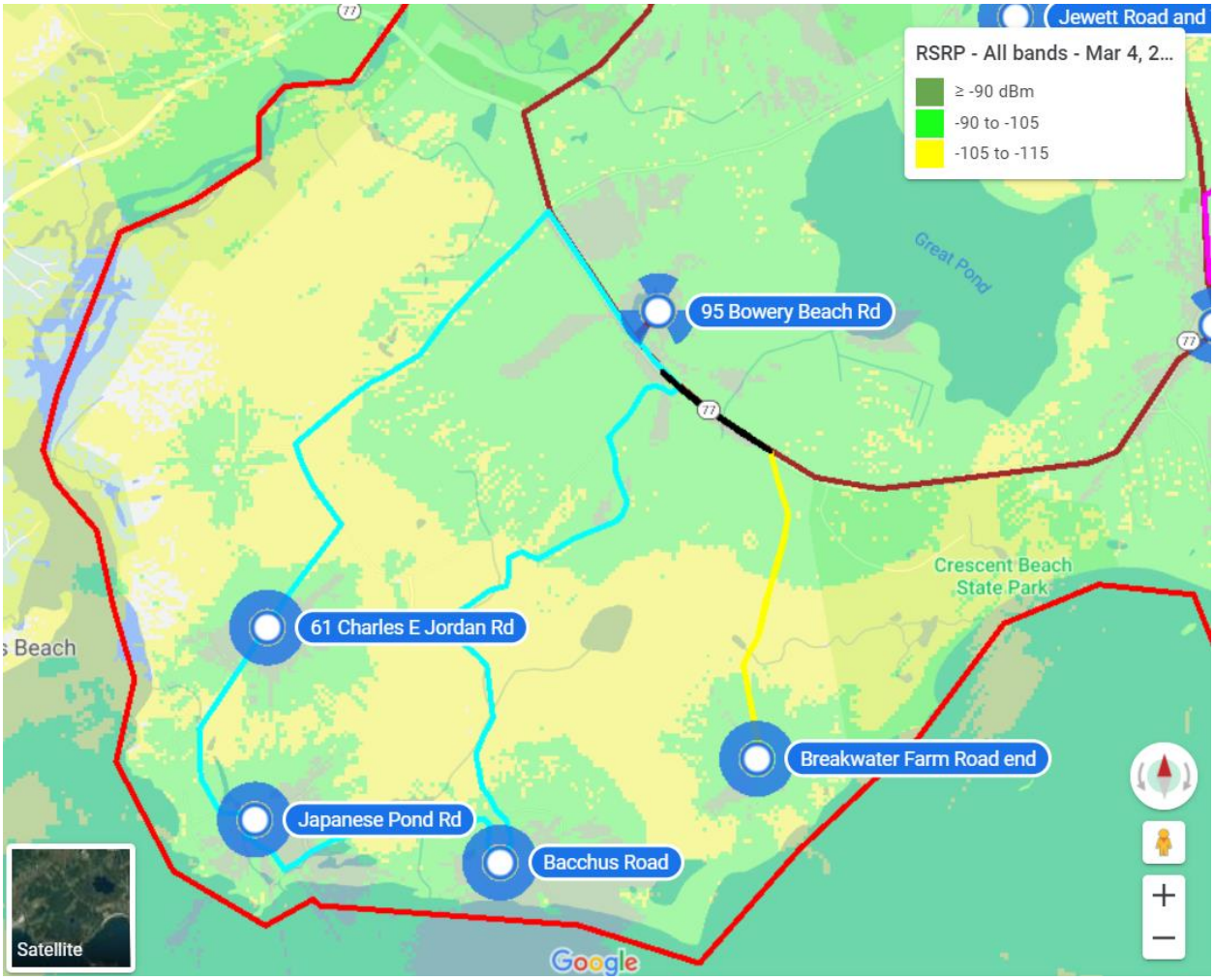
South end of Shore Road and Cape Elizabeth town center:

The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The blue loop at the top is the southern portion of the Mitchell Road and Shore Road loop. The dark brown loop in the middle is the eastern portion of the main fiber loop, the purple loop in the lower right is the northern portion of the Broad Cove loop. The red line on the lower left is a fiber connection along Fowler Road to connect one site that doesn't lie on any of the fiber loops.

Broad Cove area:

The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The dark brown loop in the left is the southeastern portion of the main fiber loop, the purple loop in the upper right is the Broad Cove loop. The blue line in the lower portion is the Two Lights fiber loop. The red line in the upper left is a fiber connection along Fowler Road to connect one site that doesn't lie on any of the fiber loops and the yellow line is a short underground line to connect one site to the Two Lights loop. The other red line is the town boundary for Cape Elizabeth.

Sprague Properties area:

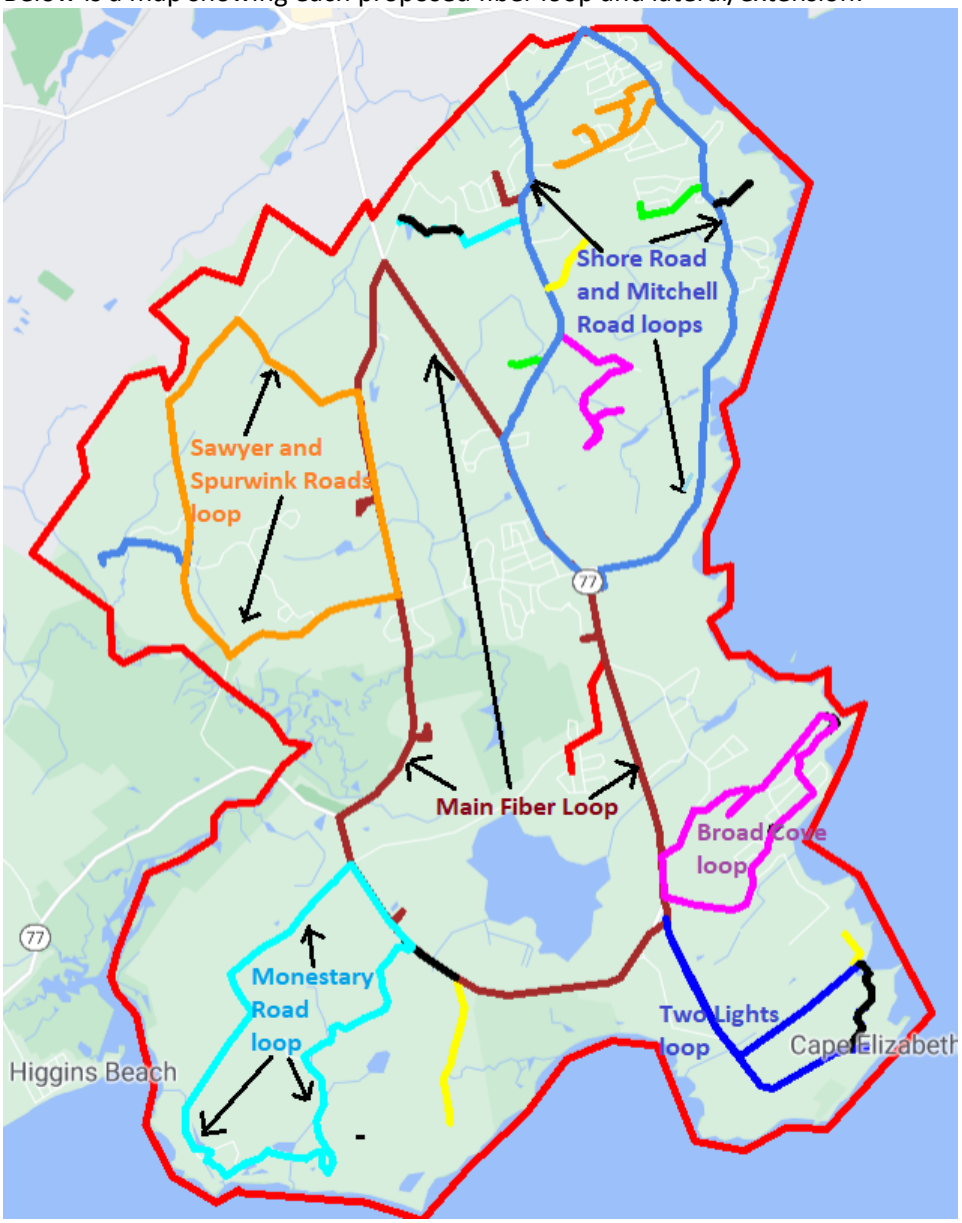


The colored lines show the proposed fiber optic cable routes to connect all these proposed sites. The dark brown loop in the upper right is the southern portion of the main fiber loop, the light blue loop on the left is the Monastery Road loop. The yellow line is to connect one site to the Main fiber loop. The red line is the town boundary for Cape Elizabeth.

Supplemental Task: Proposed fiber optic cable routes and ROM cost estimates.

Each of the proposed wireless base stations require fiber optic connections to be able to support 4G and 4G data rates. In order to support this effort, I propose a network of nested fiber loops to connect as many of the sites with relatively short lateral connections to individual or small clusters of sites that aren't on the fiber loops. Loop (ring) data circuits have the advantage of being able to automatically reroute data if there is one break or cut in the fiber ring. Nesting fiber rings increases network reliability by providing multiple alternative paths for data to travel on. This kind of network topology is the most likely to support high reliability data connections. This proposed fiber network can also be used to support data connections and services for the town of Cape Elizabeth and its residents, if desired. If portions of Cape Elizabeth are considered to be underserved by broadband services, federal subsidy dollars are available through coordination with the State Broadband Office in Augusta.

Below is a map showing each proposed fiber loop and lateral/extension:



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These fiber paths were surveyed using Google Street View, except along private roads in the Sprague Properties, which I used aerial imagery to estimate if overhead or underground utilities exist. I consulted with various engineers and firms in the fiber optic space to come up with a ROM (Rough order of Magnitude) estimate of the costs to run fiber, including material, engineering and installation labor as well as pole make-ready costs. The per mile estimates are shown in the table below.

Below is a table summarizing each fiber loop and lateral/extension:

Fiber Route	Length (mi)	Overhead length	Underground length
Main fiber loop	9.5	9.2	0.3
Broad Cove Loop	3.2	2.9	0.3
Monastery Road loop	4.7	2.3	2.4
Sawyer Road loop	3.3	3.3	
Shore Road and Mitchell Road loop	7.2	6.9	0.3
Two Lights loop	3.5	3	0.5
Belfield and Cranbrook Drive extension	1.1	0.4	0.7
Breakwater Farm Road extension	0.7	0.7	
Campion Road extension	0.23	0.23	
Columbus Road extension	0.68	0.36	0.32
Fowler Road extension	0.65	0.65	
Hobstone Road extension	0.16		0.16
Oakhurst Road extension	0.76	0.76	
Olde Fort Road extension	0.4	0.4	
Prout Place extension	0.73		0.73
Running Tide Road extension	0.19	0.1	0.1
Stonegate Road extension	0.31		0.31
Total mileage:	**37.3**	**31.2**	**6.1**
Price per mile of fiber		$26,000	$60,000
Total estimated fiber cost	**$1,178,400**	**$811,200**	**$367,200**

Wireless Expertise, LLC

Supplemental files

This report contains screen captures from Google Earth as well as the Google Network Planner and is accompanied by four files that can be opened and viewed in Google Earth:

- Predicted wireless coverage of the original tower sites from Task 1
- Predicted wireless coverage of the original tower sites plus proposed new wireless sites from this report.
- Locations of each of the current and proposed wireless sites
- Fiber optic cable routes.

Google Earth is a free program available for download at: https://www.google.com/earth/versions/

About Wireless Expertise, LLC

Wireless Expertise was founded as an engineering consulting firm in 2018, but it's founder and Principal Engineer, Steven Webster, has over 30 years of experience as a radio network design engineer in the wireless industry.

Steve has worked for AT&T, Sprint/Nextel, American Tower, Lucent, as well as for a number of wireless start-up companies. Steve was involved in the design engineering of one of the earliest digital cellular networks (in Germany), and the next evolution of digital cellular technology in Taiwan. In the past 20 years, Steve has also assembled and taught many courses and seminars on wireless technology. Before starting in the wireless industry in 1990, Steve worked as an engineering consultant to the DOD working on software simulations of radio networks and the design of communications electronic warfare systems.

Steve is currently the President of Wireless Expertise, LLC, an engineering consulting firm focused on wireless broadband design. Current wireless broadband clients include, Google, to support their Wireless Broadband Internet Planning projects and clients, NextLink Wireless (a Wireless Internet Service Provider) and Siemens (a systems vendor that uses me extensively for pre-sales support).

Steve holds a master's degree in electrical engineering from Johns Hopkins University. Steve was a student in the Cape Elizabeth school system from grades 4-9.