CITY OF SOUTH SAN FRANCISCO, CA

Broadband & Wireless Feasibility Study

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Magellan ADVISORS

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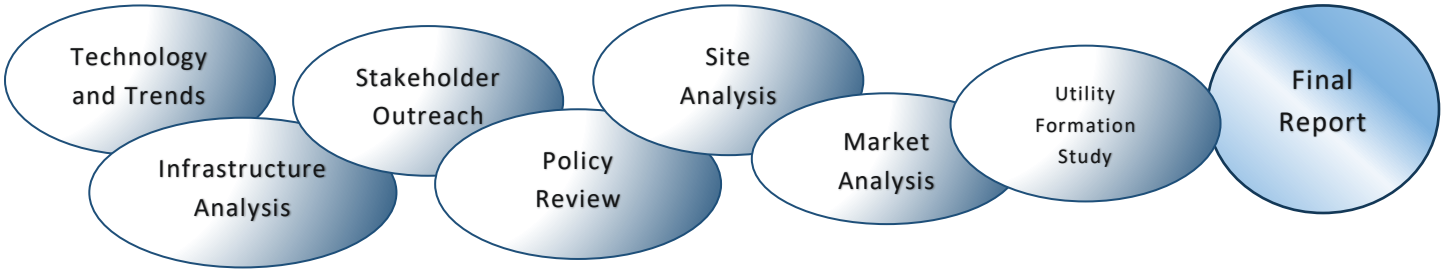
1.1 OVERVIEW OF PROJECT

Technology is advancing at unprecedented rates. Cities are embracing new technologies and platforms that require high bandwidth broadband internet connections. According to the Federal Communication Commissions (FCC), the definition of broadband internet is a minimum of 25 Mbps download and 3 Mbps upload speeds. Broadband provides high-speed internet access via multiple technologies including fiber optics, wireless, cable, DSL, and satellite.

The way the world interacts has changed, especially since the COVID-19 lockdown, with working, telehealth, distance learning, and even the economy shifting to online platforms. Cities are also becoming more technologically advanced and have a higher need for fiber networks to support the many departments, constituents, and businesses. Investing in infrastructure and partnerships is becoming increasingly important and cities see the need to plan, construct, and partner with the private sector to manage, operate, and maintain networks that will support communities into the future.

In April 2021, the City of South San Francisco hired Magellan Advisors to develop a Broadband and Wireless Network Feasibility Study that explores the current state of broadband and assess the feasibility of South San Francisco developing and implementing a municipal broadband program. Over the course of approximately nine months, Magellan Advisors studied the current state of broadband, need for additional service offerings, policy and governance issues, and existing infrastructure to develop this Feasibility Study.

Figure 1-1. Broadband & Wireless Feasibility Study Process



Magellan's team interviewed the City's departments and other stakeholders to gain an understanding of the state of broadband within South San Francisco. These interviews provided an insight of the current broadband infrastructure that could be used, how broadband currently supports City operations, costs associated with leased services, and

the need for additional bandwidth in the future. The discussions also included any policies and practices that have been implemented to aid in the planning process.

Currently, the City of South San Francisco has approximately 9.22 miles of existing fiber, another 2.33 miles of planned fiber on Westborough Blvd. The City intends to leverage these assets to create a future proof network to meet the current needs and future demand of its residents and businesses. The network also needs to have the capacity to support Smart City applications such as intelligent traffic controls, a citywide Wi-Fi network, smart parking, 5G and 6G rollouts, Public Works functions, and many others.

Magellan also engaged with organizations outside of the City departments, including South San Francisco Library System, schools, not-for-profit organizations, healthcare institutions, chambers of commerce, and internet service providers (ISPs). These interviews provided additional understanding about current and future needs of businesses, community organizations, and residents within South San Francisco. In addition, an online broadband survey was conducted to collect sentiment about current service offerings, overall satisfaction, and future plans that will require robust high-speed internet connections. The survey collected real-time data about service levels and speeds on a per address basis.

This outreach, along with Magellan's market analysis, determined that South San Francisco's current broadband coverage and offerings are sufficient to support the needs of residents and businesses. Speeds that exceed those needed for remote learning, working from home, telehealth, and daily connectivity are currently available to 99% of all residents through a variety of service providers. However, in some areas, such as Westborough, choice of provider is limited, and throughout the City, affordability is an issue since higher bandwidth service offerings are cost-prohibitive for low-to-moderate income users.

There is also a prevalent digital literacy concern in South San Francisco. Community organizations noted a need for additional devices and training for the public about using the internet. Although the Library currently does a great deal of training and provides assistance for digital inclusion, their programs would benefit from additional resources to increase their impact and sustain the level of need. The City has already partnered with a number of organizations through various grant programs to develop digital inclusion programs; however, these programs should be evaluated and supplemented to ensure that they are sustainable for meeting the needs of all of South San Francisco's population into the future.

The needs and goals of the City itself, its residents, businesses, and community groups were assessed as inputs for developing a business model that will best serve the needs

of South San Francisco into the future. Financial requirements were also considered, since capital and operational costs are paramount for determining the feasibility of supplementing broadband and wireless with a municipal broadband program. We estimate that if the City of South San Francisco pursued a citywide fiber-to-the-home utility, costs for construction would be approximately $38 million. Additional operating expenses would also be applied to the program for additional staff and other resources needed to operate and market such a network. To address the issues in the Westborough neighborhood alone, the costs would be approximately $14 million.

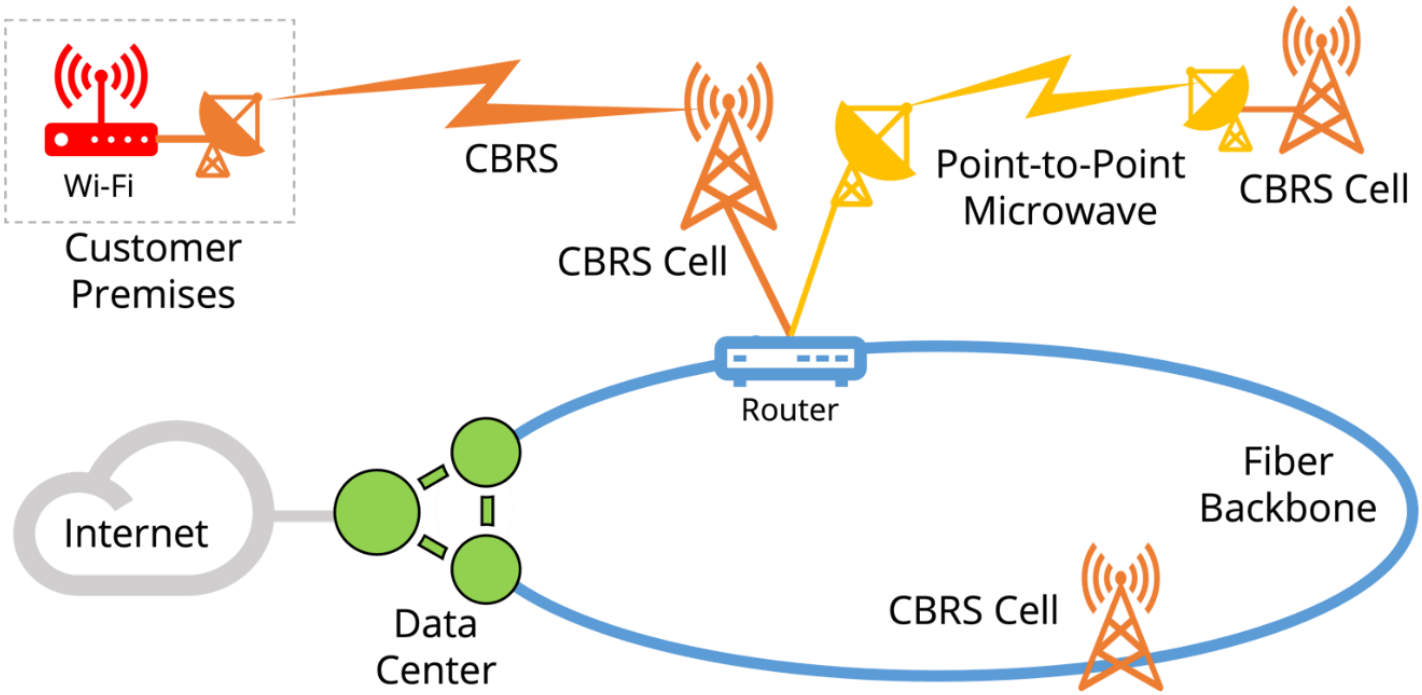
Based on the needs of the community and the costs to deploy a municipal fiber utility as well as the City's current broadband market, it is infeasible for the City to achieve an adequate return on investment for such a program. Rather, South San Francisco should use its existing and planned fiber assets to launch a program that will make fiber available for use to enhance service in the Westborough neighborhood, as well as deploy a wireless network to address the affordability barriers for low-to-moderate income areas of the City.

South San Francisco should continue constructing its planned fiber assets in the Westborough neighborhood and make them available for use by providers who want to serve the neighborhood to address the lack of choice there. The chief complaint of the Westborough neighborhood is a lack of cellular/mobile coverage and a lack of choice for broadband service. During talks with internet service providers, cost to build to Westborough, especially crossing Highway 280, is too expensive to make it worth expanding in the area. Therefore, City should use its fiber assets to alleviate this barrier and bring better coverage in Westborough by allowing the use of City-owned fiber through leases or other agreements.

Additionally, to address the digital equity and affordability issues in South San Francisco, we recommend pursuing deployment of a wireless utility available to residents citywide by leveraging the City's existing assets to create a flexible, low-cost utility. The City has already deployed 11 access points on Linden Avenue providing free outdoor Wi-Fi with great success. Additional areas need affordable broadband, and deploying free Wi-Fi in these zones will enhance the ability to access broadband and aid families. School-aged children, teenagers, working parents, and anyone will have the ability to access broadband without needing to go to community centers or libraries for internet access.

The City should leverage its existing and planned fiber to support new wireless options for service throughout the City, including in locations where residents struggle to get affordable broadband. This network, envisioned as a South San Francisco Broadband Utility (SSFBU) is diagrammed in Figure 1-2.

Figure 1-2. SSFBU Conceptual Network Design



This system is designed to flexibly extend basic broadband throughout South San Francisco, capitalizing on the City's current assets, providing near-universal availability of Wi-Fi-enabled devices, and on-radio spectrum that is available for use without a license. SSFBU users will connect via Wi-Fi through access points connected via router (and Ethernet cable) to a Citizens Broadband Radio Service (CBRS) distribution radio access network.

The network requires deployment of some new infrastructure including three new access points at Sign Hill, the intersection of Sharp Park Road and Skyline Boulevard, and City Hall. Two new fiber routes are also included in the design, including a connection to Sign Hill Tower and one crossing Skyline Boulevard. A map of the network design is shown in the figure below.

Figure 1-3. Network Map

At approximately $634,000, the cost to build the network is relatively low, as shown in the table below, and operating costs are about $3,000 per month. To avoid additional staffing needs, we recommend that South San Francisco select a partner such as Monkeybrains or a similar wireless operator to maintain the network wireless network via a contract managed by IT.

Table 1-1. Total Network Deployment Costs

Network Component	Cost
New Fiber-Optic Cable	$240,157
CBRS Deployment	$234,600
Wi-Fi Deployment	$159,476
Total	**$634,233**

The City should build the wireless network and partner with its chosen ISP to lease equipment, provide services and maintain the network. This would keep the City from becoming an ISP, obtaining CPUC registration and licensing, establishing service level agreements (SLAs) and meeting other requirements to provide reliable connectivity and services to customers. The City may also be able to negotiate a share of the revenue from these services. There are three relatively small revenue opportunities for SSFBU, described below. All of these opportunities are optional.

The first opportunity is for the City to lease network infrastructure to private entities. Under this model, businesses and households could lease equipment that SSFBU's partner would install and maintain. Baseline internet access via Wi-Fi would be included.

A second opportunity is to charge for "enhanced access" via the captive portal. Exactly what "enhanced access" means is to be determined, depending on policies for baseline access. There could be caps on bandwidth, data quantity per month, or types of services (e.g., no streaming video or gaming). Users may pay a monthly fee to eliminate these restrictions. We do not recommend establishing a full broadband operating system with means to provision services and manage subscribers due to the substantial costs and staffing requirements.

The third revenue opportunity is to provide value-adding content, including advertisements, via the captive portal.

Reasonable estimates for revenue from these opportunities, as shown in Table 1-2, are less than $500k per year, and the revenue sharing details should be negotiated with the City's selected partner to determine how much will go to the City. Based on these estimates, it would likely take a few years for the City to see a return on investment from the capital costs to deploy the network.

Table 1-2. SSFBU Estimated Revenue Opportunities

Item	Monthly Cost	Quantity	Amount
CPE lease	$100	200	$20,000
Enhanced access	$15	1000	$15,000
Portal content	$100	10	$1,000
		Monthly total	$36,000
		Annual Revenue Estimate	**$432,000**

Our cost and revenue estimates are conservative so we believe SSFBU could generate excess revenue if effectively governed. In that case, we recommend including digital

inclusion programs and services in the SSFBU enterprise fund to maximize its economic and social benefits to the community. The programming and governance considerations should be overseen by either the Library's Community Learning Center or the Community Development in order to maximize impact on digital equity programs. SSFBU should build upon existing digital inclusion efforts that are ongoing in South San Francisco. The City could also pursue additional digital inclusion efforts by getting involved with groups with a track record of tackling this task[1].

The City should establish an enterprise fund for SSFBU. It should be governed by a board of departmental representatives supplemented by a community advisory committee. We recommend the advisory committee be comprised of equal numbers of residential, small business, non-profit, and major industry representatives, selected by City Council members. The General Manager should be responsible for proposing an annual plan, including budget, to the advisory committee and board.

1.2 RECOMMENDATIONS

1. While we do not recommend that the City of South San Francisco build a Citywide fiber-to-the-home network or become an internet service provider due to the saturation of the broadband market, the City should leverage its existing assets to create a South San Francisco Broadband Utility that provides wireless connectivity throughout the City. South San Francisco should partner with a qualified wireless network operator to oversee the maintenance of the network and digital inclusion programs should be integrated into the program's governance structure.
2. Use existing City-owned fiber-optic cable, including the new fiber being placed from the downtown area to Highway 35, Skyline Boulevard, to support better broadband and cellular coverage in the Westborough neighborhood. Encourage and partner with the cellular providers to increase the coverage in the Westborough neighborhood, leveraging the City-owned fiber cable on Westborough Boulevard.
3. Deploy two new underground fiber routes at Sign Hill tower and crossing Skyline Boulevard to support a CBRS system. These routes will cost approximately

[1] Digital inclusion resources include the International Telecommunications Union (https://www.itu.int/en/mediacentre/backgrounders/Pages/digital-inclusion-of-youth.aspx) and the Nation Digital Inclusion Alliance (https://www.digitalinclusion.org/).

$240,000 and should be constructed as soon as possible to support the citywide CBRS and Wi-Fi that will allow the City to offer services to the community.

4. Deploy three new CBRS access points, one in the Westborough area, one on Sign Hill, and one at City Hall. These towers will be used for deploying high-speed broadband to wireless devices including Wi-Fi antenna, fixed wireless, and mesh networks requiring gigabit data transfer.
5. Provide for the expansion and deployment of wireless antennas in the low-to-moderate income areas of the City to create a South San Francisco Broadband Utility. The network as designed in this Study serves two zones, shown in Figure 7-1, which were identified as locations where residents struggle with affordability. Deploying free Wi-Fi in these zones will enhance the ability to access broadband and aid families.
6. Establish an enterprise fund for operating the network and enter agreements with qualified internet service providers for revenue sharing. Sharing revenue through a third party partner will not require the City to become an ISP, establish service level agreements, or provide staffing. Conversely, providing services directly to customers in exchange for revenue without a third party would require the City to become an ISP, requiring additional staffing and operational requirements to obtain certifications and meet ensure service is provided as promised.
7. Support digital inclusion programs. The City should support ongoing digital inclusion efforts by the Library's Community Learning Center, as well as exploring other digital literacy programs and groups such as National Digital Inclusion Alliance, the International Telecommunications Union, makers spaces, and other successful programs. These programs should be integrated into the governance of the Citywide Wi-Fi network, overseen by an advisory group, to ensure the most community impact.
8. Continue existing Dig Once policies and practices and consider adding a separate fund for maintaining and expanding the City's conduit and fiber systems as opportunities arise. A good starting point for this fund is approximately $250,000, to be replenished annually as needed. Should there be an increase in spending needed in any one year, we recommend using unspent capital improvement funds for street maintenance temporarily with repayment during mid-year or year-end budget processes.

2. Technology & Trends Review

2.1 OVERVIEW OF BROADBAND TECHNOLOGIES

"Broadband" is a high-capacity transmission technique using a wide range of frequencies, which enables many messages to be communicated simultaneously. There is no one technology that can accomplish this task in a complete, affordable way. It is accomplished by combinations of technologies working together, including copper, fiber optics, wireless, and satellite.

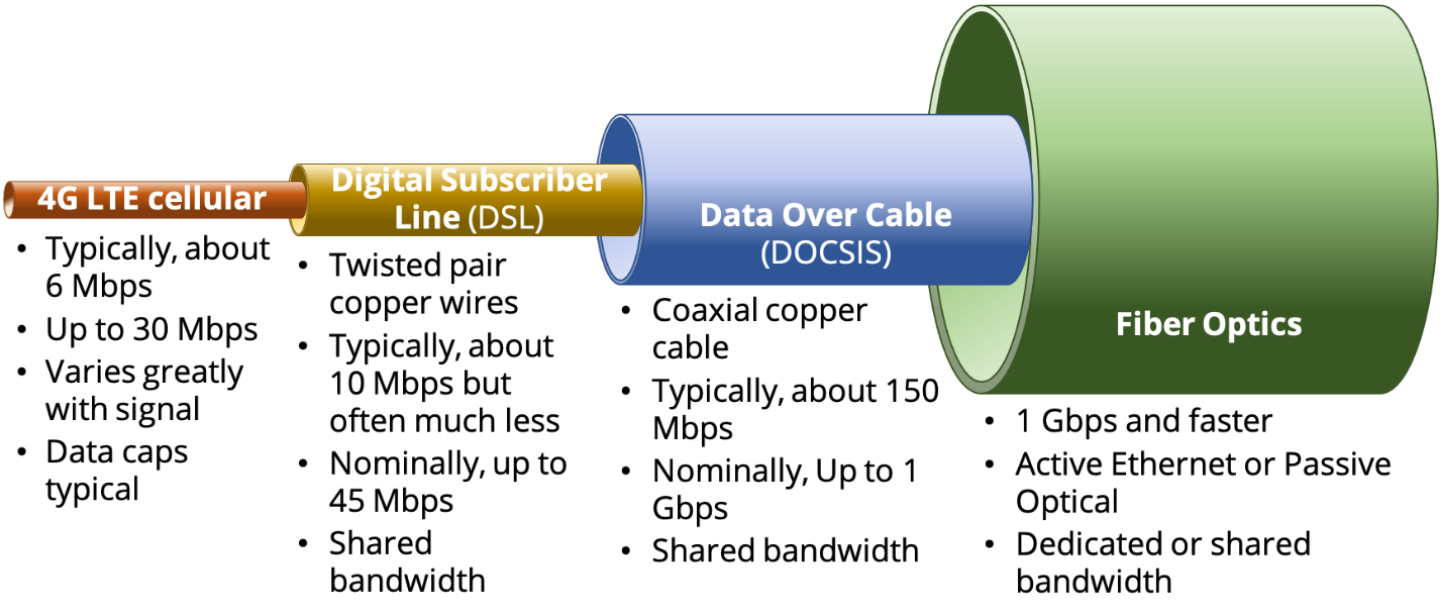
The Federal Communications Commission (FCC) defines broadband as high-speed internet that reliably delivers speeds of at 25 mbps download and 3 mbps upload. However, as the shift to virtual work, online learning, and telehealth during the COVID-19 pandemic demonstrated, the number of users, devices, and type of internet usage will ultimately define the broadband needs of the household. The more users and the types of activities the internet is used for will increase the demand for higher bandwidth. For example, if two people are working from home and need to connect to online conference calls in combination with children doing distance learning and streaming videos for classes, the bandwidth needs would greatly surpass the 25/3 Mbps definition and could easily require at least 100-200 Mbps. The table below displays average data usage for common activities.

Table 2-1. Average Data Usage by Application

Average Data Usage	
Internet activity	**Average Streaming Data Usage**
Email	20KB
Email (with attachment)	300KB
Downloading a song	4MB
Browsing the web	15MB per hour
Instagram	100MB per hour
Facebook	156MB per hour
Twitter	360MB per hour
Streaming standard-definition (SD) video	700MB per hour
Streaming high-definition (HD) video	2.5GB per hour
Streaming ultra-HD (4K) video	5.8GB per hour
Streaming music	72MB per hour
Online gaming	80MB per hour

There are only a few ways to build networks capable of supporting these speeds. As shown in the figure below, fiber optics is the only network technology that can support the ultra-high broadband demands being placed on networks in the digital age. Fiber optics uses pulsating light to transmit data through flexible glass "tubes." This enables the transmission of massive amounts of data moving at the speed of light. Fiber uses technology that allows for symmetrical speeds, equal upload and download, allowing for sufficient bandwidth to support users to both send and receive large amounts of data needed for applications such as video conferencing.

Figure 2-1. Speeds Associated with Internet Technologies



Other options available, such as wireless broadband, are subject to outside interferences and sacrifice download for upload speed and vice versa. Wireless technologies have limitations that preclude it from being used as an effective backhaul solution. Backhaul is the connection between the internet and the distribution points in a network. For this reason, fiber must be used for nearly all wireless, mobile, and cellular networks. All wireless networks, therefore, require a fiber back bone.

Wireless technology uses radio waves to transmit data and connects computers, devices, smart phones, etc. to the internet. The terms wireless and Wi-Fi are often used synonymously but shouldn't be. Wi-Fi refers to a wireless LAN (Local Area Network) connecting to a router or gateway which has internet connectivity. Wi-Fi typically uses a service set identifier (SSID) and a password to connect to the network. The term *wireless* refers to connecting to the internet through cell towers and the use of antennas. The

antennas have internet connection supplied by an internet service provider (ISP). Wireless technology typically uses subscriber identification module (SIM) cards for authenticating and securing a connection. As antennas and technology progresses, the range for Wi-Fi is getting larger and larger. Wi-fi is an emerging technology and is becoming an option for deploying outside the residence on a neighborhood and even city-wide basis.

Wireless technology has come a long way in the past few years including the FCC releasing more frequencies. Some of that frequency, such as Citizens Band Radio Service (CBRS), is open for use by cities and counties with low-cost registration. Wireless is limited to 1Gbps symmetrical which is plenty of bandwidth for residential and small businesses use.

Citizens Band Radio Service (CBRS)

Originally designated for the US Navy, regulating bodies around the world saw the potential of releasing this band for use by all. To advance 5G, the FCC has been auctioning off CBRS Spectrum. This spectrum is in the 3.5 GHz range, a band in the 5G arena which has all the benefits of 5G. A portion of the spectrum has been designated as lightly licensed and not being sold to private incumbents; rather it is open for use by municipal, private, and other uses.

CBRS is also available for use on a small geographical basis. It is also known as a private LTE 5G CBRS network. Anyone can use the lightly licensed portions of CBRS spectrum without incurring the capital and operation expenditures while being able to quickly deploy this type of network. CBRS is intended to support fixed wireless options as well as mobile devices. Using a SIM card (as opposed to Wi-Fi, which requires SSID and password) makes CBRS far more secure and safe to use for sensitive data transfers.

The high data capability coupled with the high-security features makes CBRS a front runner in cost-effective quick deployment. The low maintenance and ease of monitoring also make it a long-term cost-effective deployment method with a lower operating expense. For these reasons, CBRS has become a popular option for local governments looking to provide wireless service options to their communities, especially when they can capitalize on existing fiber assets to backhaul the connections. To use CBRS with high user counts and high data transfer rates, the antennas must use fiber as the backhaul method. The biggest drawback CBRS is that the equipment used requires unique configurations that are not available on the current off-the-shelf models like cameras and routers.

2.2 MUNICIPAL BROADBAND TRENDS

Ensuring broadband connectivity to residents, businesses, government agencies, and community anchor institutions has become a top priority for many municipalities. Ideally the private sector would have a higher interest in providing broadband to everyone but

because internet service providers require a high return on investments, many neighborhoods are not well equipped with broadband. As many activities have moved to online platforms due to the pandemic and the global digital economy, municipalities have received an increasing amount of feedback about broadband from their constituents. At the same time, governments themselves are becoming more and more reliant upon broadband-enabled devices that allow for more efficient delivery of services to their communities. As a result, many local governments have implemented municipal broadband programs to support a variety of needs.

Smart Cities

There is no one definition of what makes a Smart City. Commonly, to be a Smart City is to use technology to improve services, reduce costs, be more efficient, and save resources. Some Smart City technologies include smart traffic controls, traffic systems, public safety, cameras, utility monitoring, and smart building monitoring. A comprehensive way for communities to accomplish this is to include broadband plans that facilitate fiber networks throughout the area to support The Internet of Things.

The Internet of Things (IoT)

The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people that are provided with unique identifiers (UIDs) and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. The network most commonly used to support IoT is the internet, although it could also be supported by local networks where the devices are connected. IoT is quickly becoming such an integral part of communities, bringing together various smart systems, frameworks, intelligent devices, and sensors meant to make our lives better, more efficient, safer, longer, and easier. There are many areas of development within IoT that pertain directly to communities such as:

- Smart Home Systems is the area of IoT that focuses on homes and building monitoring. The use of sensors, appliances, and other measuring devices make it so a building can monitor heat, AC, water usage, access, security, and even energy and power consumption. This monitoring takes place automatically without human input and helps to streamline resources and costs. Some private companies update and add monitoring systems that they claim will pay for themselves in the savings of energy costs and personnel.
- Public Safety: There are many advancements in the public safety arena such as cameras, streaming body cams, contact tracing, video data, and crime prevention devices. Many local law enforcement agencies have implemented

these digital technologies to solve and prevent crime, making communities safer.

- Communication Infrastructure: Digital billboards, kiosks, splash pages, and billboards all add to the ease of sharing information with constituents with greater access and propagation. Cities are using these devices to enhance community engagement, tourism, and economic development.
- Transportation and Parking: Intelligent transportation systems, connected traffic signals, wayfinding, and digitized parking applications allow for better management of traffic flow. Increasing traffic efficiency cuts down on greenhouse gases and commuter times, and providers autonomous vehicle support.
- Smart Health Sensing Systems (SHSS): Intelligent equipment and devices are increasingly used to support the health of human beings. Devices can be used to monitor many aspects of human health such as heart activity, blood pressure, blood sugar, fitness levels, and many other aspects of health. SHSS is transforming the health care system in every area by facilitating automatic, independent, and constant monitoring with no human interaction outside of placing the device. These systems are being developed to aid the disabled, elderly, critically injured, and those in need of monitoring by allowing those individuals to live better longer lives.

Municipal Broadband Business Model Options

Selecting the right broadband business model for local government is highly dependent on several factors that will suggest the most appropriate option for the organization. For example, understanding the community needs, knowing the competitive market factors that define what infrastructure options fit well within the community, and determining organizational and operational capabilities of the local government all play into the selection process. Equally important is an understanding of the financial commitments and risk and reward that participating organizations are willing to support to fund and sustain a successful broadband initiative.

The commonly implemented business models fall on a continuum that ranges from low risk, low investment options to higher risk, high investment options. The figure below illustrates this continuum. Moving along the continuum of business model options involves increasing degrees of risk and reward: risks in terms of financial, operational,

and regulatory risk; rewards in terms of community benefits, revenue generation, and over potential for profit. Moving "up" the continuum generally requires increasing levels of investment and implies greater local government participation in the delivery of broadband services. Public policy and infrastructure only options are considered "passive" business models, where the government does not operate a broadband network as compared to "active" models such as Government Services Providers, Open Access Providers, and Retail Provider Options, where the government operates a broadband network. Public-private partnerships are not classified as a specific business model but instead fall along the continuum because these partnerships take many forms. Local governments must determine which business models meet their organization's risk/reward tolerance to achieve the community's broadband goals.

Figure 2-2. Continuum of Municipal Broadband Business Models

In many cases, multiple options may be selected by an organization; however, in some cases, a local government will not utilize multiple models, as they may conflict with one another. For example, local governments generally implement broadband-friendly public policy with any of the business models, as these policies will complement all other business model options. Conversely, a local government would not likely implement a retail model and public-private partnerships together, as these would lead to competition between the local government and one or more private partners. The table below illustrates the differences among the business models that can be utilized to achieve municipal broadband goals.

Table 2-2. Comparison of Municipal Broadband Business Models

COMPARISON OF BROADBAND BUSINESS MODELS							
	Government Passive Models			Government Active Models			
	Public Policy Only	Infrastructure Only	Public-Private Partnerships (P3)	Public Services Provider	Open Access Wholesale	Retail Provider Business-Only	Retail Provider Residential & Business
Services Provided	None	Dark Fiber Only	None	Dark Fiber, Transport, Internet, Phone	Transport	Internet & Phone	Internet, TV, Phone & Value-Added Services
Customers	None	Broadband Providers	None	Public Organizations Only	Broadband Providers	Businesses	Businesses & Residents
Funding Required	Low	Moderate	Low to High	Moderate	Moderate	High	High
Competing with Broadband Providers	No	No	No	No	No	Yes	Yes
Operational Requirements	Low	Low	Low	Low	Moderate	High	Very High
Regulatory Requirements	Low	Low	Low	Low	Moderate	High	Very High
Revenue Generation	Low	Low	Low to High	Low	Moderate	High	Very High
Operational Costs	Low	Low	Low	Low	Moderate	High	Very High
Financial Risk	Low	Low	Low	Low	Moderate	High	Very High
Execution Risk	Low	Low	Moderate	Low	Moderate	High	Very High

3. Policy Analysis

Magellan Advisors has reviewed state and federal policies and statutes to help the City ensure that any broadband and wireless services it might provide are compliant with regulations and take advantage of favorable policies pertaining to broadband services in California.[2]

3.1 CALIFORNIA BROADBAND POLICY

State of California broadband policy is very supportive of the City's potential provision of broadband services. There are no significant policy barriers to municipal provision of broadband services – wired or wireless. Governor Newsom's Executive Order on broadband policy explicitly directs state agencies to seek to bridge the "Digital Divide", which includes direction to support local government broadband deployments[3].

California broadband policy recently took a further step to eliminate the digital divide by promoting the construction of middle-mile networking. Just recently signed into law, Senate Bill 156 contains provisions which support broadband infrastructure to be provided by municipal authorities. National policy is in harmony with this direction as evidenced by provision of funding through the American Recovery Plan Act (ARPA) for broadband infrastructure.

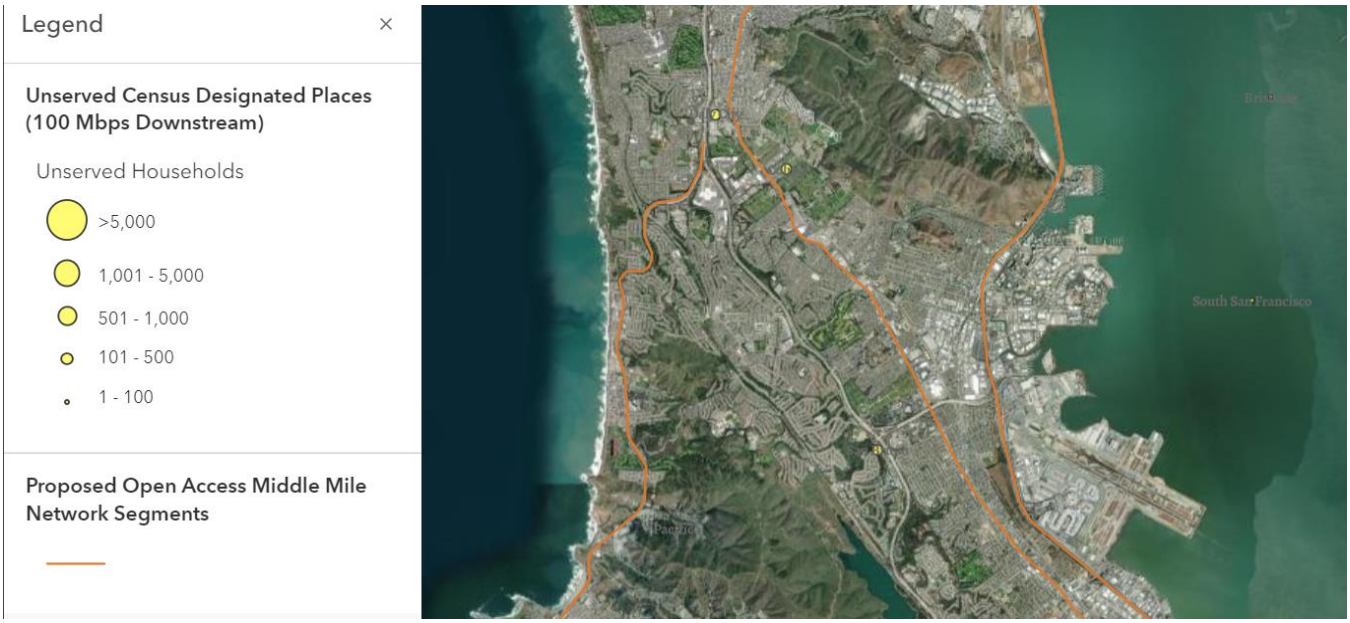
As directed by SB 156, state agencies including the California Public Utility Commission and California Department of Technology are taking necessary steps to plan and construct the statewide middle-mile network including routes through and adjacent to South San Francisco. The City could consider the state's developing middle-mile network in its planning for any cost efficiencies and opportunities it might offer. Figure 3-1, below, displays the portions of the network that are relevant to South San Francisco, as shown on the California Public Utilities Commission (CPUC) staff-proposed middle-mile network map[4]:

[2] The following discussion does not constitute a legal opinion and should not be construed as such. Questions about interpretation or applicability of these or other provisions of federal or California law should be referred to legal counsel.

[3] The Executive Order directed the California Broadband Council to create a new State Broadband Action Plan, which contains numerous provisions supporting local governments in their efforts to bring faster, cheaper, better broadband service to their residents. See, Broadband Action Plan 2020: California Broadband for All, at https://www.gov.ca.gov/2020/08/14/38666/

[4] https://www.arcgis.com/home/webmap/viewer.html?webmap=e17e4e1c88b04792ab0a2c50aa1a19a3&extent=-126.1445,34.5234,-113.5981,41.1113

Figure 3-1. State of California Proposed Middle Mile Open Network Segments



Furthermore, the Broadband Loan Loss Reserve Fund authorized by SB 156 could support necessary borrowing by the City to construct broadband infrastructure, although the fund is not yet operational (SB 156 was just recently signed into law and the CPUC has not yet developed the required rules and regulations).

Additional legislation relevant to broadband was enacted into law in October 2021:

- Senate Bill 378 (the "Broadband Deployment Acceleration Best Practices Act") requires local agencies to allow, except as provided, micro-trenching for the installation of underground fiber if the installation in the micro-trench is limited to fiber. It also requires, to the extent necessary, a local agency with jurisdiction to approve excavations to adopt or amend existing policies, ordinances, codes, or construction rules to allow for micro-trenching. SB 378 defines "Micro-trench" as a narrow open excavation trench that is less than or equal to 4 inches in width and not less than 12 inches in depth and not more than 26 inches in depth and that is created for the purpose of installing a subsurface pipe or conduit.
- Assembly Bill 41 requires the Department of Transportation, as part of those projects that are funded by a specified item of the Budget Act of 2021 and that are located in priority areas, to use the project planning phase to ensure that construction projects include the installation of conduits capable of supporting fiber optic communication cables. It also requires the CPUC, in collaboration with other relevant state agencies and stakeholders, to maintain and update a statewide,

publicly accessible, and interactive map showing the accessibility of broadband service in the state.

- Senate Bill 28 repeals certain annual reporting requirements pertaining to broadband and video franchise holders and instead requires the CPUC to collect granular data on the actual locations served by franchise holders (but without disclosure of personally identifying information), adopt customer service requirements for franchise holders, and adjudicate any customer complaints.
- Senate Bill 4 and Assembly Bill 14 pertain to the CASF authorizing an increased surcharge and requiring reporting on remaining unserved areas in the state among several items.

3.2 STATE AND FEDERAL REGULATORY POLICY

Regulatory jurisdiction over telecommunications services traditionally has been divided between the federal and state authorities – primarily the FCC and (in this case) the CPUC.[5] The FCC has from time to time preempted or attempted to preempt state and local regulatory jurisdiction over wireline and wireless telecommunications. At present there is some agreement on regulation of broadband services; wireless or wireline services are not price or entry-regulated by the CPUC or the Federal Communications Commission. The FCC's brief period of classifying broadband internet services as a telecommunications service regulated under Title II of the Communications Act – "Net Neutrality" regulations – was reversed by the FCC in early 2018.[6]

FCC preemption of state and local regulation has been more prevalent in the wireless sector (especially in recent years). Under federal law, local authorities are allowed to regulate the "placement, construction, and modification" of wireless communications facilities but subject to certain limitations.[7] These limitations and requirements on local regulatory authority include:

- Local regulations may not "prohibit or have the effect of prohibiting the provision of personal wireless services"[8];

[5] In one specific area – radio frequency (RF) emissions – the Federal Communications Commission (FCC) has been assigned complete regulatory jurisdiction, under the 1996 Telecommunications Act which preempted local regulation of RF safety standards in favor of a uniform national RF safety standard under FCC jurisdiction. *See*, 47 U.S.C. § 332(c)(7).
[6] In the Matter of Restoring Internet Freedom, WC Docket No. 17-108, FCC 17-166, Declaratory Ruling, Report and Order, and Order; Released January 4, 2018.
[7] 47 U.S.C. § 332(c)(7)(A).
[8] 47 U.S.C. § 332(c)(7)(B)(i)(I).

- Local regulations may not "unreasonably discriminate among providers of functionally equivalent services"[9];
- A local authority's denial of an application to place, construct, or modify a personal wireless facility must be based on "substantial evidence contained in a written record"[10]; and,
- Local regulations may not "regulate the placement, construction, and modification of personal wireless service facilities on the basis of the environmental effects of radio frequency emissions to the extent that such facilities comply with the Commission's regulations concerning such emissions."[11]

In 2014 the FCC adopted rules to implement the "Spectrum Act"[12] which preempted state and local authority over certain aspects of processing and approving modifications to existing towers and base stations used for 3G and 4G wireless service, including application of 60-day "shot clocks" for review and approval of modification applications.

More recently, the FCC adopted its "Small Cell Order" in September 2018[13] which sought to limit and preempt local authority over placement of 5G "small cell" facilities. The Small Cell Order broadly interpreted the "effective prohibition" provisions of the Telecommunications Act Sections 253(a) and 332(c)(7) to find that a state or local government need only "materially inhibit" placement of "small wireless facilities" to have an effect of prohibiting the provision of wireless service. The Small Cell Order has many provisions – the most discussed of which are limitations on fees and rates a local jurisdiction may charge for small cell placements (e.g., $270 per year cap on attachment fees) and preemption of local authority over aesthetic requirements for small cell installations. Numerous parties appealed the Small Cell Order and the Ninth Circuit Court of Appeals opinion[14] largely upheld the FCC's decision on issues including limitations on fees and rates but reversed the FCC's attempted preemption of local authority over aesthetics.

[9] 47 U.S.C. § 332(c)(7)(B)(i)(II).
[10] 47 U.S.C. § 332(c)(7)(B)(iii).
[11] 47 U.S.C. § 332(c)(7)(B)(iv).
[12] *See* Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, § 6409(a) (2012) (Spectrum Act), *codified at* 47 U.S.C. § 1455(a).
[13] Declaratory Ruling and Third Report and Order; In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment; WT Docket No. 17-79; In the Matter of Accelerating Wireline Broadband Deployment by Removing Barriers to infrastructure Investment; WC Docket No. 17-84; Released by the Federal Communications Commission, September 27, 2018. ("Small Cell Order" or "Order".) See Appendix C for further discussion.
[14] City of Portland v. United States, 969 F.3d 1020, 1049-1053 (9th Cir., 2020).

3.3 REVIEW OF CITY WIRELESS POLICIES

Magellan Advisors also reviewed the City's policies and practices on "small cell" wireless facilities placement and found them to be aligned with good practices. The City was an early adopter of small cell regulation (the City's Small Cell Ordinance was adopted in October 2017 which was nearly a year before the FCC's "Small Cell Order") and the City's policies and practices are in line with the Ninth Circuit Court of Appeals decision allowing local authorities to maintain local control over aesthetic requirements for small cell antenna siting and placement. The Small Cell Wireless Telecommunications Facilities Ordinance (SCWF):

- provides for the use of Master License Agreements for small cell attachments to City-owned infrastructure which is an approach now commonly used by cities for managing small cell attachments.
- contains a robust set of regulations on where small cell facilities can be placed and on what types of structures, including design and location preferences for any placements outside the public right-of-way – e.g., non-residential districts.
- contains a series of standard requirements which address the interplay of state and federal rules, RF emissions standards, operations and maintenance standards, and electrical metering and structural standards.
- lays out key design requirements to obtain a permit including general aesthetic requirements for equipment to be screened to blend in with the natural or built surroundings, concealed, "stealthed" or otherwise incorporated into the design of the pole, utilize poles engineered so that no additional supporting hardware is required beyond the pole itself, use non-reflective materials, and preserve design and aesthetic features.

The Planning Department has developed a "requirements checklist" for use by applicants for placement of small cell facilities to implement the Small Cell Wireless Facilities ordinance. Among other things, the checklist makes clear the location and design preferences for the City of South San Francisco and lays out the specific requirements for SCWF applications and facilities placement.

The City also has implemented a "Dig Once" policy designed to coordinate the installation of telecommunications facilities for certain projects meeting specified conditions in the "Open Trench Notification and Telecommunications Infrastructure Improvements" ordinance. The open trench notification process is triggered by:

- either an encroachment permit application for work in the public right-of-way or approval of specifications for a public works project which will result in an excavation that could reasonably include installation of broadband conduit, and,

- spans 900 feet/three city blocks or more, or involves terrain that is difficult/expensive to traverse or is an element of a larger project for utility infrastructure.

Notifications are sent to telecommunications service providers and the City's IT Department, each of whom has the opportunity to indicate interest in collocating facilities.

The "Dig Once" policy is good practice and serves to achieve many goals including cost effective expansion of broadband services in the City, preservation of the public investment in streets, sidewalks, and other infrastructure in the public right-of-way, minimizing traffic congestion and safety issues from repeated excavations, providing infrastructure for City operations, and other goals. In addition to practicing Dig Once coordination, we recommend that the City create a separate fund for maintaining any placed conduit and fiber as well as to fund future conduit and fiber deployment. A good starting point for this fund is approximately $250,000, to be replenished annually as needed. Should there be an increase in spending needed in any one year, we recommend using unspent capital improvement funds for street maintenance temporarily with repayment during mid-year or year-end budget processes.

4. Service, Infrastructure, and Market Analysis

4.1 BROADBAND AVAILABILITY

The major internet service providers in South San Francisco are AT&T and Comcast Xfinity. There are also a handful of smaller wireline providers offering service including Earthlink, Sonic, and Wave, as well as fixed wireless service offerings from Etheric.

Wireline Providers

AT&T is the incumbent local exchange carrier (ILEC) serving South San Francisco. AT&T is one of the world's largest providers of IP-based communications services for businesses, including Virtual Private Network (VPN) and Voice over IP (VoIP), and is very well known for its wireless network.[15] AT&T has recently acquired DirecTV, and the FCC conditioned its approval of the transaction on AT&T extending fiber connections to additional locations as well as offering gigabit connections to E-rate eligible schools and libraries.[16] BroadbandNow.com states that AT&T provides services to 98% of South San Francisco with speeds up to 940/1000 bps.

Xfinity is the broadband brand for Comcast. Comcast is the largest cable internet provider in the US with and the incumbent cable provider in the City of Fremont. BroadbandNow.com states that Xfinity provides services to 99% of South San Francisco with speeds up to 1200/35 Mbps. Comcast has plans for overbuilding the Oyster Point Area with a new fiber network to support the high-tech, biotech, and other high data usage businesses.[17]

Earthlink is a nationwide internet service provider headquartered in Atlanta, Georgia and offering service in 36 states. Earthlink's infrastructure is primarily DSL, although the company also offers fiber services through Hyperlink in some markets. In South San Francisco, Earthlink offers speeds up to 1gb symmetrical and reports service availability in 99% of the City.

[15] http://www.att.com/gen/investor-relations?pid=5711

[16] In the Matter of Applications of AT&T Inc. and DIRECTV For Consent to Assign or Transfer Control of Licenses and Authorizations; MB Docket No. 14-90; Memorandum Opinion and Order; FCC 15-94, Released July 28, 2015, at page 148.

[17] Comcast interview with Magellan Advisors- December 14th 2021: Dillon Auyoung

Raw Bandwidth Communications is a California-based CLEC serving communities in the Bay Area. Raw Bandwidth uses DSL and copper infrastructure to deliver services and offers speeds up to 100/10 mbps in about 56% of South San Francisco.

Sonic is a California based fiber and DSL internet service provider available to customers in many markets within the state. In South San Francisco, Sonic provides DSL or fiber connectivity with speeds up to 1gb. BroadbandNow reports service availability in about 40% of the City.

Wave Broadband is based in Washington State and provides service across areas of Washington, Oregon, and California. Currently Wave only provides fiber to businesses in South San Francisco. Residential services are provided via hybrid fiber/coax.

Service Provider Offerings for Residents

To gain an understanding of service offerings from the incumbents, six address locations across various residential locations in South San Francisco were selected to investigate coverage options. Each location was researched for availability and service options at that location. Below are a map of the locations and a summary of the service offerings from each provider.

Figure 4-1. Map of Locations Analyzed for Market Assessment

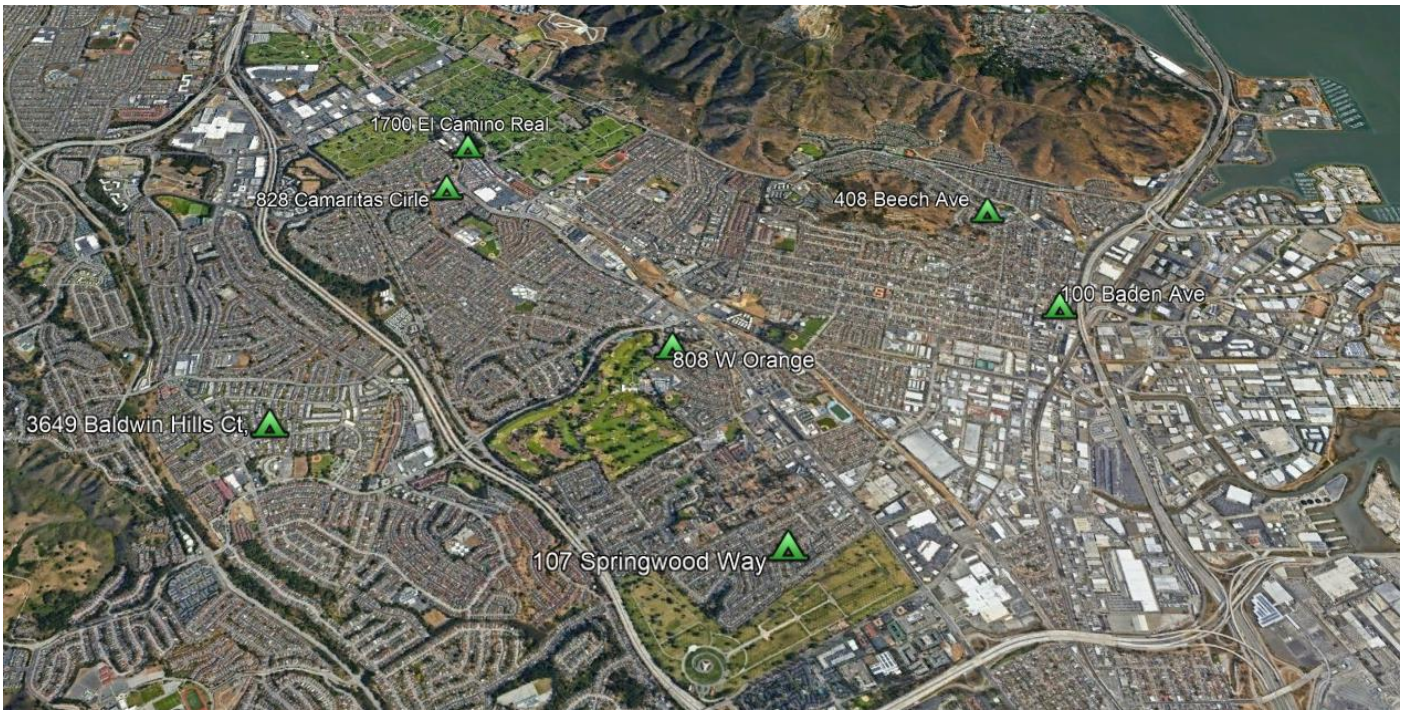


Table 4-1. Summary of Service Offering Analysis

Address	Type	Service Tiers and MRC						
408 Beech Ave								
Wave	Coax	50 Mbps $49.95	100 Mbps $69.95	250 Mbps $79.95	500 Mbps $89.95		1 GB $99.95	
AT&T	Fiber			300 Mbps $35.00	500 Mbps $45.00		1 GB $60.00	
Sonic	Fiber						1GB $39.99	
Earthlink	Fiber	50 Mbps $49.95	100 Mbps $79.95				1GB $99.95	
Xfinity	Fiber	50 Mbps $19.95	100 Mbps $34.99	200 Mbps $49.99	400 Mbps $64.99	600 Mbps $60.00	1 GB $70.00	2 GB $299.95
828 Camaritas Cir								
Wave	Coax	50 Mbps $49.95	100 Mbps $69.95	250 Mbps $79.95	500 Mbps $89.95		1 GB $99.95	
AT&T	Fiber			300 Mbps $35.00	500 Mbps $45.00		1GB $60.00	
Sonic	Fiber						1 GB $49.99	
Earthlink	Fiber	50 Mbps $49.95	100 mbps $79.95				1 GB $99.95	
Xfinity	Fiber	50 Mbps $19.99				800 Mbps $60.00	1200 Mbps $70.00	
3649 Baldwin Hills Ct								
Wave	Not Available							

AT&T	DSL			300 Mbps $35.00	500 Mbps $45.00		1 GB $60.00	
Sonic	DSL	50 mbps $49.99						
Earthlink	DSL	12 Mbps $49.95	24 Mbps $59.95	50 Mbps $69.95				
Xfinity	Coax	50 Mbps $19.95	100 Mbps $34.99	200 Mbps $49.99	400 Mbps $64.99	600 Mbps $60.00	1200 Mbps $70.00	2GB $299.95
808 W Orange								
Wave	Coax	50 mbps $49.95	100 mbps $69.95	250 Mbps $79.95	500 Mbps $89.95		1 GB $99.95	
AT&T	Fiber	300 Mbps $35.00			500 Mbps $45.00		1 GB $60.00	
Sonic	Fiber						1 GB $49.95	
Earthlink	Fiber	50 Mbps $49.95	100 Mbps $79.95				1 GB $99.95	
Xfinity	Fiber	50 Mbps $19.95	100 Mbps $34.99	200 Mbps $49.99	400 Mbps $64.99	600 Mbps $60.00	1200 Mbps $70.00	2GB $299.95
107 Springwood Way								
Wave	Coax	50 mbps $49.95	100 mbps $69.95	250 Mbps $79.95	500 Mbps $89.95		1 GB $99.95	
AT&T	Fiber	300 Mbps $35.00			500 Mbps $45.00		1 GB $60.00	
Sonic	Fiber						1 GB $49.95	

Earthlink	Fiber	50 Mbps $49.95	100 Mbps $79.95				1 GB $99.95	
Xfinity	Fiber	50 Mbps $19.95	100 Mbps $34.99	200 Mbps $49.99	400 Mbps $64.99	600 Mbps $60.00	1200 Mbps $70.00	2GB $299.95
100 Baden Ave								
Wave	Coax	50 mbps $49.95	100 mbps $69.95	250 Mbps $79.95	500 Mbps $89.95		1 GB $99.95	
AT&T	Not Available							
Sonic	DSL	10 Mbps $39.99	20 Mbps $59.99					
Earthlink	DSL	3 Mbps $49.95						
Xfinity	Fiber	50 Mbps $19.95	100 Mbps $34.99	200 Mbps $49.99	400 Mbps $64.99	600 Mbps $60.00	1200 Mbps $70.00	2GB $299.95

Most of the addresses analyzed had an array of affordable service offerings from many competing ISPs. There were two notable exceptions: 3649 Baldwin Hills Court and 100 Baden Avenue both show many fewer options for higher service tiers, although both locations do have at least two high speed offerings from either Wave or AT&T and Xfinity. The Baldwin Hills address is in the Westborough neighborhood of the City, while Baden Avenue is on the eastern side of the City near downtown. Both of these locations represent areas where additional investment in broadband infrastructure may be needed in order to increase service offerings.

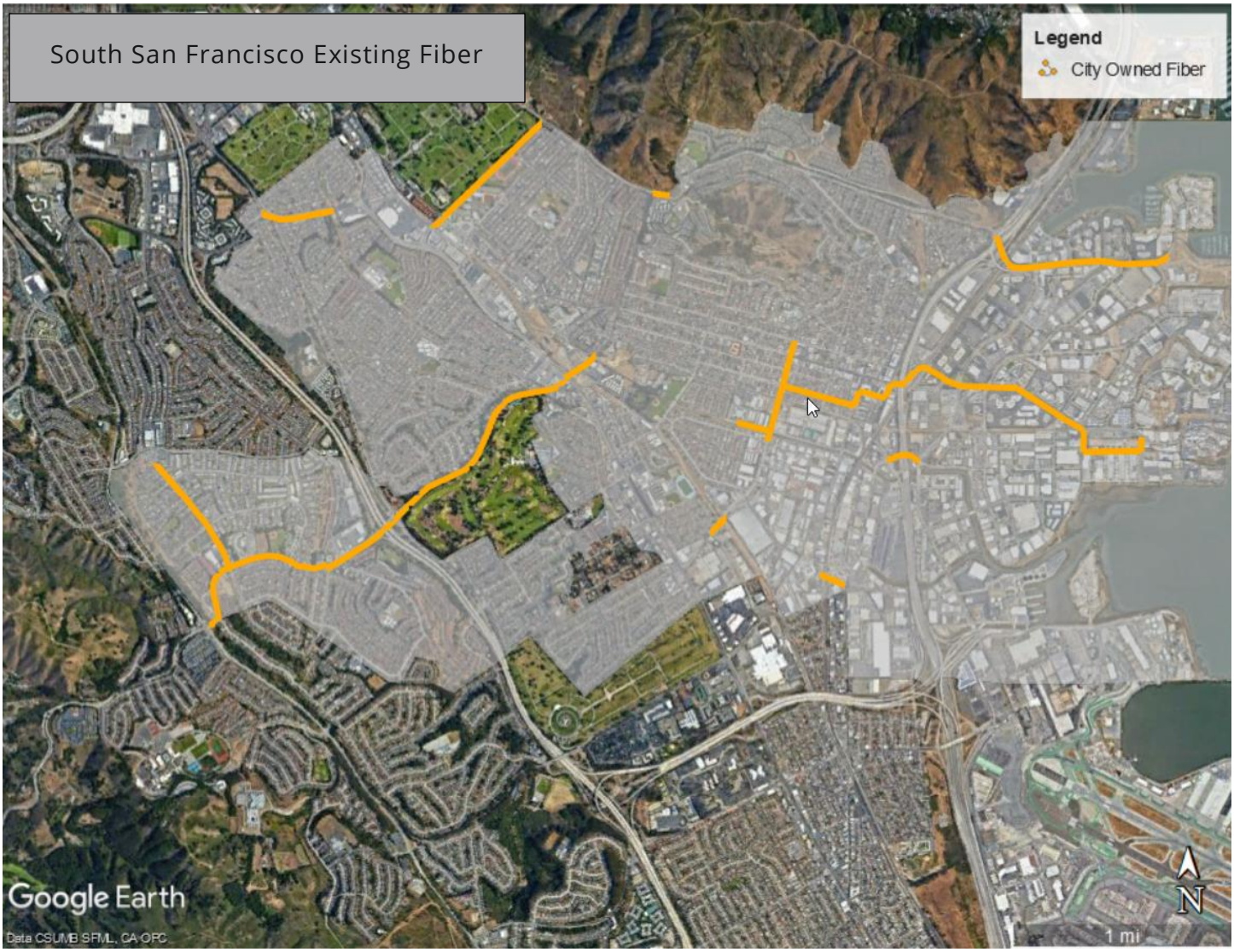
4.2 BROADBAND INFRASTRUCTURE IN SOUTH SAN FRANCISCO

South San Francisco has several providers of fiber, including both long-haul routes that connect the City to a national fiber network and more localized metro routes that connect the different areas to each other and all of the market to the long-haul networks.

Existing City Infrastructure

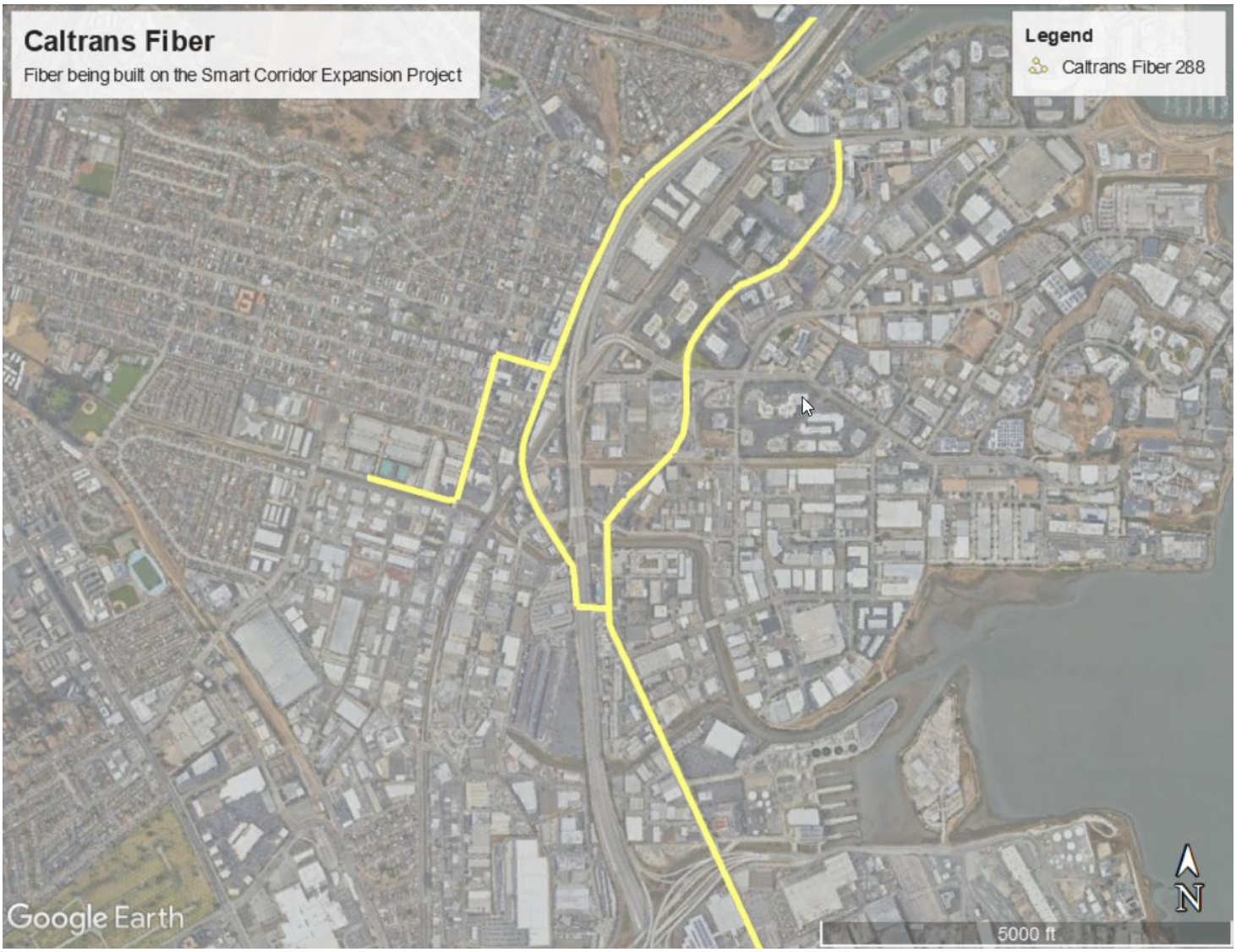
South San Francisco owns fiber optic cables and has limited use of some other fiber. Currently the City owns 38,550 feet of fiber optic cable, shown in the figure below. The City also plans to install additional fiber cable on Westborough Boulevard using $2 million of the City's designated American Rescue Plan Act (ARPA) funds. This cable will be instrumental in creating P3 agreements to bolster the Westborough area as well as connecting a CBRS antenna at the Pacifica Water Storage Tank near the Westborough neighborhood.

4-2 City Owned Fiber Cables



South San Francisco also has limited use of 27,620 feet of Caltrans fiber being placed on the Caltrans Smart Corridor Expansion Project. The Caltrans fiber is a part of a large county-wide project to help alleviate traffic build up on HWY 101 during accidents and large crisis incidents.

Figure 4-3 Caltrans Smart Corridor 288 Fiber Cable



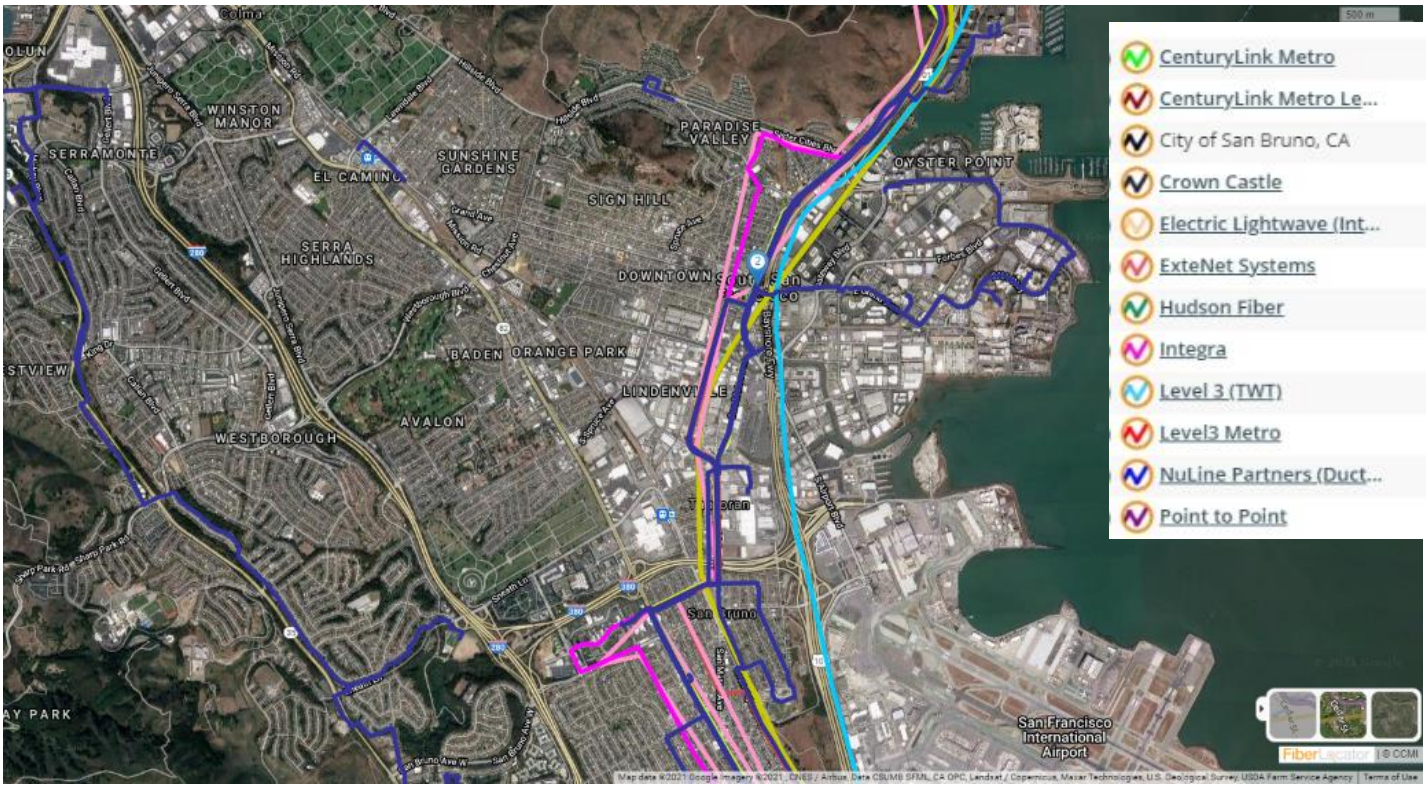
Long-Haul Routes

Long-haul fiber networks carry data to internet points of presence over long distances, but do not provide local connections. Such fiber runs through many communities such as South San Francisco, often along railway or major highway alignments, but because these networks have no local connections, they do not offer services to the community. The connections they offer are wholesale, transport, data center connections, and backhaul services for local providers. Long-haul providers are crucial to smaller ISPs being able to bring services to South San Francisco without the extreme expense of

building private fiber to the City. Long-haul providers are also used to connect to many area data centers including 200 Paul in San Francisco and 11 Great Oaks in San Jose, which can be used to connect to anywhere in the world. The cellular providers use these networks to connect all cell traffic to regional Mobile Switch Centers (MSCs) for routing around the world.

South San Francisco has a reported 11 long haul providers using fiber running through the City, as shown in the map below.

Figure 4-4. Long-Haul Fiber Routes in South San Francisco

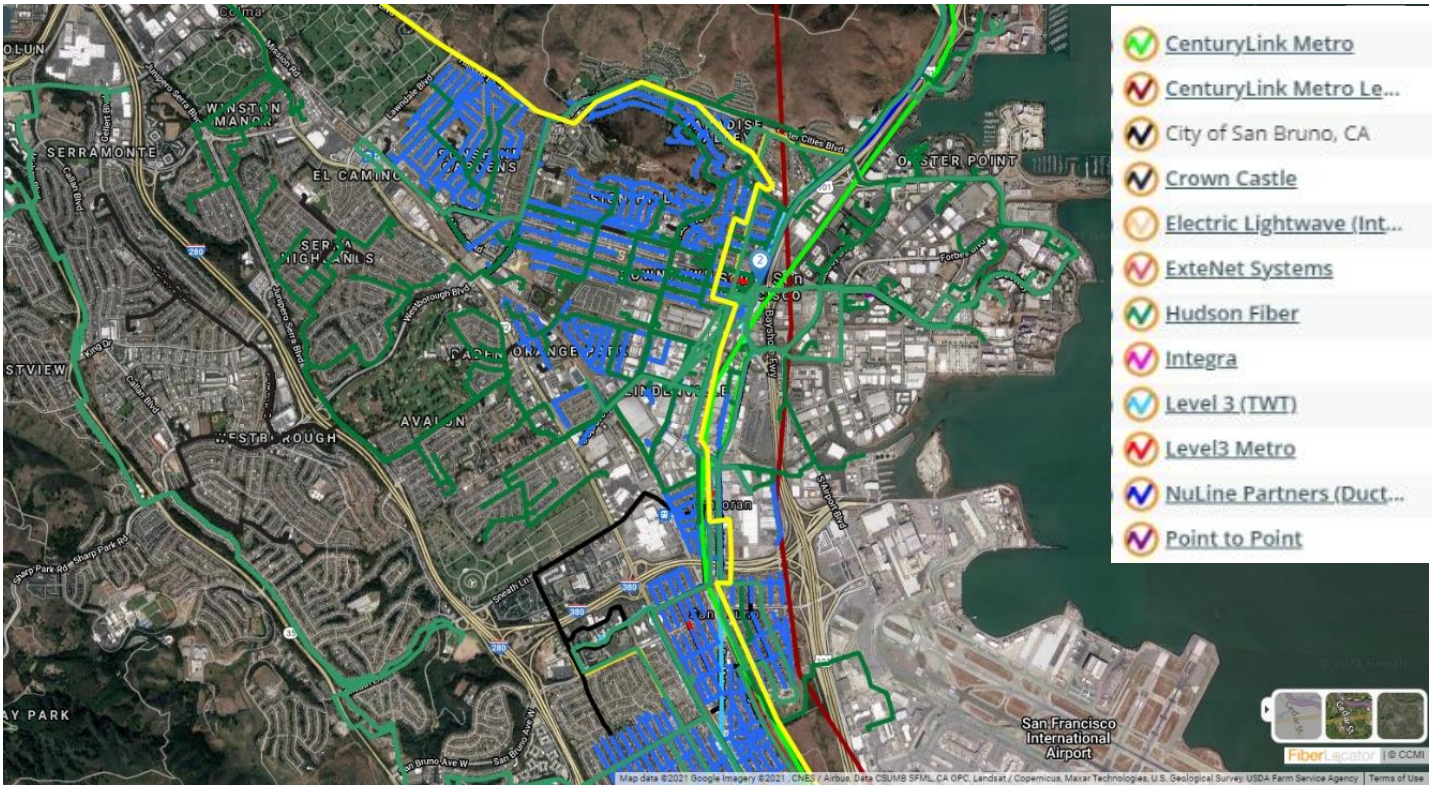


Metro Routes

Metro fiber networks consist of local connections that serve business, residential, or government customers. Unlike long-haul fiber, this infrastructure is capable of serving the community by providing connectivity to end users. The metro routes in South San Francisco are primarily provided by Wave, Xfinity, AT&T, and Sonic. Although most will not share a map of their infrastructure, Wave and Xfinity were able to provide general footages and what the plan for additional cable to the network is. Wave currently has approximately 82 miles (432,500') of fiber optic cable, all of it east of Highway 280. Wave would like to expand into the Westborough area, however, crossing Hwy 280 is cost-prohibitive. Comcast has fiber to all of the nodes for residential service and state that they can offer 1G download speeds to all of South San Francisco, although survey data

indicate that actual speeds are far less. Comcast is also engineering a new fiber optic network in the Oyster Point area to provide better coverage.

Figure 4-5. Metro Fiber Routes in South San Francisco



4.3 CONCLUSIONS

South San Francisco has a robust network of fiber including both long-haul and local metro networks. Discussions with some of the local providers also indicate plans for upgrades to their infrastructure in South San Francisco to continue to support residential needs and economic development. Internet service offerings are quite abundant and most businesses have several choices and ample broadband for any needs they may have now or in the future. Residents in most neighborhoods also have a selection of options for high-speed broadband. The choice is not always symmetrical with fiber, but it is fiber back-hauled nodes which can offer speeds of up to 1Gbps download and 50Mbps download. Those speeds are sufficient for most residences with typical activities such as emailing and streaming; however, home-based businesses with higher upload speed demands may suffer slightly.

The Westborough neighborhood has fewer options, and results from the online broadband survey, discussed in the next section, reveal some frustration with the lack of options there. A larger issue is the affordability of service, which may be a challenge for some residents throughout South San Francisco.

5. Needs Assessment

Magellan Advisors interviewed over two dozen City staff members to determine needs for connectivity. We asked about major trends, plans, and goals as well as current connectivity to identify the full range of opportunities and future potential requirements. General direction from City leadership was to focus on removing barriers to providers and promoting investment in particular parts of the City to ensure equity.

We heard about requirements for additional infrastructure and service for Westborough, digital inclusion programs focused on working families and small businesses, and commute/transit for tech workforce. The City has key programs in Community Learning Centers, Economic Development, and Public Works that could benefit from greater connectivity but also could be leveraged to improve availability and benefits of broadband. Emergency services, first responders, and other public safety personnel have evolving needs related to changes in how they monitor and respond to incidents.

The key broadband needs seem to be related to wireless connectivity for municipal functions, including event and visitor connectivity at parks and other facilities. Field access for City personnel was inconsistent, as was Wi-Fi coverage. Cellular coverage in some areas is excellent—super-fast 5G—while other areas seem to have none. More broadly, South San Francisco needs to balance tech industry development with housing costs, retaining support industry, and traffic congestion.

5.1 CURRENT CONNECTIVITY

Broadband connectivity in South San Francisco appears to be fast and robust in the Oyster Point and surrounding areas, uneven in Downtown and urban core neighborhoods, but less than adequate in Westborough. Anecdotal accounts are that "Westborough feels it keeps getting left behind" and internet services are "terrible." In contrast, investments by Genetech, 230 other biotech companies, and related development east of the 101 have driven commensurate investment in network infrastructure. Core neighborhoods west of 101 have a lot of gig workers and multigenerational households, many of which have their own small businesses.

The City of South San Francisco has an enterprise-wide area network (WAN) build of dark fiber from Wave that connects all municipal sites. Key buildings are interconnected at 10 Gbps to form a core ring. Other buildings are spurs connected at 1 Gbps. Dense wavelength division multiplexing is used to accommodate more sites and provide higher bandwidth in the future. The Police Department uses the City's primary 1 Gbps circuit and has a backup circuit through Comcast, as well as a Hurricane Electric circuit that

provides upstream connections for their applications, including backups, with secure tunnels from cellular providers for mobile data and remote devices. Radio communications utilize a tower on 600 ft. Sign Hill, with point-to-point microwave links to San Bruno and 100 Mbps backhaul to dispatch; the City's fiber does not extend up the hill.

The City has miles of conduit developed via dig once, including routes with 2-2" conduits alongside conduit and fiber owned Intermountain and other providers, signal interconnect cable (SIC) with spare conduit and wireless devices, and a set of conduit along the 101 for a Smart Corridors project that uses CCTV cameras, ITS devices, signal controllers, and variable message signs for incident management.

The City recently updated its permitting standards for network construction. Micro-trenching and rock-wheel installation must be above sewer laterals with additional requirements in areas that require de-confliction. The Public Works staff would like to have a road moratorium. The City's small cell program includes PG&E poles, City streetlights, and public buildings. Public Works has used Verizon LTE mifi hotspots or internal WLAN SIM cards to communicate with street cleaning trucks and other vehicles for field work, work orders, etc. It could also provide a redundant system for adaptive traffic control.

All cell carriers have cell sites in South San Francisco where they have deployed some 5G with approximately 100 Mbps download speeds. But some areas of the City have poor coverage, including critical facilities like fire stations. They have considered cellular boosters at fire stations to keep engines continuously connected when they move or are stationary. Police have problems with mobile data connections in much of Westborough, including Westborough Square.

South San Francisco Public Library is a member of the Peninsula Library System (PLS) with 34 libraries in 8 cities across San Mateo County. Cenic is their ISP using AT&T circuits in a hub & spoke configuration with 10 Gbps central location, the main data center at College of San Mateo, and 1 Gbps at libraries. The network is at about 10% utilization. Public Wi-Fi is available at Main and Grand Library. Other branches throughout the City don't have outdoor space, although there is Grand Ave Outdoor Wi-Fi.

Most of the City's parks have Wi-Fi but it is inconsistent. A lot of folks use parks with their iPad or phone. The City has numerous apps, including an internally developed version of Pokemon Go that highlights various areas with proximity sensors, recreation management software, a tree inventory, and EngageSSF, the City's white-labelled version of See-Click-Fix for submitting service requests. They also have automated building

access, environmental controls, and irrigation systems. Most registration and facility rentals are online. Parks Division were planning electronic point-of-sale and piloting check-in with iPad for indoor events. These were not considered for outdoor events due to cost of connectivity.

A new multi-sport field will be fitted with online electronic scoreboard technologies supported by fiber and wireless. Live streaming events is an emerging trend, handled by external production companies. Kids in childcare don't get online but the Department's personnel need connectivity for coordination, registration, etc. Improved and additional public safety video in general would be the number one thing for addressing vandalism and safety issues.

5.2 GOALS AND ISSUES

Digital Literacy

Changes from the COVID-19 pandemic include virtual church and school, reduced congestion, and businesses doing more online. Availability of computers and other devices is an issue as well as connectivity. Basic digital skills and language skills are issues for some residents. The Community Learning Center provided digital literacy programs to seniors before the pandemic and recently launch afterschool program with distance learning, which increased connectivity requirements. They actively promote current topics such as the Emergency Broadband Benefit. A group of Skyline College Honor Society students were helping seniors with cell phones and other basic tech prior to COVID, and they plan to restart.

The libraries do a lot of digital literacy training. Patrons can make appointments and get assistance over the phone to use Zoom. Their after-school center has kids recommended by teachers come in to do homework, while their parents come in to do training. There are makerspaces at all three libraries that were heavily used prior to COVID. They did hackathons and coding clubs for kids. Digital literacy programs were offered twice a week on different subjects. The libraries offer programs on how to use Linked In or databases to find customers for small businesses. That's a harder audience to pull in, usually consisting of fewer people who come back multiple times to get various skills.

The libraries offer a low-literacy program version with English or Spanish literacy skills, funded by grants through the Community Learning Center. A lot of patrons can't afford broadband or don't have a device. Lower income households only have one device with multiple simultaneous uses. Facilities located in lower-income areas do a lot of community outreach and advertising and work with a lot of seniors. Some patrons have mobility issues and limited ability to get to a library.

The libraries have been looking at adding Wi-Fi to "Learning Wheels" pre-school on wheels with a childhood learning station that goes to WIC centers, events, and daycares, which sees a few thousand families a month. They have taken Wi-Fi hotspot and some devices to senior centers. That requires a lot of staffing. They looked at lending hotspots and ways to give or loan devices but could not commit to the upfront cost of devices or regular charges for cellular Wi-Fi hot spots.

The libraries would like to provide some type of service in low-income neighborhoods, downtown, Sunshine Gardens, Mayfair Village, Boys & Girls Clubs and a makerspace bus to take tech to teens and seniors. They also need to replace equipment, such as laptops that have died. Efforts to get big money for digital inclusion need coordination. There are some sponsors that get hit a lot and others without established relationships. Cybersecurity is a key issue. The libraries need to improve security profiles and help patrons stay safe. Awareness training programs may be beneficial for this purpose.

Industrial Development

According to ECD personnel, South San Francisco's strategy is primarily to retain industries, such as the logistics industry that is getting pushed to East Bay by lack of housing and real estate. Businesses operating in old buildings need upgrades to expand or grow. As new developments come in, old businesses paying under market rates are getting pushed out. It's difficult for them to find additional space so the City is trying to relocate them and keep them on this side of the bay. Major issues are cost of rent and cost of upgrading facilities. For example, some don't have adequate security or are having issues with loading/unloading docks. It goes beyond connectivity issues.

A lot of South San Francisco support industry connected to the airport (limousines, shuttles, etc.) and large catering industry connected to offices severely suffered from pandemic. Many have moved to doing sales online. A lot of research & development (R&D) tenants have been moving into incubator spaces in large buildings that don't have connectivity issues. Lindenville, just south of downtown, has lots of warehouse space. It is envisioned with housing and creative arts spaces that will need infrastructure. The City is currently doing a General Plan that includes how to treat the utility issues.

Commuting and Traffic Management

The workforce for industry east of 101 consists primarily of commuters. All that changed with the pandemic but commuting patterns are coming back. People aren't using public transit so traffic has been worse than normal times. East of the 101 the traffic is particularly congested. Last-mile links from the transit station to corporate campuses is the big issue. The City has some smart signalization east of 101 and is doing a feasibility study for a people mover between the Caltrans station and the campuses.

An planned adaptive traffic control project will eventually be citywide and will use existing conduit to connect all signals east of 101 to a hub at the Corporate Yard. Areas west of 101, particularly Westborough, don't have communications but also have less need for traffic control. Public Works would like to put new fiber from the Corporate Yard to Westborough in existing conduit. There were multiple capital projects, including a regional stormwater project at Orange Memorial Park and street rehabilitation, that don't appear to include network facilities.

Housing

Regionally, housing is an issue. The supply has been limited with high housing turnover in the last several years. This seems related to not having people live and work in the area. Almost no one who lives in South San Francisco works in biotech and almost no one who works in biotech lives in the City. Broadband doesn't seem to be an issue developers discuss when they are looking at sites. In some instances, housing providers provide services for the entire building in a bundle but in other cases, it is up to the household to purchase the service.

The City's Community Development Block Grant (CDBG) program provided free laptops and free internet to qualified participants. Other initiatives include expanding Wi-Fi at public facilities by working with the Housing Authority and other affordable housing providers. The intent was to provide students devices in perpetuity and to address telehealth for seniors. It was mostly concentrated in the downtown area.

5.3 BROADBAND SURVEY

To gain further insight into the current state of broadband and need for future connectivity, Magellan Advisors and the City of South San Francisco conducted a broadband survey among businesses and residents. The survey was open for approximately eight weeks between August and October 2021 and received a total of 379 valid responses. As shown in the table below, the majority of responses came from households in South San Francisco.

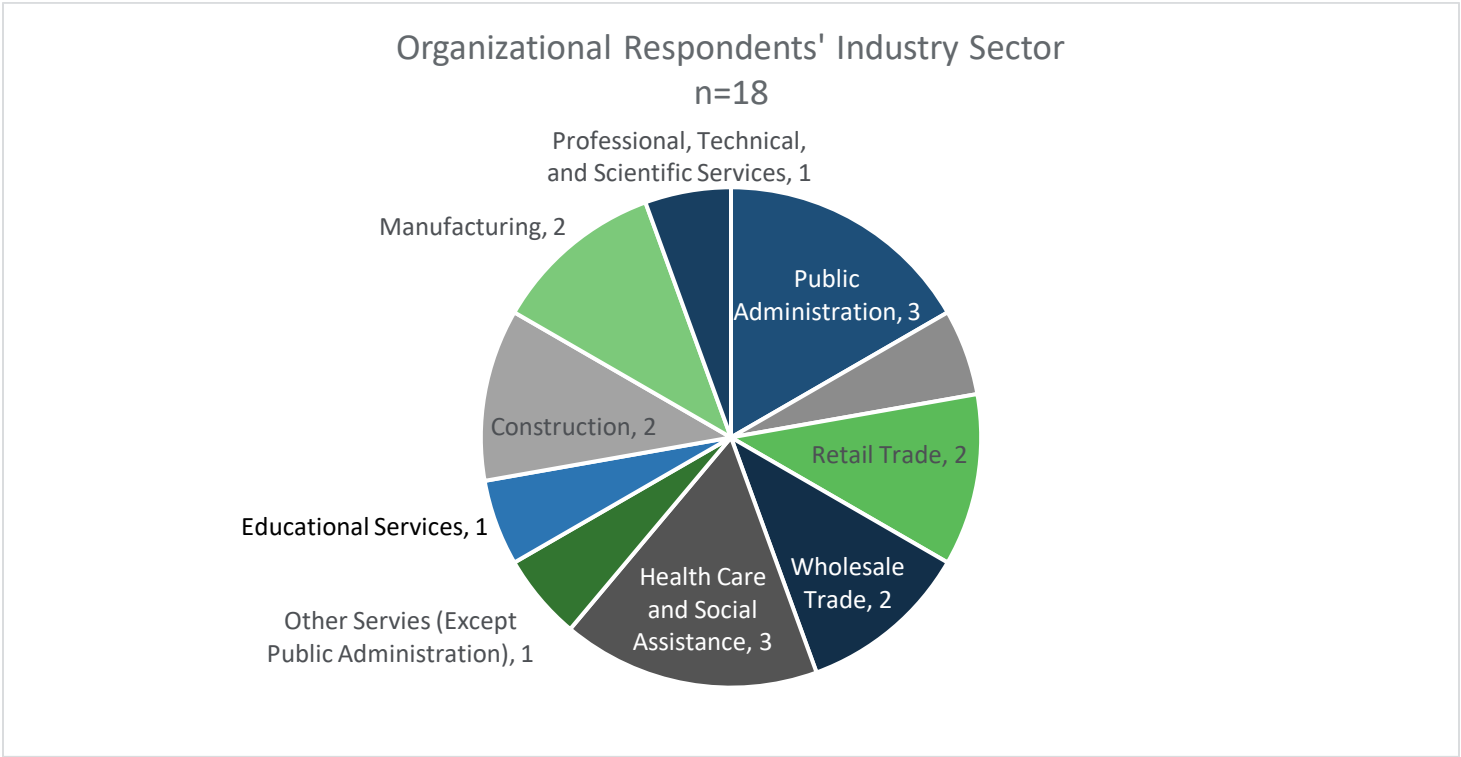
Table 5-1. Survey Responses by Type

Response Type	
Household: Location is primarily a residence	335
Organization: Location is a business, government, non-profit, etc.	44
Total	**379**

Among residential respondents, the average household size was 3.07 people, close to the 3.12 average size according to Census data. Thirty four percent (61) of respondents indicated that they were retired or otherwise out of the workforce, which is relatively quite high compared with Census data. About one quarter of respondents (44) worked in Arts, Business, Management, or Science and about 15% (27) worked in Service including Hospitality, Education, or Healthcare. Almost half of respondents (43%) indicated having Bachelor's degrees and 23% indicated having Masters degrees. Residential respondents had relatively higher levels of educational attainment and a higher number of retirees than Census data.

Survey respondents from organizations were asked to identify their industry sectors. Among the 18 responses, organizations came from a variety of sectors including Public Administration and Healthcare and Social Assistance, as shown in the figure below. Relative to the local economic base,[18] the survey had relatively even responses from these service-related sectors, although given the low number of responses, the data cannot be said to be statistically reliable.

Figure 5-1. Organizational Respondents' Industry Sectors



[18] Local industry data is for San Mateo County from the California Employment Development Department, online at https://www.labormarketinfo.edd.ca.gov/LMID/Size_of_Business_Data.html. This data does not include disaggregated service sectors.

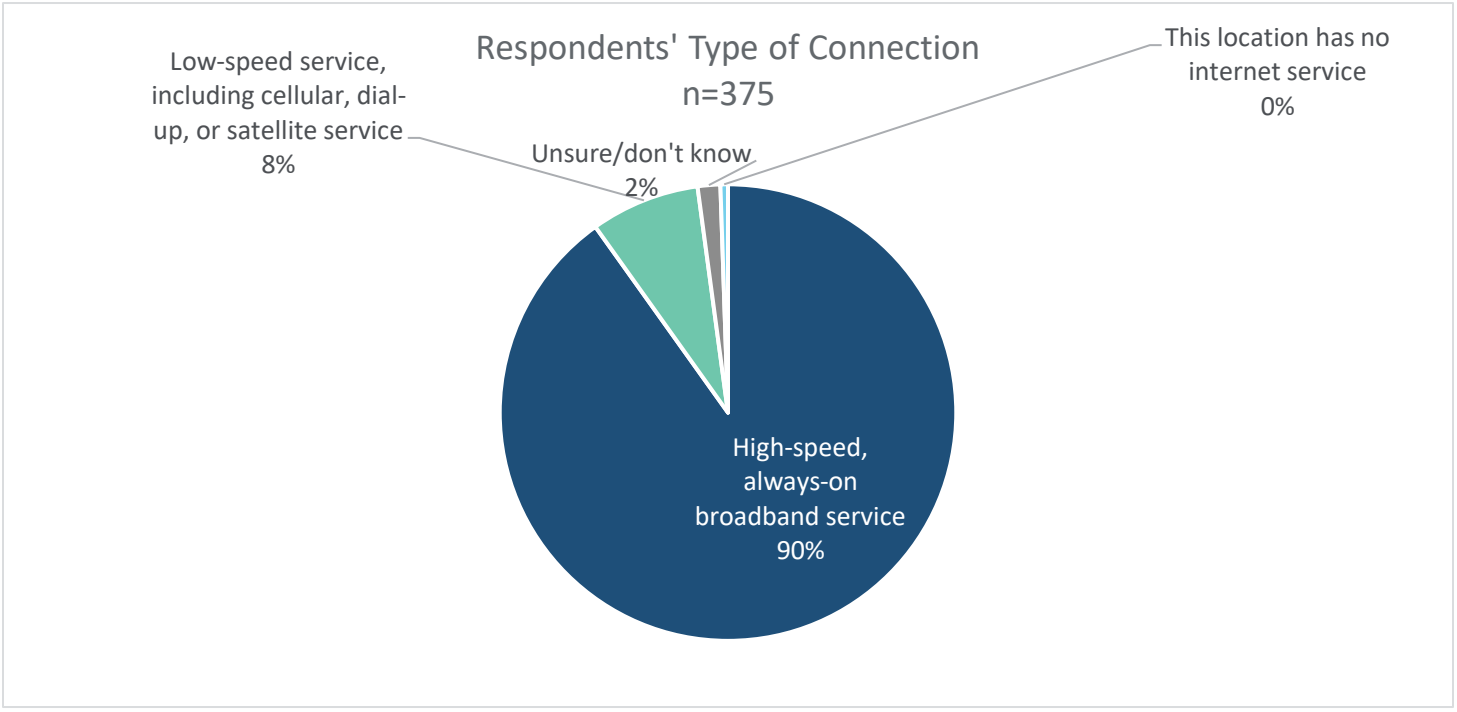
Respondents tended to be better educated and older than South San Francisco's entire population. Professionally, respondents roughly mirrored the City's economy, although those who were retired or otherwise out of the workforce were overrepresented. Given the distribution methods, number of responses and respondent demographics, we cannot say that the survey results are statistically reliable. We can say that the survey results document the experience and perspective of close to 400 households and organizations in South San Francisco.

The survey yielded useful empirical indicators of broadband in the City. Recognizing results of survey analysis as indicators, we report statistics but use approximate language in discussing the findings. Generally, these results should be considered the "best case" for the more affluent and informed residents of the community. Additional effort will be required to determine the situation for younger, less educated residents. The same applies to large, multi-location service and wholesale companies.

Type of Broadband Connection

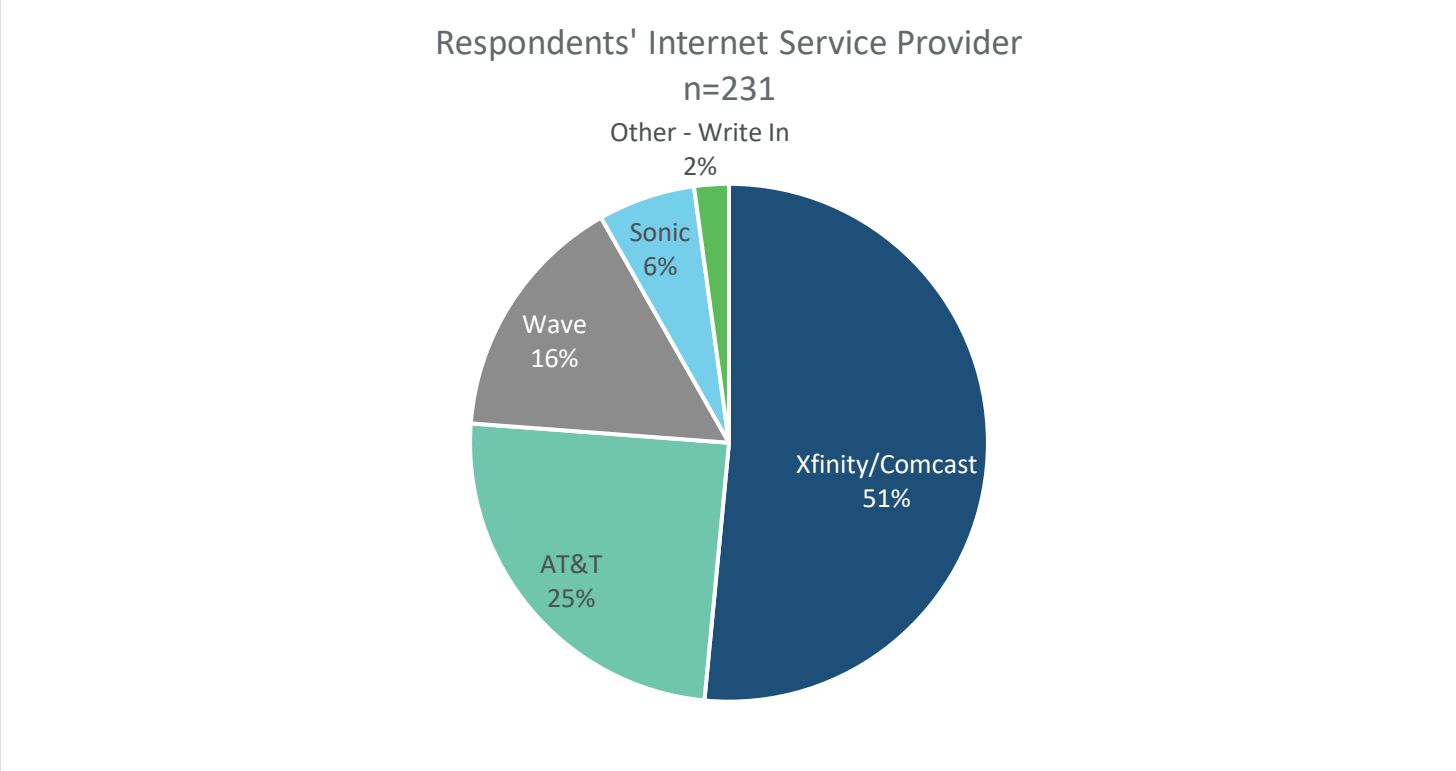
Most of the respondents (90%) had broadband connections, defined as high-speed, always-on internet service, as shown in the figure below. Approximately 8% of respondents had low-speed service including cellular, dial-up, or satellite service, while 2% did not know what kind of connection their locations use. None of the respondents reported not having internet service.

Figure 5-2. Respondents' Type of Connection



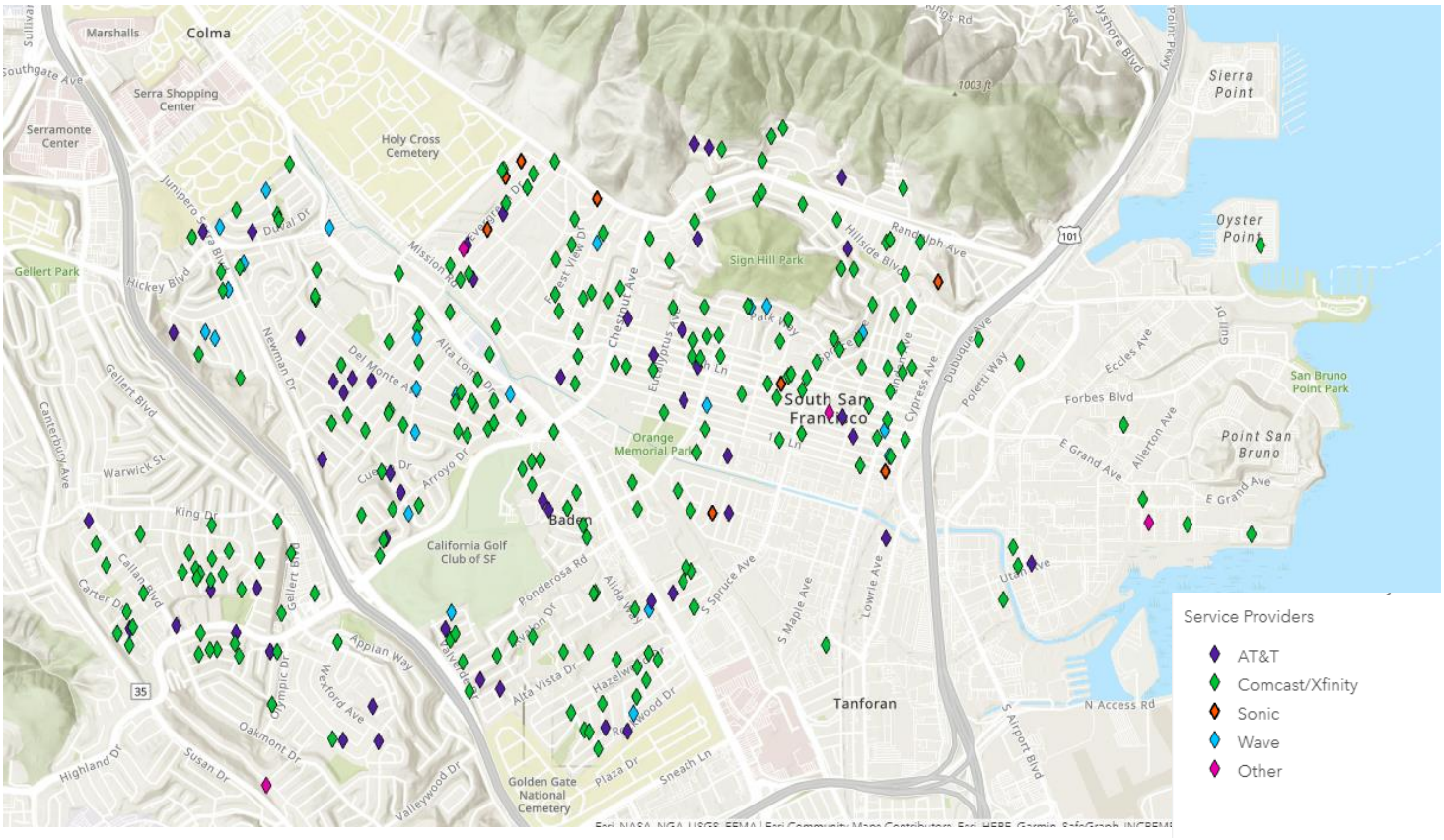
Just over half of the survey respondents had internet through Xfinity/Comcast and about one quarter of them had service through AT&T. As the two major incumbents in South San Francisco, these results are as expected. A smaller amount of respondents (16%) had service through Wave Broadband and a handful (6%) subscribed to services through Sonic. The remaining 2% of respondents wrote in other service provider options including San Bruno CityNet Services, Sprint, and Wiline.

Figure 5-3. Respondents' Internet Service Provider



These results were also mapped to provide insight into which providers are available at various locations throughout the City. As shown below, areas east of Interstate 280 seem to have more options for service providers, while areas to the west of Interstate 280 have just one or two options (Comcast or AT&T).

Figure 5-4. Respondents' Internet Service Provider by Location



Performance

Respondents were asked how much they paid for broadband and related services and what contracted speeds they paid for. These were "best guesses" by the person responsible for choosing and paying for the service. Variance would diminish with a large number of responses but should be assumed high in this situation. Actual performance was recorded automatically via a speed test integrated into the survey but performance will vary over time based on network congestion and other factors. Therefore, we report a full set of descriptive statistics, including average, maximum, median, and minimum speeds.

On average, survey respondents reported contracted-to-receive speeds of approximately 407 mbps download and 215 mbps upload. To get a better understanding of actual performance, the survey contained an embedded speed test that respondents ran from their locations. The actual speed test results were much lower than contracted speeds, with an average download speed of 157 mbps and an upload speed of 44 mbps.

Table 5-2. Descriptive Statistics for Broadband Cost and Performance Among Survey Respondents

	MRC (Internet Only)	Contracted Speed (Mbps)		Actual Speed (Mbps)		Cost per Mbps
		Download	Upload	Download	Upload	
Average	$78.42	414.85	217.94	158.05	43.77	$0.39
Median	$70.00	200	20	73.01	12.63	$0.82
Mode	$50.00	1000	10	54	5.87	$0.84
Maximum	$434.00	1412.8	1200	914.11	940.17	$3.23
Minimum	$1.00	1	1	0.12	0.19	$0.23

On average, respondents who subscribed to services through Comcast were paying more than double the cost of others ($163.34) for internet services only, although their average download speeds were also relatively higher. Overall, respondents who identified Sonic as their provider were getting the best value, with an average cost of $.10 per mbps per month.

Table 5-3. Survey Respondents Average Costs and Speeds by Provider

Provider	Responses	Average Cost (Broadband Only)	Average Actual Download (Mbps)	Average Actual Upload (Mbps)	Cost per Mbps
AT&T	57	$74.50	92.26	61.45	$0.48
Comcast/Xfinity	120	$163.34	194.60	18.44	$0.77
Wave	36	$72.92	108.44	13.41	$0.60
Sonic	14	$57.77	290.93	262.62	$0.10
T-Mobile (Sprint)	1	NA	223.74	36.54	NA
WiLine	1	$434.00	NA	NA	NA
Verizon	1	$95.00	5.8	27.98	$2.81

Respondents were also asked to provide a range of pricing that they would be willing to pay for broadband at various speed tiers. For super-fast 1gb connections, most were willing to pay between $50 and $100 per month.

Figure 5-5. Respondents' Willingness to Pay for Broadband Services

	Would not pay anything	No more than $25	Between $25 and $50	Between $50 and $100	Between $100 and $150	Over $150	Responses
Slow, 10 Mbps: enough for checking email Count Row %	151 82.5%	18 9.8%	5 2.7%	6 3.3%	1 0.5%	2 1.1%	183
Basic, 25 Mbps: enough for surfing the web Count Row %	101 55.2%	58 31.7%	16 8.7%	6 3.3%	2 1.1%	0 0.0%	183
Real, 50 Mbps: enough for video calls and conferencing Count Row %	49 25.8%	72 37.9%	52 27.4%	12 6.3%	4 2.1%	1 0.5%	190
Fast, 300 Mbps: enough multiple games or videos simultaneously Count Row %	27 14.3%	26 13.8%	85 45.0%	42 22.2%	7 3.7%	2 1.1%	189
Super fast, 1,000 Mbps: enough anything and lots of it Count Row %	13 6.9%	13 6.9%	59 31.2%	84 44.4%	14 7.4%	6 3.2%	189
Totals Total Responses							190

The survey also asked respondents to rank their current internet service on a variety of factors, as shown below. Roughly half of respondents (48.5%) ranked their overall service as Good, while slightly fewer (42.7%) ranked their Performance/Speed as Good. The area of most concern among respondents was Price, with 28.2% reporting that Price was Bad and 8.7% ranking Price as Terrible.

Figure 5-6. Respondents' Assessment of Current Internet Service Performance

	Terrible	Bad	Neither/Not sure	Good	Excellent	Responses
Overall Count Row %	9 4.4%	27 13.1%	33 16.0%	100 48.5%	37 18.0%	206
Performance/speed Count Row %	10 4.9%	34 16.5%	38 18.4%	88 42.7%	36 17.5%	206
Price Count Row %	18 8.7%	58 28.2%	53 25.7%	57 27.7%	20 9.7%	206
Reliability Count Row %	6 3.0%	35 17.2%	39 19.2%	91 44.8%	32 15.8%	203
Customer service and support Count Row %	17 8.4%	28 13.8%	66 32.5%	66 32.5%	26 12.8%	203
Totals Total Responses						206

Most respondents reported slowdowns and service outages, although they were relatively infrequent, as shown in the figure below. Slowdowns appear to occur every few months and service goes out for an hour or two about once a year. About 17% of respondents did experience slow downs on a daily basis and about 6.2% of respondents were seeing brief outages on every day.

Figure 5-7. Respondents' Assessment of Internet Service Outages and Slow Downs

	Never	Once a year or less	Every few months	Every few weeks	Every few days	Daily, every day	Responses
The service slows down. Count Row %	35 14.5%	32 13.3%	65 27.0%	34 14.1%	34 14.1%	41 17.0%	241
The service is out briefly. Count Row %	28 11.6%	66 27.4%	66 27.4%	41 17.0%	25 10.4%	15 6.2%	241
The service is out for less than an hour. Count Row %	42 17.8%	76 32.2%	64 27.1%	30 12.7%	16 6.8%	8 3.4%	236
The service is out for an hour or two. Count Row %	70 30.0%	91 39.1%	47 20.2%	13 5.6%	9 3.9%	3 1.3%	233
The service is out for several hours. Count Row %	96 40.9%	90 38.3%	27 11.5%	13 5.5%	6 2.6%	3 1.3%	235
The service is out for a day or more. Count Row %	153 66.5%	56 24.3%	12 5.2%	4 1.7%	4 1.7%	1 0.4%	230
Totals Total Responses							241

Use

To better understand how internet is being used for critical services, we asked household respondents to identify how frequently they used internet for telehealth, online learning or training, operating a home-based business, and telecommuting.

Most respondents (64.8%) use internet a few times a year to consult a healthcare professional. Just over half use internet more than once a week to telecommute, and

close to half use it once a week to do online schoolwork or training. About 28% of respondents use internet more than once a week to run a home-based business.

Figure 5-8. Household Respondents' Internet Use

	Once a year or less	A few times a year	About once a month	About once a week	More than once a week	Responses
Consult a healthcare professional Count Row %	25 14.2%	114 64.8%	25 14.2%	10 5.7%	2 1.1%	176
Do online schoolwork or training at home Count Row %	39 22.5%	22 12.7%	15 8.7%	22 12.7%	75 43.4%	173
Do home-based business, contract or "gig" work Count Row %	92 54.8%	9 5.4%	8 4.8%	12 7.1%	47 28.0%	168
Telecommute, work from home as an employee Count Row %	55 33.3%	8 4.8%	1 0.6%	11 6.7%	90 54.5%	165
Totals Total Responses						176

Based on the responses above, internet has become a critical tool for residents. To collect further information about these trends, respondents were asked to rank how important internet is for a variety of functions.

Well over half said that internet is extermely important or essential for finding and buying products and services, getting information for general purposes, and getting information for special interests or hobbies. Just over half of respondents said that being connected is extremely important or essential for learning, making money, or staying healthy and staying in touch with family and friends, while just under half said it was extremely important or critical for playing games, watching video, or other entertainment.

Figure 5-9. Importance of Internet Among Household Respondents

	Extremely or essential	Very but not essential	Helpful but not really important	Minimally useful	Of no use	Responses
Finding and/or buying products or services Count Row %	120 67.0%	38 21.2%	15 8.4%	4 2.2%	2 1.1%	179
Generating income or selling things Count Row %	47 27.2%	21 12.1%	24 13.9%	30 17.3%	51 29.5%	173
Getting information for general purposes Count Row %	126 70.8%	44 24.7%	5 2.8%	2 1.1%	1 0.6%	178
Getting information for special interests or hobbies Count Row %	105 60.0%	46 26.3%	19 10.9%	4 2.3%	1 0.6%	175
Learning, making money, or staying healthy Count Row %	98 56.0%	42 24.0%	23 13.1%	7 4.0%	5 2.9%	175
Playing games, watching video, or other recreation Count Row %	80 45.5%	45 25.6%	28 15.9%	13 7.4%	10 5.7%	176
Staying in touch with family and friends Count Row %	101 58.0%	48 27.6%	21 12.1%	2 1.1%	2 1.1%	174
Totals Total Responses						179

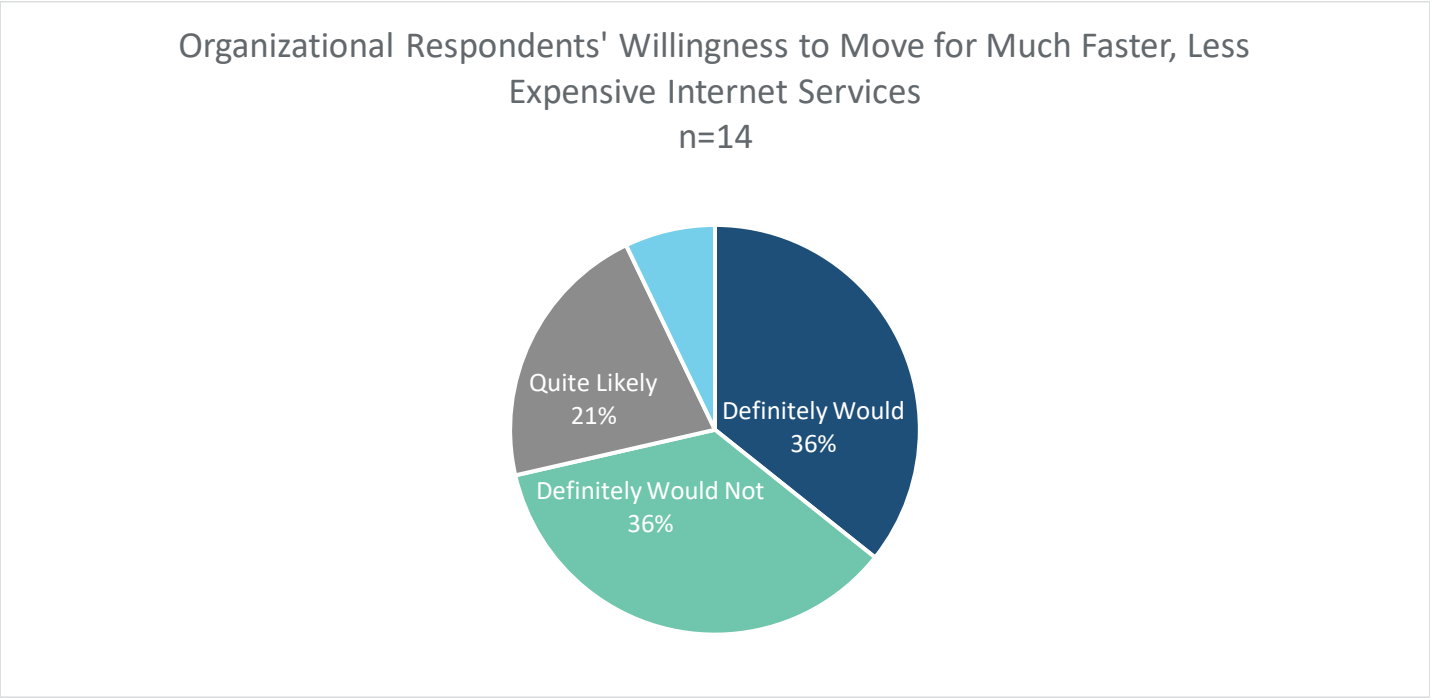
Among organizational respondents, digital technologies were most useful for managing or operating their organizations and for supporting customers. More than half of organizational respondents also said that digital technologies were critical for buying materials and hiring employees and tracking inventory and work activities.

Figure 5-10. Usefulness of Digital Technologies for Organizational Respondents

	Extremely useful or essential	Very useful but not essential	Helpful or somewhat important	Minimally useful, not important	Of no use	Responses
Buying materials or equipment and hiring employees Count Row %	10 55.6%	7 38.9%	1 5.6%	0 0.0%	0 0.0%	18
Managing or operating the organization Count Row %	14 77.8%	2 11.1%	0 0.0%	1 5.6%	1 5.6%	18
Tracking inventory, materials, and work activities Count Row %	10 55.6%	6 33.3%	0 0.0%	1 5.6%	1 5.6%	18
Producing goods or providing services for customers Count Row %	8 47.1%	5 29.4%	3 17.6%	1 5.9%	0 0.0%	17
Tracking orders, fulfillment, and delivery Count Row %	8 47.1%	6 35.3%	1 5.9%	1 5.9%	1 5.9%	17
Selling, marketing, and getting customers to buy Count Row %	8 47.1%	5 29.4%	2 11.8%	1 5.9%	1 5.9%	17
Supporting customers, providing customer service Count Row %	14 77.8%	2 11.1%	2 11.1%	0 0.0%	0 0.0%	18
Totals Total Responses						18

To understand just how critical broadband is, we asked organizational respondents whether they would be willing to move their business for much faster, less expensive internet services. About 36% of respondents said they would definitely not move, while the other 64% would either definitely move (36%), quite likely move (21%), or possibly move (7%), indicating just how important affordable, reliable internet is for operations.

Figure 5-11. Organizational Respondents' Willingness to Move for Broadband



5.4 CONCLUSIONS

Generally, affluent consumers (relatively older and better educated) in South San Francisco have reasonably fast broadband. Unfortunately, younger residents with lower levels of educational achievement did not respond so we cannot draw any conclusions about their connectivity. Competition was the major issue for most respondents. While respondents generally indicated low willingness to pay—many said they would not pay more than $50 for 50 Mbps, which is common in non-competitive markets—they were actually paying relatively high monthly bills for their internet. Although broadband speeds were acceptable, the cost per capacity was rather high, especially for Comcast customers who made up the majority of survey respondents.

Households recognize the importance of robust broadband, especially to do online schoolwork and telecommuting. Connectivity was a critical issue for many organizational respondents, particularly for management and customer service.

6. Utility Formation Study

The formation of a utility generally involves a plant, the utility's infrastructure, and governance to ensure the utility is adequately financed and that spending is aligned with the utility's purpose. The nature and scale of both should be determined by the utility's customer base. The focus and scope of utility operations and maintenance should, in turn, be based on the utility's governance and plant. Utilities provide a basic commodity service to an area, so the simple question for any utility is "how do we benefit everyone?"

The customer base for a broadband utility in South San Francisco is substantial but so is the competition. While many residents, particularly older, more affluent ones, have reasonably good broadband, they pay a premium for it. Younger, less affluent residents may face financial challenges getting broadband, especially larger households and residents of multi-dwelling unit buildings. At the same time, the City has four facilities-based retail broadband providers—AT&T, Comcast, Sonic, and Wave—as well as several enterprise and/or wireless service providers.

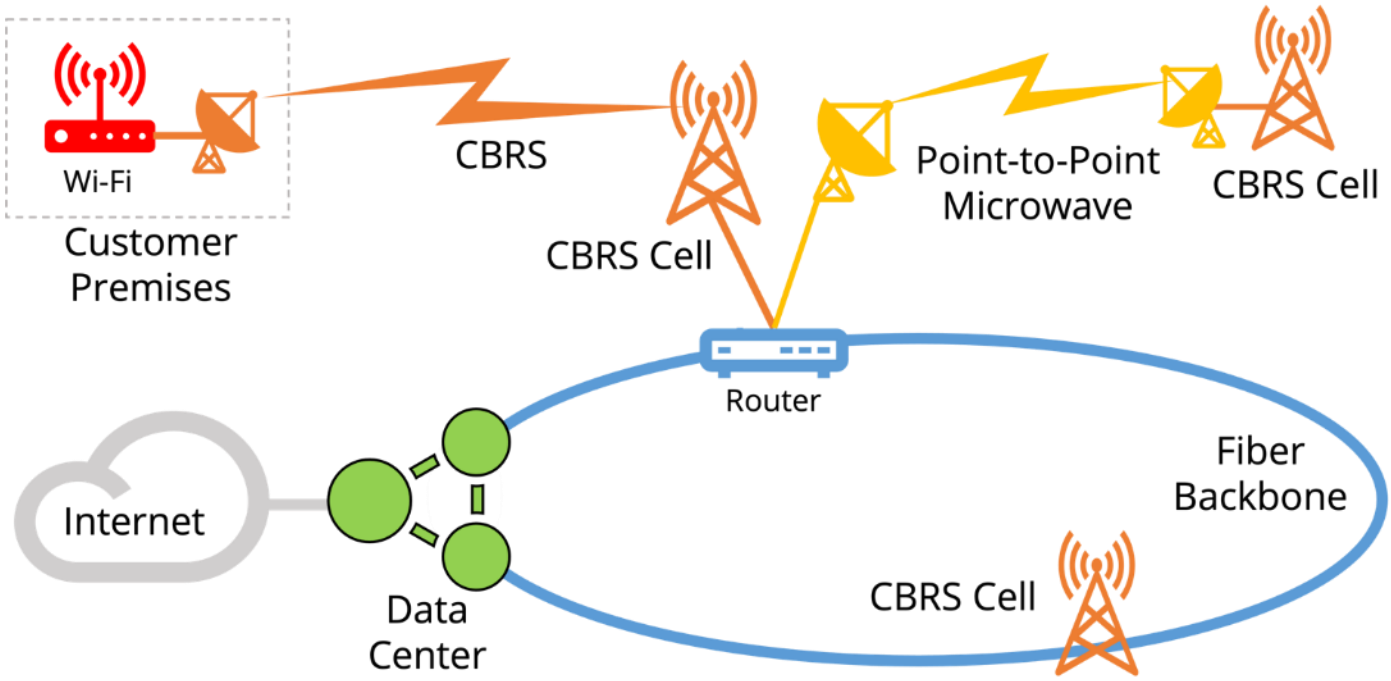
Given this situation, the common area-wide sole source utility does not make sense. Any broadband utility for South San Francisco would need to focus on digital equity, making sure everyone has baseline connectivity. The purposes would be to (1) ensure everyone can participate in the digital economy and society, (2) accommodate guests and visitors in the City, and (3) put some competitive pressure on private providers to extend services and improve pricing. As residents get greater value from internet and retail prices moderate, customers of this utility can be expected to upgrade to private providers. This model doesn't justify a full broadband operating system, including billing, customer service associates, and network operations center.

The best general model for the South San Francisco Broadband Utility (SSFBU) is a highly flexible and low-overhead community amenity and baseline internet service. If South San Francisco were to establish such a utility, Magellan Advisors recommends wireless service that uses Wi-Fi as the access technology, CBRS radio access network (RAN) for backhaul, and a combination of fiber and microwave for the core network. Access control would be via a captive portal with an integrated authentication and billing system, governed by a community advisory committee. We recommend the utility be integrated with programs to increase digital literacy and promote digital transformation for small businesses.

6.1 CONCEPUTAL NETWORK DESIGN

The conceptual design describes the components of a network, their functions, and their general placement. It is used to estimate costs and coverage, which allows for revenue projection. The overall purpose is to inform key decision makers and influencers about options for achieving their goals by and for providing connectivity. The objective of the design is to provide abundant connectivity to the community in an economically viable and sustainable manner, to address the goals and issues identified above. As of the writing of this report, the City is in the process of updating its General Plan. We recommend this design be revisited to consider outputs of that plan.

Figure 6-1. SSFBU Conceptual Network Design

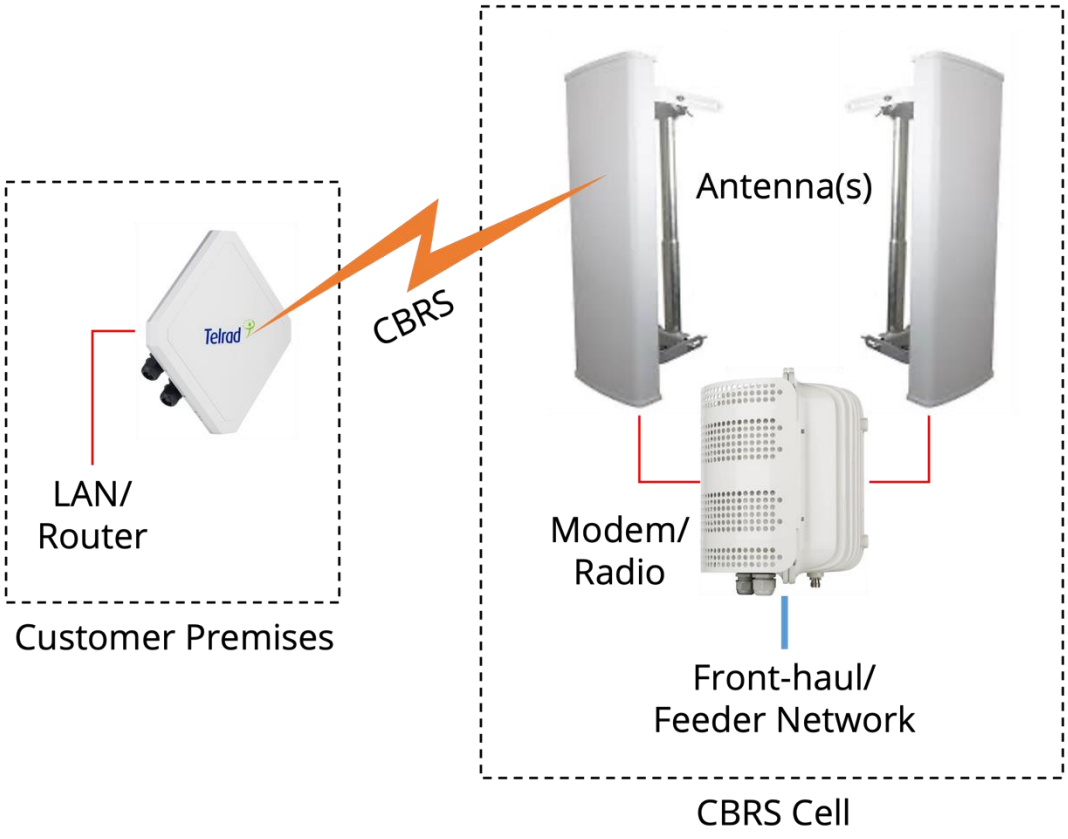


The SSFBU network, diagrammed in Figure 6-1, is designed to flexibly extend basic broadband throughout the City. It capitalizes on the City's current assets, near-universal availability of Wi-Fi-enabled devices, and on radio spectrum that is available for use without a license. SSFBU users will connect via Wi-Fi, via a particular Wi-Fi service set identifier (SSID) or logical network deployed over a variety of Wi-Fi access points. SSFBU Wi-Fi access points will be connected via router (and Ethernet cable) to a Citizens Broadband Radio Service (CBRS) distribution radio access network. Traffic will be aggregated through a few CBRS cells, which will connect to administrative systems and bulk internet services via City-owned fiber and point-to-point microwave.

Citizens' Broadband Radio Service (CBRS)

CBRS is a point-to-multipoint system in which a single antenna-base station combination connects multiple user devices or other equipment. Each antenna covers from 30° to 360° around it—with a trade-off between coverage and power—and each base station can support a limited number of users. Therefore, more antennas and base stations equate to greater capacity and more users. The combination of CBRS/LTE antenna, base station, and customer equipment, illustrated in Figure 6-2, comprises a radio access network (RAN). A RAN has a network core that authenticates and authorizes user equipment and manages connections to multiple base stations. This allows for mobile roaming from base station to base station without loss of connectivity and makes RANs very secure. The downside of a CBRS/LTE RAN is that some entity must operate to network core and the Spectrum Access System (SAS). These are relatively inexpensive services that can be purchased from vendors or run-on private servers.

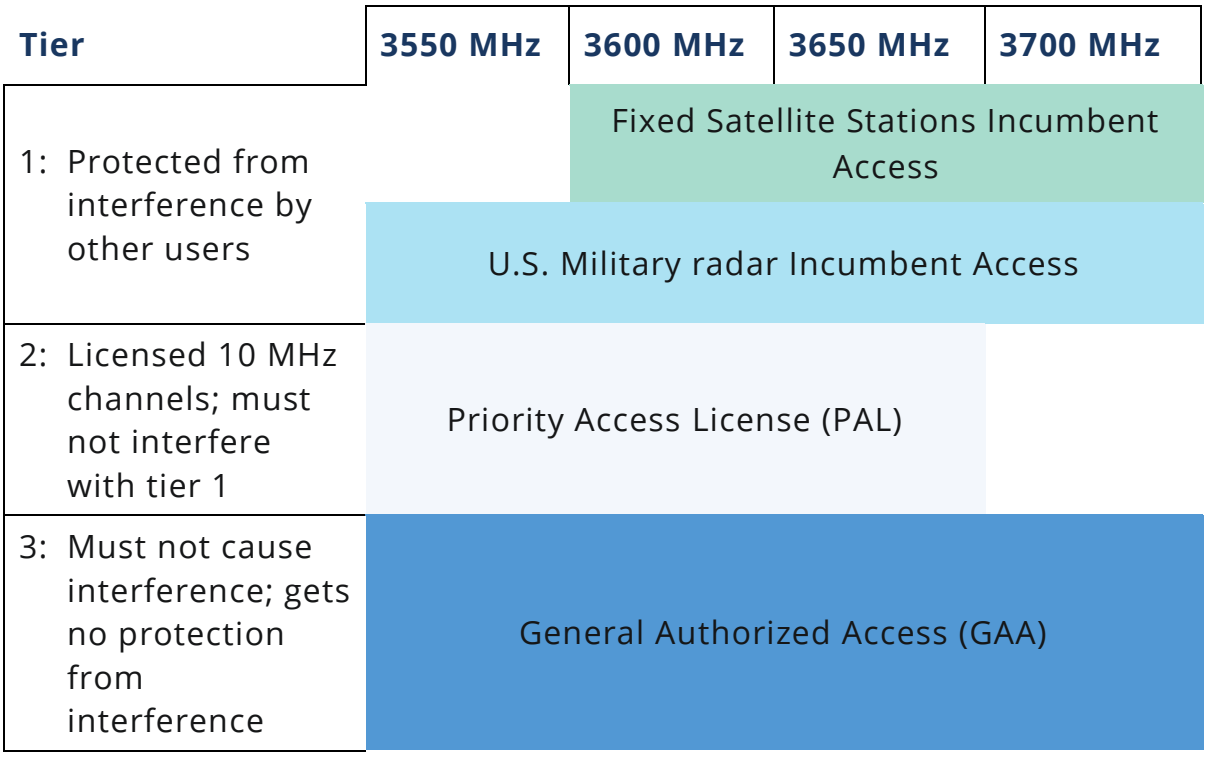
Figure 6-2. CBRS Equipment



CBRS uses the 3550-3700 MHz (3.5 GHz) shared spectrum, also known as LTE band 48. There are three tiers of CBRS users, diagrammed in Figure 6-3. Current, incumbent, tier 1 spectrum users, which include US military, fixed satellite stations, and, for a limited

time, wireless internet services providers (WISPs) are protected from interference by other users. Ten Priority Access Licenses (PAL) for 10 MHz channels between 3550 and 3650 MHz in a specific county were auctioned off by the FCC in July 2020. These licensees are protected from interference by other users but may not interfere with incumbent users. Any portion of the spectrum may be used without a license for General Authorized Access (GAA), but this may not interfere with incumbent or PAL users. The higher frequencies are not covered by PAL.

Figure 6-3. CBRS User Tiers



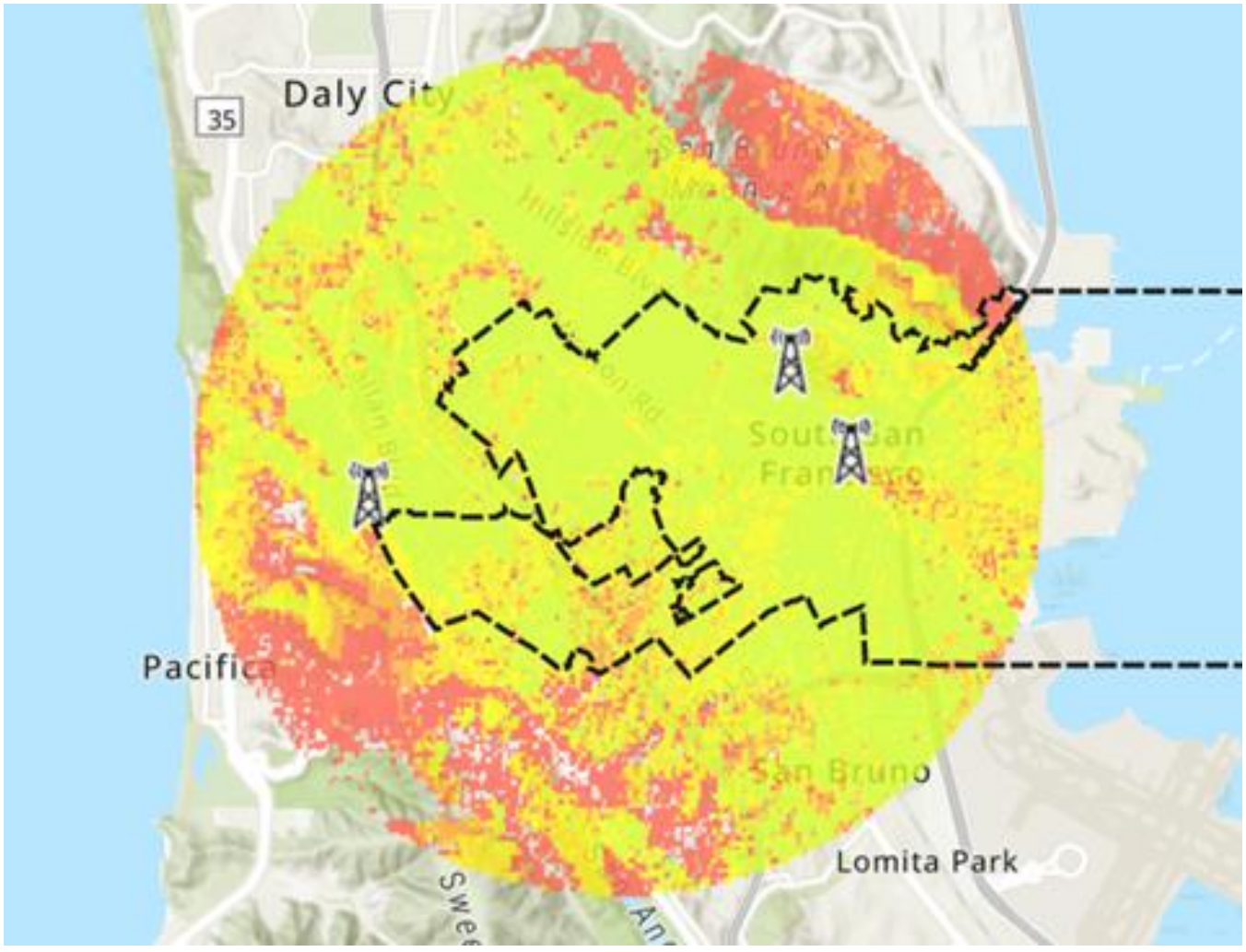
CBRS use is managed by a Spectrum Access System (SAS) with which all Citizen Broadband Service Device (CBSD) base stations must be registered. There are two classes of CBSD. Class A base stations, which can transmit at 1 watt of power, are meant for smaller-scale indoor, enterprise, or campus use. Class B base stations can transmit at 50 watts, giving them much greater range. Strategically placed radio signal sensors will ensure that uses do not interfere with each other, particularly military radar.

Another important characteristic of CBRS is the Long Term Evolution (LTE) protocol is commonly used with the spectrum. LTE is also used for 4G cellular data service, so it is widely implemented in user equipment. CBRS involves different (band 48) equipment but smartphones and tablets, as well as fixed outdoor and indoor CPE, with antenna that

operate in the CBRS bands are becoming more common and less expensive. It is reasonably easy and economical to add CBRS/LTE to devices without changing their operating characteristics or systems. Therefore, there are few barriers to end user adoption.

CBRS can be deployed very flexibly but generally requires a tower or other structure well above ground level (50+ feet) to mount antennas. For South San Francisco we selected three sites that exemplify deployment options but also provide reasonably good coverage: City Hall, Sign Hill, and Skyline Blvd Water Tank. As shown in Figure 6-4, these three cells with four 65° sectors each should provide good coverage for most of South San Francisco (and a good bit of Colma, Daly City, and San Bruno).

Figure 6-4. CBRS Coverage Estimates from Three Cells—City Hall, Sign Hill, and Skyline Blvd

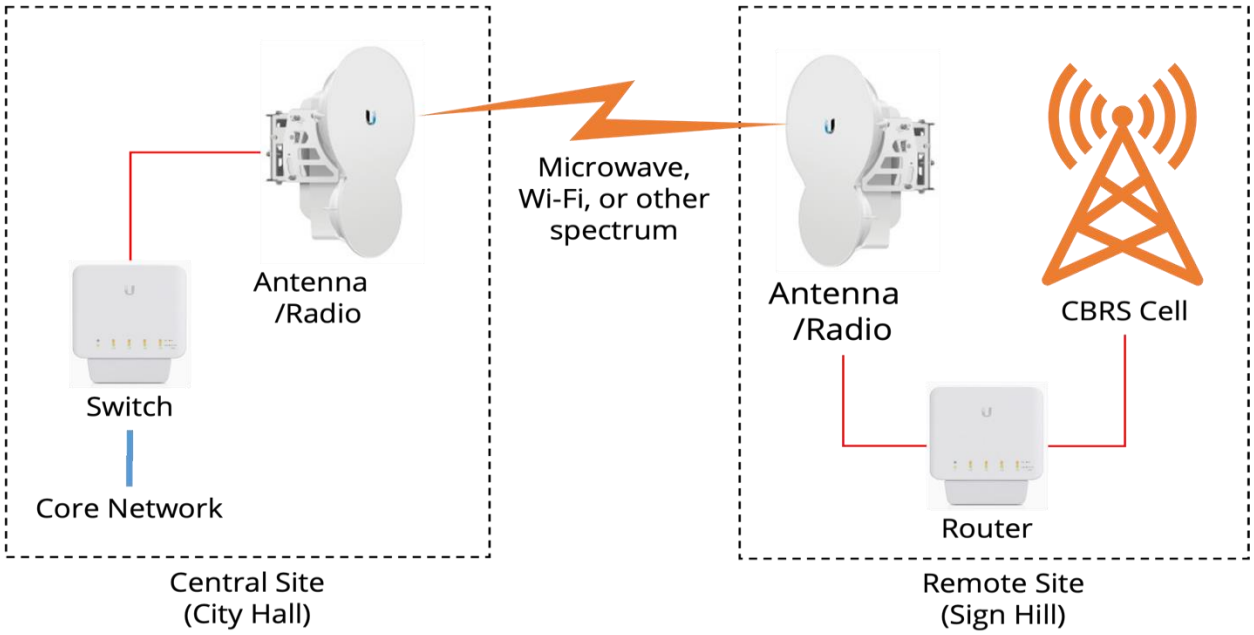


The network would accommodate 2,000 subscribers on each cell—500 subscribers per base station—with 200 Mbps throughput per base station, which would be divided among all users in that sector. Users should generally get 50 Mbps to 100 Mbps throughput, depending on the number of other simultaneous users. The design should cover most of Oyster Point and could be extended to increase coverage.

Point-to-Point Connections

Point-to-point connections use two antennas (and base stations) pointed directly at each communicating via radio spectrum. The spectrum may be in either licensed (i.e., microwave) or unlicensed (Wi-Fi) bands. Licensed connections have less interference, are in the higher frequencies, and typically operate at higher power. Therefore, they can be reasonably high-capacity and reliable. While their performance doesn't approach that of fiber, neither does their cost. Equipment, diagrammed in Figure 6-5, can be as little a few hundred dollars, particularly for unlicensed spectrum. This design includes a single Point-to-Point (PtP) link—which requires two antenna/radios, one at each end—between City Hall and Sign Hill.

Figure 6-5. Point-to-Point (PtP) Equipment



Wi-Fi

Wi-Fi, which was originally termed "Wireless Fidelity," is an open standard that was developed to connect computers to a local area network (LAN) via unlicensed radio spectrum (the same frequencies used for cordless phones, garage door openers, and other non-network wireless devices). Generally, Wi-Fi is a Point-to-MultiPoint (PtMP) technology: Wi-Fi access points connect multiple devices within limited range, typically

no more than 150 feet indoors and up to 1,500 feet outdoors. There are multiple standards or versions of Wi-Fi. Some can provide up to 1 Gbps of throughput. Other new Wi-Fi standard can cover large area with minimal power requirements.

Wi-Fi coverage and speed depends on multiple factors such as buildings, foliage, and other physical barriers, interference from other spectrum users, radio spectrum used, transmission power, type of antenna(s), and weather. New versions of the Wi-Fi protocol operate at greater distances and/or speeds. It can be deployed PtP to interconnect sites and is being adapted for Low Power Wide Area Network (LPWAN) applications.

Figure 6-6. Examples of integrated CBRS Wi-Fi hotspots for residential (TelRad and Zyxel), enterprise (Ruckus), and industrial (MultiTech) settings; each of which is approximately 6 inches in size.

Wi-Fi access points are often integrated into routers that interconnect the Wi-Fi network (also called a service set identifier or "SSID") to other networks, specifically a CBRS network connected to the internet in the present case. Each customer premises or user location would have a CBRS antenna transceiver connected to router and Wi-Fi, all of which are available in single devices (see examples in Figure 6-6). Multiple access points can be interconnected to each other as well as a router—forming a mesh network—to cover a larger area. A Wi-Fi network can even be extended over multiple otherwise independent routers via a centralized server to create "community" Wi-Fi. The latest version, Wi-Fi 6, improves these functions as well as expands the spectrum and increases speeds for Wi-Fi connections.

A Wi-Fi component for two low-to-moderate income zones in South San Francisco is included in the recommended program and is further described in Section 7.

Administrative Systems and Captive Portal

Both CBRS and Wi-Fi can be very flexibly deployed and managed due in large part to the software behind them. Most CBRS vendors provide sophisticated but usable software to control access and monitor performance. This often includes ability to configure SSIDs for connected Wi-Fi devices. The SSFBU will require a captive portal for public SSIDs. All users of those networks are sent to the captive portal when they connect and must authenticate through them to access the internet and other online resources. Captive portals can be used to bill users, display ads, limit bandwidth or time online. They can also create "walled gardens" containing specific services or web sites. For example, users may be able to connect to the City website without authenticating. A library SSID could route through the library's unfiltered internet access, whereas a school SSID would connect to student resources behind a firewall. Registered users may get more access or faster speeds and may be able to get even more by paying s subscription fee. All of this is possible with captive portals, depending on the vendor and configuration.

6.2 GOVERNANCE STRUCTURE

SSFBU is relatively low-cost infrastructure. The revenue opportunities are limited. For these reasons we do not recommend establishing a separate entity. The potential rewards and risks simply don't justify it. As the purpose of the utility is to provide baseline connectivity options for everyone, we recommend incorporating SSFBU's programming and governance into an existing department or program. The two prime candidates are the Library's Community Learning Center—physically and virtually extending it into the community—or the Community Development Program. The latter is funded via HUD Community Development Block Grant, which requires initiatives to be formally included in local plans. The former is more flexible and more closely related to SSFBU's purpose but may have less fiscal capacity. Alternately, SSFBU could be established as a separate department in the City or as a division in the IT department.

Wherever it is in the City's organizational structure, we recommend the City establish an enterprise fund for SSFBU. Sharing revenue through a third-party partner will not require the City to become an ISP, establish service level agreements or provide staffing for the network, so it is recommended that the City partner with a qualified internet service provider to provide services directly to end users.

The program should be governed by a board of departmental representatives supplemented by a community advisory committee. We recommend the advisory committee be comprised of equal numbers of residential, small business, non-profit, and major industry representatives, selected by City Council members. The General Manager should be responsible for proposing an annual plan, including budget, to the

advisory committee and board. The design and model presented here could effectively achieve the goal of providing baseline connectivity to all of South San Francisco. Our cost and revenue estimates are conservative so we believe SSFBU could generate excess revenue if effectively governed. In that case, we recommend including digital inclusion programs and services in the SSFBU enterprise fund to maximize its economic and social benefits to the community.

SSFBU should build upon existing digital inclusion efforts that are ongoing in South San Francisco. The City could also consider other programs that have been successful in other communities including youth and elder programs, makers spaces, and more. Some of these programs and resources include:

- Self-Help for the Elder is a Comcast 10-month program for youth ages 14-21. The program teaches young people digital literacy skills and includes a community service component. More information can be found at: https://www.selfhelpelderly.org/our-services/digitallearning/youth-leadership-technology-program
- Mentorships are an ideal way for local companies to give back to the community. The City should reach out and partner with local technology companies allowing them the opportunity to teach and mentor local youth.
- National Digital Inclusion Alliance (NDIA) is an excellent resource for programs including low-cost internet, Digital Literacy 101, and Digital Navigators that help assess, connect, and direct digital inclusion. More information and a Digital Inclusion Startup Manual can be found at https://startup.digitalinclusion.org/.
- The International Telecommunications Union https://www.itu.int/en/mediacentre/backgrounders/Pages/digital-inclusion-of-youth.aspx includes additional resources for youth digital inclusion programs.

7. Programming & Finance Evaluation

The needs and goals of the City itself, its residents, businesses, and community groups were assessed as inputs for developing a programming and finance evaluation to determine the feasibility of building out and operating a Citywide broadband utility. Financial requirements were also considered, since capital and operational costs are paramount for determining the feasibility of supplementing broadband and wireless with a municipal broadband program.

We estimate that if the City of South San Francisco pursued a citywide fiber-to-the-home utility, costs for construction would be approximately $38 million. Additional operating expenses would also be applied to the program for additional staff and other resources needed to operate and market such a network.

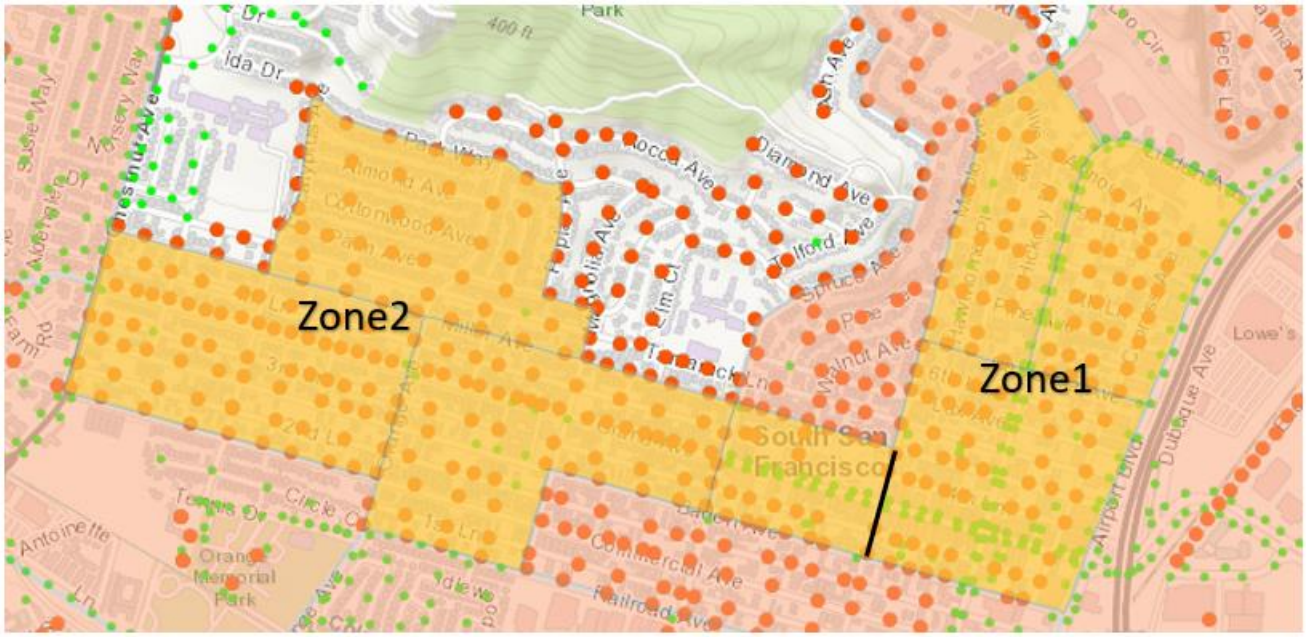
To address the issues in the Westborough neighborhood alone, the costs would be approximately $14 million. Based on these estimates and conversations with service providers, it is more feasible for the City to consider constructing public assets in the Westborough neighborhood which could be made available for use by providers who want to serve the neighborhood.

Based on the needs of the community and the costs to deploy a municipal fiber utility as well as the City's current broadband market, it is infeasible for the City to achieve an adequate return on investment for such a program. Therefore, to address the digital equity and affordability issues in South San Francisco, we recommend pursuing deployment of a wireless utility available to residents citywide by leveraging the City's existing assets to create a flexible, low-cost utility.

7.1 WIRELESS DEPLOYMENT PLAN

Affordability is the glaring problem in the low-to-moderate income areas, especially in Zones 1 and 2 (see Figure 7-1, below). South San Francisco has offered free Wi-Fi, through signup to the City network, on Linden Avenue with great success thus far. In order to best support those areas lacking affordable internet, it is best for the City to build out additional free Wi-Fi antennas and gain full coverage of low-to-moderate income areas. The Wi-Fi network is intended to deliver free Wi-Fi outside homes and does not require installation or equipment deployment or provision of any other offerings. Rather, the City's existing network should be expanded to Zones 1 and 2, as shown in the figure below.

Figure 7-1. Wi-Fi Zone Coverage Areas



The most cost-efficient network with high-bandwidth and wide coverage is a Wi-Fi antenna network placed on streetlights and power poles. The antennas will connect to a wireless CBRS backhaul network that will connect the whole network to the internet. Depending on the number of users, this system can easily support 1Gb download speeds.

The deployment of this network should happen via a phased approach starting with the CBRS towers, equipment, and licensing. The CBRS will require two new underground fiber paths on the north and southwest sides of the City (shown in Figure 7-2) to connect to the City's existing fiber network. These are described in further detail below.

After the CBRS antennas are functional, the next step is to deploy 45 new Wi-Fi antennas in Zone 1 and Zone 2 which are within the census low-income areas of South San

Francisco. Other areas will be future projects. Antennas that need to be on PG&E poles will require approval from PG&E with an agreement for leasing the pole space yearly. Once in place, the Wi-Fi apparatus can be linked to the CBRS network and the internet.

Figure 7-2. Network Map

Costing for the new fiber routes as well as for the CBRS and Wi-Fi deployment is detailed below.

7.2 ESTIMATED COSTS

Fiber Deployment

As a first step, the City should deploy two new fiber routes to connect the CBRS antennas to enable high-speed internet access. The wireless components of the network can handle the network traffic from the end-users through the Wi-Fi antennas ending the wireless portion at the CBRS apparatus. CBRS antennas need to be backhauled with fiber optics to connect to the internet.

There are two new underground fiber sections that need to be constructed. The first is a 2600-foot bore connecting the Sign Hill tower to a fiber optic cable owned by Wave Broadband. The other is a 411-foot bore under Skyline Boulevard connecting City owned fiber to the Pacifica Water Storage Tank. The City will need to coordinate with the Westborough Water District, who owns the tank, to use the tanks for wireless deployment. This route will connect to the City's new fiber routes along Westborough. Both routes are shown in the figures below.

Figure 7-3. Proposed Fiber at Sign Hill

Figure 7-4. Proposed Fiber Westborough

The cost for these two new segments is approximately $240,157, as shown in the table below.

Table 7-1. Costs for New Fiber Deployment

Segment Name	Construction Type	Footage	$/ft	Total
Westborough Water Tower	New Underground	411	$82.50	$33,907.50
Sign Hill	New Underground	2500	$82.50	$206,250.00
Total	New Underground	**2,911**	**$82.50**	**$240,157.50**

CBRS Deployment Costs

The total estimated cost for CBRS distribution network, presuming SSFBU faces no costs to put antenna on City-owned property, is less than $250k, as shown in Table 7-2. Each 4-sector cell requires four 65-degree, 4-port antennas and base stations, which may come as an integrated unit, one per sector. The cost estimates are based on TelRad equipment (CPE as well as cell). Microwave equipment is required for PtP between City Hall and Sign Hill. The cost is an approximate average for this equipment, including state license, at the writing of this report. Market trends generally show higher performance equipment for lower costs over time, so costs may be decreased in the future. Similar

trends hold true for the routers, one of which is required for each site. An equipment cabinet may or may not be needed.

Table 7-2. SSFBU CBSR Distribution Network Capital Expense

Item	Cost	Units	Total Cost
Tower Cost (Existing Towers)	-	1	-
County Owned Towers/Water Tanks	-	2	-
Antenna and Base Station	$15,000	12	$180,000
Base Station Installation	$1,000	12	$12,000
Microwave Equipment	$3,000	2	$6,000
Outdoor Router (1 per tower)	$1,000	3	$3,000
Outdoor cabinet (1 per new Tower	$1,000	3	$3,000
		Subtotal	$204,000
Engineering, Project & Construction Mgmt.	15%		$30,600
		Total Estimated Cost	**$234,600**

Wi-Fi Deployment Costs

A total of 45 Wi-Fi access points is included in this conceptual design, meshed to 15 CBRS CPE. Thirty of these 60 devices will be pole-mounted outdoors; the others would be mounted on buildings, indoors, or other locations that involve no recurring cost. The total cost for SSFBU's access infrastructure including professional services is approximately $160k. Additional access infrastructure can be added at a marginal cost.

Each CBRS CPE with integrated Wi-Fi hotspot costs about $360, and about that much to install. CBRS CPE must register with an evolved packet core (EPC) to manage connections and capacity across the RAN. The $1,200 Wi-Fi access point costs are typical for commercial grade, outdoor units capable of mesh interconnections. The ratio of Wi-Fi access points to CBRS CPE is variable but three is a reasonable average. Each end-user location would need at least one CBRS CPE.

Table 7-3. SSFBU Wi-Fi Access Network Capital Expense

Item	Cost	Units	Total Cost
CBRS CPE cost ($356 equipment, $350 labor)	$706	15	$5,400
EPC Access Fee Per CPE (One Time Fee)	$35	15	$525
CBRS CPE Installation	$200	15	$5,250
Wi-Fi Access Points	$1,200	45	$54,000
Wi-Fi installation	$200	45	$9,000
		Subtotal	$74,175
Engineering, Project & Construction Mgmt.	15%		$11,126
	Total Estimated Cost		**$159,476**

Total Deployment Costs

The total deployment costs for the new fiber, CBRS, and Wi-Fi deployment are approximately $634,233, as detailed in the table below.

Table 7-4. Total Network Deployment Costs

Network Component	Cost
New Fiber	$240,157
CBRS	$234,600
Wi-Fi	$159,476
Total	**$634,233**

Monthly Costs

Monthly operating expenses for this design are just over $3,000, detailed in Table 7-5, including utilities for CBRS cell sites and pole attachments for CPE and access points. CBRS CPE must be part of a spectrum access system (SAS), which are available as a software service, to manage radio spectrum and ensure users do not interfere with each other. Tower rental and utilities are approximate. While tower rental is not included in this design, it may be required to expand the SSFBU network.

Table 7-5. SSFBU Network Estimated Monthly Operating Expenses

Item	Cost	Units	Total Cost
Tower Rental for Commercial Towers	$1,000	-	$0
Utilities	$100	3	$300
PG&E Pole Mount Costs	$30	30	$900
CPE SAS cost	$3	15	$45
Internet Data	$1,500	1	$1,500
		Subtotal	$2,745
Contingency	15%		$412
	Total Estimated Cost		**$3,157**

This design is for fixed wireless CPE. CPE could be moved reasonably easily, and the network would accommodate temporary installations—Wi-Fi for a block party or movable surveillance cameras, for examples. The CBRS network could, in concept, support mobile connections with an enhanced, and quite a bit more costly, EPC. Wi-Fi does not support fully mobile devices, but this design would allow users to stay on a particular Wi-Fi SSID as they move between access points. As mentioned above, SSFBU should have a captive portal and other administrative systems to deliver value-adding content and manage Wi-Fi connections and users. The upfront and recurring costs of such software are highly dependent on context and specific requirements, which are beyond the scope of this study. We recommend budgeting $50k to establish and $2k for monthly recurring costs.

Revenue Opportunities

There are three relatively small revenue opportunities for SSFBU. These opportunities are optional and we note that in order to avoid additional staffing requirements and certifications, the City should partner with a third party ISP partner to directly provide services in exchange for a negotiated revenue share with the City.

The first revenue opportunity is to lease network infrastructure to private entities. Under this model businesses and households could lease equipment that SSFBU would install and maintain. Baseline internet access via Wi-Fi would be included.

A second opportunity is to charge for “enhanced access” via the captive portal. Exactly what “enhanced access” means is to be determined, depending on policies for baseline access. There could be caps on bandwidth, data quantity per month, or types of services (e.g., no streaming video or gaming). Users may pay a monthly fee to eliminate these restrictions. We do not recommend establishing a full broadband operating system with

means to provision services and manage subscribers due to the substantial costs and staffing requirements.

The third revenue opportunity is to provide value-adding content, including advertisements, via the captive portal. Reasonable estimates for revenue from these opportunities, as shown in Table 7-6, are less than $500k per year, meaning that it would likely take a few years for the City to see a return on investment from the capital costs to deploy the network.

Table 7-6. SSFBU Estimated Revenue Opportunities

Item	Monthly Cost	Quantity	Amount
CPE lease	$100	200	$20,000
Enhanced access	$15	1000	$15,000
Portal content	$100	10	$1,000
		Monthly total	$36,000
		Annual Revenue Estimate	**$432,000**

Staffing

There are no additional staffing requirements for the implementation of this plan. We recommend that South San Francisco develop a partnership with a wireless operator to install and maintain the network wireless equipment via a contract managed by IT. As previously stated, the programming and governance considerations for the community Wi-Fi network could be overseen by the Library's Community Learning Center or the Community Development Program while IT continues to manage the contract with the selected partner for equipment leasing and installation and operation and maintenance of the network.

7.3 FUNDING OPTIONS

Because much of the available grant and loan opportunities are targeted at rural communities, the funding options for South San Francisco using federal and/or state programs are very limited.

The most promising option for funding is the use of American Rescue Plan Act (ARPA) money, for which the final rules, which are favorable toward broadband, have recently been published. The rules, which should be reviewed by the City's Finance team, provide the City with broad discretion for using the funding for broadband infrastructure. South San Francisco has already set aside $2 million of ARPA funds to be used for new fiber.

Although no other Federal opportunities exist, the City should closely track funding through the Coronavirus Capital Projects Fund, of which $540 million will be distributed to the State of California. This money will be used by the state for a broad range of infrastructure projects, including broadband, and we expect for state grant rules to be released sometime in mid-2022.

8. Recommendations & Next Steps

South San Francisco's current broadband coverage and offerings are enough to support the needs of residents and businesses. Speeds that exceed those needed for remote learning, working from home, telehealth, and daily connectivity are currently available to 99% of all residents through a variety of service providers, although in some areas, such as Westborough, choice of provider is limited. Businesses, especially those in Oyster Point, have multiple options and are generally satisfied with the state of their broadband. There are multiple long-haul fiber providers connecting South San Francisco to data centers in San Francisco, San Jose, and Oakland. Through fiber routes, these data centers connect South San Francisco to the world and any future applications that would benefit the City.

Despite the sufficiency of the infrastructure and offerings in the City, however, affordability is an issue. South San Francisco's residents have sufficient offerings but higher bandwidth service offerings are cost-prohibitive for low-to-moderate income users. The COVID-19 pandemic highlighted this issue as multiple residents competed to perform remote activities at the same time, forcing students to seek internet connections at libraries, boys' and girls' clubs, and parking lots to complete homework and distance learning.

To address the lack of affordable broadband options, South San Francisco should take a number of steps to ensure that its residents have the connectivity they need to thrive. The City should leverage its existing infrastructure to deploy a relatively low cost South San Francisco Broadband Utility as a community amenity that ensures equity of access. The network, as described in this Plan, will require a minimal amount of new fiber and wireless equipment, keeping costs low and providing a flexible option that fits within the City's current operational capacity.

This new utility should be operated through a partnership with a qualified wireless internet service provider, eliminating the need for ongoing operational expenses. This partnership should include a revenue sharing agreement between the City and its chosen partner and an enterprise fund should be established for the program. Additionally, the SSFBU should include programming and governance considerations handled by an agency with roots in the community and integrated into existing digital literacy and digital equity efforts, with oversight a board of departmental representatives supplemented by a community advisory committee to ensure effective community impact.

NEXT STEPS

1. While we do not recommend that the City of South San Francisco build a Citywide fiber-to-the-home network or become an internet service provider due to the saturation of the broadband market, the City should leverage its existing assets to create a South San Francisco Broadband Utility that provides wireless connectivity throughout the City. South San Francisco should partner with a qualified wireless network operator to oversee the maintenance of the network and digital inclusion programs should be integrated into the City's governance structure.
2. Use existing city-owned fiber optic cable, including the new fiber being placed from the downtown area to Highway 35, Skyline Boulevard, to support better broadband and cellular coverage in the Westborough neighborhood. Encourage and partner with the cellular providers to increase the coverage in the Westborough neighborhood, leveraging the City-owned fiber cable on Westborough Boulevard. The chief complaint of the Westborough neighborhood is a lack of cellular/mobile coverage and a lack of choice for broadband service. During talks with internet service providers, cost to build to Westborough, especially crossing Highway 280, is too expensive to make it worth expanding in the area. Therefore, City should use its fiber assets to alleviate this barrier and bring better coverage in Westborough by allowing the use of City-owned fiber through leases or other agreements.
3. Deploy two new underground fiber routes at Sign Hill tower and crossing Skyline Boulevard to support a CBRS system. These routes will cost approximately $240,000 and should be constructed as soon as possible to support the citywide CBRS and Wi-Fi that will allow the City to offer services to the community.
4. Deploy three new CBRS access points, one in the Westborough area, one on Sign Hill, and one at City Hall. These towers will be used for deploying high-speed broadband to different types of apparatus including Wi-Fi antenna, fixed wireless, and mesh networks requiring gigabit data transfer.
5. Provide for the expansion and deployment of wireless antennas in the low-moderate income areas of the City to create a South San Francisco Broadband Utility. The City has deployed 11 access points on Linden Avenue providing free outdoor Wi-Fi with great success and is well received. These areas need affordable broadband, and deploying free Wi-Fi in these zones will enhance the ability to access broadband and aid families. School-aged children, teenagers, working parents, and anyone will have the ability to access broadband without needing to go to community centers or libraries for internet access.
6. Establish an enterprise fund for operating the network and enter agreements with qualified internet service providers for revenue sharing. Sharing revenue through

a third party partner will not require the City to become an ISP, become certified with the CPUC, or provide staffing. The program should be governed by a board of departmental representatives supplemented by a community advisory committee.

7. Support digital inclusion programs. The City should support ongoing digital inclusion efforts by the Library's Community Learning Center, as well as exploring other digital literacy programs and groups such as National Digital Inclusion Alliance, the International Telecommunications Union, makers spaces, and other successful programs. These programs should be integrated into the governance of the Citywide Wi-Fi network, overseen by an advisory group, to ensure the most community impact.
8. Continue existing Dig Once policies and practices and consider adding a separate fund for maintaining and expanding the City's conduit and fiber systems as opportunities arise. A good starting point for this fund is approximately $250,000, to be replenished annually as needed. Should there be an increase in spending needed in any one year, we recommend using unspent capital improvement funds for street maintenance temporarily with repayment during mid-year or year-end budget processes.

Appendix A: Additional Technologies and Trends

The FCC currently defines broadband as a minimum of 25Mbps (megabits per second) download and 3 Mbps upload, which can be delivered by any of the means above. Underserved areas are those census blocks that are not supported by the minimum speeds. To apply and receive federal monies and grants this is the 25/3 is the definition that has to be met to be considered underserved. Some states are setting their own standards and in California it is being set at 100 Mbps symmetrical, meaning up and download speeds are the same.

The primary modes for delivering "wired" broadband services are DSL (digital subscriber line), Cable (coax), and Fiber Optics (Fiber). Broadband over powerline (BPL) has been in development for many years however, it has not yet been proven as a viable option. It is assumed that the demand for broadband will continue to increase, and the 25/3 FCC definition will not be sufficient. Several communities are targeting a 1 gigabit per second (Gbps) symmetrical and above to meet the demand.

DSL uses twisted pair, largest existing infrastructure, but it has been proven to be inadequate. Coax can meet the download speeds but does not offer symmetrical speeds. See chart below. Some wireless technologies are getting closer to meet the Gbps speeds as long as it is being incorporated with the use of Fiber optics to provide the bandwidth to each antenna.

Fiber is considered to be "future proof" infrastructure. Simply put, after fiber is placed as the infrastructure medium it will not have to be replaced with a new one in the future. Although the construction costs are substantial, in the long run fiber will be the cheaper choice. The maintenance is comparatively easy and . Fiber networks are the easiest to operate requiring a Network operations center (NOC) for monitoring the system and provide troubleshooting and on demand system analysis. For future growth and more high-speed circuits, the only upgrades will simply be the electronics and equipment on either end of the fiber.

The use of light makes the signal not affected by electrical services. All analogue and digital (copper-based communications), are susceptible to errors from electronic induction and must be constructed at least 4 feet away. Fiber, being light, is not affected by and can be placed in the same conduits as even high-voltage electrical lines.

Wireless technology today is pervasive in our work, homes, and wide area geographical locations. We depend on it for voice, video, and data communications. The foundation for wireless technologies are the governing bodies, FCC in USA and

EU in Europe, and the standards bodies like 802.11 and 3GPP. The spectrum used for wireless is divided into 3 different categories.
These are licensed, lightly licensed, and unlicensed bands.
Compared to the other deployment options wireless can be very economically constructed. It does have a fair amount of equipment maintenance as well as line of sight maintenance. Line of sight is dependent being able to “see” the antenna that is being communicated with. From foliage growth, new construction, storm damage, pole/tower damage, or even animal interference, the line of sight has to be maintained.

LICENSED BANDS

The majority of todays licensed bands are the cellular 4G and 5G systems. Frequencies are purchased at auction or allocated by the government and cellular carriers have exclusive use of the frequency bands allocated to them. AT&T, Verizon and T-mobile all hold different bands. These licenses are granted on a wide geographical area, even nationwide. The cellular carriers around the world have adopted the standards proposed by the Third Generation Partnership Project (3GPP). This international standards body develops the standards for the way cell phones communicate with one another and the internet. The standards committee is composed of cellular carrier representatives, government bodies and equipment manufacturers.

3G was designed primarily for voice communications and SMS (texting) service. It still exists in many countries.

4G LTE is the predominant current standard. Its main use case is high speed mobile data. It does support voice and text services, but primarily was designed to transmit high speed data to mobile users. The 4G system is widely adopted and today operates in bands all over the world. These bands are lower than 6 GHz. With some of that spectrum becoming fully utilized, the telecommunications industry developed new plans for a NR (New Radio) band commonly called 5G.

The 5G system changed the architecture of the cellular networks. It had 3 primary use cases driving the design. First was continuing and increasing the mobile broadband data that 4G provides, second was a fixed wireless use case where the cellular operators want to challenge the cable operators providing internet data to homes today with a wireless service and third is an ultra-low latency use case. This is to be used for self-driving cars and other services that require immediate response. 5G also utilizes frequencies up to 36GHz. These frequencies that are in the higher bands have short range but can carry incredible amounts of data. 5G architecture also changed the way the cellular core systems work. Previously all information was passed through a common core. In 5G the

core is divided into “slices” and can have priority applications running on different slices. This enables greater privacy, security and prioritization. Also the core can be run as a web service “in the cloud”. Major vendors are implementing this service since most everything today is more data and less voice. Also in 5G the number of users that can be supported was greatly increased to target Internet of Things markets.

There are also licensed bands for public safety that usually employ narrow low speed channels that are delivered with high power for long range and reliability. The latest standard in these bands is P25. This is the band where Motorola, Harris and others run Push to Talk radios (PTT). These frequencies are at 450 and 900 MHz bands. Utility companies also use these licensed bands for controlling SCADA systems.

LIGHTLY LICENSED BANDS

The FCC has also created lightly licensed bands. The owner and location of equipment operating in a lightly licensed band must be registered with the FCC. There may be different requirements for installing them. The 4.9GHz spectrum that was originally dedicated to public safety was a lightly licensed band. Citizens Broadband Radio Service (CBRS) has portions that are lightly licensed. CBRS has 15 10 MHz wide channels in each county. The FCC auctioned off up to 7 channels in each county and left 8 as lightly licensed. The location, power, antenna orientation and height along with owner information must be registered with the FCC but entities do not have to pay for the frequency usage. This band is for broadband data. Operators are not required to use LTE in this band, but most equipment does adhere to that 3GPP standard. So, 7 channels are exclusively licensed to entities and eight are lightly licensed shared channels. Also, the usage of channels is coordinated by an entity called the Spectrum Access System (SAS). The lightly licensed users (Called GAA) can access any portion of the 15 channels that are not in use at the time. The SAS helps GAA users share channels in any given area where 2 entities want to deploy a network.

UNLICENSED CHANNELS

The FCC and other worldwide organizations set aside multiple bands to be completely unlicensed. There is no notification required to put up and operate a device in these bands. They are unlicensed bands at 900 MHz, 2.4 GHz, 5.8 GHz, 24 GHz and 60 GHz. The FCC and other organizations worldwide do specify the power output these devices can transmit. All devices operating in these bands in the USA must be certified by an FCC appointed test organization for power output and adjacent channel interference. The 802.11 standards organization, made up of wireless equipment manufacturers and chipset vendors, creates the specifications and protocols for the unlicensed bands. All

the Wi-Fi access points are created to meet the various 802.11 standards. There were so many that the group decided to go to 1 number like Wi-5 or Wi-6 rather than 802.11 a/b/g/n/ac/ad/ax. These devices run everything from our in-home Wi-Fi, Bluetooth connections, Point to Point radio, and fixed wireless point to multipoint radio supplying internet to remote areas. The 802.11 standards encourage and specify a "Listen before talk" protocol to promote band sharing, but it is not required. In listen before talk a device listens on a channel for a moment. If quiet, the device transmits. If someone else talks at the same time and collides, both senders back off for different random intervals and try to listen and talk again. This is effective unless there are lots of devices crowded together all trying to talk. The 24 GHz band is mainly used for PTP narrowly pointed channels to avoid interference. The 60 GHz bands are also very narrowly pointed channels. Facebook Terragraph utilizes this band for backbone communications.

WI-FI

Wireless technology that is used to connect computers, tablets, smartphones and other devices to the internet.

Wi-Fi is the radio signal sent from a wireless router to a nearby device, which translates the signal into data you can see and use. The device transmits a radio signal back to the router, which connects to the internet by wire or cable. Connections to Wi-Fi networks require the use of a SSID and password.

One use of Wi-Fi is for indoor wireless deployment. Most homes have broadband to the house in one of the various ways and goes into a wireless router and deployed without the use of wires throughout the residence. The strength of the signal in the residence is dependent upon the interferences (walls, roofs, concrete) between the router and the device using it. The more the interference the weaker the signal.

SATELLITE BROADBAND

is network connectivity provided through low-earth-orbit (LEO) or geostationary satellites, with the latter providing much faster data rates. Satellite broadband enables Internet access via satellite in two steps with similar requirements of wireless. There is a transmit and receive unit at the end user's location that sends and receives signals from one of the LEO satellites.
Satellite communication has some technical limitations in comparison to the traditional deployment methods. The most prevalent of these are: Signal latency, Rain Fade, and Line of Sight. The latency, time delay, is due to the distance the signal has to travel, from earth to space and back to earth. Emerging technologies are helping to make

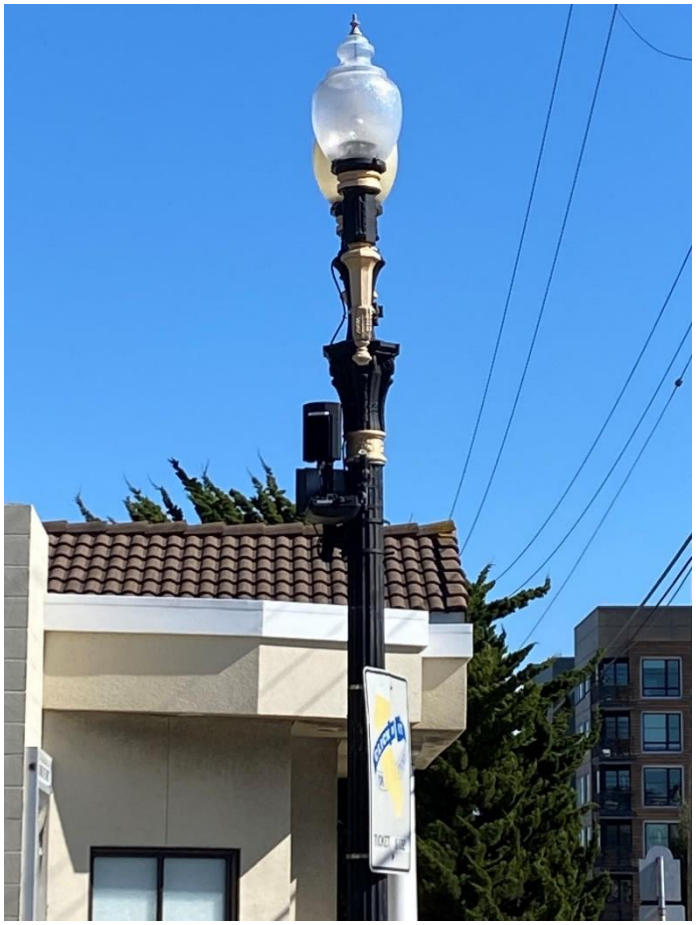
satellite communications a possibility. Rain Fade refers to the moisture in its various forms that are in the signal path between the end user and the satellite being used. The faster bands, K_u and K_A are most affected by rain fade. The final main drawback is line of sight. The end user must have a straight line without interference to the satellite. From forested areas to mountains, there is a limited number of end users that can use satellite broadband. Satellite communication offers a wide variety of features as well as some technical limitations compared to traditional broadband Internet services. Satellites placed in geostationary orbit can deliver Internet speeds of about 0.5 Mbps. However, the speed is limited to 80 Kbps on transmissions from the user. In rural areas, this speed is typically more than what is available through other means. The greatest advantage of satellite broadband is that it can be quickly established on a mobile device that is less prone to attacks or a natural disaster.

We enjoy the reliability of licensed channels that provide great coverage, low latency, and throughput like 4G LTE. There is more and more demand for increased capacity and speedier reaction time (latency) so 5G was planned and implementation has begun. It would be difficult to imagine life without all our headsets, home networks, business connections and outdoor gatherings without our unlicensed wireless connections.

Appendix B: Wi-Fi Streetlight Location Photos

Below are sample photos of Wi-Fi devices placed on City-owned streetlight structures. These serve as examples of Wi-Fi antenna that blend nicely and does not detract from the decorative nature of the streetlights.

Figure A-2. Wi-Fi Streetlight Location Photos




DIVERSITY
PARKING ONLY