City of Salinas Broadband Plan Update

24 May 2019

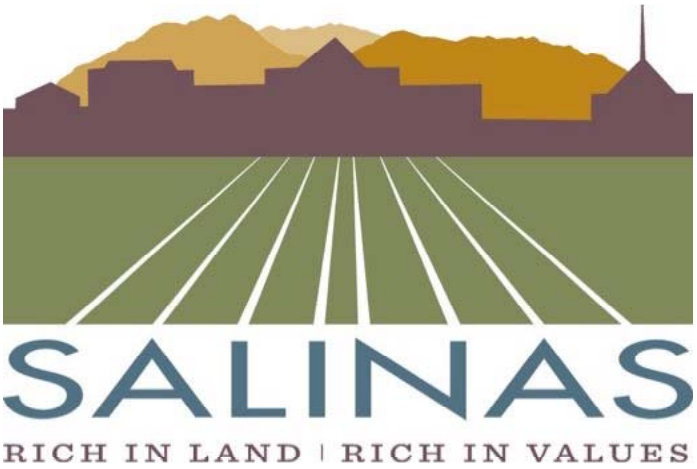

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Table of Contents

1. Executive Summary

The City of Salinas has adopted broadband-friendly policies during the past four years, and consistently pursued the development of better broadband availability and upgraded broadband infrastructure. During that time Salinas' broadband infrastructure grade has improved significantly from “C” (2.0) to “C+” (2.3).

Generally broadband infrastructure in the City of Salinas is above average, as compared to California as a whole, and above average compared to other communities in Monterey County. This achievement is particularly notable because the 2019 grading criteria is significantly more stringent, due to higher average service levels in California and the need for greater broadband capacity and speeds.

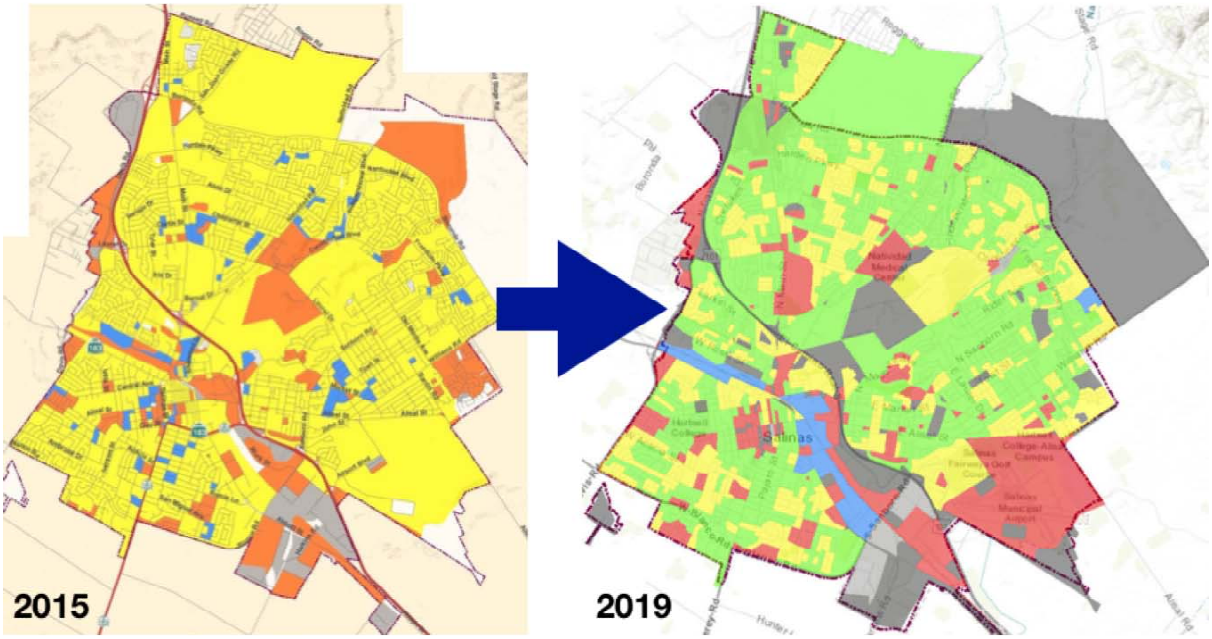


Figure 1.1 – Salinas Broadband Report Card: yellow “C” turns to green “B” in four years; overall grade improves from “C” (2.0) to “C+” (2.3).

This study also finds:

- The quality of broadband infrastructure and the level of service available to Salinas residents depends on how much money they make. There is a median household income gap of more than $10,000 between people with access to average or better broadband service and those without, and between people that AT&T and Comcast have chosen to serve and those they do not.

- AT&T and Comcast are the two primary telecommunications carriers in Salinas and offer broadband service to nearly all homes and businesses, on generally the same terms and at the same or better service level as elsewhere in California. Nearly two-thirds of Salinas residents either have access to, or are located near access to, AT&T highest level of DSL-based service, and nearly all have access to Comcast’s highest level of cable modem service. This represents significant

infrastructure and service upgrades by both companies since 2015. It should be noted, however, that actual performance typically does not match advertized service claims.

- The most recent field test data (September 2017) collected by the California Public Utilities Commission indicates that mobile service in Salinas is substandard. Since then, several mobile broadband companies have engaged in negotiations with the City to upgrade infrastructure and service, and the City has adopted policies to encourage this kind of investment.

- Salinas is served by an increasing number of intercity and metro fiber optic routes that provide connections to major Internet exchanges. In the past three years, one major intercity route, owned by Crown Castle (formerly Sunesys LLC) and one large scale metro network, owned by Extenet, were deployed in Salinas.

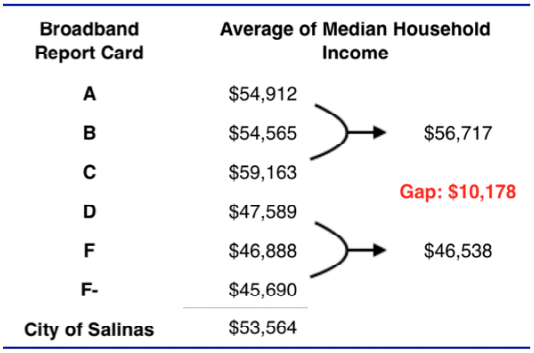


Figure 1.2 – Salinas' Digital Divide: lower grade broadband corresponds to lower income.

- The City embarked on a municipal fiber project in Downtown Salinas that will connect to at least one major intercity fiber route, providing access to wholesale Internet bandwidth that can support economic development and municipal operations. This municipal fiber network will support the City's economic development goals in the Downtown and Alisal Marketplace area and, through extensions or interconnections, has the potential to support the Agricultural Technology Corridor in southeast Salinas, and the development of the East Salinas/Alisal community.

- Combined with existing metro fiber and/or new City construction, the new municipal fiber network can be extended to the North Salinas area, and support competitive fiber-to-the-premise broadband service in newly constructed homes and businesses. Development conditions can be adopted that require the installation of conduit and, perhaps, fiber optic facilities to support competitive, FTTP service.

Taken together, these findings show that the City successfully implemented a broadband development program over the past four years that resulted significant improvements in broadband availability, capacity and bandwidth for consumers and businesses, and provide valuable support to economic development efforts.

This study concludes that current broadband development policies and programs be continued. Additional steps recommended for adoption by the City include:

1. Develop and implement a business plan for operation of the City's new municipal dark fiber network, including an open access policy, operations and maintenance procedures, published rates and interconnection agreements.

2. Develop a roadmap for growing the municipal network, either through extensions or interconnections, to reach the East Salinas/Alisal area, the Agricultural Technology Corridor and

the North Salinas area, and for extending the coverage of the network in the Downtown and Alisal Marketplace areas.

3. Leverage the City's fiber and wireless assets to help address the City's broadband infrastructure and service gap by offering incentives to wireless and wireline companies to expand service and infrastructure upgrades across the entire city.

4. Coordinate municipal fiber development with the City's wireless asset leasing program, and work with mobile carriers and infrastructure companies to increase access to both fiber-based and wireless broadband service.

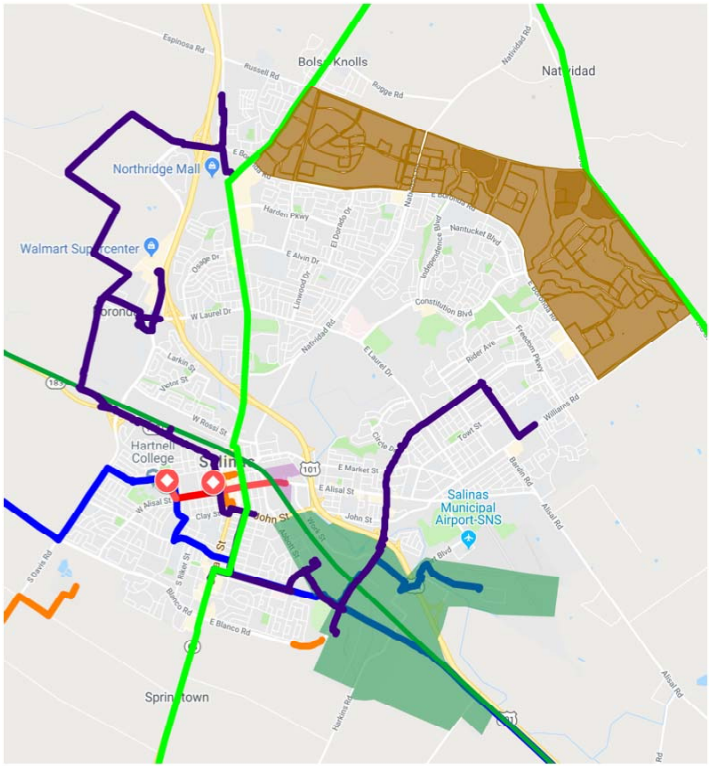


Figure 1.3 – Expanded fiber optic routes and economic development opportunities in Salinas.

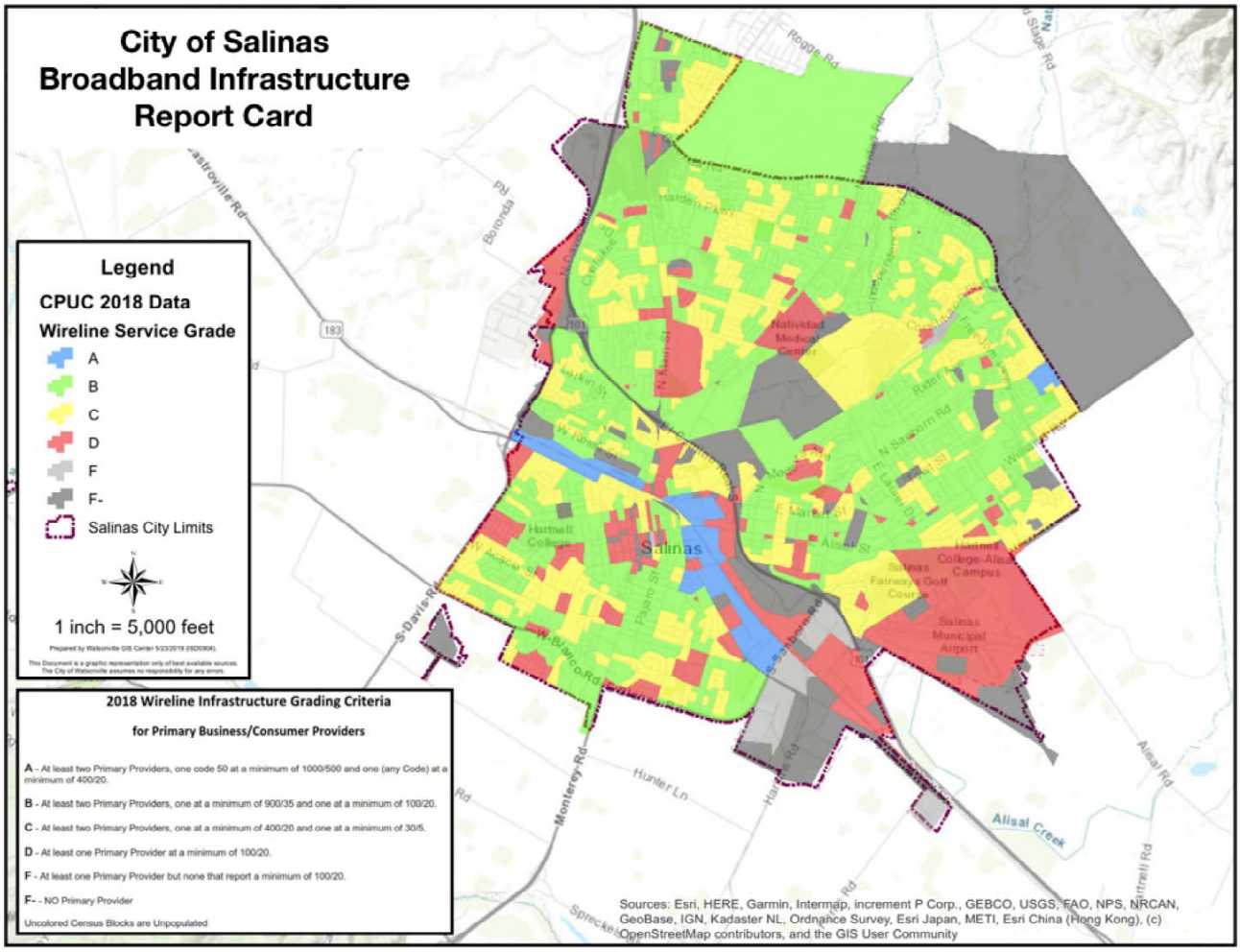
5. Establish and implement broadband conduit and fiber installation conditions for greenfield residential, commercial and industrial development, and develop a business plan for using these expanded resources to improve broadband access for all Salinas residents.

2. Commercial broadband infrastructure in Salinas

2.1. Infrastructure overview

Access to acceptable levels of broadband service will determine whether or not a community develops a vibrant and green economy that provides living wage jobs, prepares its students for the careers of tomorrow, and delivers social, public safety and healthcare services.

Broadband access is as essential as electricity or water to the effective functioning of businesses and government. It is likewise a necessity for residents. When broadband is unaffordable or unavailable, people, businesses and institutions are denied twenty-first century opportunities and suffer a lower standard of living. Broadband cost and availability is one of the first criteria assessed when businesses consider relocating or expanding. It is considered to be a non-negotiable resource that is necessary for businesses to operate and to keep pace with global competitors.



"Broadband" refers generally to any telecommunications service capable of supporting digital data transmission at high speeds. These services can include and/or support Internet, television, telephone, private data networks and various specialized uses.

A study conducted in 2018 by the Central Coast Broadband Consortium (CCBC) and the Monterey Bay Economic Partnership (MBEP) of the three-county Central Coast region (Monterey, San Benito and Santa Cruz counties) determined that the minimum broadband speed level required by both consumer and commercial users is 100 Megabits per second (Mbps) download and 20 Mbps upload[1]. This contemporary standard sharply contrasts to the 6 Mbps download and 1 Mbps upload speeds that the California legislature considers to be adequate residential broadband service and the Federal Communications Commission and the U.S. Department of Agriculture standard of 25 Mbps download and 3 Mbps upload speeds.

Consumer-grade Internet access is typically a shared resource, with many subscribers contending for the same bandwidth, and is subject to speed, capacity and monthly data limits as determined by the provider. This type of service often meets the needs of small and medium businesses, but not always. And it is generally inadequate for larger companies, which need commercial and industrial grade broadband facilities.

"Commercial grade" service is defined as being similar to residential service in that the provider takes effectively all responsibility for installing, maintaining and supporting the service. Speeds are similar or higher. Quality levels, reliability, consistency and pricing are higher than residential service, although essentially the same infrastructure is used. Both Comcast and AT&T offer commercial grade service.

Figure 2.2 – Fiber optic conduit construction.

"Industrial grade" service refers to service where the customer plays a much greater role in building and supporting the necessary facilities, including buying different elements from different vendors and managing installation and support. Speeds would be higher – there is effectively no limit except cost – and quality of service levels can be as high as the best found in top tier Internet exchanges. DS-3 circuits, dark fiber strands and dedicated Internet access via data centers are examples of industrial grade service.

[1] *Achieving Ubiquitous Broadband Coverage in the Monterey Bay Region*, Monterey Bay Economic Partnership, November 2018.

It is much easier for primary broadband service providers such as AT&T or Comcast to make a business case for recovering construction and operating costs in urban and suburban residential areas, which have a high density of potential customers. Standardized equipment can be used to provide a managed level of service, and each home can be offered a wide range of products including Internet access, television programming and telephone service. It is a predictable business, and capital investments can be made with a reasonable degree of certainty, recent decreases in cable television subscription numbers notwithstanding.

Industrial and commercial customers are much more diverse and less predictable. One business might need gigabit speeds at top "quality of service" levels, while the one next door is content with a standard, relatively slow DSL connection. As a result, incumbent carriers tend to approach commercial and industrial customers on a case by case basis or, as AT&T and Comcast are doing, be very selective in choosing locations to upgrade. They do not prospectively build high speed infrastructure. Businesses seeking higher grade service are frequently presented with installation estimates in the thousands and tens of thousands of dollars range.

Broadband service can be delivered in a variety of ways, including telephone lines (e.g. AT&T DSL), coaxial cable (e.g. Comcast cable modem), fiber optic cable, wireless cellular/mobile service (e.g. cell phones, tablets, wireless modems), WiFi, point-to-point and point-to-multipoint fixed wireless service and hybrid networks.

Although improvements continue to be made in the technology used to move data over legacy networks, the primary means of increasing speed is to build fiber infrastructure closer and closer to end users, so they can be directly served by such networks, but also to make copper wire and wireless links shorter, faster and more reliable.

The capacity of mobile data networks – AT&T, Verizon, Sprint and T-Mobile – continues to increase, however the demand for mobile bandwidth is also increasing. As with legacy copper networks, one of the primary means of increasing mobile capacity is to extend the reach of fiber backbones in order to build more cellular facilities and make the area covered by cell sites smaller and smaller.

2.2. Salinas's residential and commercial infrastructure grades

Wireline broadband infrastructure within the city limits of Salinas is better than average for California, receiving a "C+" grade (2.3) using criteria developed by the Central Coast Broadband Consortium (CCBC) and the Monterey Bay Economic Partnership (MBEP) in combination with the most recent broadband availability data submitted by Internet service providers to the CPUC, which is current as of 31 December 2017. It is significantly better than the typical broadband infrastructure found in Monterey County, which received an overall grade of "D+" (1.4). Salinas ranks 4th out of 30 incorporated cities and census designated places in Monterey County. More information on comparative rankings of Monterey County communities is in Appendix C.

The infrastructure grade of a census block is determined by the technology deployed and the broadband service level it supports, as reported by primary wireline carriers. Service level reports filed by providers should not be taken literally or on faith. Actual performance is typically less than claimed.

However, when companies make exaggerated claims, they tend to do so consistently. By comparing claims made in, say, Salinas by AT&T and Comcast, to the claims they make on a statewide basis, a comparative picture can be drawn of the infrastructure present.

A “C” grade means a census block has the most common wireline service choices found in California, typical of the standard packages offered by AT&T and Comcast: at least two providers, one offering service at a minimum of 400 Mbps download and 20 Mbps upload speeds and one offering service at a minimum of 30 Mbps download and 5 Mbps upload speeds. A “D” grade – below the Californian average – is given when this level of service is not available but there is at least one provider offering service at the 100 Mbps download and 20 Mbps upload level, which is the minimum standard for full participation in the 21st century digital economy identified by the CCBC/MBEP study. If no service meeting this minimum standard is available, a failing grade – “F” – is given. “A” and “B” grades are given where superior or above average service is offered. Details regarding the grading method are in Appendix C.

There are isolated pockets of poor infrastructure in Salinas, including along a largely industrial and commercial corridor that runs between the Union Pacific railroad tracks and U.S. 101, from East Market Street in the north to the city limits in the south, and extending south of Abbot Street and east of Blanco Rd. The data indicates that there is superior – “A” grade – service along the railroad right of way, but it appears to be the result of incorrect reports filed by a fiber company, Vast Networks. There are also pockets of substandard broadband infrastructure in commercial areas in the Downtown area, and in other locations scattered throughout the City. These particular census blocks received “D” and, in some cases, “F” grades.

Table 2.1 – City of Salinas Broadband Infrastructure Report Card

Grade	Census Bocks		Housing Units		Population	
A	9	1%	310	1%	1,075	1%
B	428	36%	27,357	64%	97,016	64%
C	383	32%	11,970	28%	41,699	28%
D	160	13%	2,320	5%	8,783	6%
F	7	1%	5	0%	9	0%
F-	201	17%	689	2%	1,859	1%
	1,188	100%	42,651	100%	150,441	100%

On the other hand, 36% of census block in Salinas, representing 64% of homes and population, have above average broadband infrastructure and received a “B” grade. These are census blocks where both Comcast and AT&T have deployed their highest level of cable modem and DSL-based service, respectively.

Table 2.2 – Broadband availability by primary wireline carrier

	Housing units	Population	Census blocks	Area (sq mi)
AT&T	41,471	145,730	911	15.9
	97%	97%	77%	69%
Comcast	41,951	148,551	964	17.2
	97%	98%	81%	74%
With at least 1 provider	41,956	148,567	975	17.8
	98%	99%	82%	77%
Salinas totals (per CCBC database)	42,651	150,441	1,188	23.2

AT&T and Comcast are the two primary wireline carriers and Internet service providers in Salinas. Both own and operate extensive fiber optic backbone networks (see maps in Appendix A) that are connected to copper lines (or, in one AT&T census block, FTTP/fiber-to-the-premise facilities) that ultimately deliver service to homes and businesses.

2.3. Digital divide

The quality of broadband infrastructure, and by extension the associated broadband service levels, correlates to household income, with . At the extreme, there is a $13,500 household income gap between census blocks that have service that meets the California average – a "C" grade – and census blocks with no broadband service at all – an "F-" grade.

The income gap between census blocks with average service or better ("A", "B" and "C" grades) and census blocks with substandard or no service ("D", "F" and "F-" grades) is almost as severe. Households located in census blocks with below average broadband infrastructure and service make $10,200 less than households that have access to the same or better level of broadband infrastructure that is available to the average Californian.

Table 2.3 – Broadband Infrastructure by Median Household Income

Broadband Report Card	Average of Median Household Income		
A	$54,912		
B	$54,565	→	$56,717
C	$59,163		
		Gap: $10,178	
D	$47,589		
F	$46,888	→	$46,538
F-	$45,690		

	Unserved	Served	Gap
AT&T	$44,554	$56,316	**($11,762)**
Comcast	$45,034	$55,546	**($10,512)**

Table 2.3 – Broadband Infrastructure by Median Household Income

Broadband Report Card	Average of Median Household Income	Unserved	Served	Gap
City of Salinas	$53,564			

The same gap exists when AT&T's and Comcast's deployment patterns are examined. Households located in census blocks where AT&T or Comcast do not provide broadband service make, respectively, $11,800 and $10,500 less than households located in census blocks where the companies do offer service at some level.

2.4. Comcast

Comcast claims to offer a uniform level of service in nearly the entire city (97% of homes and 74% of the land area in Salinas), but its ability to actually deliver the speeds it advertizes depends on the level of investment it has made in particular neighborhoods and the usage patterns of residents – the more people subscribing to and accessing the Internet in a given area, the lower the speeds each will receive. The network architecture used by cable companies typically results in hundreds of homes sharing a limited amount of broadband capacity. A customer might receive the advertized level of service at times, but only under ideal conditions.

Comcast reports uniform service availability of 986.5 Mbps download speed and 35 Mbps upload speeds using DOCSIS 3.1 technology, which is the most advanced cable broadband technology generally available. However, actual speeds experienced by both residential and commercial users will vary from that standard, depending on the age and condition of the lines, the number of users in a neighborhood and the overall capacity of the system.

Figure 2.3 – Comcast's claimed service area in Salinas.

Comcast has claimed that it offers service of up to 10 Gigabits per second (Gbps), which is equal to 10,000 Mbps, to businesses in the Salinas Airport area, which is generally in the Agricultural Technology Corridor, discussed below. The decision to focus on this area is similar to the strategy followed by secondary providers, who focus on serving commercial and industrial customers, also as discussed below. Details regarding pricing, including installation costs which can be anywhere from zero to tens of thousands of dollars, were not disclosed. The company's announcement referred to the new offering as "Ethernet service", which indicates it is a managed service that might or might not be partially delivered via existing copper lines (see Appendix F for a glossary of terms). Comcast's marketing claims also

characterized the service as “fiber-based”, however that does not necessarily mean that it utilizes 100% fiber-to-the-premise infrastructure. In fact, if that were the case, then it should have been emphasized, since it is a significant selling point. It is significant that Comcast has not reported actually delivering such service in its mandatory filings with Federal Communications Commission and the California Public Utilities Commission.

2.5. AT&T

AT&T provides broadband service throughout Salinas (97% of homes and 69% of the land area), but the level of service it provides varies greatly by neighborhood.

With the exception of one census block where it reports using fiber-to-the-premise (FTTP) facilities, AT&T uses various kinds of copper wire-based DSL technology to deliver service to homes and businesses in Salinas. Its reports of technology deployed and the range of speed levels offered (from 1.5 Mbps to 100 Mbps download and 384 Kbps to 20 Mbps upload) indicates that it uses a mix of its three mostly commonly used types: 1990s-style basic DSL, intermediate ADSL and the newest type, VDSL. According to AT&T’s reports, VDSL service is available in 92% of the census blocks it serves, although it is unlikely that every home and business in a given census block has such access.

Two major limiting factors in DSL performance are distance from the nearest hand-off point from the copper telephone lines that serve homes to fiber optic lines that connect to core network resources, and the amount and quality of those resources in any given location. Generally speaking, longer copper wire connections, and antiquated or poorly provisioned core resources result in slower speeds and poorer quality service that is often significantly worse than advertized.

The most common service level that AT&T offers, though, is 100 download and 20 Mbps upload speeds via VDSL technology, which is available to 65% of homes in Salinas. This level of service is above the average DSL service offered in California and generally corresponds to the census blocks in Salinas that received a “B” grade.

The one census block where AT&T reports using FTTP technology is in east Salinas and contains what appears to be recently constructed homes. It is common for telecommunications infrastructure installed in new home developments to be fully fiber optic-based because of the rising cost of copper and the falling price of fiber. AT&T has developed its fiber-based services to the point where it can offer gigabit-level service to isolated FTTP neighborhoods such as this one.

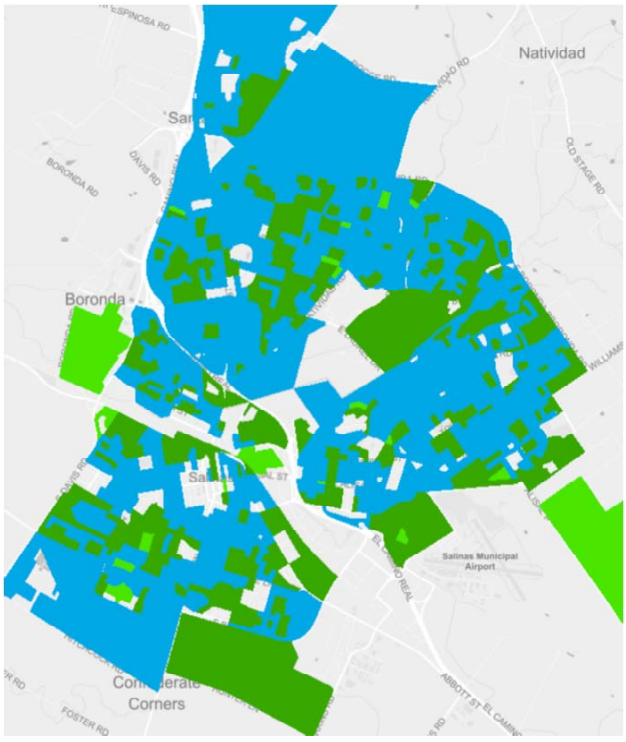


Figure 2.4 – AT&T’s claimed VDSL service area in Salinas.

AT&T claimed that it offers Ethernet-based

commercial service of up to 10 Gbps in the Downtown area and elsewhere Salinas, similar in nature to that offered by Comcast in the Airport area. This similarity includes the likelihood that customer connections are copper-based, rather than fully delivered by fiber-to-the-premise facilities. It is significant that AT&T has not reported that it actually offers that level of service in its regulatory filings.

Table 2.4 – AT&T service levels

Download (Mbps)	1.5	3	6	10	12	18	25	50	75	100	1,000		
Upload (Mbps)	0.384	0.384	0.512	0.6	0.512	0.768	5	10	20	20	1,000	Total	No service
Housing units	14	186	582	66	68	325	602	5,527	6,447	27,631	23	41,471	1,090
	0%	0%	1%	0%	0%	1%	1%	13%	15%	65%	0%	97%	3%
Population	63	670	1,985	251	189	895	1,919	19,477	22,226	97,937	118	145,730	4,711
	0%	0%	1%	0%	0%	1%	1%	13%	15%	65%	0%	97%	3%
Census blocks	1	11	28	3	6	23	21	204	181	432	1	911	277
	0%	1%	2%	0%	1%	2%	2%	17%	15%	36%	0%	77%	23%
Area (sq mi)	0.0	0.2	0.4	0.1	0.1	0.2	0.3	2.5	2.4	9.8	0.0	16	7
	0%	1%	2%	0%	0%	1%	1%	11%	10%	42%	0%	69%	31%

Customers are often asked to pay the costs of upgrading facilities to provide higher levels of services. AT&T did state that “any infrastructure work on a customer’s private property, necessary to complete the circuit installation” is “free of charge”, although no information was given regarding other applicable terms, such as the length of service contracts required. It is also likely that this offer only applies in certain circumstances, such as at particular kinds of commercial properties or locations where existing facilities have already been upgraded, or that are within a certain distance of key telephone company resources, such as particular nodes or central offices.

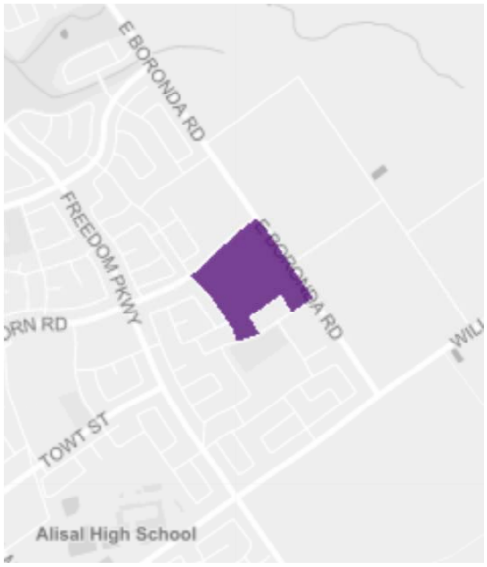


Figure 2.5 – AT&T’s sole reported census block with fiber-to-the-premise in Salinas.

Nationally, AT&T is extending the reach of its fiber optic networks directly to commercial properties in the central business districts of major cities, and reports healthy uptake so far. However, AT&T has also been candid in saying it will be very selective about where it builds new network infrastructure and it only intends to do so in locations where it can generate a high rate of return on its investments. Anecdotal reports from AT&T field service

personnel indicate that the company is moving ahead with further FTTP deployments in Salinas, which might be reflected in future regulatory filings.

2.6. Secondary wireline broadband service providers

Several second-tier companies offer broadband service in Salinas, either using copper lines leased from AT&T or via direct fiber connections, according to reports they've filed with the FCC and CPUC.

Zayo, Windstream, Verizon, TPx, Level 3 and Earthlink report offering business customers various level of service using leased copper lines. Level 3 provides FTTP service to one census block in Downtown Salinas and to another census block in the southeast corner of Salinas.

Table 2.4 – Maximum fiber-to-the-premise speeds (Mbps)

	Download	Upload
AT&T	1,000	1,000
Level 3	100,000	100,000
Vast Networks	10,000	10,000
TPx Communications	50	50
Windstream	120	8
Zayo	20	20

Windstream and Zayo each report FTTP service in one census block, Windstream in Downtown Salinas and Zayo in East Salinas. Both companies report speeds which are less than is typically associated with FTTP service. TPx reports FTTP service in ten census blocks, also with lower speed levels. As noted above, Vast's FTTP service reports are likely erroneous. See Appendix A for location details.

2.7. Intercity and metro fiber optic routes

Three intercity fiber optic routes currently connect Salinas to major Internet exchanges and data centers in the San Francisco Bay Area and southern California (see maps in Appendix B).

The largest route generally runs along the Union Pacific railroad right of way. At least three companies own fiber cables along this route: AT&T, Level 3 (now owned by CenturyLink) and Verizon. This route is primarily designed to connect northern and southern California, however a handful of access points exist in Salinas, mostly in the Downtown and southeast areas of the city. Many more companies lease fiber strands on these cables and offer various levels of broadband service to commercial, industrial and institutional users.

The second existing route comes into Salinas from San Juan Bautista, generally over the San Juan Grade. It splits north of Salinas, with one leg following Old Stage Road and connecting to the fiber routes along the railroad right of way near Spence Road, south of Salinas. The other leg continues into Salinas, generally along North Main Street, passes through the Downtown area, and continues via State Route 68 to Sand City. Both legs of this route pass alongside a major residential and commercial

development area in north Salinas. Two companies, AT&T and OpticAccess, own or control fiber cables along this route. OpticAccess has designated 24 strands for “metro” (i.e. local) use, which makes it suitable for connecting two points within Salinas, rather than being limited to to long haul connections between Salinas and northern and southern California.

Sunesys LLC (now owned by Crown Castle) constructed a new fiber optic route from Santa Cruz to Soledad. This route generally passes through Salinas from the west to the southeast, south of the Downtown area. It connects to long haul fiber routes to southern California in Soledad, and to its existing fiber route that connects Santa Cruz to Silicon Valley. Some of the capacity on this route will also be available for metro use.

The route is largely subsidized by a grant from the California Advanced Services Fund, and Sunesys is required by the CPUC to make dark fiber strands available at a price of $8.50 per stand per mile per month, with a $500 per month minimum, until 2022. Sunesys has also committed to offering gigabit-class “lit” services, ranging from a maximum of $700 per month for 1 Gbps to $3,000 per month for 10 Gbps. Several broadband service providers, including AT&T, Charter Communications, Cruzio and, apparently, TPx have connected to the Sunesys route and are using it to deliver service. As more companies take advantage of this resource, lower prices and/or a broader choice of service level offerings is likely to develop.

Beginning in 2016, Extenet constructed a metro fiber optic network that extends from North to East Salinas, through Downtown. This network was built to support upgrades to Verizon’s mobile network, but it also available to other users. See map in Appendix B for details.

2.8. Mobile broadband service

All four major mobile carriers – AT&T, Sprint, T-Mobile and Verizon – offer broadband service in Salinas. According to field tests conducted by the CPUC in September 2017 (the most recent data available), average mobile service in Salinas offers no better than 3 Mbps download speeds, and in some cases drops below 200 Kbps. See map in Appendix A for details.

Mobile carriers and infrastructure companies that support them have been actively pursuing upgrades in Salinas and have engaged the City in negotiations that may lead to significant improvements.

The capacity of mobile data networks – AT&T, Verizon, Sprint and T-Mobile – continues to increase, however the demand for mobile bandwidth is also increasing. There is no prospect for it to be a substitute for high capacity wired services. In fact, like legacy copper networks, one of the primary means of increasing mobile capacity is to extend the reach of middle mile fiber in order to make the area covered by cell sites smaller and smaller. Cost is also an issue for mobile networks. Typical monthly usage limits are adequate for smart phones and other hand held devices, but in-home use can be an order or two of magnitude greater leading to bills ranging from several hundred dollars to more than a thousand dollars a month.

Although improvements continue to be made in the technology used to move data over legacy networks – wireless or wireline – the primary means of increasing speed is to build fiber infrastructure

closer and closer to end users, in order to make copper wire connections shorter and enable the construction of more mobile cell sites.

As described below, the City of Salinas has established policies to encourage the further deployment of mobile broadband infrastructure and service. These policies are particularly important at the present time, as mobile carriers begin to deploy the next generation of broadband service, based on fifth-generation or "5G" technology, which will be deployed over the next ten years.

True 5G systems have two defining characteristics: they employ technology that meets international 5G standards and they supplement and replace large scale, third and fourth generation cellular sites with many smaller facilities mounted closer to the ground and to customers, often on light poles and utility poles.

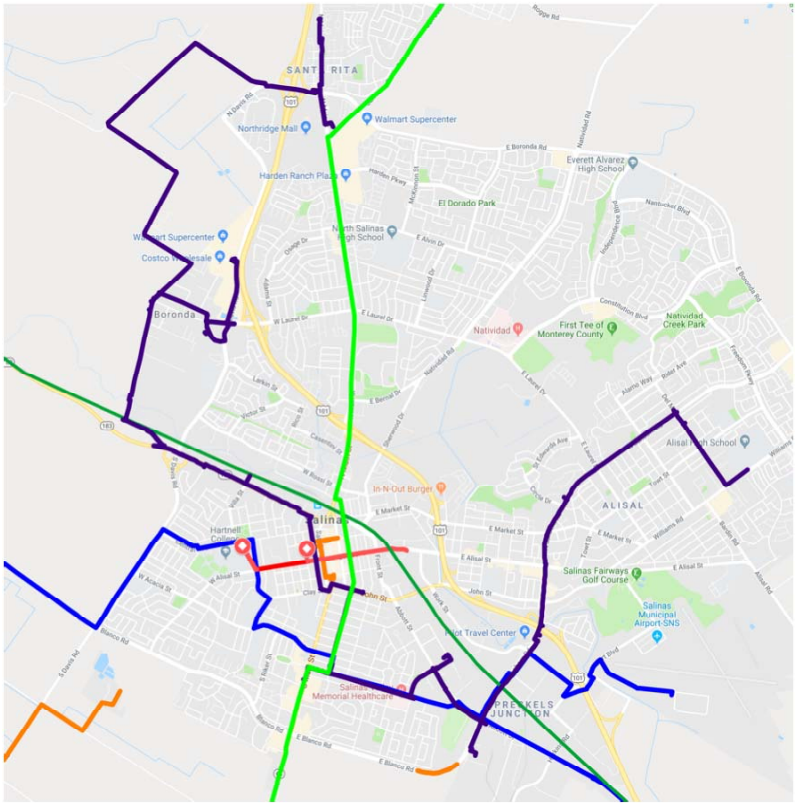


Figure 2.6 – Major intercity and metro fiber routes through Salinas. Blue = Sunesys, light green = AT&T & OpticAccess, dark green = north/south routes along railroad right of way, purple = Extenet, red = City of Salinas Municipal Dark Fiber Network, orange = City of Salinas conduit.

This "densification" allows wireless spectrum to be reused more often over a given geographical area and reduces the distance that broadband traffic needs to travel in order to reach access points and active components, such as routers and processors, that are deployed on the "edge" of networks. The result is significantly higher bandwidth capacity (at least ten times current capacity and speeds, and perhaps more), and less delay – lower "latency" – in transmissions, which allows for development of applications that are severely time sensitive, such as self-driving cars.

It should be noted, however, that 5G systems are a complement to and not a replacement for wireline broadband infrastructure and service. Although 5G systems will have significantly more capacity than current 4G systems, the demand for mobile broadband service is growing at an equally fast rate. A recent experiment by Verizon in Sacramento demonstrated the technical and economic limitations of using a 5G system to replace traditional residential wireline broadband service. The conclusion of the Wall Street analysts[2] who investigated Verizon's Sacramento experiment was that large scale, commercially competitive in-home broadband service delivered by 5G technology is not economically feasible.

[2] *Fixed Wireless Broadband: A Peek Behind the Curtain of Verizon's 5G Rollout*, MoffettNathanson Research, 20 March 2019, as reported in *Multichannel News*, 22 March 2019.

2.9. Other broadband service

One fixed wireless Internet service provider – Razzo Link – submitted service reports to the CPUC and FCC, claiming that it offers service in a few locations in Salinas, and many around the periphery, at up to 50 Mbps download speeds. Fixed wireless service is based on technology that uses a permanently installed radio link between two specific points or from a central hub to many different users.

Another local Internet service provider is RedShift, which is based in Monterey. It did not submit reports that could be validated by the CPUC, but its offerings include dial-up, re-sold AT&T DSL lines and fixed wireless service.

3. City of Salinas infrastructure and development

3.1. City-owned fiber and conduit

The City of Salinas has routinely added empty, city-owned conduit to public works projects that involve excavations, such as road construction. As a result, the City of Salinas owns underground conduit that can be used as the foundation of a fiber optic broadband network, and has plans to build more. In addition the City owns buildings, land, and right of ways throughout the city limits.

So far, the City of Salinas has built a total of 16,000 feet of broadband conduit that is available for use (see maps in Appendix B). Approximately 5,400 feet is in the core Downtown business district, 1,600 feet near the planned Agricultural Technology Corridor and another 9,000 feet in an unincorporated area southwest of the city.

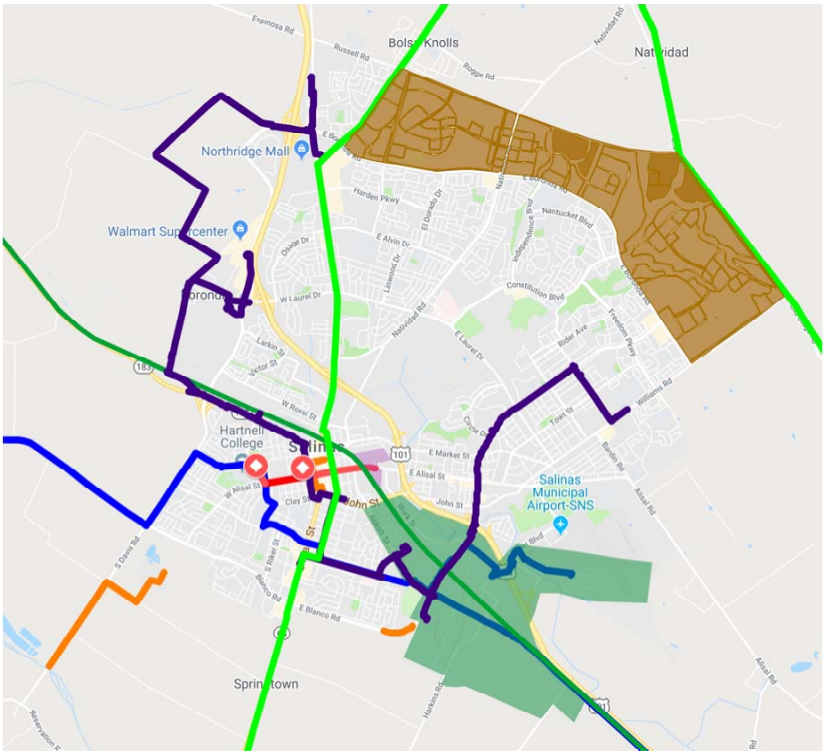


Figure 3.1 – Overview of fiber routes and city-owned conduit in Salinas. See Appendix B for more detail.

3.2. Downtown Fiber Optic Network

A new, City-owned fiber optic network is under construction in Downtown Salinas. It will extend from the new public safety facility on East Alisal Street, along East and West Alisal Street, to City Hall via Church Street, and to Hartnell College, where it will connect to the open access Connected Central Coast fiber route, which provides long-distance connections to major Internet hubs, via Soledad, Santa Cruz and inter-city fiber routes

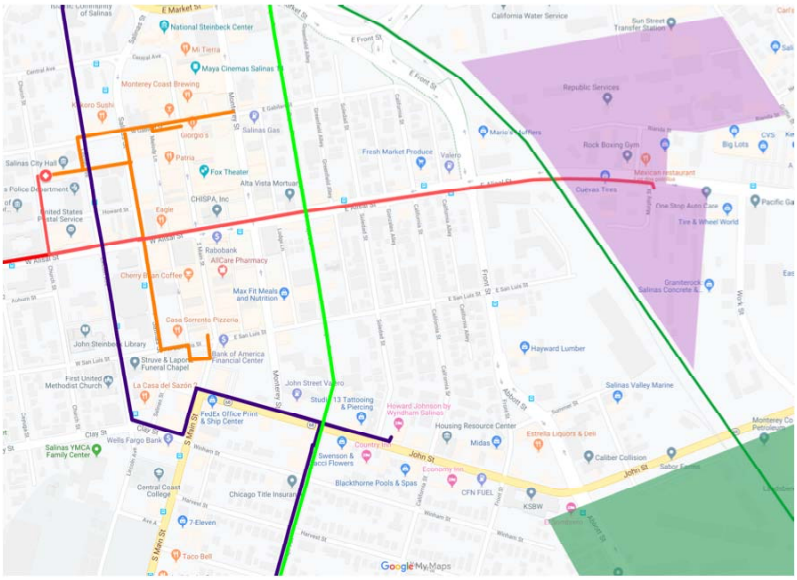


Figure 3.2 – Fiber routes and city-owned conduit in Downtown Salinas and Alisal Marketplace. See Appendix B for more detail.

which run along the Union Pacific railroad right of way in Salinas. Hartnell College has the option of leasing rack space and interconnection facilities to private sector service providers. Alternatively, the City can establish a colocation facility on City property.

The City of Salinas' primary municipal facilities, including City Hall and public safety agencies, are located in the Downtown area and will be connected to this network. Salinas is the county seat of Monterey County, and major facilities, including courts and county offices, are located in and around the Downtown area and will have direct access to the City's fiber network. The National Steinbeck Center, a transit hub and several new commercial developments, including the Taylor Building, are in close proximity to the City's fiber network and can be connected via relatively short lateral connections that may be newly constructed or be placed in existing conduit and ducts.

The City's network can be integrated into existing and future privately owned telecommunications facilities. This network intersects, and has the potential to connect to, the Extenet and Optic Access fiber routes. In addition to the city-owned conduit described above, the City owns streetlights and other assets in the Downtown area which can be leased to wireless broadband companies, including mobile carriers.

The City's network also reaches the Alisal Marketplace district, which is just to the east of Downtown, between the Union Pacific right of way and U.S. 101. Plans are underway to develop it into a mixed use environment, including professional office space, and commercial and residential developments. Lateral connections to the City's network can be included in redevelopment plans.

Figure 3.3 – Construction of Crown Castle/ Sunesys fiber route, connecting Salinas to Santa Cruz and Soledad.

The primary broadband infrastructure in Downtown Salinas is varied, with grades ranging from "A" to "F". The variance is primarily due to AT&T's decision not to deploy its most advanced VDSL technology in the principally governmental areas of Downtown and Comcast's less-than-complete coverage of commercial areas.

As described above, it is possible for larger companies in Downtown Salinas to purchase high capacity, commercial and industrial grade Internet service from specialty suppliers. However, the process for obtaining this kind of access is complicated and expensive. The City's new dark fiber network will be used as the basis for commercially-focused Downtown fiber service and support industrial-class applications as well.

The City will own this network and plans to operate it as a dark fiber enterprise, leasing surplus capacity to Internet service providers, other government and education agencies, and corporate users on industry standard terms. Those terms generally involve long term agreements – twenty years or more –

and an obligation to respond to service outages in a timely manner. As a practical matter, this service obligation should impose no significant additional burden on the City, because the network will also support critical City functions and must be maintained in a operational condition regardless of whether or not other users are present.

Lease rates may be set on a flat fee or per mile basis. A summary of municipal dark fiber lease rates and colocation terms, and a sample operations and maintenance responsibility matrix is in Appendix D.

3.3. Agricultural Technology Corridor

The southeast area of Salinas is being developed into a center for new agriculture-oriented technology companies, as well as the City's existing, core agricultural industry base. It extends from south of the Downtown area, generally between the Union Pacific right of way and U.S. 101, to currently unincorporated (and undeveloped) area south of the city limits. It also encompasses existing industrial developments located to the west of the corridor, and major facilities to the east, such as the airport, fiber network access nodes and Monterey County offices, including the county's information technology center.

The City received a $3.5 million federal grant to rebuild infrastructure in the area, in order to support more intensive use of existing industrial properties and the development of new ones.

This area is also well served by existing intercity fiber optic routes, as discussed above, and will be a major hub for the new Sunesys intercity and metro fiber route that is currently under construction. Together with the City's existing and planned conduit in the area, the Agricultural Technology Corridor will have an accessible fiber optic backbone. Lateral connections can be easily made, either as properties are built or redeveloped, or retrofitted with other construction techniques, such as microtrenching, as appropriate.

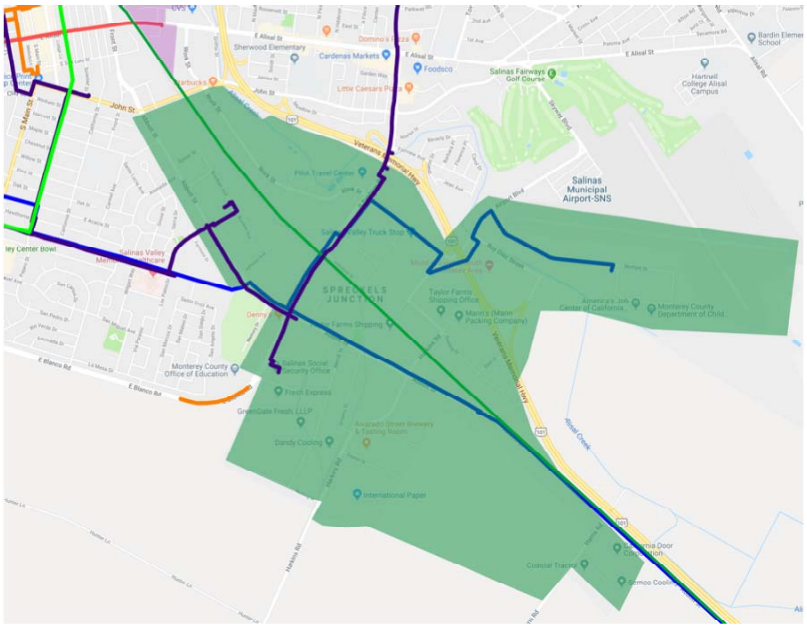


Figure 3.4 – Fiber routes and city-owned conduit in Salinas Agricultural Technology Corridor.

On the other hand, service from the primary incumbent broadband service providers is below the minimum standard determined by the CCBC/MBEP study in most areas of the Agricultural Technology Corridor. As mentioned above, Comcast does offer service near the airport, but there are significant gaps in its coverage of the area. AT&T's service levels are generally low and fail to meet the CCBC/MBEP standard, with upload speeds being particularly bad. The

inconsistent nature of Comcast's availability and the poor quality of AT&T's service indicates that existing broadband infrastructure in the Agricultural Technology Corridor is poor.

Although the agricultural operations in the Salinas Valley are outside of the City of Salinas' jurisdiction, connecting them to the Agricultural Technology Corridor is essential to its success. The intercity fiber routes that pass through Salinas on the way south are an important way of doing that. But wireless technology is also essential to the development of agricultural technology, such as centrally controlled smart irrigation systems, and can be an alternative means of providing connectivity to homes, farms and businesses, particularly in rural areas.

The existing fiber optic access points and routes, and planned new network construction in the Agricultural Technology Corridor can provide a solid foundation for extending wireless connectivity to the Salinas Valley. As noted above, the coverage and capacity of mobile networks depends greatly on the availability of long haul fiber connections, and the same is true for fixed wireless links. The Agricultural Technology Corridor can be the telecommunications hub for the entire Salinas Valley.

3.4. North Salinas

Undeveloped land, generally on the north side of East Boronda Road in north Salinas, is targeted for residential and commercial development. Plans include up to 15,000 new homes, as well as new business and office developments. As discussed above, the City has existing plans to include broadband conduit in street construction and improvement projects in the area, and intercity and metro fiber routes pass by two sides of it. City plans include construction of intersecting conduit along East Boronda Road.

As described above, it is common practice for fiber optic technology to be installed in new developments, instead of traditional copper wire infrastructure. However, as the experience with AT&T and Comcast in Salinas shows, incumbent service providers do not always use it to provide inexpensive, high speed service to residents, instead opting to maintain existing pricing and service plans.

Three cities in California have addressed this problem by requiring newly constructed or remodelled homes to include independent conduit and/or fiber optic connections in development plans.

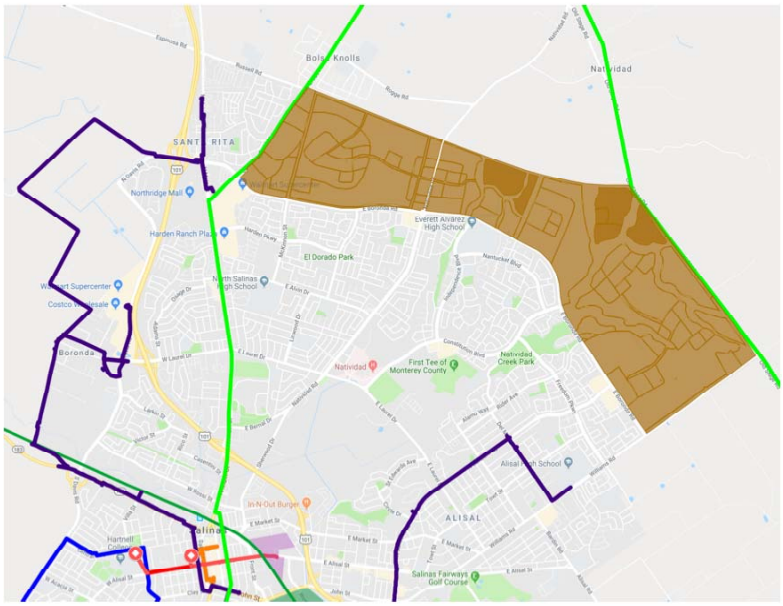


Figure 3.5 – Fiber routes and city-owned conduit in north Salinas.

The City of Brentwood requires new homes to be provisioned with two fiber optic conduits, one with fiber optic cable installed for the incumbent cable television company and the empty one deeded to the city. Brentwood subsequently made an agreement with an independent Internet service provider to lease the empty conduit, install fiber and offer gigabit Internet service to residents for $40 per month.

The City of Ontario has similar requirements for greenfield development, and goes two steps further by 1. requiring the installation of city-owned and operated fiber optic cables and supporting facilities, and 2. using this infrastructure to provide FTTP service via a public-private partnership with an independent Internet service provider.

The City of Riverside incorporated fiber conduit requirements into the specifications that its municipal electric utility adopted for utility construction in new developments. The city has no immediate plans to make use of this conduit, but it is building an inventory that can be used to support its Dark Fiber Leasing Program (like many municipal electric utilities, Riverside Public Utilities installed fiber optic lines in conjunction with its electric transmission and distribution system, and leases spare capacity to third parties).

The City of Loma Linda also requires the installation of conduit, along with fiber and structured inside wiring, in new homes. This conduit and fiber are connected to the Loma Linda's municipal network, and residents can purchase Internet service from the City. This system also supports high capacity networks for a university, medical school and several hospitals.

Appendix E contains sample specifications that the City of Salinas may consider for inclusion in conditions attached to development of the North Salinas area. The City of Ontario's specifications were written for a specific development. The City of Brentwood adopted a general requirement to conform to specifications published and periodically updated by the engineering division of the public works department. The City of Riverside's specifications are written to conform to standard practice developed by its electric utility, and are included in the standard conditions attached to development permits.

4. City of Salinas Policy

The City of Salinas adopted several policies to encourage the development of broadband infrastructure and services for residents and businesses. In doing so, the City has reduced barriers to broadband deployment and provided incentives for telecommunications companies to increase investment in broadband infrastructure and address City goals, such as ubiquitous and equitable access to broadband service throughout Salinas.

There is a clear correlation between these policies and the significant improvements in broadband infrastructure and service Salinas has experienced over the past four years, although it is difficult to draw an equally clear causal connection. At a minimum, it can be concluded that the broadband-friendly policies and community focused broadband objectives that the City consistently pursues create opportunities that telecommunications companies have embraced.

These policies include:

- Small Wireless Facility regulations and fees, adopted by City Council resolutions in April 2019. This policy sets default fees and requirements for wireless facilities that are installed pursuant to an encroachment permit and without a Master License Agreement.

- Master License Agreement policy for lease of City-owned assets to wireless companies, adoption by City Council resolution in April 2018. This policy provides direction to staff as they negotiate agreements to lease city-owned property to wireless companies for the purpose of expanding broadband access in Salinas. Notably, the policy allows staff to negotiate lease rates and terms that might be less than what the market would otherwise provide, if the wireless company "will create an exceptional benefit to the community, including, but not limited to, the use of exceptional design standards, placement of facilities to provide high-level service to historically underserved portions of the City, and/or the speed at which new technologies and networks are deployed".

- "Dig Once" policy, adopted by City Council resolution in November 2016. This policy provides for the installation of city-owned broadband conduit in public works projects and establishes a process to notify potentially interested telecommunications companies of opportunities to install conduit that may be created by public or private sector projects that involve excavation in the public right of way.

- Requirements for wireless telecommunications facilities in the public right of way, adopted by City Council resolution in July 2015. This policy creates a streamlined approval procedure and minimal design specifications for wireless broadband facilities that are installed on structures, including but not limited to utility poles, located in the public right of way.

There are additional steps the City can consider to build on its existing policy and provide further incentives for private companies to expand broadband infrastructure, as well as expand the base of city-owned assets:

- Continue to develop the City's municipal dark fiber network, with the objective of providing access to high performance, low cost Internet bandwidth to competitive Internet service providers and major users, such as government agencies, schools and universities, major corporations and agricultural technology start-ups.

- Develop broadband facilities requirements for new or major remodeled construction, either residential or commercial or both, similar to those in Brentwood, Ontario, Riverside and Loma Linda.

- Evaluate development plans in order to 1. identify critical broadband infrastructure gaps and develop specific plans to fill those gaps, and 2. identify opportunities for low cost broadband infrastructure extensions, such as proactive microtrenching ahead of planned City street work.

- Evaluate the feasibility of using City-owned broadband assets, such as fiber, conduit and streetlights, to support a competitive broadband service option for residents and businesses. This option may be created through a variety of means, including but not limited to public-private partnerships, open access leasing and a municipal enterprise.

- Review permit processes and determine if any streamlining can be done.

- Evaluate the feasibility of creating a master encroachment permit and inspection process for large scale broadband infrastructure projects. Such a process would reduce costs and delays for prospective competitive broadband service providers and reduce the City's workload: a system intended to evaluate and manage unique, small scale projects is different from one used to manage a citywide project that uses standardized techniques, for example. This sort of process is similar to the one requested by Google Fiber[3] as it evaluated U.S. cities as locations for expansion of its fiber-to-the-home business. It is not necessary to formally write and adopt this kind of policy, though. The objective is to be prepared to respond if a telecommunications company were to make such a request.

- Investigate potential sources of funding for broadband infrastructure development. Such sources include transportation and economic development grants, U.S. Department of Agriculture programs, the California Advanced Services Fund, other State of California and federal programs such as E-rate, and California Teleconnect, Telehealth and public safety funds. This development work can either be carried out independently by the City, or done in partnership with incumbent and/or independent private sector broadband companies.

[3] *Google Fiber City Checklist*, Google Fiber, February 2014.

5. Findings and recommendations

5.1. Findings

The information gathered and analyzed during the course of this study, regarding existing broadband infrastructure, City resources and policy, and development objectives, leads to the following conclusions:

- The City of Salinas adopted broadband-friendly policies over the past four years, as developed and recommended by staff, and has actively pursued the development of better broadband service availability and upgraded broadband infrastructure.

- Since 2015, Salinas' broadband infrastructure grade has improved from "C" (2.0) to "C+" (2.3). Generally broadband infrastructure in the City of Salinas is above average, as compared to California as a whole, and above average compared to other communities in Monterey County. This achievement is particularly notable because the 2019 grading criteria is significantly more stringent than the 2015 version, due to higher average service levels in California and the documented need for greater broadband capacity and speeds.

- The quality of broadband infrastructure and the level of service available to Salinas residents depends on how much money they make. There is a median household income gap of more than $10,000 between people with access to average or better broadband service and those without, and between people that AT&T and Comcast have chosen to serve and those they do not.

- AT&T and Comcast are the two primary telecommunications carriers in Salinas and offer broadband service to nearly all homes and businesses, on generally the same terms and at the same or better service level as elsewhere in California. Nearly two-thirds of Salinas residents either have access to, or are located near to, AT&T highest level of DSL-based service, and nearly all have access to Comcast's highest level of cable modem service. This represents significant infrastructure and service upgrades by both companies since 2015.

- The most recent field test data (September 2017) collected by the California Public Utilities Commission indicates that mobile service in Salinas is substandard. Since then, several mobile broadband companies have engaged in negotiations with the City to upgrade infrastructure and service, and the City has adopted significant policies to encourage this kind of investment.

- Salinas is served by an increasing number of intercity and metro fiber optic routes that provide connections to major Internet exchanges in the San Francisco Bay Area and southern California, and, in some cases, offer the potential to provide local service directly to locations within the city. In the past three years, a major intercity route, owned by Crown Castle (formerly Sunesys LLC) and a large scale metro network, owned by Extenet, were deployed in Salinas.

- The City embarked on a municipal fiber project in Downtown Salinas that will interconnect with at least one major intercity fiber route, providing access to wholesale Internet bandwidth that can

support economic development and municipal operations. This municipal fiber network will support the City's economic development goals in the Downtown and Alisal Marketplace area and, through extensions or interconnections, has the potential to support development of the Agricultural Technology Corridor in southeast Salinas and the East Salinas/Alisal area.

- Combined with existing metro fiber and/or new City construction, the new municipal fiber network can be extended to the North Salinas area, and support competitive fiber-to-the-premise broadband service. Development conditions can be adopted that require the installation of conduit and, perhaps, fiber optic facilities to support competitive, FTTP service.

- The City owns approximately 16,000 feet of conduit that is available to support construction of additional fiber optic networks, and has plans to build 108,000 feet of additional conduit in the next few years. In some cases, this conduit is installed in locations that correspond to the City's economic development goals and/or are complementary to the City's new municipal fiber network.

- The City issued a request for proposals for the development of a Downtown fiber network. This process resulted in constructive discussions with potential fiber operators and service providers, but did not result in construction of new infrastructure. These relationships will prove valuable, however, as the City brings its own dark fiber network online, and considers extending it beyond the Downtown area.

Taken together, these findings show that the City successfully implemented a broadband development program over the past four years that resulted significant improvements in broadband availability, capacity and bandwidth for consumers and businesses, and provide valuable support to economic development efforts.

5.2. Recommendations

This study recommends the following steps:

1. Develop and implement a business plan for operation of the City's new municipal dark fiber network, including an open access policy, operations and maintenance procedures, published rates and interconnection agreements.

2. Develop a roadmap for growing the municipal network, either through extensions or interconnections, to reach the East Salinas/Alisal area, the Agricultural Technology Corridor and the North Salinas area, and for extending the coverage of the network in the Downtown and Alisal Marketplace areas.

3. Leverage the City's fiber and wireless assets to help address the City's broadband infrastructure and service gap by offering incentives to wireless and wireline companies to expand service and infrastructure upgrades across the entire city.

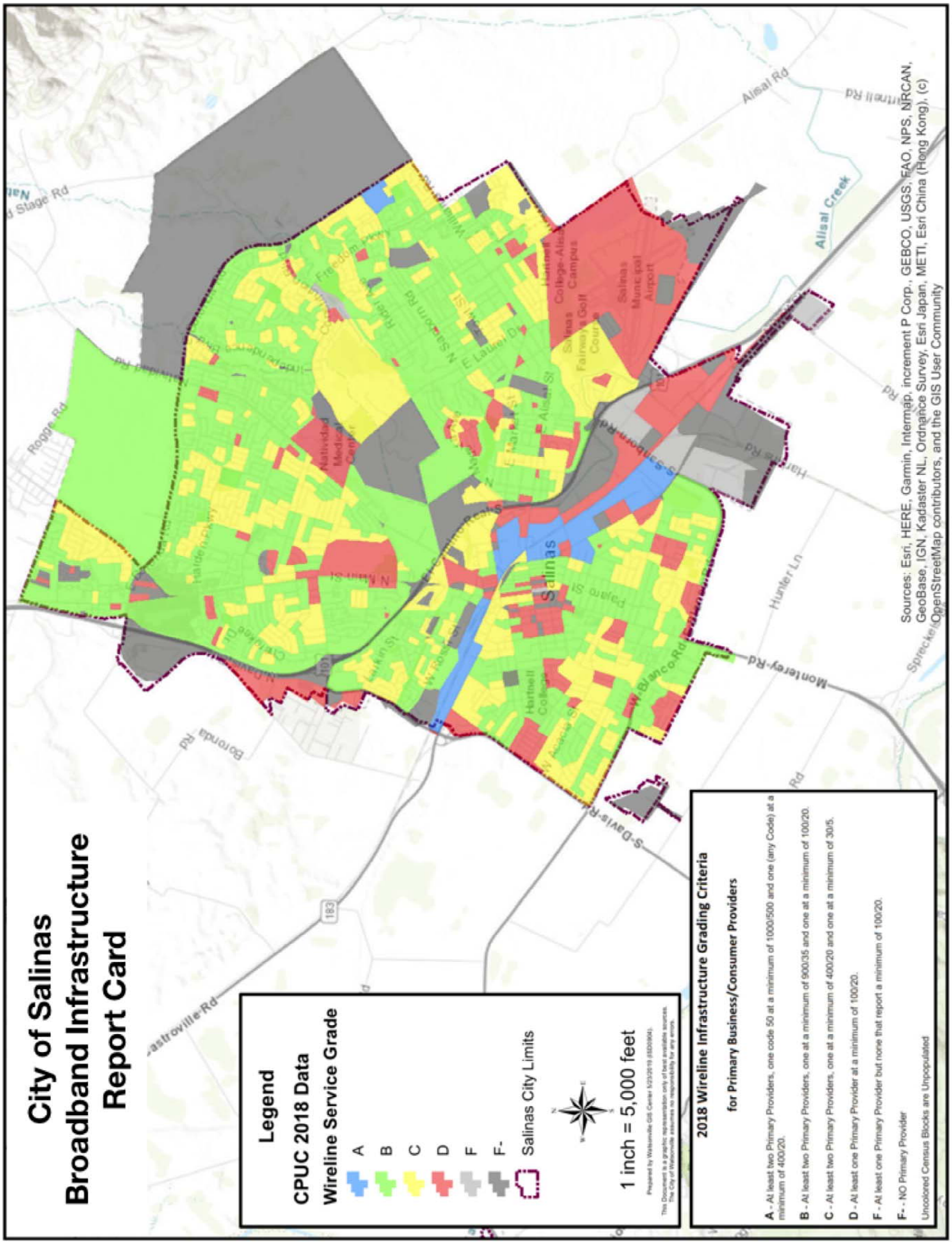
4. Coordinate municipal fiber development with the City's wireless asset leasing program, and work with mobile carriers and infrastructure companies to increase access to both fiber-based and wireless broadband service.

5. Establish and implement broadband conduit and fiber installation conditions for greenfield residential, commercial and industrial development, and develop a business plan for using these expanded resources to improve broadband access for all Salinas residents.

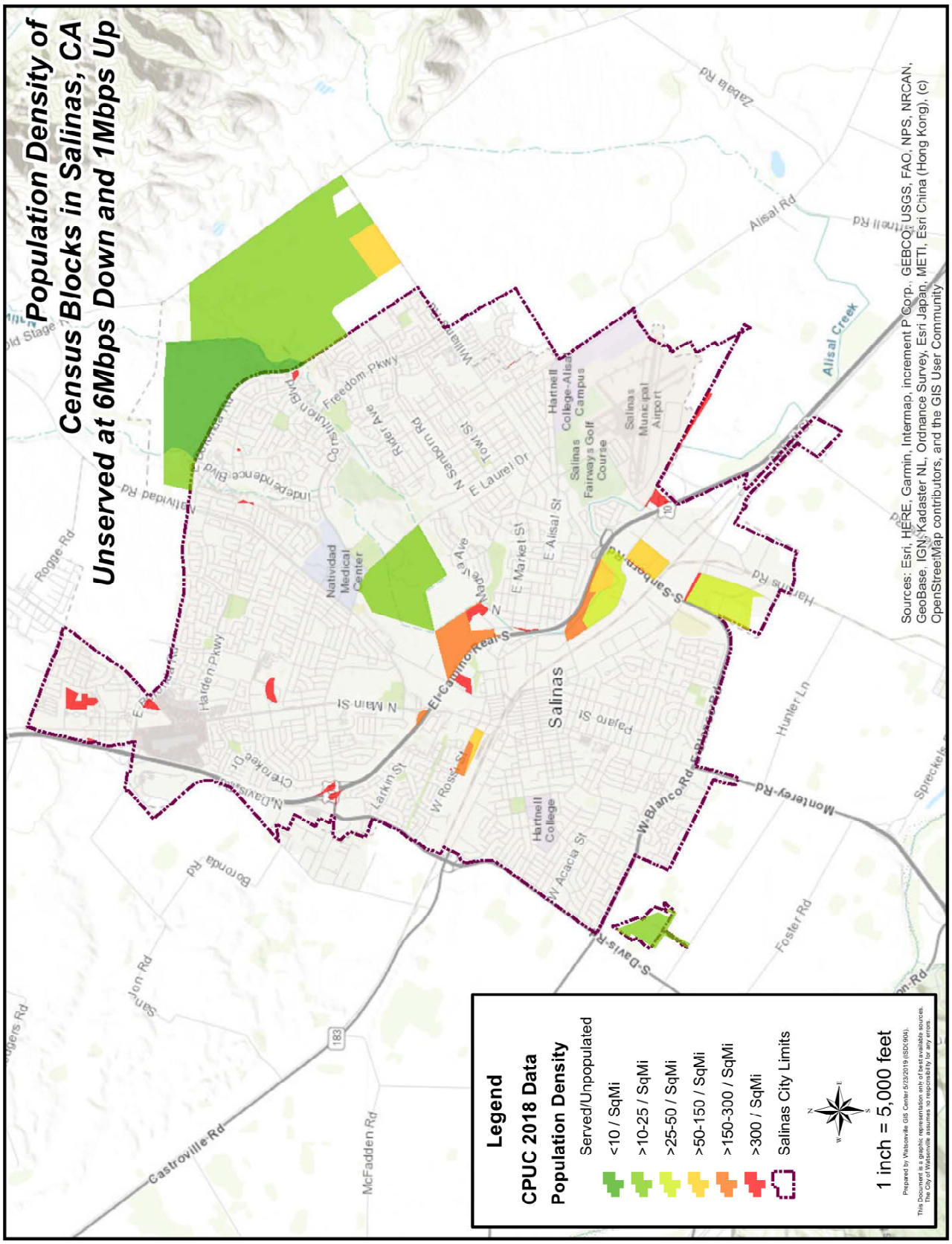
6. Consider adoption of additional broadband-friendly policies, such as permit streamlining and funding development, as detailed in Section 4 above.

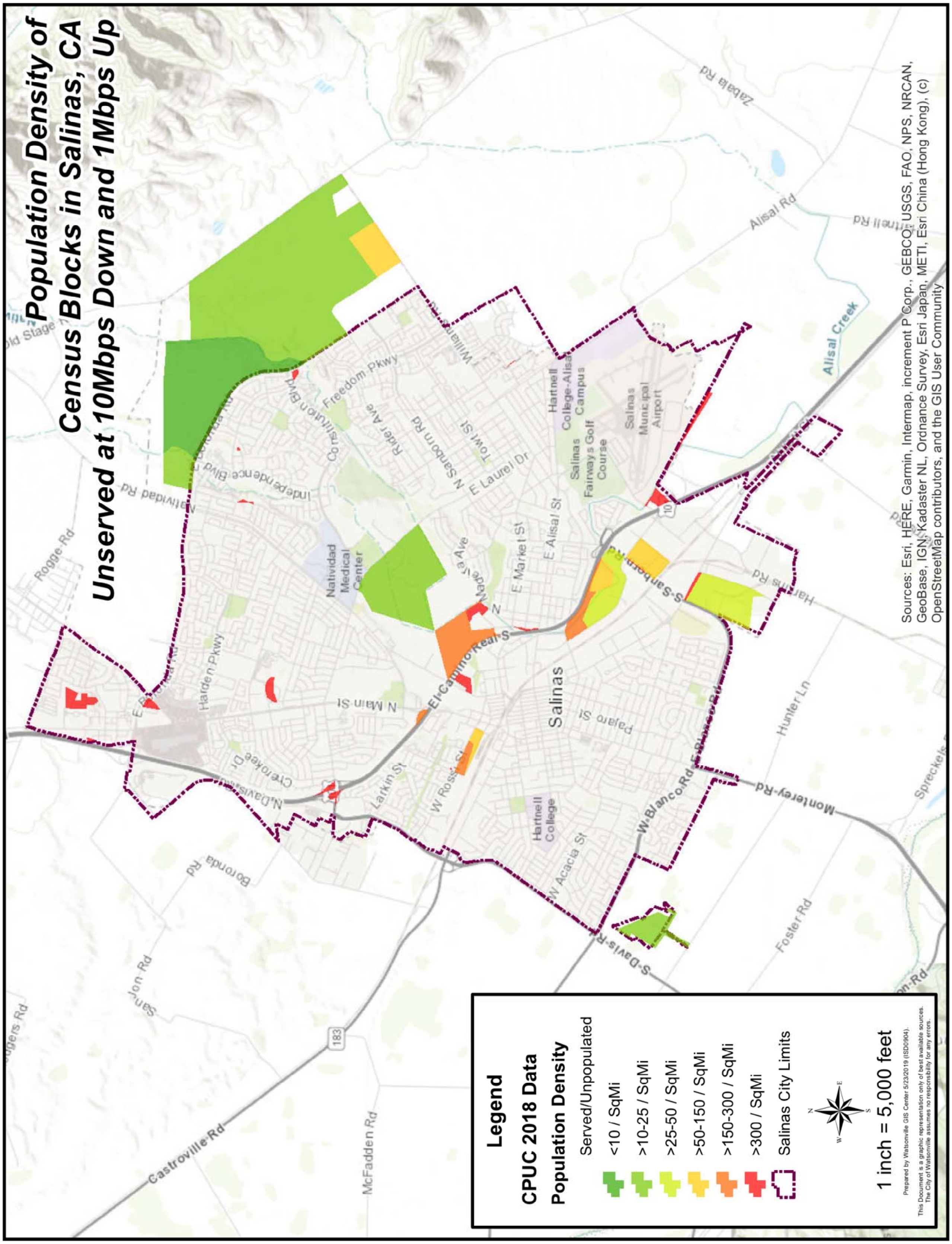
Appendix A - Salinas infrastructure and service maps

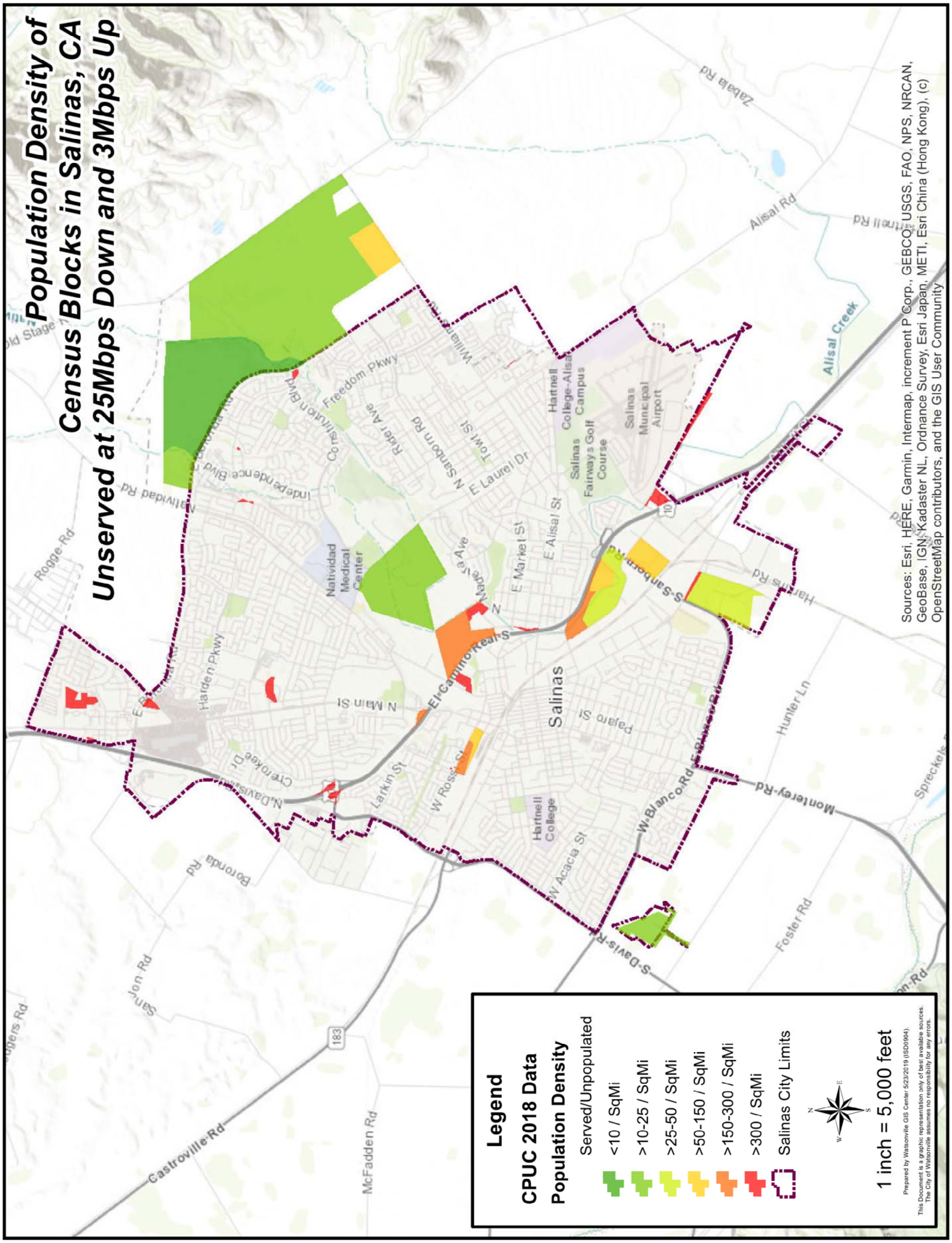
Salinas Broadband Report Card



Service level gaps by population density




Population Density of
Census Blocks in Salinas, CA
Unserved at 10Mbps Down and 1Mbps Up
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Legend
CPUC 2018 Data
Population Density
Served/Unpopulated
<10 / SqMi
>10-25 / SqMi
>25-50 / SqMi
>50-150 / SqMi
>150-300 / SqMi
>300 / SqMi
Salinas City Limits
1 inch = 5,000 feet
Salinas
Natividad Medical Center
Hartnell College
Salinas Municipal Airport
Salinas Fairways Golf Course
Alisal Creek


Population Density of Census Blocks in Salinas, CA
Unserved at 25Mbps Down and 3Mbps Up
Legend
CPUC 2018 Data
Population Density
Served/Unpopulated
<10 / SqMi
>10-25 / SqMi
>25-50 / SqMi
>50-150 / SqMi
>150-300 / SqMi
>300 / SqMi
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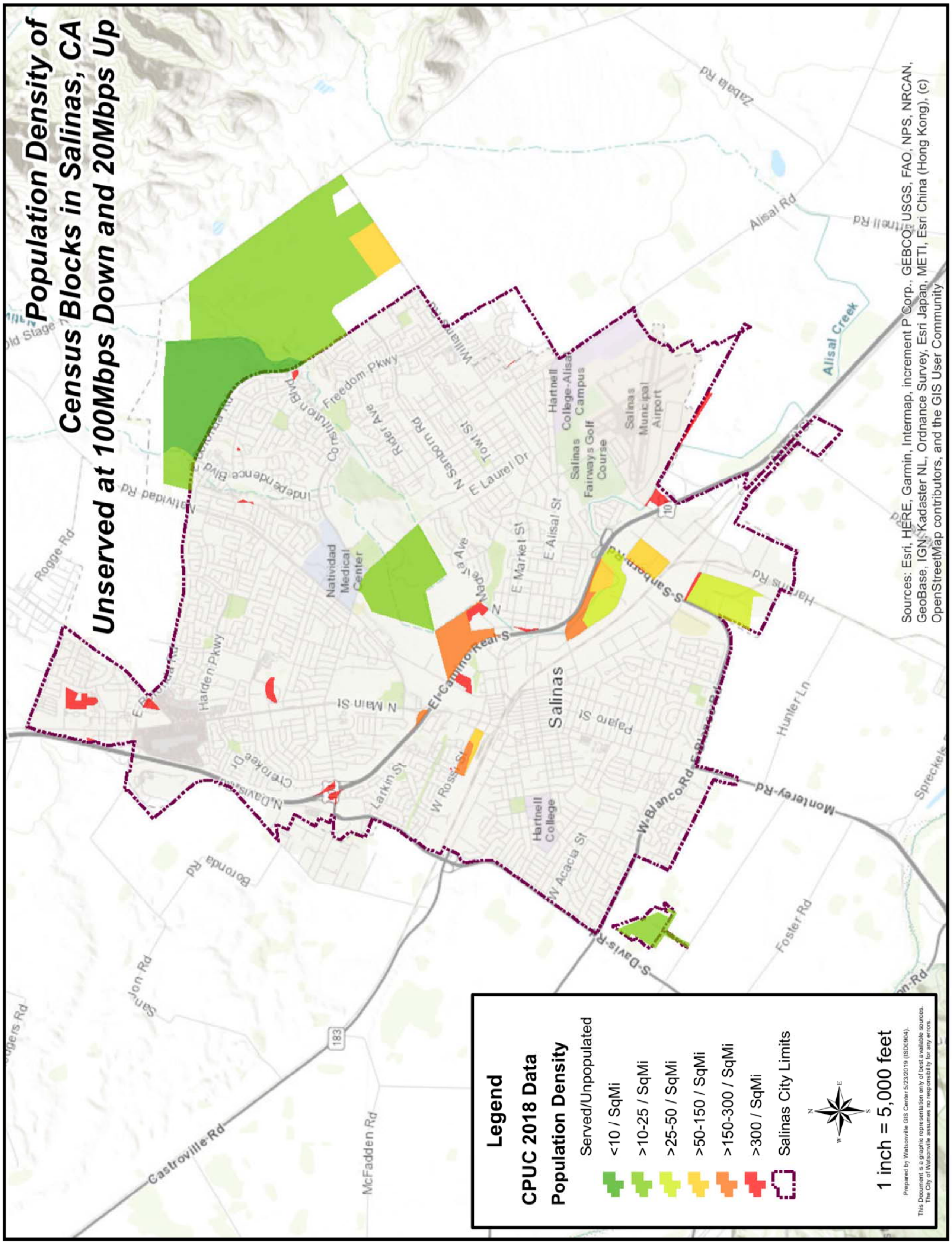
Salinas
Natividad Medical Center
Hartnell College
Salinas Municipal Airport
Salinas Fairways Golf Course
Hartnell College-Alisal Campus
Alisal Creek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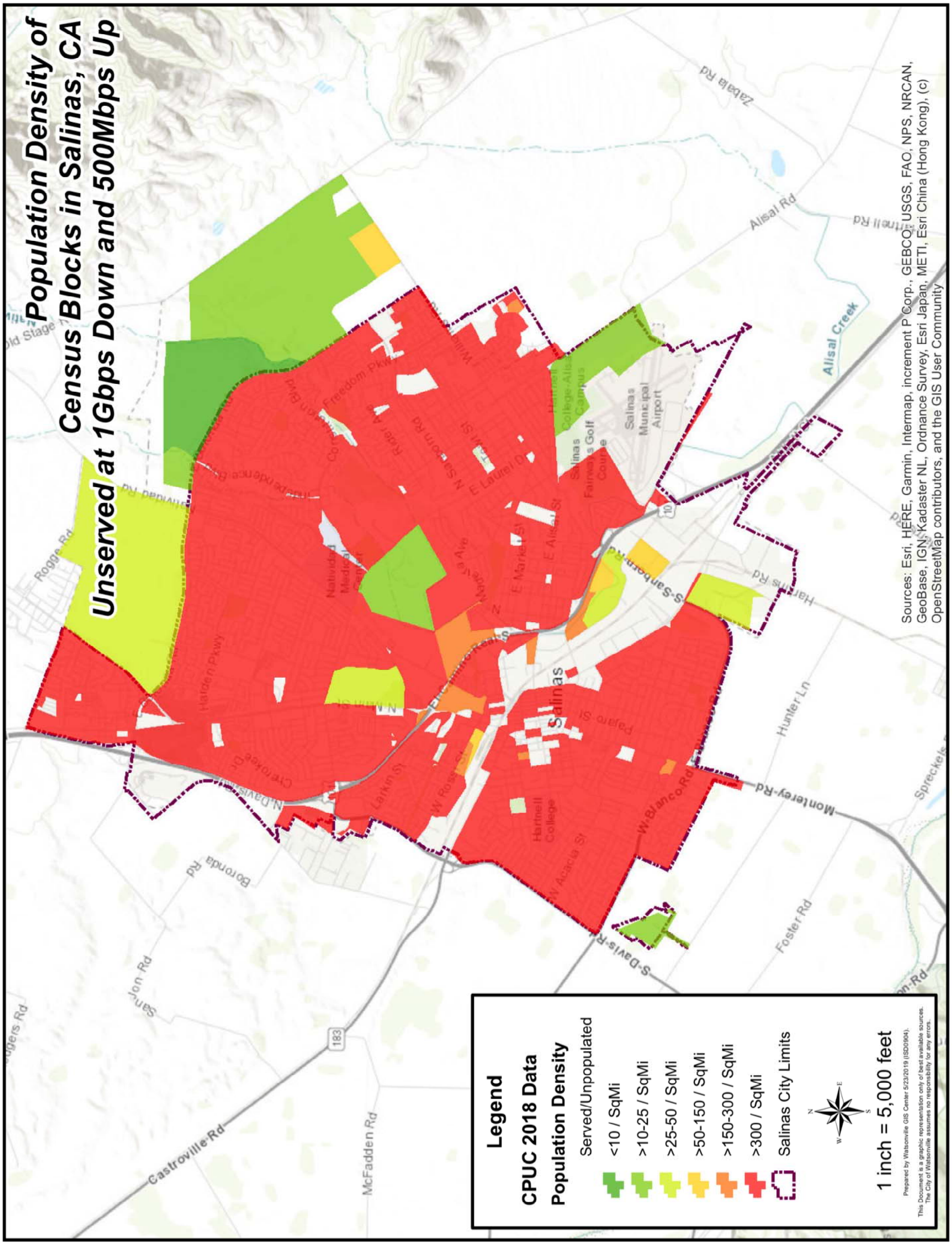
Salinas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<10 / SqMi
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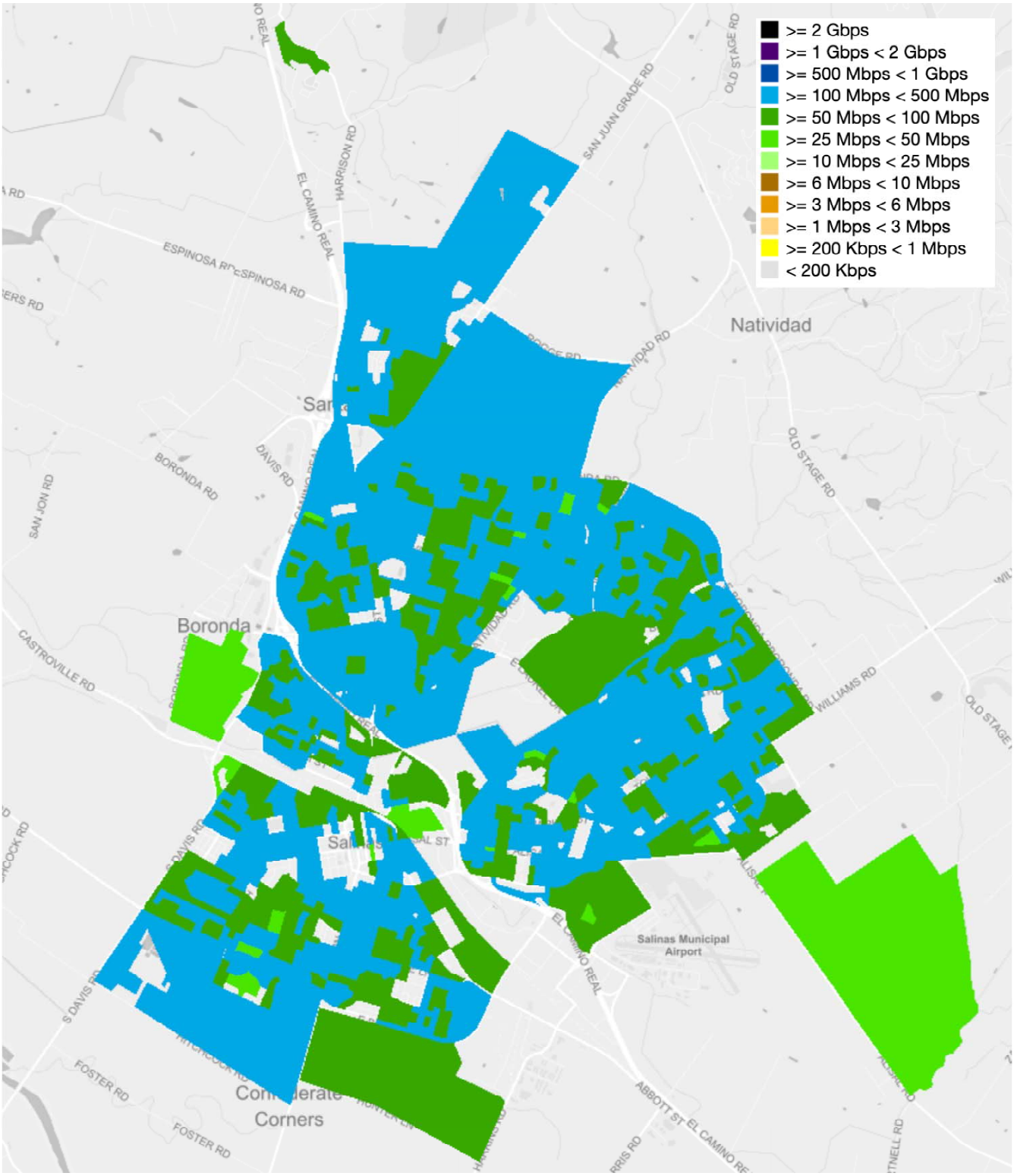
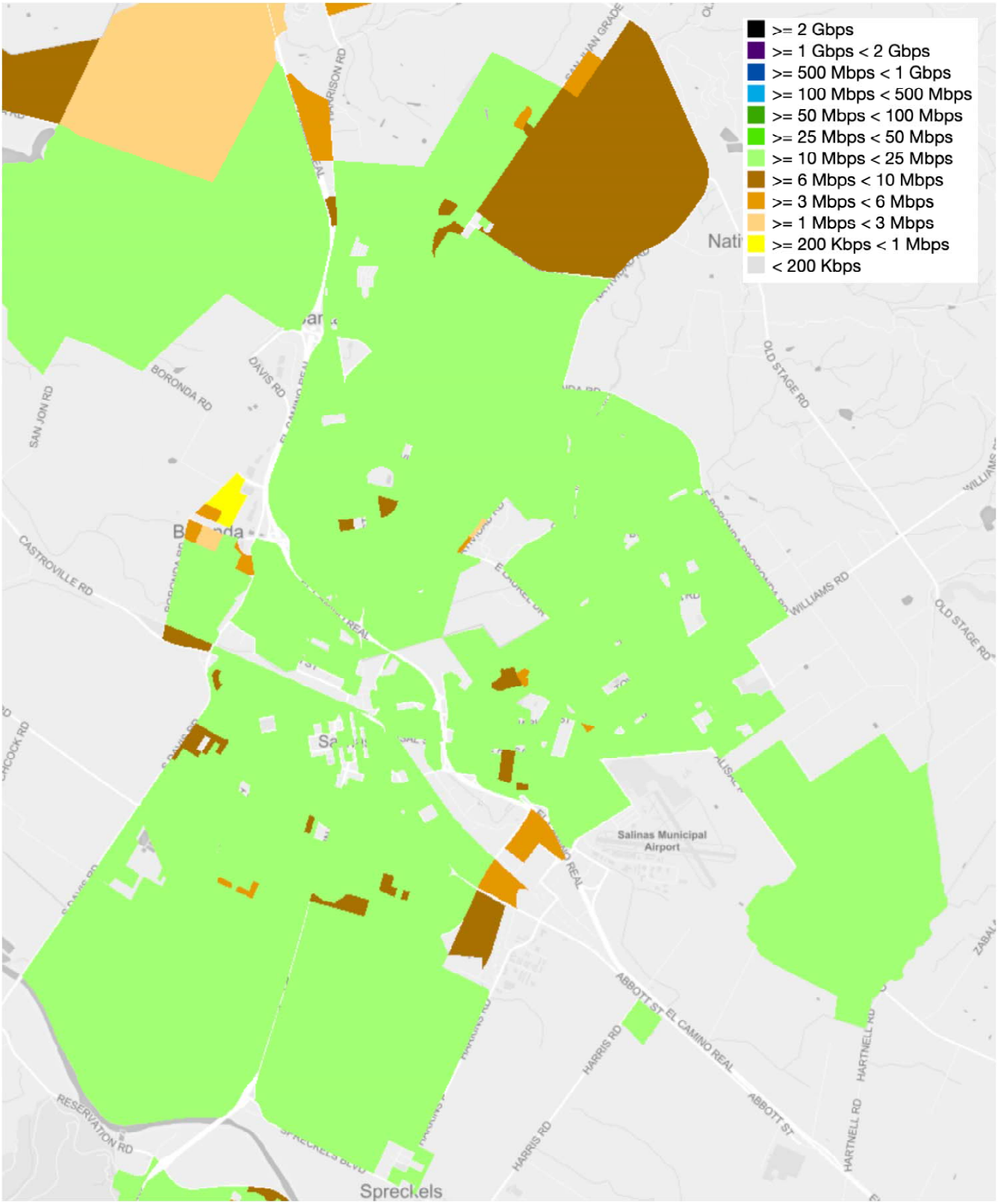
Salinas
Salinas Municipal Airport
Hartnell College
Alisal Creek
Alisal Rd
Monterey Rd
Castroville Rd
McFadden Rd
Boronda Rd
Foster Rd
Hunter Ln
Harris Rd
W Blanco Rd
N Main St
E Laurel Dr
E Market St
E Alisal St
Freedom Pkwy
Natividad Medical Center
Rogge Rd
Zabala Rd

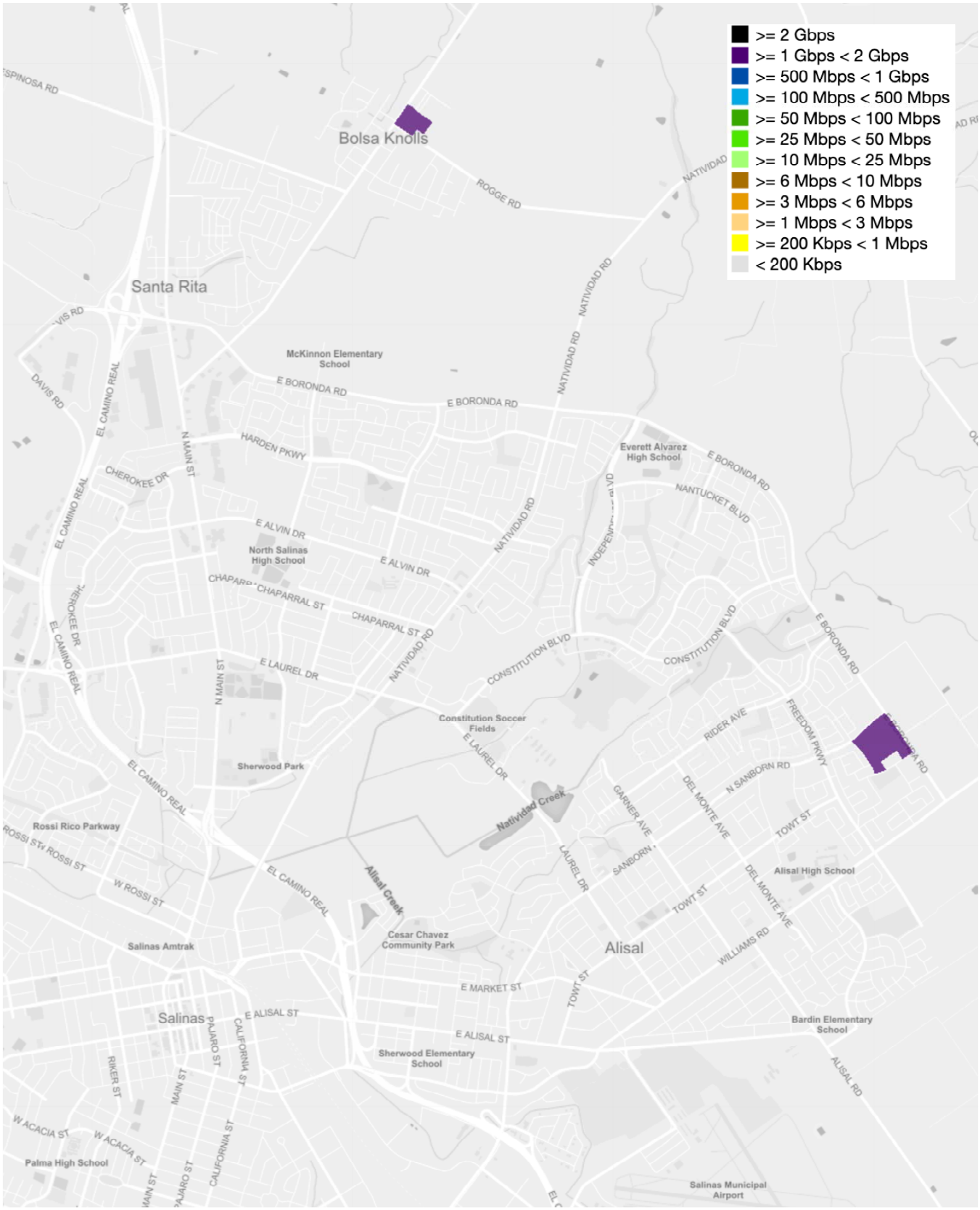
AT&T VDSL service



AT&T ADSL service

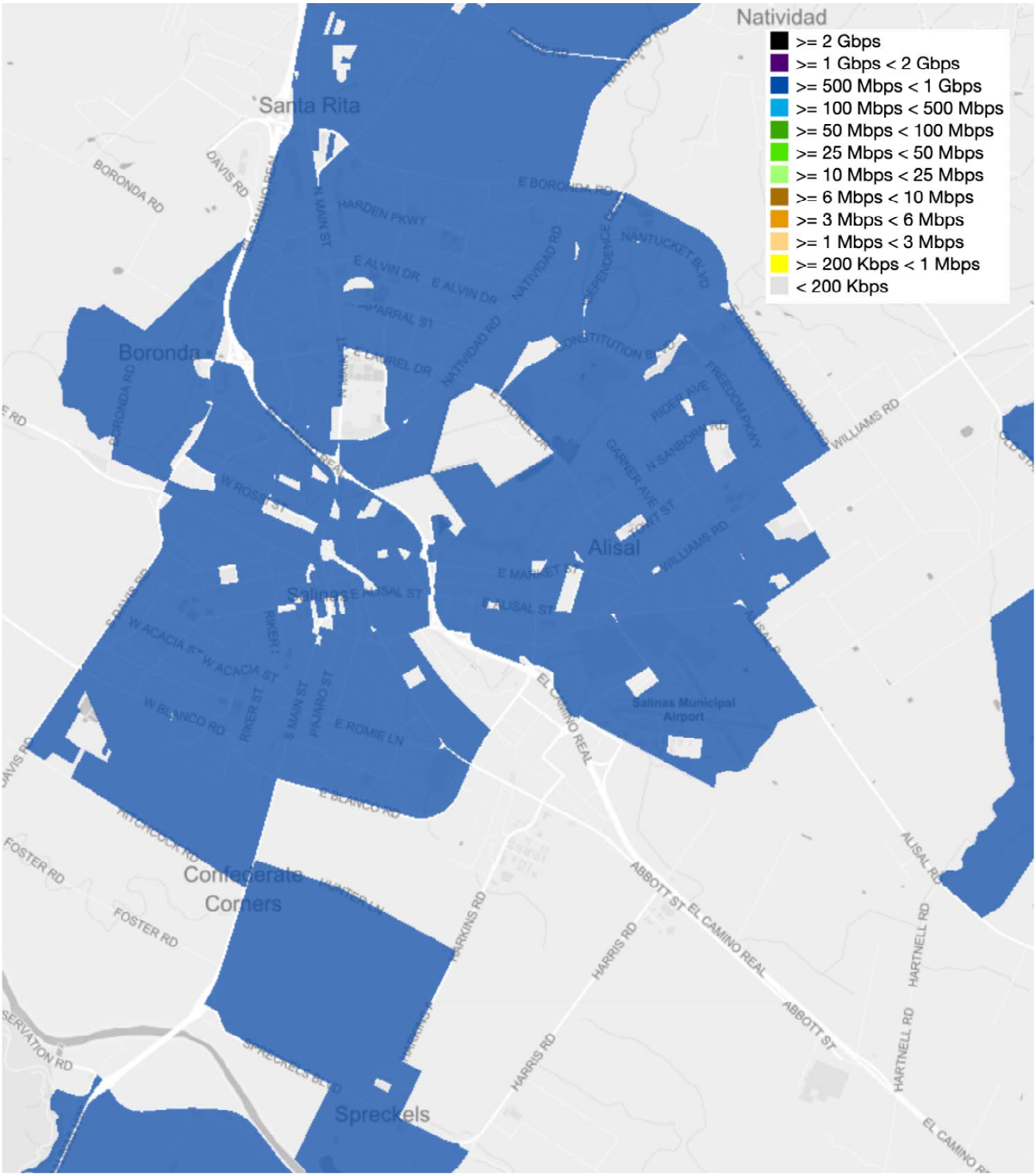


AT&T FTTP service

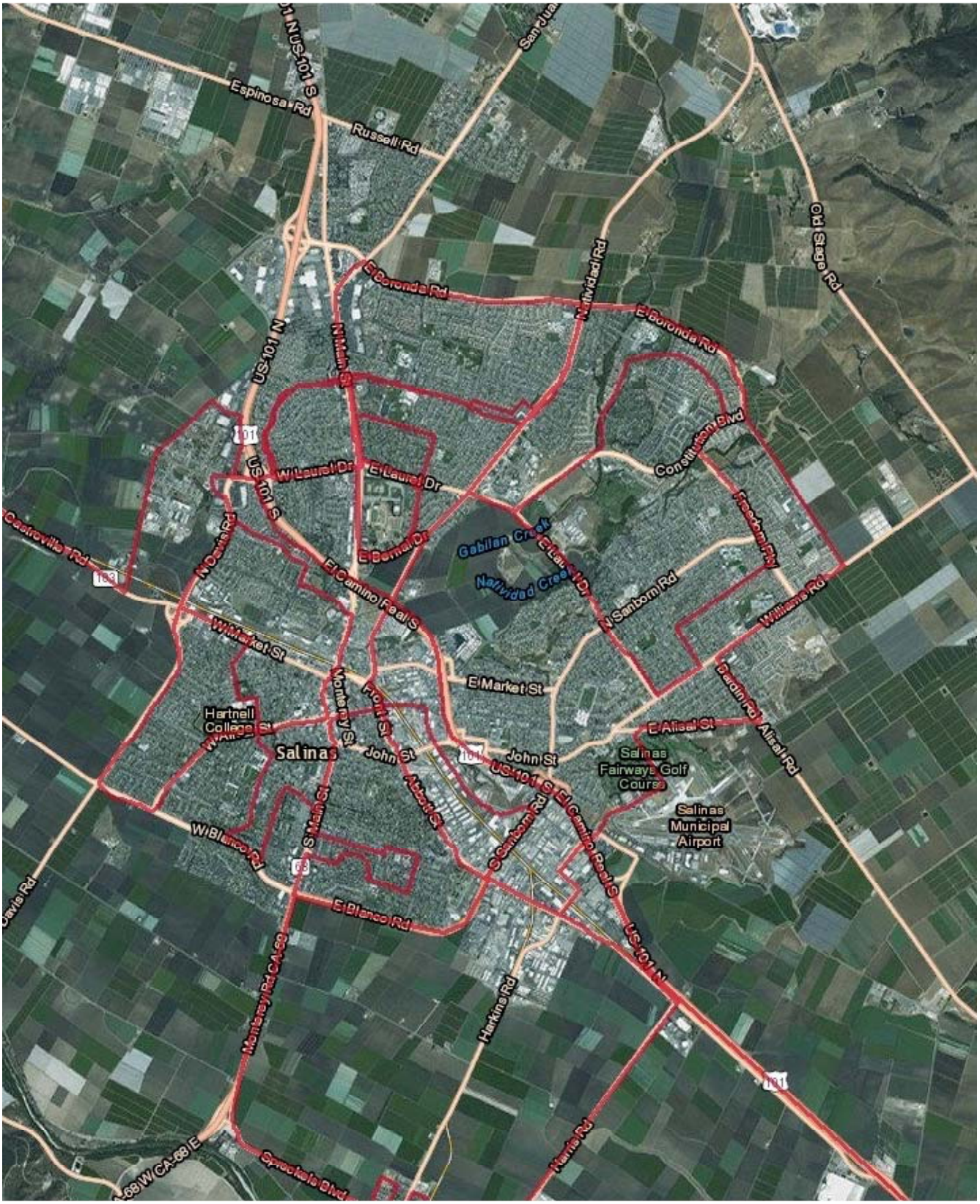


AT&T local backbone fiber network

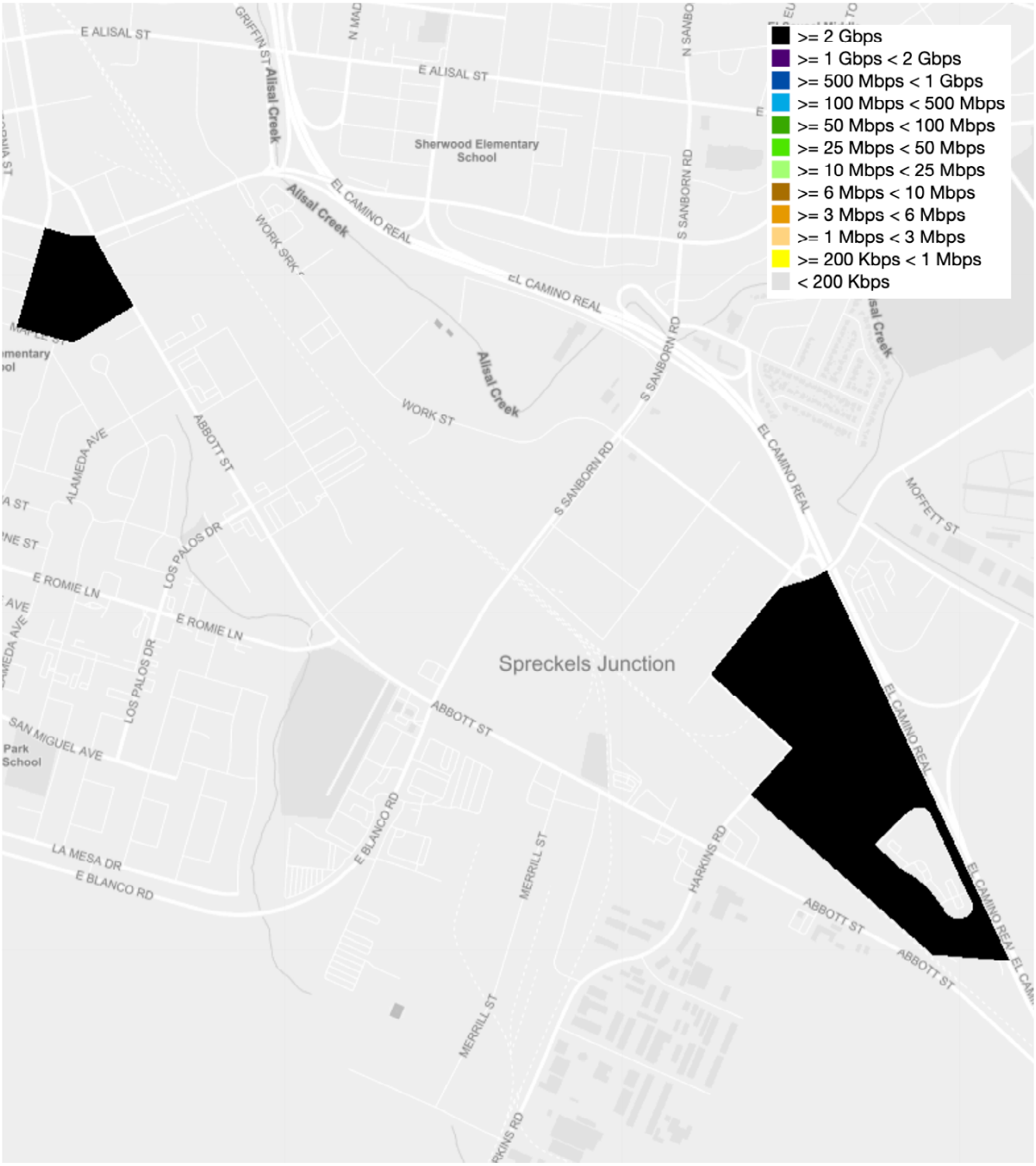
Comcast DOCSIS 3.1 service



Comcast backbone fiber network

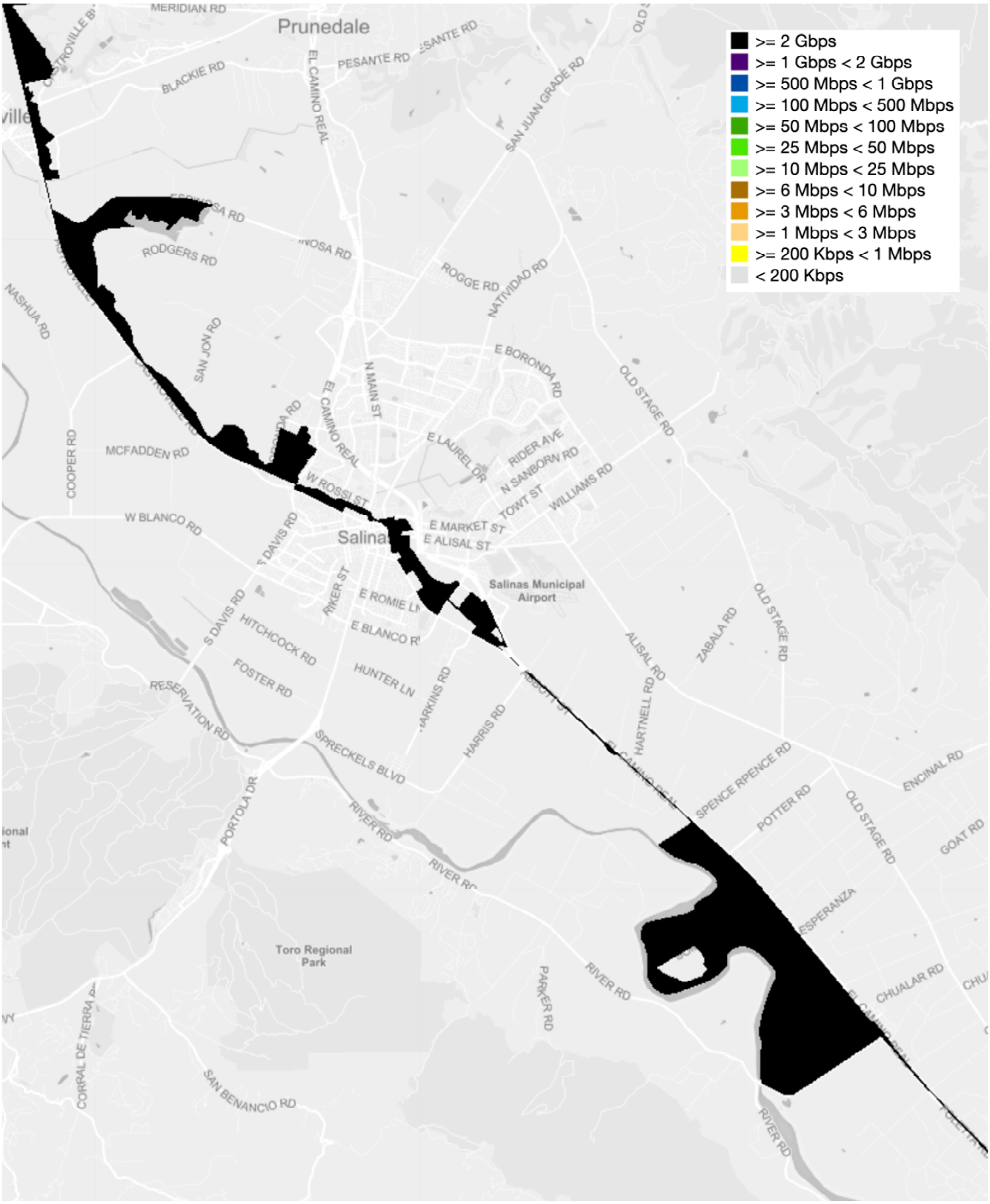


Level 3 fiber service



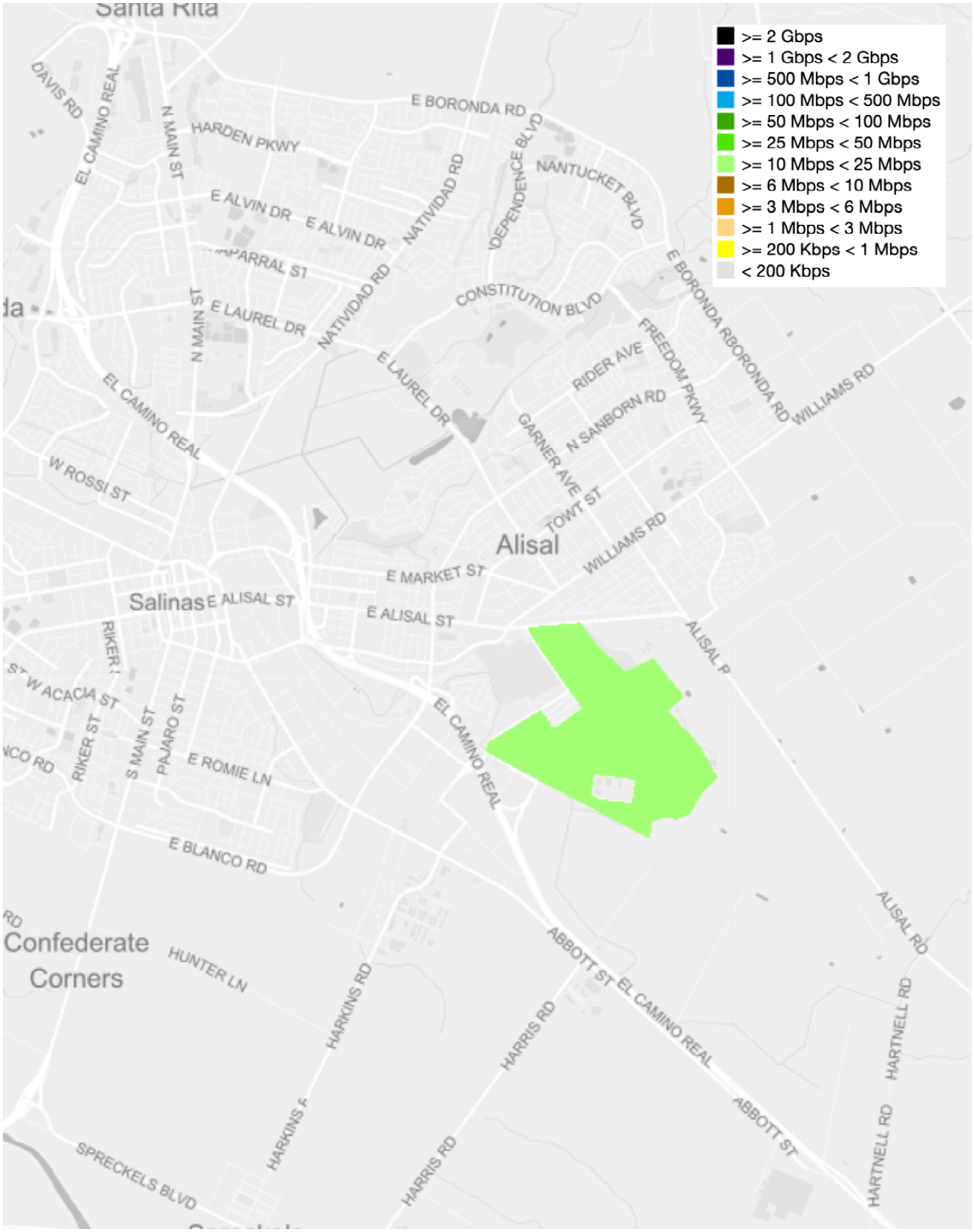
TPx fiber service

Vast fiber service

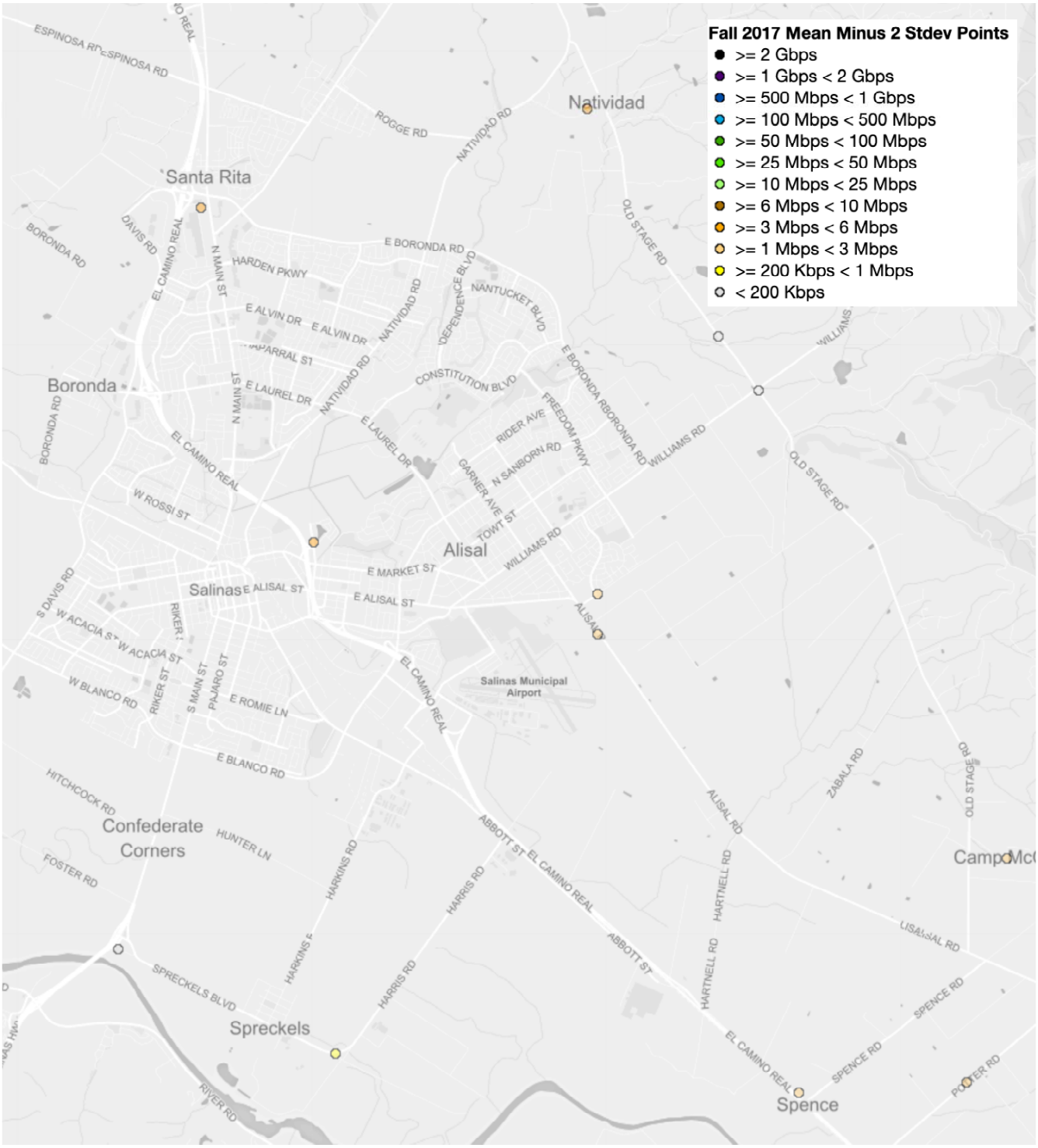


Windstream fiber service

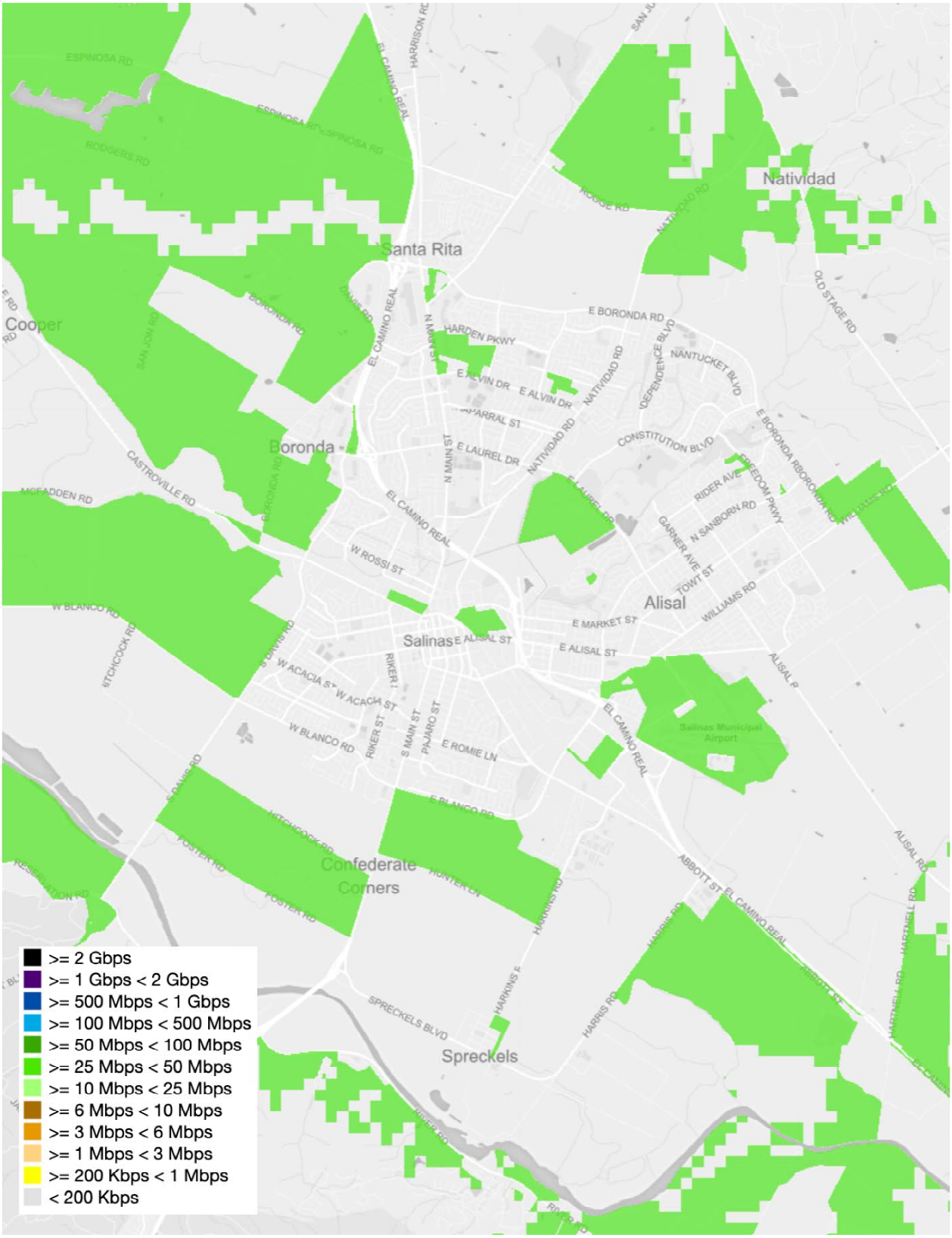
Zayo fiber service



CPUC mobile broadband service field test results – Fall 2017

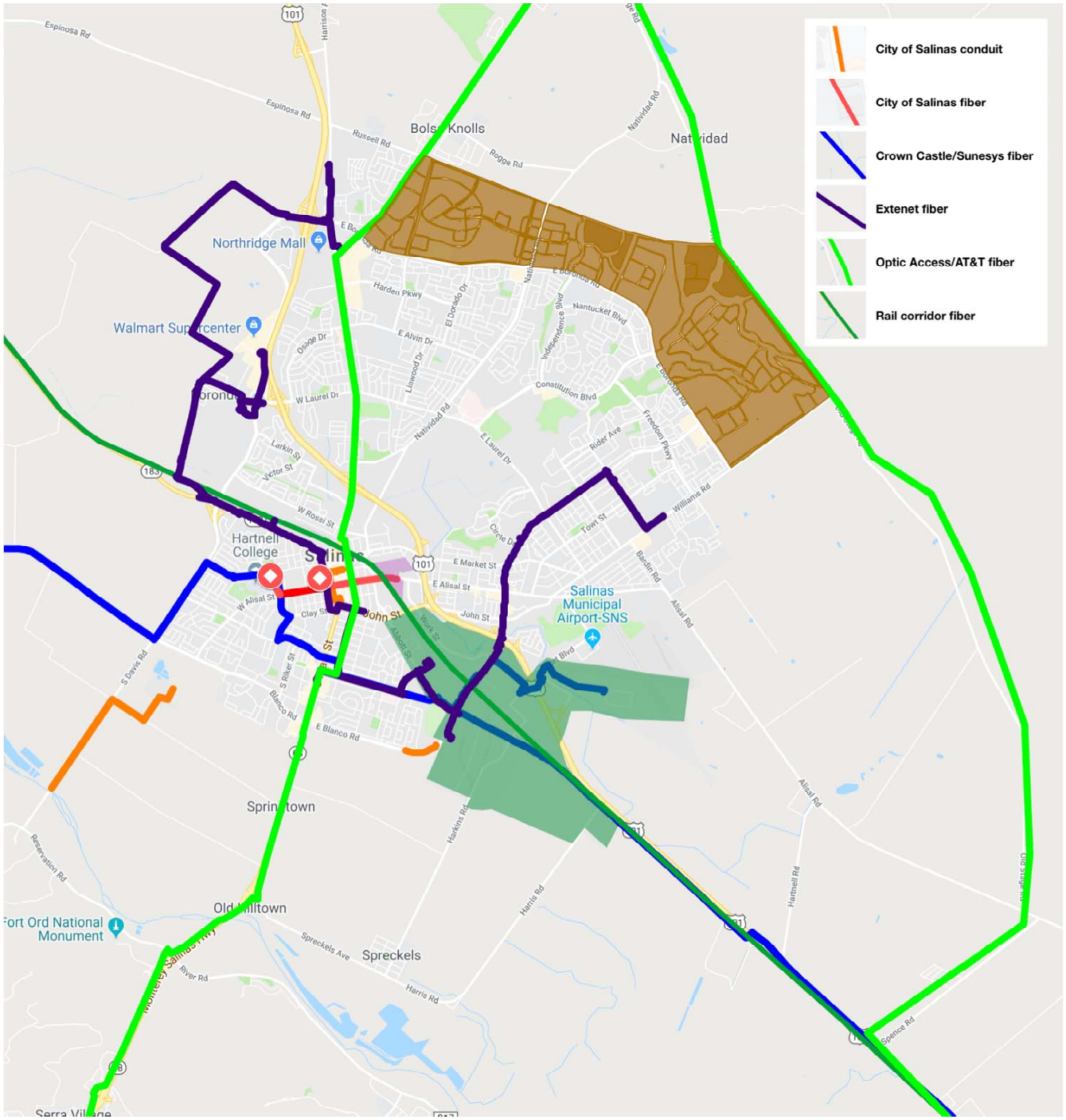


Razzo Link fixed wireless service

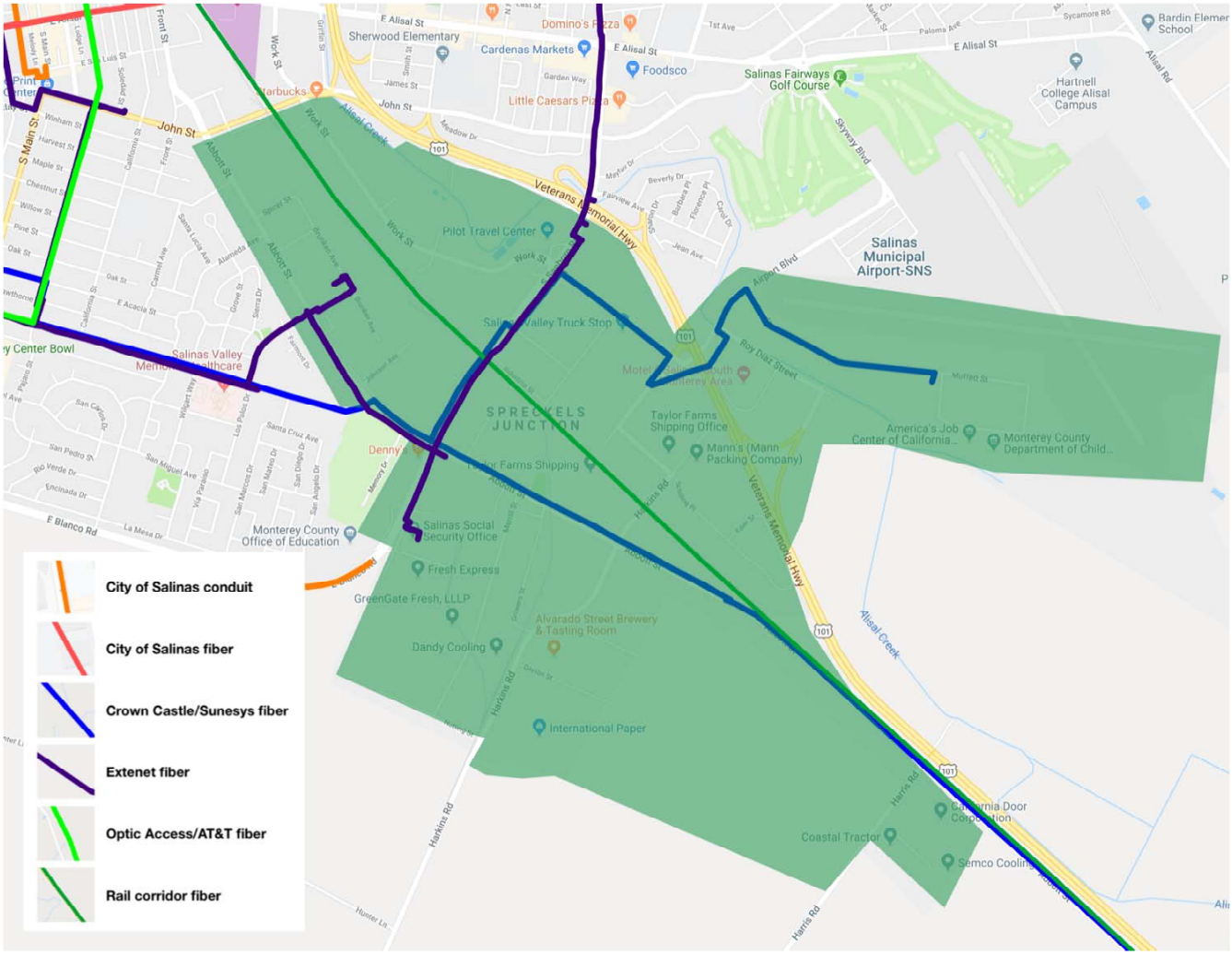


Appendix B - Salinas fiber networks

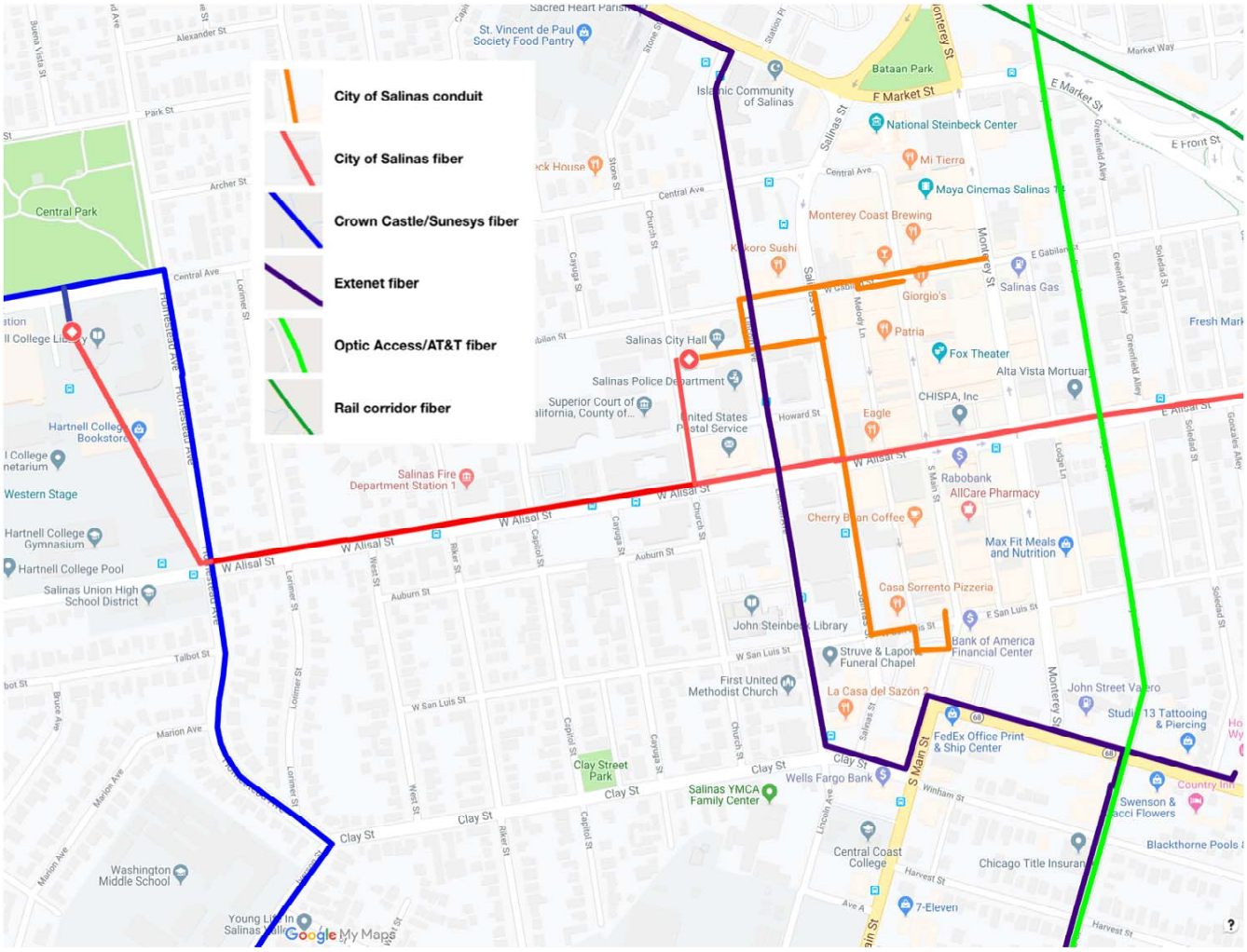
Overview



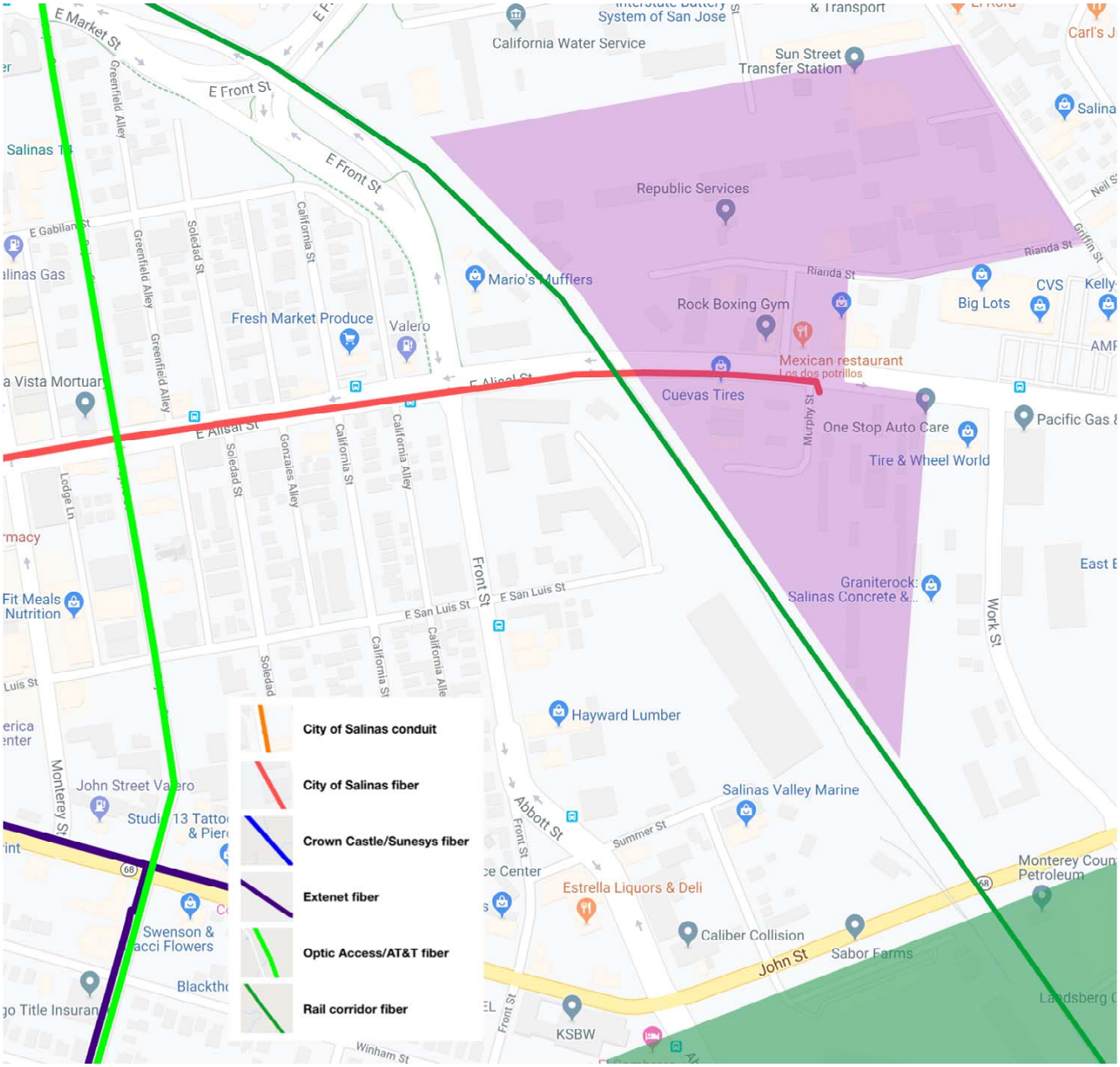
Ag Tech Corridor



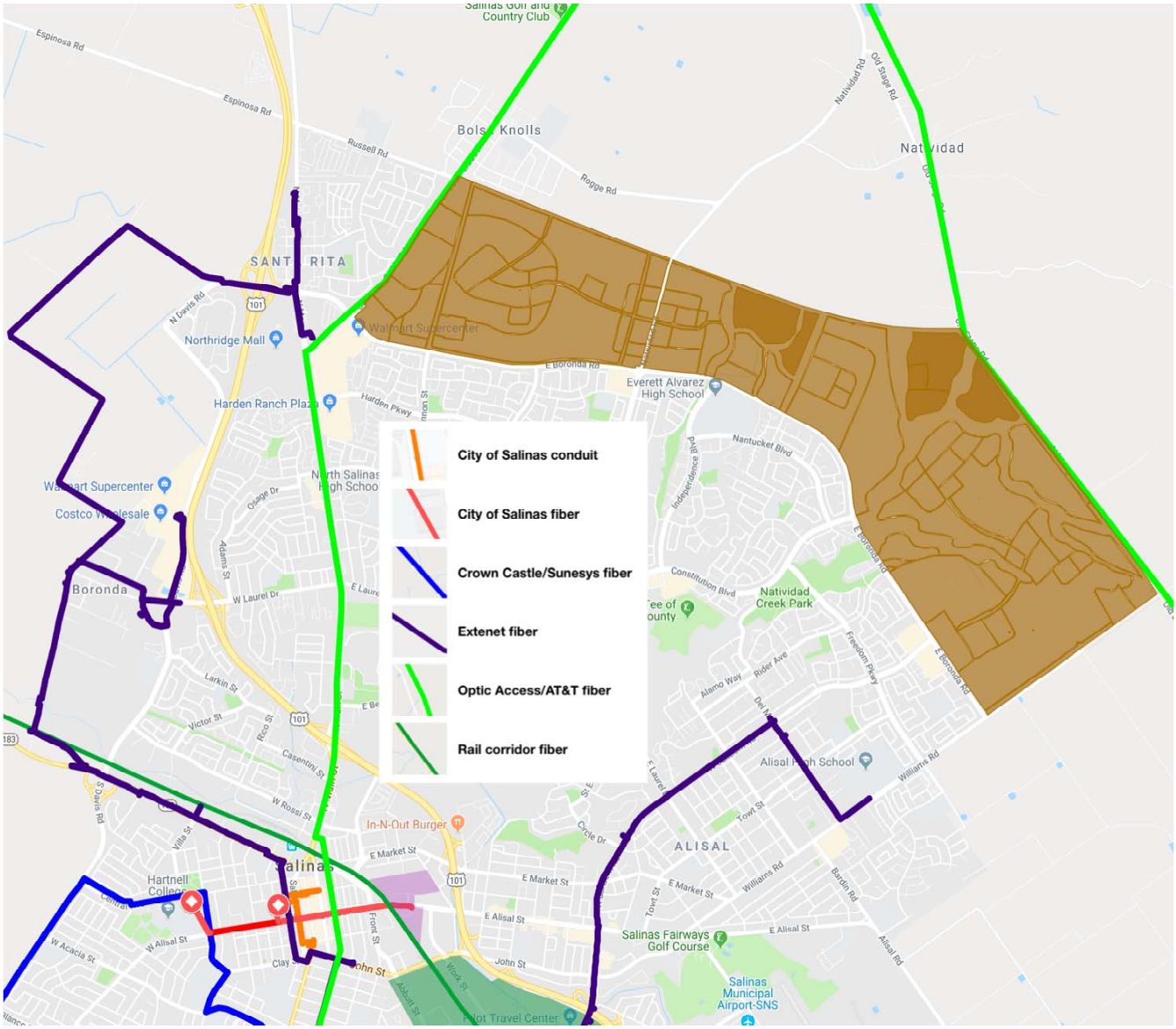
Downtown Salinas



Alisal Marketplace



North Salinas



Appendix C - Infrastructure grades

Broadband Report Card - Monterey County

Rank	Community	Grade	GPA
1	Del Monte Forest CDP	B+	3.5
2	Seaside city	C+	2.3
3	Marina city	C+	2.3
4	**Salinas city**	**C+**	**2.3**
5	Pacific Grove city	C	2.2
6	Monterey city	C	2.1
7	Sand City city	C	2.0
8	Boronda CDP	D+	1.4
9	Del Rey Oaks city	D	1.1
10	Spreckels CDP	D	1.0
11	Carmel Valley Village CDP	D-	0.9
12	Carmel-by-the-Sea city	D-	0.8
13	Rest of Monterey County	F+	0.5
14	Las Lomas CDP	F+	0.4
15	Pajaro CDP	F+	0.4
16	Elkhorn CDP	F+	0.3
17	Soledad city	F	0.1
18	Prunedale CDP	F	0.1
19	Gonzales city	F	0.1
20	Aromas CDP	F	0.0
21	Bradley CDP	F	0.0
22	Castroville CDP	F	0.0
23	Chualar CDP	F	0.0
24	Greenfield city	F	0.0
25	King City city	F	0.0
26	Lockwood CDP	F	0.0
27	Moss Landing CDP	F	0.0
28	Pine Canyon CDP	F	0.0
29	San Ardo CDP	F	0.0
30	San Lucas CDP	F	0.0
	Monterey County (overall)	**D**	**1.4**

Methodology

In a study conducted for the East Bay Broadband Consortium (EBBC) in 2013[4], in cooperation with the Central Coast Broadband Consortium, core broadband infrastructure was evaluated in Alameda, Contra Costa and Solano Counties using data submitted to the California Public Utilities Commission by Internet service providers. A comparative report card was developed, with the average grade – "C" – set at the most prevalent infrastructure, and corresponding service levels, available to residents of California: a combination of relatively high speed cable modem and mid-range telephone company DSL facilities.

This methodology was subsequently used by the Central Coast Broadband Consortium to evaluate Californian broadband infrastructure and service on a statewide basis, on behalf of the California Emerging Technology Fund and the California Center for Rural Policy, and to do in-depth analysis of broadband service and infrastructure in Monterey, Santa Cruz and San Benito counties.

The primary data for assessing the quantity and quality of broadband infrastructure comes from the California Public Utilities Commission, which collects service level reports submitted by providers to the Federal Communications Commission annually, and then runs that data through a validation process. The most recent data available was submitted by carriers as of 31 December 2017. This data can be broken down to the census block level, and shows what level of service Internet companies claim to provide, but not necessarily what they deliver. The accuracy of this data and the definition of service levels varies from company to company, although it is generally consistent within any given company. In other words, if Company Z exaggerates the speeds and availability of home Internet service, it tends to do so to more or less the same extent everywhere. By using a comparative system for ranking, rather than using the absolute values provided, the variation in the accuracy of the data can be smoothed out and an apples-to-apples comparison can be achieved.

Consumer-grade service throughout California was assessed, and the averages of available service (median, mode and mean) used as one of the two primary grading benchmarks. The other benchmark was the minimum level of service of 100 Mbps download and 20 Mbps upload speeds, which was determined by a 2018 study conducted by the Central Coast Broadband Consortium and the Monterey Bay Economic Partnership[5] to be the minimum necessary to conduct business, do homework, enjoy online entertainment and otherwise fully participate in today's digital economy.

Upload speed was given equal weight to download speed because upload speed provides a reliable indication of the capacity of the underlying infrastructure. It is increasingly important to consumers and businesses alike. When a service provider skimps on upload speeds, as frequently happens, it is usually because its cables and other core equipment have a limited capacity.

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[4] *East Bay Broadband Report Card*, Tellus Venture Associates, 28 January 2014.

[5] *Achieving Ubiquitous Broadband Coverage in the Monterey Bay Region*, Monterey Bay Economic Partnership, November 2018.

The data was examined, and irrelevant data points that skewed results were removed. Grades were then assigned as follows:

A	**Superior infrastructure**. At least two competing primary wireline providers. At least one advertizing fiber-to-the-premise service at a minimum of 1 Gbps download/500 Mbps upload speeds, and another offering service at a minimum of 400 Mbps download/20 Mbps upload speeds using any technology.
B	**Above average infrastructure**. At least two competing primary wireline providers. At least one advertizing service at a minimum of 900 Mbps download/35 Mbps upload speeds, and another offering service at a minimum of 100 Mbps download/20 Mbps upload speeds.
C	**Average infrastructure.** At least two competing primary wireline providers. At least one advertizing service at a minimum of 400 Mbps download/20 Mbps upload speeds, and another offering service at a minimum of 30 Mbps download/5 Mbps upload speeds.
D	**Barely passing**. At least one wireline provider that meets the Central Coast Broadband Consortium/Monterey Bay Economic Partnership minimum standard of 100 Mbps download and 20 Mbps upload speeds.
F	**Fail**. At least one wireline provider offers service, but no service is available that meets the Central Coast Broadband Consortium/Monterey Bay Economic Partnership minimum standard of 100 Mbps download and 20 Mbps upload speeds.
F-	**Unserved**. No broadband service available

A "C" grade indicates that consumer grade broadband service, and consequently the underlying core infrastructure, in a given area meets the statewide average. A "D" grade means it meets the minimum service standard determined by the CCBC/MBEP study. "F" grades indicate full or partial failure. "A" and "B" grades show that service in an area is superior to the California average.

The first step in grading was to give a letter grade to each census block in California. Then, the grade points were tallied, weighted by population and averaged for the census blocks within cities, counties and unincorporated areas, to produce a numerical grade on a four point scale, which was rounded to the nearest tenth.

The numerical grade point average for an area was then converted to a letter grade on the following scale:

Infrastructure Grade Point Scale

A	4.0	**C+**	2.3-2.6	**D-**	0.7-0.9
A-	3.7-3.9	**C**	2.0-2.2	**F+**	0.3-0.6
B+	3.3-3.6	**C-**	1.7-1.9	**F**	0.0-0.2
B	3.0-3.2	**D+**	1.3-1.6	**F-**	No service available
B-	2.7-2.9	**D**	1.0-1.2		

Appendix D – Municipal fiber business planning

Table 1 - Monthly Rental Rate Benchmarks

Dark Fiber	Per strand-mile low	Per strand-mile high	Added strands	Drop - low	Drop - high	Monthly min.	Long term discount
City of Burbank	$135	$200	$175				33%
City of Glendale	$200	$200					
City of Loma Linda	$97	$194	$97			$775	
City of Los Angeles	$100	$250		$100	$100		
City of Riverside (commercial)	$100	$125	$100	$150	$150		30%
City of Riverside (public agency)	$15	$15	$15				
City of Pasadena	$175	$250					30%
City of Palo Alto (private customers)	$250	$425	$167	$210	$250	$675	
City of Palo Alto (public agencies)	$213	$362	$142	$179	$213	$574	
City of Santa Clara	$136	$200					32%
City of Watsonville	$200	$200	$150			$660	
Sacramento RTD (urban rate)	$125	$125					
Sacramento RTD (suburban rate)	$75	$75					
Sacramento RTD (rural rate)	$60	$60					
Axia Mass Broadband (MA)	$60						
Bonneville Power Administration (WA)	$30	$45					
Frankford, KY	$300		$100				
Franklin, KY	$500		$100				
Menasha, WI	$185	$205					
California average	**$152**	**$194**		**$160**	**$178**		
National average	**$173**	**$202**					

Full Rack with Power		**Per rack unit (RU)**	
City of Shafter	$900	City of Loma Linda	$60
City of Kirkland, WA	$650	Snohomish Co., WA	$25
City of Watsonville	$775	City of Watsonville	$40
Netripid	$960	CreativeData.net	$30
Fiber.net	$850	Netripid	$40
		HostforWeb.com	$50
Muni average	**$775**	**Muni average**	**$42**
All average	**$827**	**All average**	**$41**

Benchmark rates

Monthly lease rates for dark fiber strands were gathered from ten California agencies (nine cities and one transit district) and five agencies from out of state. California rates ranged from $100 to $425 per strand-mile per month. Out of state rates varied even more widely, from $30 to $500 per strand-mile per month.

Agencies typically set high and low rates for fiber strands, with actual price determined by several factors, including distance, number of strands, full versus partial routes, term of contract and other negotiating points.

The average low rate for a strand-mile leased to a private company from a California agency is $152 per month and the average high rate is $194 per month when an outlier is factored out. The City of Palo Alto charges up to $425 for the first strand-mile (or fraction thereof), because businesses there often need less than a mile. The city typically adds a drop charge of up to $250, for a monthly minimum price of $675 per account.

Palo Alto also has a published rate for public agencies, which is discounted 15% from the rate charged private customers. This rate was not factored into the averages. Other agencies contacted indicated that discounts could be informally negotiated for public sector customers.

The Sacramento Regional Transit District has a three-tier rate structure, depending on the type of area. Their urban rate was used to calculate the averages.

When out of state rates are factored in, the low/high averages are in the same range, $173 and $202 per month respectively.

The most commonly charged high rate in California is $200 per strand-mile per month, by Santa Clara, Watsonville, Glendale and Burbank, with Loma Linda close at $194. Low rates vary more widely, from $97 in Loma Linda to $200 in Glendale and Watsonville, including discounts offered for multiple strand leases. Loma Linda charges a flat rate of $775 per month for a strand on a full loop – they don't actually charge by the mile and don't sell partial segments. Additionally, discounts averaging in the 30% range are offered for long term contracts and/or long mileage runs.

Three agencies – Palo Alto, City of Los Angeles, City of Riverside – impose separate fees for terminations and mid-route drops and laterals, with an average of $155 to $175 per drop/lateral per mile (or fraction thereof), with up to 12 strands supported. Others sell only on a point-to-point or full network basis.

The nearly universal approach to non-recurring costs is to have the customer pay the entire cost of any new construction necessary to hook up to a city’s existing network, or extend it to a new location. Charges are calculated on a cost-recovery basis, and a 15% surcharge is common (in addition to a City’s standard overhead and/or indirect costs mark up). Exceptions to this practice are usually made

when a city has other objectives in mind, such as a internal need for the work or a desire to subsidize some of the work for economic or business development purposes.

There are four factors to consider when comparing prices amongst cities:

1. *Distance between customer end points*. In Palo Alto, where per mile charges are high, customers frequently lease connections of less than one mile and buy few lease connections of more than two to three miles, because of the relatively compact nature of the city. In nearby Santa Clara, where the per mile rate is much lower, customers frequently lease full loops of several miles, because the city is less dense and end points are further apart. Otherwise, the two cities have similar characteristics in terms of fiber supply and demand, and proximity to major Internet exchanges. This same relationship can be found in the range of pricing offered by the Sacramento Regional Transit District: the longer the fiber runs and the sparser the surroundings, the lower the per mile cost.

2. *Competing and complementary infrastructure*. The City of Watsonville can charge the relatively high price of $200 per mile for dark fiber because it is the only option. The same is true of Glendale and Pasadena, where there are relatively few options. On the other hand, there is a wealth of competing fiber in key areas of Santa Clara, where the per mile rate is significantly lower. Complementary infrastructure, such as the PAIX exchange in downtown Palo Alto where low cost, high bandwidth Internet connectivity is available, raises the value of municipal fiber: even if it is costly compared to fiber in other locations, the overall cost of connectivity is still low when all network elements are considered.

3. *Network complexity*. Where networks are complex, with several locations served by a single fiber account, per drop and/or lateral fees take on more significance.

4. *City goals*. Although distances in Loma Linda are relatively short and there is little or no competing fiber supply, the city charges comparatively low rates for its fiber because it sees it as an economic development driver. A similar choice was made in San Leandro, where the city decided to forgo immediate lease revenue for its conduit system because the economic development gain was perceived – correctly, as it turned out – to be much greater.

Data center services are less commonly offered on a commercial basis by public agencies, but the prices charged tend to fall in line with industry averages. OpticAccess pays $900 per month for a full rack with power in Shafter, and Kirkland, WA sells the same for $650 per month to other public agencies. Industry prices for a full rack typically range from $800 to $1,000 per month, but since it is a competitive business many exceptions can be found. Rates for one rack unit with power range from $25 per month in Snohomish County, WA to $60 per month in Loma Linda, with the overall industry average around $40 per month.

Sample Municipal Fiber Network Rate Card

Standard Fiber Services

	Per Month	Notes
First two strands	$1,000	$200 per mile, 2.5 miles x 2 strands, full route leasing only
Additional strands	$375	$150 per mile, 2.5 miles, full route leasing only
Drops/laterals	$150	Per mile or fraction thereof, up to 12 strands

All necessary construction and equipment charged at cost plus 15%.

Colocation Services

Full rack	$775	20 amps nominal usage
1 rack unit	$40	5 amps nominal usage

Discount for 10 year minimum contract	30%

Operations and Maintenance Matrix

Facility		Ownership	Maintenance and Repair	Operation	USA Marking Responsibility	Notes
Conduit Mains	Constructed by City	City	City	City	City	Available for use by FiberCo in conduits as shown in agreement
	Constructed by FiberCo	City	City	City	City	Requires written consent by City. An encroachment permit does not constitute consent.
Conduit Laterals	Constructed by City	City	City	City	City	
	Constructed by FiberCo with ownership granted	FiberCo	FiberCo	FiberCo	FiberCo	
	Constructed by FiberCo, no ownership granted	Property owner	Property owner	Property owner	Property owner	FiberCo will assist property owner
Fiber Cable	Main Cable installed by City	City	City	City	City	
	Main Cable Installed by FiberCo	FiberCo	FiberCo	FiberCo	City	City will mark if conduit containing cable has been accepted
	Lateral Cable installed by City	City	City	City	City	
	Lateral Cable installed by FiberCo	FiberCo	FiberCo	FiberCo	FiberCo	City may mark at its sole discretion
Fiber Strands	Within cable installed by City	City	City	City	Per enclosing cable	
	Within cable installed by FiberCo	FiberCo	FiberCo	FiberCo	Per enclosing cable	
	Within cable installed by FiberCo for use by City	City	FiberCo	City	Per enclosing cable	FiberCo to make all connections
	Within cable installed by third party	TBD	Per enclosing cable	TBD	Per enclosing cable	
Other	Boxes Installed on Main Lines	City	City	City	City	Includes boxes where laterals connect to mains
	Boxes on Lateral Lines with ownership granted	FiberCo	FiberCo	FiberCo	FiberCo	
	Boxes on Lateral Lines, no ownership granted	Property owner	Property owner	Property owner	Property owner	FiberCo will assist property owner
	City Installed Boxes	City	City	City	City	
	City Installed Splice Enclosures	City	City	City	N/A	
	FiberCo Installed Splice Enclosures	FiberCo	FiberCo	FiberCo	N/A	
	End devices (modems, termination panels, etc)					Responsibility is determined by the fiber strand connected to the device
Definitions						
Main – Conduit or cable that terminates at both end at a box or manhole within the public right of way.						
Lateral – A conduit or cable that terminates at one end in a box or manhole within the public right of way and the other end serves as a point of connection for an end device (ie modem, termination panel, etc).						

Appendix E – Conduit installation standards

1. City of Ontario fiber optic design specifications summary

Within [greenfield developments]…where applicable, trenching, joint trenching, and boring shall be used to install the Fiber Conduits and the previous reference Figures to be utilized. Fiber Optic conduit placement will generally be in a joint trench with Street Light conduits, placed behind the curb and under the sidewalk resulting conduit placement will be on the north side of street and the east side of street. It is acknowledged that upon full build out of [a greenfield development], conduit will be installed on both sides of the streets; however, for new street improvements, fiber optic conduits shall be placed as recommended above.

Fiber Optic Standards

All Fiber Optic Cable recommended within the Master Plan will be approved by the Engineering Department. The following are the general requirements and description and must be equivalent to the Fiber Optic Characteristics detailed listed in the Fiber Optic Master Plan supporting memorandum, Conceptual Layout of Needed Infrastructure Memorandum.

Singlemode Loose Tube Non-Armored

- Gel-Free/ Dry High Density Buffer Tubes
- Twelve (12) Fibers Per Each Buffer Tube
- Color Coded Buffer Tubes
- Jacketed Central Member
- Dielectric Strength Elements
- Outer Polyethylene (PE) Jacket
- Sequential Markings (Meters)
- Ripcord
- Meets ITU-T G.655 (2009)
- Follows ANSI/TIA/EIA

Conduit Standards

All Conduit recommended within the Master Plan will be approved by the Engineering Department. The minimum acceptable depth for fiber optic cabling / fiber optic conduits shall be 36”. The following are the general design standards to comply with:

Primary Ring (PR)

- One (1) - 2” HDPE SDR-11 (Smoothwall) roll pipe (Orange) or equivalent
- Two (2) - 7 Way MicroDuct (Duraline) – 16mm Tubes or equivalent

Secondary Ring (SR)

- One (1) - 2” HDPE SDR-11 (Smoothwall) roll pipe (Orange) or equivalent

- One (1) - 7 Way MicroDuct (Duraline) – 16mm Tubes or equivalent

Laterals

- One (1) - 2” HDPE SDR-11(Smoothwall) roll pipe (Orange) or equivalent
- One (1) - 7 Way MicroDuct (Duraline) – 16mm Tubes or equivalent

Handhole Placement

The fiber optic conduit infrastructure design will place and utilize five (5) different sized Handholes within the communication infrastructure and Handhole details can be found in CITY Standard Drawing No. TBD. Each Handhole has a unique use and placement, and the table below illustrates, based on fiber strand count, when each will be used:

Handhole Utilization - Fiber Strand Count	
Description	**Fiber Strand Count**
HH-FP	Less than or equal to 6 strands
HH-1	Less than or equal to 144 strands
HH-2	Less than or equal to 288 strands
HH-3	Less than or equal to 432 strands
HH-4	Greater than 432 strands

General Handhole Spacing Requirements

It is understood that as each project (Backbone / Lateral / Residential / In-tract) will require a unique design, so an exact standard will not fit the bill. Boxes along the backbone are generally placed every 500’ to allow for pulling in the fiber and splicing to adjacent buildings and infrastructure.

Conduits sweeping into the Handholes shall enter in flush with the cut out mouse holes aligned parallel to the bottom of the box and come in perpendicular to the wall of the box. See Design Guideline Figure 6 for Handhole Conduit Entry. Conduits shall not enter at any angle other than near parallel. Sweeps from the mainline to the conduit shall be accomplished using radii recommended by the manufacturer.

2. City of Riverside

C. Duct and Conduit Requirements.

a) 1-4” conduit will be required for all primary [electric] cable to a single phase or three phase residential system.

b) New residential tract developments with a street improvement involving new curb, side- walk and gutter, 4-5” conduits are required for primary feeders. 2-4” conduits are required for distribution and 2-2” conduits are required for fiber communications running along the frontage. The 2-2” conduits for fiber Communications consists of 1-2” conduit for main trunk line and 1-2” conduit for spare. 2’x3’x2’ pull boxes are required for main trunk line, patch panel closure ,

and to feed a maximum of 12 homes. Pull boxes to be spaced to a maximum of 500 feet from each other. Install 9” round x 10” deep irrigation boxes to feed 2 homes. Install 1-3/4” conduit from pull box to 9” round x 10” deep irrigation box, and 2-3/4” conduits out to feed the two homes. For situations of a single home feed, install 1-3/4” conduit directly from the pull box to the home. Each home to be fed with 1-3/4” conduit stubbed up adjacent to the electric service conduit. The conduits for fiber com- munications will bypass PJC’s and transformer pads so QEW’s will not be required in the future. The fiber communication conduits should never enter high voltage, PJC’s, vaults, CST’s and transformer pads…For new single family residences 1-2” conduit for fiber optic communications to joint trench with 1-3” secondary conduit and terminate adjacent to electric meter. For up- grades where there is no civil work involved, no fiber communication conduit is required.

c) The equivalent straight pull footage of each secondary/primary conduit run should not exceed the maximum allowable straight pull footage for the cable being used as shown in DDM-5.

d) Service conduits will normally be three-inch for residential services and will be installed to accommodate the expected main switch or pull section capacity in accordance with DDM-2, 2.2F-5.

e) The number of bends along the service conduit route should be kept to a minimum to facilitate pulling of cable and to minimize the need for pulling structures. No more than three 90 degree bends shall be allowed in a service run. See DDM-5.

f) Use 12.5 foot radius sweeps for primary conduits and 4 foot radius sweeps for service conduits.

7. City of Brentwood

Policy

The City of Brentwood requires developers to install two broadband conduits “in the public right of way” and to each new home (the policy uses the term “advanced technology system”, which was a 1999 working description of what generally came to be known as “broadband”). The city owns conduit installed in the ROW; property owners own conduit installed on their land. Fiber is required to be installed in one of the conduits, and ownership of the overall system falls to the city.

Per City of Brentwood Ordinance 609:

C. Advanced Technology Systems.

1. The developer shall design, install, test, and dedicate to the City two advanced technology system conduits, size to be determined, within the public right of way. The developer shall install, in one of the conduits, a fiber optic system designed to serve the subject development for use by the City of Brentwood or one of its licensed franchisee. The fiber optic system shall be installed in accordance with the Citywide Advance Technology Master Plan and approved by the City Engineer. The fiber optic system shall be installed in accordance with the Citywide Advance Technology Master Plan

and approved by the City Engineer. The second conduit shall remain empty and shall be reserved to serve the subject development for the use of a City licensed franchisee not wishing to utilize the City's fiber optic system. Both conduits shall be installed to each lot line. The developer shall bear all design, construction, inspection, and testing costs associated with these underground requirements. Furthermore, the developer shall design, install, test and dedicate to the City all necessary components of the advanced technology system as depicted on the Citywide Advanced Technology Master Plan.

2. The developer shall design, install, test, and dedicate to the property owner two advanced technology system conduits, size to be determined, to connect the public advanced technology system to the individual home or building. The developer shall install, in one of the conduits, a fiber optic system designed to serve the subject property. The fiber optic system shall be installed in accordance with the Citywide Advance Technology Master Plan and approved by the City Engineer. The second conduit shall remain empty and shall be reserved to serve the subject property for the use of a City licensee franchisee not wishing to utilize the City's fiber optic system. The developer shall bear all design, construction, inspection, and testing costs associated with these underground requirements.

3. The cable television or advanced technology company franchisee that elects to install facilities in the City's vacant conduit shall provide plans and specifications to the developer and the City of Brentwood. The licensed franchisee shall also inspect the facilities and certify to the City prior to final approval of the development that the cable television facilities or advanced technology systems are properly installed and serviceable. The design and installation shall meet the minimum criteria as outlined in the City of Brentwood Standard Plans and Specifications.

Specifications

(a) Conduit Material Specifications

	Quantity and Diameter Size	Material of Conduit
Fiber Optic Trunk Line (T)1/	2 – 4”	PVC Schedule 40
Fiber Optic Main Line (M)2/	1 – 4” ϕ	PVC Schedule 40
Coaxial Distribution (C)3/	2 – 2”	PVC Schedule 40 (color orange)
Services (S)4/	2 – 1-1/4”	PVC Schedule 40 (color orange)
1/ The “Fiber Optic Master Ring” carries all optical fibers throughout the trunk line system from the point(s) of connection to the node vaults (Vn). 2/ It carries all optical fibers from node vaults (Vn) to fiber optic splice boxes (Vf). 3/It carries distribution cables from node vaults (Vn) to service vaults (Vs). 4/ It carries service drop cables from service vaults (Vs) to serviced residences.		

(b) Vault Material Specification

(aa) Vault for Fiber Optic Node (Vn)

- Minimum size: 3' (W) x 5' (L) x 4’-6" (D)
- Type and material of box: concrete, AT&T – 3660 standard
- Type and material of lid: Utility Vault or equal, H10 loading, torsion assist, adjustable frame style, penta head bolts, diamond, and painted black
- Marking of lid:”City of Brentwood"
- Conduit Entrance into Box: from the side
- Maximum number of terminations: 12 (4 - 4", plus 4 - 2” pairs)
- Only the fiber optic trunk line (T), main line (F) and/or coaxial conduits (C) shall interconnect this node vault.
- Add rigid cap for all empty conduits.

(bb) Vault for Splices of Fiber Optic Main (Vf)

- Minimumsize:30"(W)x48"(L)x34"(D)
- Type and material of box: reinforced concrete
- Type and material of lid: reinforced concrete, single lid – type “D”
- Marking of lid:”City of Brentwood"
- Acceptable Manufacturer: Christy N48 Utility Box, or equal, with two extensions
- Maximum number of terminations: 4-4"
- Conduit Entrance into Box: from the side
- After installation of box and conduits, pour concrete sump.
- Only the fiber optic trunk line (T) and/or main line (F) enters and exits this splice vault.
- If the Vf vault is not on the property line, the box shall be installed within the right-of-way (ROW) and not within the five-foot (5’) public utility easement (PUE).
- Add rigid cap for all empty conduits.

(cc) Vault for Services (Vs)

- Minimumsize:24”(W)x36”(L)x34”(D).
- Type and material of box: reinforced concrete.
- Type and material of lid: reinforced concrete, single lid – type “D.”
- Marking of lid:”City of Brentwood."
- Acceptable Manufacturer: Christy N40 Utility Box, or equal, with two extensions.
- Maximum number of terminations: 20 (4 - 2" Φ pairs, plus 6 - 1 1⁄4 " Φ pairs).
- Conduit entrance into box: from the side
- Only the coaxial conduit (C) and services (S) shall interconnect at this service vault.
- Maximum number of homes to serve: 6 (5 homes is not allowed).
- If the Vs vault is not on the property line, the box shall be installed within the right-of-way and not within the five-foot (5’) public utility easement (PUE).
- Add rigid cap for all empty conduits.

(dd) Sweeps: Minimum radius is 24” horizontal or vertical.

(ee) Installation

A pull rope shall be installed in all conduits that are to receive future cables. A pull rope shall be nylon or polypropylene with a minimum tensile strength of 500 pounds. At least 2 feet of pull rope shall be doubled back in to the conduit at each termination. Prior to acceptance by the City of Brentwood, all fiber optic and coaxial conduits shall be cleaned with a mandrel.

(ff) Terminations intPrivate Dwellings
All communications, cable and fiber optic conduit shall terminate intone (1) joint use panel, to be shared by all providers. (Contact Building Division for latest panel specification) Supply separate #10 copper ground wire from the UFER common building electrode to panel. A dedicated 20 amp circuit shall be located adjacent to the distribution hub and installed on the inside wall of the structure.

3. CCBC/MBEP Shadow Conduit Specifications

The Monterey Bay Economic Partnership and the Central Coast Broadband Consortium held a technical expert group meeting, including a representatives from the City of Salinas, on 16 August 2016 and, after two rounds of reviewing drafts, reached consensus on an initial version of standards for installation of conduit on a prospective basis in public works projects. Items include:

General considerations

The City and County of San Francisco's Department of Technology Order No. 1 – Requirements Implementing San Francisco's "Dig Once" Ordinance (draft version 8) and the accompanying report prepared by Columbia Telecommunications Corporation are good general references to use when interpreting these standards or when considering specific design or policy questions.

These specifications are guidelines that generally assume that empty conduit is being installed. If conduit is being installed to support a specific user, purpose or fiber project, then those considerations will drive design decisions and feasibility determinations.

Conduit installation

Conduit size:

2-inch conduit is sufficient for multiple high capacity fiber cables using current technology (432 strands or more), and can be subdivided using inner-duct that would allow multiple service providers to share a single conduit.

4-inch conduit has even more capacity but, due to its larger size, can present design problems, for example when connecting to vaults. This size of conduit was standard when telecommunications systems depended on thick bundles of copper cables, but is not necessary for most modern fiber applications. However, 4-inch conduit should be considered for installation on bridges, railroad crossings and in other circumstances where future changes would be particularly difficult or impossible.

Smaller conduit, e.g. 1.25-inch, is useful when it is not possible to install 2-inch conduit or when many, separate conduits are installed. It may be preferred when conduits are expected to be used by a single

service provider, rather than shared among many over time, or when it meets the needs of an anticipated project or service provider.

The size and number of conduits installed depends on the particulars needs of any given project, and the number of likely or confirmed participants. For example, installation of a bank of four 2-inch conduits provides sufficient flexibility to accommodate a range of needs, and is a better option than installing two 4-inch conduits. However, because of the ability to subdivide it, installing two 2-inch conduits would not necessarily be less useful than two 4-inch conduits. As a starting point, installation of a bank of four 2-inch conduits can be considered as a reasonable standard when construction is done on a prospective basis on a main street, while a single conduit capable of supporting multiple inner-ducts might be sufficient for a smaller or more peripheral street.

An additional factor to consider is whether future conduit installation would be particularly problematic, as with railroad right of ways, or even impossible, which is often the case with bridges. In these circumstances, installation of more and/or bigger conduit than would normally be the case is advisable.

Conduit may be located in either streets or sidewalks, however installation in sidewalks is typically easier and less expensive. Traffic control is a much smaller issue, there are usually fewer existing underground utilities, and vault lids do not need to be traffic rated. Contractors are responsible for locating gravity feed lines, and this responsibility should be spelled out in the bid documents and/or the jurisdiction's standards.

Sweeping conduit bends should be used to allow cable to be pulled without exceeding pull-tension thresholds when placing high-count fiber cables (e.g. 864-count). Unsupported conduit bends should have a minimum bend radius of 48-inches, and bends utilizing manufactured elbows should have a minimum radius of 36-inches (45-degree elbow maximum). However, when necessary, modern fiber optic cables are capable of supporting bends of up to 90-degrees.

A number of factors should be considered in determining if the addition of conduit to a host project is feasible. These factors include:

- Length of the conduit section that would be installed. There is no absolute, minimum useful length for conduit sections. However, very short or isolated sections might not be cost effective to use, unless installed as part of a larger plan.
- Proximity to current or planning public facilities and community anchor locations, and economic development needs and plans.
- Presence of other city or county-owned communications infrastructure, or other open access communications facilities or services.
- Whether physical constraints (bridges, freeway underpasses, underground utility districts) would make it unlikely that there are cost-effective alternatives in the vicinity if needed in the future.
- Whether any partners or customers or other users can or will make immediate use of it.

- The cost of alternative routes, such as placement on utility poles, if needed in the future.
- Budgetary constraints, or added costs that render the host project infeasible.
- Time constraints, particularly the possibility of delaying installation of critical infrastructure.
- Risk of interfering with operation or maintenance of host project facilities.

Installing detector wire/warning tape 3 inches to 6 inches above the conduit is a common standard, but circumstances can vary widely and this question should be addressed on a case by case, engineering design basis. Pull ropes should be included as a standard design element. Pull ropes with built-in detector wire are available and, depending on the circumstances, could perform adequately.

Choice of material depends on circumstances, however HDPE and PVC are commonly used materials.

Backfill type and materials, and other remediation/construction measures should be determined by the standard specifications used by the jurisdiction concerned.

When conduit is installed on a generic, “open trench” basis, a minimum standard is to install conduit the entire length of the trench, with sweeps installed to a future access point and with both ends capped and buried for future use. Where possible, vaults or hand holes should be placed at either end, and any lateral conduit that is installed should likewise terminate at an access point.

Vault installation

The base size for a vault is 24-inches by 36-inches (Number 6 vault). A vault this size can accommodate two 2-inch conduits, with some room for splicing, assuming that it is not being used for lateral/customer service purposes. It is an ample size for splicing cables smaller than 432 strands. A 30-inch by 48-inch vault would be generally capable of supporting more splice points and/or larger cables, including those used for lateral/customer service purposes. The minimum size for a vault is 18-inches by 25-inches (Number 5 vault), although its usefulness could limited. For example, it might not have sufficient room for slack loops or a large number of splices.

Standard municipal security specifications should be followed, however bolted-down lids are considered a normal security measure. Labels on lids should include the name of the relevant jurisdiction.

The base assumption for vault design is that shared vaults will only accommodate through-splices and connections of main fiber cables, and will not be used for lateral connections, customer aggregation or other service taps or drops. When planning vault locations, sufficient space should be allowed for future installation of third party vaults which can be used for service connection purposes. When possible, designs should assume that at least one additional vault of a similar size will be installed next to every planned vault.

Where possible, conduit should enter vaults on an end wall, parallel to the direction of the conduit run, rather than on a side wall or perpendicular to the direction of the conduit run. Vaults should be placed

deep enough to allow conduit to enter horizontally, as it is preferable to avoid upward conduit sweeps. 36-inches is a benchmark for minimum depth.

Installation of grounding rods is preferred.

Electronic markers (EM) are an effective method of marking and locating vaults.

Spacing of vaults depends on circumstances and needs. As a general guide in urban and suburban areas, 600-feet is a benchmark for maximum spacing and 300-feet is a common standard when the need to support lateral connections is anticipated. In rural areas, spacing can be greater. 2,500-feet is a benchmark distance for long haul (i.e. no lateral connections anticipated) conduit and can support "blown-in" installation techniques. However, it may be more efficient to install longer segments of 3,500 feet to 4,000 feet in a longer project, such as a highway project, or in rural areas.

Prospective installation of vaults is not always necessary or even desirable if there is uncertainty about the eventual use of the conduit or if the additional cost of vaults would make the project infeasible. In many cases, it is not possible to anticipate the future needs of service providers.

Appendix F - Glossary

4G	4G is the fourth generation of cellular network technology that supports mobile broadband service. It is defined by the services supported rather than strict technology specifications, although for practical purposes it can be considered to be service supported by networks using technology that meets the LTE (Long Term Evolution) standards adopted by the industry. From a practical perspective, it is the first generation of mobile broadband technology that was designed and deployed to support routine video viewing.
5G	5G is the the fifth generation of cellular network technology that supports mobile broadband service. Prototype deployments began in the U.S. in 2018, with general consumer availability expected in a relatively small number of areas in 2020. The working technology specifications are defined by an international, 3GPP, which conforms to the International Telecommunications Union standard IMT-2020. 5G service areas are divided into a mosaic of small geographical areas called cells. The local antennas are connected with the telephone network and the Internet by a high bandwidth optical fiber or wireless backhaul connection. It is intended to support applications with high bandwidth or low latency demands.
ADSL	Asymmetric Digital Subscriber Line: DSL service with a larger portion of the capacity devoted to downstream communications, less to upstream. Typically thought of as a residential service. ADSL2 is the second generation of ADSL technology and provides higher service levels.
ATM	Asynchronous Transfer Mode: A data service offering by ASI, that can be used for interconnection of customer's LAN. ATM provides service from 1 Mbps to 145 Mbps utilizing Cell Relay Packets.
Backhaul	Connecting Internet access to a location over long or short distances. Usually, wired networks, particularly fiber networks, are necessary to provide sufficient interconnection capacity, but wireless technology is also used for some applications.
Bandwidth	The amount of data transmitted in a given amount of time; usually measured in bits per second, kilobits per second, and megabits per second.
Bit	A single unit of data, either a one or a zero. In the world of broadband, bits are used to refer to the amount of transmitted data. A kilobit (Kb) is approximately 1,000 bits. A megabit (Mb) is approximately 1,000,000 bits.
Broadband	"Broadband" refers generally to any telecommunications service capable of supporting digital data transmission at high speeds. These services can include and/or support Internet, television, telephone, private data networks and various specialized uses. Broadband service can be delivered in a variety of ways, including telephone lines (e.g. DSL), coaxial cable (e.g. cable modem), fiber optic cable (e.g. Lit San Leandro), wireless cellular/mobile service (e.g. cell phones, tablets, wireless modems), WiFi, point-to-point and point-to-multipoint

	wireless service (e.g. TelePacific, Etheric) and hybrid networks (XO Communications). Although different organizations use different criteria, the California Public Utilities Commission considers 6 Mbps download and 1.5 Mbps upload speed to be a standard for adequate broadband service availability. Unless otherwise stated, this report uses the CPUC definition.
Byte	The amount of memory space needed to store one character, which is normally 8 bits.
Cable modem	A device that hooks to your cable TV line to allow your computer to receive Internet service.
CDMA	The type of digital cellular phone network used for 3G (and older) service by some carriers in much of the United States, but rare elsewhere in the world. CDMA stands for Code Division Multiple Access, and CDMA2000 1x is the third-generation, or 3G, extension to which CDMA cellular operators are upgrading their networks. It is a digital cellular technology that uses spread-spectrum techniques.
Cell	The geographic area covered by a cellular telephone transmitter. A connected group of cells form a cell system, which is what you gain access to when you sign up for cellular telephone service.
Cellular	A mobile communications system that uses a combination of radio transmission and conventional telephone switching to permit telephone communications to and from mobile users within a specified area.
CLEC	Competitive Local Exchange Carrier: Wireline service provider that is authorized under state and Federal rules to compete with ILECs to provide local telephone service. CLECs provide telephone services in one of three ways or a combination thereof: a) by building or rebuilding telecommunications facilities of their own, b) by leasing capacity from another local telephone company (typically an ILEC) and reselling it, and c) by leasing discreet parts of the ILEC network referred to as UNEs.
Coaxial cable	A type of cable that can carry large amounts of bandwidth over long distances. Cable TV and cable modem service both utilize this technology.
Commercial class	Broadband service similar to residential service in that the provider takes effectively all responsibility for installing, maintaining and supporting the service. Speeds are similar (6 to 100 Mbps), but service levels, reliability, consistency and pricing are higher.
Copper	Most telephone and cable lines are built using copper wires, which is a telecommunications technology that has been in use since the 19th century. The term is to distinguish lower capacity copper wires (and cables) from higher capacity fiber optic strands (and cables) that are made from glass or plastic.
CPCN	Certificate of Public Convenience and Necessity: Authorization given by the CPUC to telecommunications carriers in order to provide service in the state of California.

Dark fiber	Fiber optic cables are composed of many, very thin fiber optic strands made of glass. A laser is used to send a beam of light through a fiber optic strand, and this beam carries data from one end to the other. If no electronic equipment (i.e., the laser) is connected to a strand, it is literally dark, and cannot carry data. Dark fiber is sought after and used by telecommunications carriers and large companies that prefer to install and operate their own electronic equipment at either end.
Dial-Up	A technology that provides customers with access to the Internet over an existing telephone line.
DS3	A dedicated phone connection supporting data rates of about 43Mbps (megabits per second). Also called a T-3, the line actually consists of 672 individual channels, each of which supports 64Kbps. DS3 lines are used mainly by Internet Service Providers (ISPs) connecting to the Internet backbone. Large businesses also use DS3 lines when they have large sites to interconnect.
DSL	A common form of broadband Internet connection. DSL stands for Digital Subscriber Line.
E-Rate	A Federal program that provides subsidy for voice and data lines to qualified schools, hospitals, CBOs, and other qualified institutions. The subsidy is based on a percentage designated by the FCC. CTF benefits are calculated net of the E-rate subsidy.
E911	Enhanced 911, an emergency service that automatically sends phone number and location information to the operator. E911 comes in handy, say, when you need to get emergency help and are unable to speak or don't know your location.
Ethernet	The most common networking standard in the world, formally known as IEEE 802.3.
Fixed wireless	Broadband systems based on fixed wireless technology provide Internet service using outdoor antennas installed on homes and businesses. It is most commonly found in rural areas, but it is also sometimes used by businesses to compensate for poor wireline service in urban areas. Fixed wireless systems can provide services between two specific locations – i.e., point to point – or from a central access point to many locations in the surrounding areas – i.e., point to multipoint.
FTTN	Fiber To The Neighborhood: A hybrid network architecture involving optical fiber from the carrier network, terminating in a neighborhood cabinet with converts the signal from optical to electrical.
FTTP	Fiber To The Premise.
Gigahertz	A measure of electromagnetic wave frequency equal to one thousand million (1,000,000,000) hertz, often abbreviated as GHz and used to specify the radio frequency used by wireless devices. 802.11a networks operate at 5 GHz.

	802.11b and g networks use 2.4 GHz, which is susceptible to interference from nearby cordless phones and microwave ovens that use the same frequency.
GPON	Gigabyte-Capable Passive Optical Network, a type of distribution network often used for fiber to the premise service.
GSM	Global System for Mobile Communications: This is the current radio/telephone standard in Europe and many other countries except Japan and the United States.
Hub	A common connection point for devices, such as computers and printers, in a network.
ILEC	Incumbent Local Exchange Carrier. An ILEC is a telephone company that was providing local service when the Telecommunications Act of 1996 was enacted. Compare with CLEC, a company that competes with the already established local telephone business.
Industrial class	Broadband service where the customer plays a much greater role in provisioning and supporting the service, including buying different elements from different vendors and managing installation and support. Speeds would be higher – perhaps as high as a Gigabit per second or more – and quality of service levels could be as high as Tier 1. Comcast's Business Class service or AT&T's business DSL service are examples of commercial class service. A DS-3 or dark fiber strands are examples of industrial class service.
I-Net	Institutional Network. Provides a high-speed connection between government, educational and community entities. It is often negotiated with a cable franchise, in exchange for using right-of-way in a jurisdiction.
ISP	Internet Service Provider: A company providing Internet access to consumers and businesses, acting as a bridge between customer (end-user) and infrastructure owners for dial-up, cable modem and DSL services.
LAN	Local Area Network: A geographically localized network consisting of both hardware and software. The network can link workstations within a building or multiple computers with a single wireless Internet connection.
Last mile	Infrastructure (e.g., fiber optic lines, distribution boxes, equipment vaults, poles, conduit) that provides broadband service to end users or end-user devices (including households, and businesses).
Lit fiber	Fiber optic cables are composed of many, very thin fiber optic strands made of glass. A laser is used to send a beam of light through a fiber optic strand, and this beam carries data from one end to the other. When this kind of electronic equipment (i.e., the laser) is installed and operating, then the fiber strand is literally "lit" and ready to transmit data, either for the company that operates it or for third-party customers.
Local Loop	A generic term for the connection between the customer's premises (home, office, etc.) and the provider's serving central office. Historically, this has been

	a wire connection; however, wireless options are increasingly available for local loop capacity.
MAN	Metropolitan Area Network: A high-speed date intra-city network that links multiple locations with a campus, city or local telephone service area. A MAN typically extends as far as 50 kilometers.
Managed services	The type of service provided by dominant incumbent providers, such as AT&T and Comcast. Rather than providing a simple connection between points – via lit or dark fiber – these companies provide full Internet bandwidth services, at a speed and quality of service level they specify, and sometimes with quantity limits, i.e., data caps. It is analogous to water service: these companies sell "water" and don't rent out access to their "pipes".
Mbps	Megabits per second: 1,000,000 bits per second. A measure of how fast data can be transmitted.
Middle mile	Broadband infrastructure that does not predominantly provide broadband service to end users or to end-user devices, and may include interoffice transport, backhaul, Internet connectivity, or special access. Middle mile facilities are the link between last mile facilities and major interconnection points, such as those that form the core of the Internet.
Modem	Short for modulator/demodulator. A modem modulates outgoing digital data into analog signals so they can be sent over copper phone lines, and demodulates incoming analog signals into digital.
Overbuilders	Building excess capacity. In this context, it involves investment in additional infrastructure project to provide competition.
PON	Passive Optical Network: A Passive Optical Network consists of an optical line terminator located at the Central Office and a set of associated optical network terminals located at the customer's premise. Between them lies the optical distribution network composed of fibers and passive splitters or couplers. In a PON network, a single piece of fiber can be run from the serving exchange out to a subdivision or office park, and then individual fiber strands to each building or serving equipment can be split from the main fiber using passive splitters / couplers. This allows for an expensive piece of fiber cable from the exchange to the customer to be shared amongst many customers thereby dramatically lowering the overall costs of deployment for fiber to the business (FTTB) or fiber to the home (FTTH) applications.
Rights-of-Way	Legal rights of passage over land owned by another. Carriers and service providers must obtain rights-of-way to dig trenches or plant poles for cable systems, and to place wireless antennae.
Router	An intelligent network device that goes one step beyond bridging by converting address-based protocols that describe how packets of information move from one place to another. In practice, this generally comes down to translating between IP addresses and MAC addresses for data flowing between your local

	network and the Internet. Many people use the term interchangeably with "gateway."
Subscribership	Subscribership is how many customers have subscribed for a particular telecommunications service.
Switched Network	A domestic telecommunications network usually accessed by telephones, key telephone systems, private branch exchange trunks, and data arrangements.
T-1	The T-1 standard was introduced in 1961 in order to support a bi-directional speed of 1.5 Mbps at a high quality-of-service level, using the copper wires of the time. Because it is a dedicated and managed circuit, its performance is usually substantially better than shared services such as DSL or cable modem, even in cases where the claimed top speed of those shared services is many times higher. A T-1 circuit is generally considered to be the lowest level of service that can be described as industrial or carrier class.
Telco	An abbreviation for Telephone Company.
Telecommunications	Refers to all types of data transmission, from voice to video.
Throughput	The amount of data that can be transmitted in a given amount of time. Throughput is commonly measured in bits per second. (Although throughput is not really a measurement of speed, most people, including us, use the word "speed" when talking about a high-throughput network.)
Universal Service	Originally a congressionally mandated federal program of providing every home in the United States with basic telephone service. The FCC has extended this definition to include broadband service. In California, the program is run by the California Public Utilities Commission and is supplemented with state funds.
VDSL	Very-high-bit-rate digital subscriber line (VDSL or VHDSL) is a digital subscriber line (DSL) technology providing data transmission faster than asymmetric digital subscriber line (ADSL) over a single flat untwisted or twisted pair of copper wires (up to 52 Mbit/s downstream and 16 Mbit/s upstream),[2] and on coaxial cable (up to 85 Mbit/s down- and upstream)[3] using the frequency band from 25 kHz to 12 MHz.[4] These rates mean that VDSL is capable of supporting applications such as high-definition television, as well as telephone services (voice over IP) and general Internet access, over a single connection. VDSL is deployed over existing wiring used for analog telephone service and lower-speed DSL connections. This standard was approved by ITU in November 2001.
Videoconferencing	Conducting a conference between two or more participants at different sites by using computer networks to transmit audio and video data.
VLAN	Virtual Local Area Network. A network of computers that behave as if they are connected to the same wire even though they may actually be physically located on different segments of a LAN.

VoIP	Voice Over Internet Protocol: A new technology that employs a data network (such as a broadband connection) to transmit voice conversations.
VPN	A method of creating an encrypted tunnel through which all traffic passes, preventing anyone from snooping through transmitted and received data. VPN stands for virtual private network.
WAN	Wide Area Network, A collection of local area networks connected by a variety of physical means. The Internet is the largest and most well-known wide area network. Wide area network is generally abbreviated to WAN.
WiFi	Short for wireless fidelity and is meant to be used generically when referring of any type of 802.11 network, whether 802.11b, 802.11a, dual-band, etc. The term is promulgated by the WiFi Alliance. Any products tested and approved as "WiFi Certified" (a registered trademark) by the WiFi Alliance are certified as interoperable with each other, even if they are from different manufacturers. A user with a "WiFi Certified" product can use any brand of access point with any other brand of client hardware that also is certified. Typically, however, any WiFi product using the same radio frequency (for example, 2.4 GHz for 802.11b or 11g, 5 GHz for 802.11a) will work with any other, even if not "WiFi Certified." Formerly, the term "WiFi" was used only in place of the 2.4 GHz 802.11b standard, in the same way that "Ethernet" is used in place of IEEE 802.3. The Alliance expanded the generic use of the term in an attempt to stop confusion about wireless LAN interoperability.
WiMAX	Another name for the 802.16 wireless networking specification used for long-haul and backhaul connections.
Wireless ISP	A company that provides wireless Internet access. The term is often abbreviated to WISP.
WLAN	Wireless Local Access Network, a LAN that can be connected to via a wireless connection.

Sources: Tellus Venture Associates, California Public Utilities Commission, Neratech, Wikipedia.