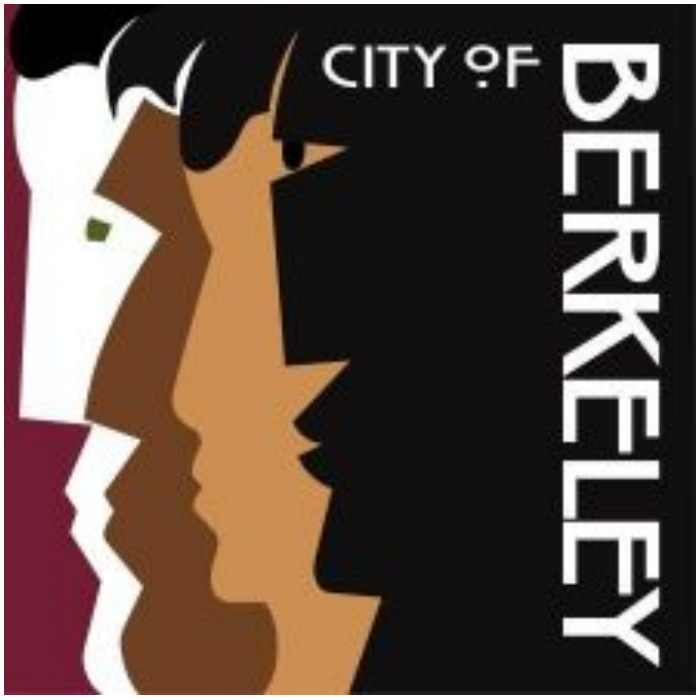
City of Berkeley Broadband Development Assessment

29 May 2015



Tellus Venture Associates

Stephen A Blum
Tellus Venture Associates

www.tellusventure.com

Table of Contents

1. Executive Summary

Broadband infrastructure in Berkeley

Wireline broadband infrastructure within the city limits of Berkeley is substandard, receiving a "C-" grade (1.7 on a 4-point scale), using criteria developed for the East Bay Broadband Consortium. This grade is below average for both California ("C", 2.0) and Alameda County ("C", 2.0), and significantly – about 20% – worse than the adjacent cities of Albany ("C", 2.2), Oakland ("C", 2.1) and Emeryville ("C", 2.1)[1].

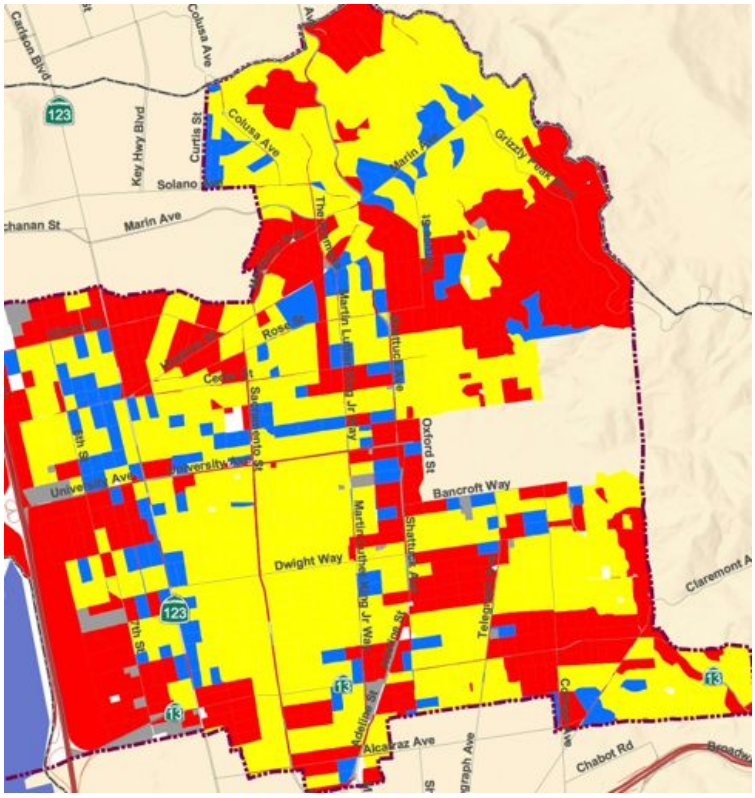


Figure 1.1 – Blue is good, yellow is average, red is bad, grey is worst.

The quality of the infrastructure that supports broadband service to businesses and homes generally follows a pattern commonly seen in the East Bay: more infrastructure investment tends to go into residential neighborhoods, where service providers can also sell video services, commercial districts receive less attention and industrial areas least of all. Terrain is also a factor, with hilly areas generally presenting more, and more costly, challenges.

The City of Berkeley owns broadband-related infrastructure that could be used to improve service in poorly served commercial and industrial districts. A comparison of the City's conduit and fiber optic cable infrastructure map with a map showing census block-specific grades shows that city-owned broadband assets are located in areas that have sub-standard broadband infrastructure, particularly on the western side of Berkeley.

The City also has plans for upgrading its traffic signal control network and for repaving or otherwise improving City streets. These kinds of projects often present opportunities to install extra conduit or

[1] 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: a minimum of two providers, one just meeting the minimum standard of broadband service set by the California Public Utilities Commission (6 Mbps download and 1.5 Mbps upload) and the other exceeding it. A "D" grade – below the Californian average – is given when wireline service meets but does not exceed this standard or where consumers only have one qualifying service provider available. If no qualifying service is available, a failing grade – "F" – is given. "A" and "B" grades are given where superior service is offered. Details regarding the grading method are in Appendix A.

fiber optic capacity and can be used to improve the broadband infrastructure and service available in Berkeley.

Broadband policy

Although the City of Berkeley has virtually no authority to regulate or otherwise directly control the actions of privately owned Internet service providers, it still has many options for both direct and indirect action which can influence the level, cost and availability of service. These options include:

- Identify existing city assets, such as conduit, which can support Internet service.
- Proactively install new broadband infrastructure, such as conduit and fiber optic lines.
- Make City-owned assets available for a fee to private Internet service providers on either on a neutral basis or awarded to specific companie(s) following an open, competitive process.
- Identify potential sources of funding, such as grants, bonds, service subsidies or enterprise funds.
- Develop policies which encourage the development of broadband infrastructure by public agencies and/or private companies.

In many regards, City of Berkeley policy regarding telecommunications infrastructure meets or exceeds most best practice policy recommendations. BMC Chapter 16.10 provides for notification and coordination of construction – sometimes referred to as “open trench” and “dig once” policies – and collection of information. Routine implementation of these policies would provide a means of ensuring that utility work in general and broadband infrastructure projects in particular are done in such a way as to maximize the public benefit within the constraints of state and federal law.

Municipal broadband initiatives

Several cities in California and elsewhere have taken direct action to upgrade fundamental broadband infrastructure and the service that is offered to businesses and consumers. For example, municipal electric utilities owned by the cities of Palo Alto and Santa Clara have built fiber optic networks that provide inexpensive connectivity to local businesses. The City of San Leandro worked with a private company to achieve the same goal.

The cities of Brentwood and Loma Linda use developer-financed conduit to support fiber-to-the-home service. Austin and Kansas City adopted broadband-friendly policies to attract Google Fiber. San Francisco, Watsonville and Santa Monica provide networking services to businesses using broadband infrastructure originally built to serve city information technology needs. However, every city is unique.

Recommendations and policy options

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

- Formalize a policy requiring entities that do certain kinds of excavation work in the public right of way provide the City with the opportunity to install conduit.
- Investigate the feasibility of strengthening the existing requirements for conduit sharing, joint use of trenches and use of City-owned facilities.
- Formalize procedures for implementing both new and existing policy regarding street cuts and other types of excavations.
- Establish detailed standards for submitting mapping data in GIS format, for both third party projects and City-owned facilities.
- Formalize inspection procedures for project work, and collection procedures and requirements for associated documentation.
- Develop broadband facilities requirements for new or major remodeled construction, either residential or commercial or both.
- Review permit processes and determine if any streamlining can be done.
- Establish the feasibility of creating a master encroachment permit and inspection process for large scale broadband infrastructure projects.

Possible initiatives to consider, roughly in increasing order of risk, include:

1. Reduce barriers to private sector investment in broadband infrastructure by extending existing policies and considering new ones.
2. Attract new private sector, commercially focused carriers to Berkeley by likewise offering access to City facilities on a partnership basis.
3. Use City resources to try to entice a new or existing private sector carrier into upgrading residential service, particularly by building a fiber to the home system.
4. Build and operate a municipal dark fiber network or a “lit” network offering industrial grade ethernet connectivity.
5. Build and operate a municipal Internet service utility, for residential and/or commercial purposes.
6. Build a municipal network, to any desired extent, and lease it out to a private operator.

2. City's role in broadband planning

2.1. Berkeley's residential and commercial infrastructure is below average

Wireline broadband infrastructure within the city limits of Berkeley (excluding the U.C. campus) is well below both the California and Alameda County averages, receiving a "C-" grade (1.7) using criteria developed for the East Bay Broadband Consortium[2] in combination with the most recent broadband availability data submitted by Internet service providers to the California Public Utility Commission (CPUC).

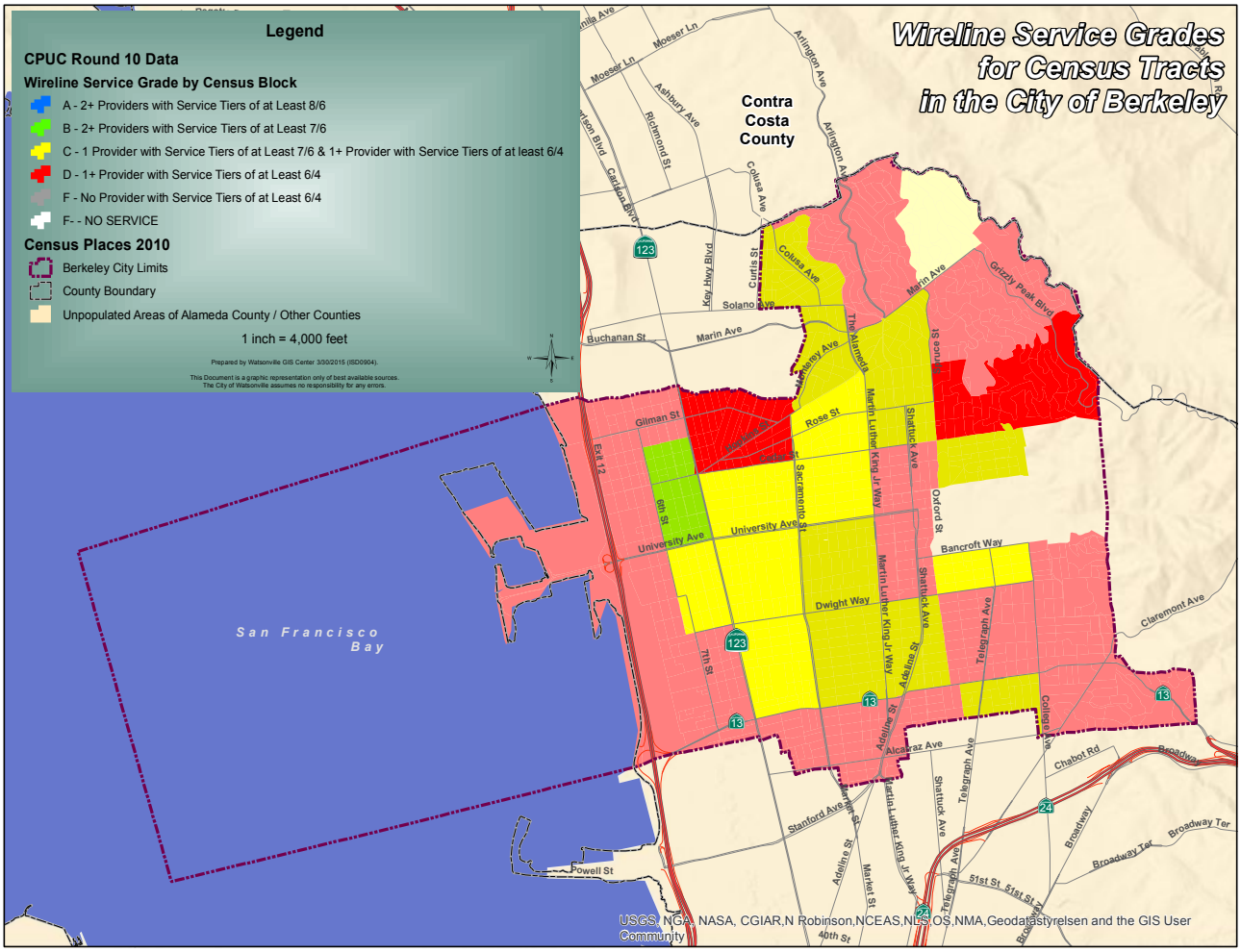


Figure 2.1 – Berkeley's primary wireline broadband infrastructure grades, by census tract.

The infrastructure grade of a census block is determined by the generally available level it supports. 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: a minimum of two providers, one just meeting the minimum standard of broadband service set by the CPUC (6 Mbps download and 1.5 Mbps upload) and the other exceeding it. A "D" grade – below the Californian average – is given when

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

wireline service meets but does not exceed this standard or where consumers only have access to one qualifying service provider. If no qualifying service is available, a failing grade – "F" – is given. "A" and "B" grades are given where superior service is offered. Details regarding the grading method are in Appendix A.

AT&T and Comcast are the two primary Internet service providers in Berkeley. Comcast claims to offer a uniform level of service in nearly the entire city, but its ability to actually deliver promised speeds depends on the level of investment it has made in particular neighborhood and the usage patterns of residents – the more people accessing the Internet in a given area, the lower the speeds each will receive. AT&T provides more or less the same landline telephone service throughout Berkeley, but the level of broadband service it provides also varies greatly by neighborhood. Figure 2.1 shows composite grades for census tracts in Berkeley. The pattern that emerges is one where broadband infrastructure is better in central residential neighborhoods, and poorer in commercial, industrial and peripheral residential areas.

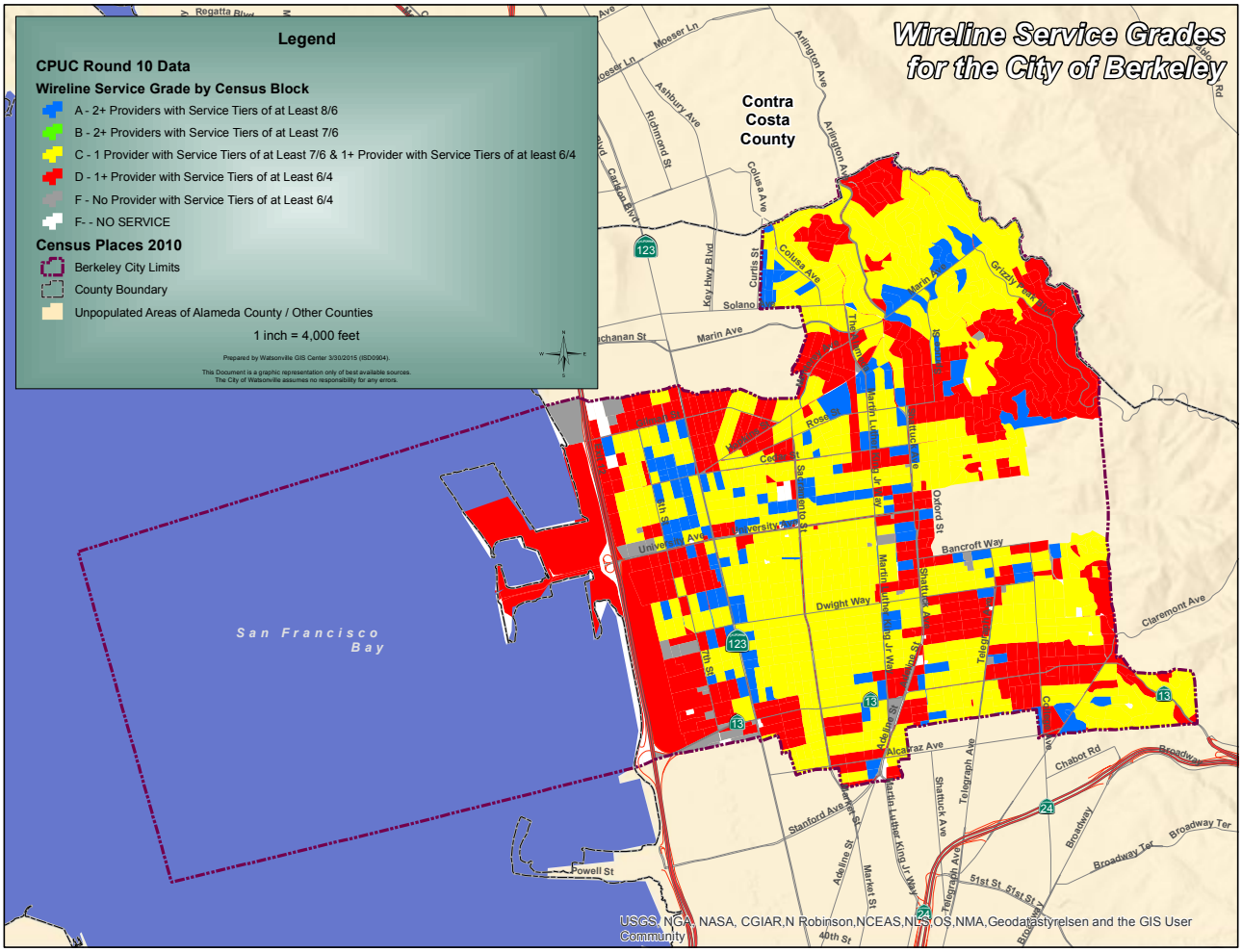


Figure 2.2 – Berkeley's primary wireline broadband infrastructure grades, by census block. The worst broadband infrastructure – an "F" grade – is in industrial and commercial areas.

Figure 2.2 shows a more granular picture, with wireline infrastructure grades broken out by census block. The best broadband infrastructure (see Appendix B) tends to be located along University Avenue, and between Sacramento Street and 6th Street. Although there are exceptions, the quality of commercially available broadband service tends to drop as you move further away from that central area. This pattern is consistent with other urban East Bay communities, where AT&T and Comcast have a tendency to neglect industrial and some commercial areas, and focus investment in the residential neighborhoods where revenue potential is highest and construction costs are lowest. Residential customers are more likely to buy high value bundles of television, telephone and Internet service, while business customers are less likely to do so.

On the other hand, Berkeley is well served by inter-city fiber optic carriers. U.C. serves as an anchor customer for several fiber companies, and Berkeley's position on major rail lines, including BART, means that a number of major fiber routes pass through the city. More information on existing service providers is in Section 4 below.

Other East Bay cities

By comparison, Oakland received a "C" (2.1), Emeryville a "C" (2.1), Albany a "C" (2.2) and Piedmont a D+ (1.5). Overall, Alameda County received a "C" (2.0), which is defined as the type and quality of broadband infrastructure most commonly found in California, i.e. a combination of relatively high speed cable modem and mid-range DSL service provided by a telephone company. The methodology is further explained in Appendix A.

Berkeley has several characteristics in common with other low scoring communities. The neighborhoods receiving the lowest grades (see Appendix B) tend to be either hilly or industrial in character, albeit with significant exceptions. Communities with challenging terrain, such as Orinda and Moraga, or with under developed legacy industrial areas – Pittsburg and Hercules, for example – also received low grades.

Berkeley is similar in other respects to Piedmont, the city with the worst grade in Alameda County, where obtaining permission to build infrastructure is generally difficult, and particularly so when it comes to gaining approval for wireless broadband facilities. Although mobile broadband was not factored into this study, there is an indirect connection between its availability and high quality, relatively low cost wireline consumer service.

AT&T and Verizon, the two biggest wireline and wireless telephone companies in California, give first priority for capital investment to mobile infrastructure, including high capacity fiber optic lines that serve cell sites. Lines built to support mobile networks are also used to improve local service for residents and businesses. If there are no cell sites to support, however, there is little chance that fiber lines will be built simply to upgrade service to residential, small business or industrial customers.

2.2. Broadband technology

There are two principal types of broadband technology: wireline and wireless. Both types have advantages and disadvantages. There are applications where either might work, and applications where

only one type of technology is suitable. Wireline technologies include copper telephone and cable television systems as well as fiber optic lines.

Definitions

Wireless technology includes cellular telephone and data services, such as those offered by AT&T, Verizon and other mobile phone companies, WiFi access points, satellite services and fixed wireless systems.

"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, 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. Technical distinctions can be made between "broadband" and "Internet" service and facilities, but in this report the terms are used interchangeably.

Another distinction that's often made is between "middle mile" and "last mile" infrastructure. Similar to local streets and driveways, last mile facilities provide direct service to homes and businesses. Wireline networks installed by telephone and cable companies, and cellular tower sites are examples. Middle mile infrastructure connects last mile systems to the core of the Internet, providing bulk bandwidth that, in turn, is shared among customers. It's similar to arterial streets and highways, in that it's used to stitch neighborhood facilities together and link these larger systems to inter-city and international networks.

Service standards

Although different organizations use different criteria, the California Public Utilities Commission (CPUC) currently considers 6 Mbps download and 1.5 Mbps upload speeds to be the standard for adequate residential broadband service. The Federal Communications Commission, on the other hand, recently adopted 25 Mbps download/3 Mbps upload as the minimum acceptable level of service, and efforts are under way in the legislature and at the CPUC to raise the Californian standard to that level. It should be noted that, in either case, the standard refers to the capacity of the infrastructure installed by service providers. So long as the minimum level is available, consumers may also be offered the option of purchasing less expensive, lower speed service.

Types of systems

Many different kinds of technology can be used to deliver broadband service, and most are currently in use in and around Berkeley. Dedicated wireless links, copper wires and even mobile services can support high speed service. However, these technologies quickly hit limits that are frequently inadequate for businesses, including home-based ones, and often fail to meet the needs of consumers, particularly when cost is considered.

Last mile infrastructure is usually owned and used by consumer-focused telephone and cable companies, although competitive carriers have some rights of access to copper lines owned by telephone companies. Ownership of middle mile infrastructure is split between the major last mile providers and specialized fiber optic network operators.

Mobile networks

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. Although typical monthly usage limits are adequate for smart phones and other hand held devices, 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, 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.

Fiber optic networks

Fiber optic cables themselves, though, can support the highest levels of service and provide the maximum degree of flexibility for sophisticated users, particularly businesses. Newly built networks, whether designed for business or residential customers, tend to be completely fiber based – fiber to the home (FTTH) or fiber to the premise (FTTP) – because the cost of installing fiber is roughly the same as, and sometimes less than, traditional copper wire facilities. The labor involved in installing cables in conduit or on poles, and installing or upgrading conduit and poles, constitutes most of the cost in either case.

Fiber network enterprises are often categorized as “lit” or “dark” or “managed services” systems. A lit network is one where the operator installs both the fiber optic cable and the electronics that’s used to transmit information over it, and then sells a transportation service between two or more points to the end user. Dark fiber comes without any electronics and only provides a physical connection between two or more points. The customer is responsible for installing, maintaining and operating all the required equipment.

“Managed service” is the type of service most commonly – often exclusively – offered by major carriers such as AT&T and Comcast. The carrier simply agrees to provide broadband service that meets particular, company-defined specifications for speed, availability and quality, and customers have a limited range of options from which to choose. The available options can be adequate for consumer and small business purposes, but often fail to meet the needs of larger and/or more sophisticated enterprises.

2.3. Role of municipalities

The California Public Utilities Commission (CPUC) regulates "telephone corporations" and, to a lesser extent, "cable television corporations" and "video service providers"[3]. These categories include AT&T and, to a restricted extent, Comcast, which are the two primary retail broadband service providers in Berkeley. Intercity carriers are also regulated as telephone corporations.

Responsibility for regulating telephone corporations is shared between the CPUC and the Federal Communications Commission (FCC). Municipalities are allowed no authority in that regard.

Cable television regulation

Originally, regulation of cable television corporations was the responsibility of local government in California. The City of Berkeley issued its first cable franchise in 1967, and was actively involved in regulating franchisees to the extent allowed by federal and state law until the Digital Infrastructure and Video Competition Act of 2006 (DIVCA) was approved by the California legislature.

DIVCA established statewide franchises for video service providers, which now includes telephone companies such as AT&T. DIVCA severely limits the role cities and other local government entities may play in regulating or otherwise influencing video service providers. Cities still receive a 5% franchise fee from video franchise holders, and have a limited opportunity to inspect their books to ensure compliance. Requirements for public access channels, consumer protection rules and obligations to build out infrastructure are also subject to municipal review, but enforcement authority is severely limited, often to the point of being impractical.

Encroachment permits

The primary regulatory role remaining to cities is the ability to approve or deny applications for encroachment permits for the use of the public right of way on the basis of neutral "time, place and manner" standards.

The FCC's recent decision[4] to bring "broadband Internet access service" under common carrier regulation (often referred to as the "network neutrality" decision) tries to draw a clear line between what kind of regulation does and does not apply to providers of those services. In particular, the FCC has ruled out regulation, by itself or states, of Internet service offerings, rates, or access to infrastructure by third parties, except to say that it will review complaints on an after-the-fact basis using a "just and reasonable" standard. The decision specifically allows "any body politic, or municipal organization", as well as individuals and state utility commissions, to file complaints. It establishes formal and informal procedures for doing so, and creates an ombudsman's position to facilitate the process.

---

[3] The distinction between "cable television corporation" and "video service provider" is *de minimis* for the purpose of this report, and the terms will be used interchangeably.

[4] *In The Matter of Protecting and Promoting the Open Internet;* Report and Order on Remand, Declaratory Ruling, and Order; Federal Communications Commission; adopted February 26, 2015 and released March 12, 2015.

However, some aspects of Internet service and infrastructure are still open to regulation under common carrier rules, including pole attachments and conduit access and, to an unspecified extent, universal service policies, both of which are under the CPUC's jurisdiction. Other rules that will be enforced include those that relate to consumer protections and privacy, and accessibility provisions.

Cities have greater flexibility when it comes to managing publicly-owned assets and providing services directly. Cities in California are free to decide whether or not to build and operate telecommunications facilities, establish Internet service utilities or manage assets that could be used for those purposes. The FCC has reaffirmed that cities maintain wide discretion when negotiating with telecommunications companies over the use of city-owned facilities, as opposed to simply regulating access to the public right of way.

Municipal broadband utilities

The FCC has also affirmed the right of cities to compete on an even basis with privately-owned Internet service providers. In a decision[5] that pre-empted state-imposed restrictions on municipally owned broadband utilities, the FCC said, in effect, that states have the authority to prevent cities from building broadband infrastructure and providing Internet service, but cannot impose restrictions that put municipal systems at a competitive disadvantage to privately owned ones.

California law contains no such ban and makes a few, relatively minor distinctions between municipal and privately owned Internet service providers. This preemption of authority by the FCC is being appealed in federal court by two States – Tennessee and North Carolina – but assuming it withstands those challenges it would inhibit changes to the status quo in California.

[5] *In the Matter of City of Wilson, North Carolina Petition for Preemption of North Carolina General Statute Sections 160A-340 et seq. and the Electric Power Board of Chattanooga, Tennessee Petition for Preemption of a Portion of Tennessee Code Annotated Section 7-52-601*; Memorandum Opinion and Order; Federal Communications Commission; adopted February 26, 2015 and released March 12, 2015.

3. Broadband planning overview

3.1. Types of infrastructure

Definitions

Consumer-grade Internet access is typically a shared resource, with many subscribers contending for the same bandwidth, and is subject to speed and volume 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 (6 to 100 Mbps), but service levels, reliability, consistency and pricing are higher. Comcast's Business Class service or AT&T's business DSL service are examples of commercial grade service.

"Industrial grade" service refers to situations where the customer plays a much greater role in building 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 found in top tier Internet exchanges. DS-3 circuits or dark fiber strands are examples of industrial grade service. Large industrial customers frequently buy services directly from middle mile providers.

Differences

It is much easier for broadband service providers to generate an acceptable return on investment in residential areas than in commercial or industrial ones, particularly densely populated urban and suburban neighborhoods. 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.

Industrial and commercial customers are more diverse and less predictable than residential subscribers. One business might need Gigabit speeds at the highest 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 is doing, be extremely selective in choosing which neighborhoods and business districts 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.

The experience of other cities, particularly those in the Bay Area (see below), shows that relatively small-scale efforts can result in significant improvements in commercial and industrial grade broadband infrastructure by reducing the risk for private telecommunications companies. These steps have included streamlining permitting procedures, directing redevelopment funds towards broadband projects and other measures.

3.2. Broadband policy

As discussed above, cities have little or no direct role in regulating Internet service providers. However, cities can implement policies that help or hinder broadband infrastructure development and competition. Options include managing the use of city-owned facilities by Internet service providers, setting policy for shared use of public right of ways and becoming directly involved in developing broadband infrastructure and even providing services, with or without private sector partners. Policy initiatives that encourage broadband infrastructure development can have a significant impact on the availability of service and facilities. Cities have attracted private, competitive broadband service providers by lowering barriers to entry and leveraging existing city infrastructure and budgets.

City facilities

City facilities that can support broadband development fall into two general categories: conduit and pole routes, and real estate.

Pole routes

Most California cities do not own pole routes. The exceptions are cities that also operate municipal electric utilities, such as Alameda, Santa Clara and Palo Alto. Not coincidentally, these three cities were the first in the San Francisco Bay Area to embark on large scale, municipal broadband projects.

Conduit

On the other hand, it's common to find cities that own significant conduit routes, particularly ones used to manage traffic signal networks. Because traffic signals tend to be installed on busy streets in commercial areas, the conduit routes that serve them are usually well suited to support business-oriented broadband service and middle mile facilities. The City of San Leandro was the first in the Bay Area to make large scale use of traffic signal conduit for this purpose

Other types of municipal conduit include empty conduit installed on a prospective basis – the Cities of Brentwood and Watsonville are examples – as well as conduit specifically designed to support internal city data networks and street light systems. Conduit installed for IT network purposes can be useful, but is usually more limited in scope than traffic signal systems. Electrical conduit installed for street light purposes is usually not well suited for broadband systems because of differences in the way electrical distribution networks are designed and maintained. Using other city utility systems, such as sanitary and storm sewers, is likewise problematic.

Real estate

City-owned real estate – either vacant land or space inside buildings – can be used to house network electronics and data centers for fiber and other wireline projects. City buildings, street lights and other facilities can support public WiFi access points. Towers, tall structures and vacant land can be used for cellular sites.

As discussed in Appendix D below, cities can use these resources to build municipally owned broadband infrastructure. Many different kinds of business arrangements can also be made with major incumbent providers and competitive independent companies, including swaps of service for access to facilities, partnerships and normal purchase agreements. Cities are also in a position to use economic development resources, including federal and state grants and other financing vehicles to expand existing facilities, either on behalf of private companies or as part of a municipal enterprise. Examples of potential funding sources include the federal Economic Development Administration, the California Teleconnect Fund, the California Advanced Services Fund and the California Infrastructure and Economic Development Bank.

Agency IT budgets

Public agencies are usually among the biggest users of broadband service at the local level. Although there are restrictions on the use of services and facilities purchased with public funds, particularly those earmarked for educational purposes, public agencies can serve as anchor customers of new broadband projects. Within limits, municipal information technology and telecommunications budgets can be directed in ways that support broadband development goals.

Although educational money cannot be used to subsidize municipal or public broadband service, it can be used to purchase service from competitive private service or municipal providers. For example, purchase commitments made on behalf of U.C. Santa Cruz provided the critical initial revenue stream which made it possible for a private company, Sunesys LLC, to build a fiber line from Silicon Valley to Santa Cruz, and to apply for state grant funds to build a second line from Santa Cruz to Soledad.

Management of street cuts

Cities retain the ability to establish reasonable conditions and procedures for utility companies, including telecommunications carriers, to do construction work in the public right of way. There are many different approaches, but in general most street cut policies intended to promote broadband fall into two categories: “open trench” and “shadow conduit”.

Open trench policies (also sometimes referred to as “dig once” policies) require some degree of advance notice of any digging that’s done in streets, sidewalks or other public places. This notice goes to other utilities that might be interested in installing facilities in that location or local agencies or both. If another utility wants to take advantage of the opportunity presented by the work, cost sharing arrangements can be negotiated or specified by policy. Some policies, such as one written for the City and County of San Francisco, go one step further and require a moratorium – five years is common – on any other utility work at that location. As discussed below, the City of Berkeley has already established an open trench policy.

Shadow conduit policies build on the opportunity presented by open trench notifications. Cities can make it a routine practice to install empty conduit prospectively any time a suitable trench is available. Or requirements for installation of empty, fiber-ready conduit can be imposed on new construction and major remodeling projects. Ownership of the conduit can be passed to the city, as in Brentwood, or

remain with the property owner with the requirement it be connected to a municipal network, as in Loma Linda.

An important adjunct to both open trench and shadow conduit policies is a requirement that all conduit installed by public agencies and, ideally, private utilities, be logged into the city's GIS database. The City of Watsonville was able to build its own city-wide data network because it had taken care over the years to keep its records up to date. Cities that have failed to do so often lose track of where municipal conduit has been installed.

Finally, complicated permitting processes can serve as barriers to entry for broadband companies that want to bring competitive service into a city. Although care must be taken to protect the public's interests and ensure community values are maintained, some jurisdictions – the City of Berkeley notably included – are moving plan reviews for broadband facility construction out of planning departments and completely into the hands of public works departments, which can use a relatively streamlined encroachment permit process to achieve the same ends.

3.3. Municipal enterprises

Several cities, including San Leandro, Benicia, Palo Alto and Santa Clara in the Bay Area, either own and operate commercial and industrial grade fiber optic networks, or partner with private companies to make sure those resources are available to the community.

Dark fiber

Palo Alto and Santa Clara operate dark fiber networks which have proved very profitable. Once installed these systems require little upkeep other than fixing accidental breaks, and customer service is mostly limited to making the initial connections – for a fee – and sending periodic bills. San Leandro has given a local company non-exclusive access to its traffic signal network, a near-loop of approximately 11.5 miles in length, and to 7.5 miles of new conduit it built using a federal grant. In return, the city received ownership of approximately 10% of the fiber installed by the company and eventually will receive cash payments, as the business becomes profitable.

Direct service

On the other hand, direct municipal involvement in providing consumer-grade service has a less successful track record, particularly in communities such as Berkeley which are served by two consumer-oriented, full service broadband providers. Comcast and AT&T offer high speed residential Internet service, extensive television lineups and telephone service in Berkeley. Although both companies are the target of complaints about service and prices, on most days they generally meet the broadband needs of most people in their service areas. Both companies have a national presence and millions of customers. They enjoy substantial operating economies of scale, including the ability to negotiate favorable terms with television programming providers, and can pick and choose which neighborhoods to upgrade on the basis of expected return on investment.

City-run systems do not have those economies of scale and cannot discriminate amongst residents on the basis of their economic potential. Consequently, it is usually impossible to compete with entrenched incumbents on the basis of lower prices, due to national-scale purchasing power, or lower costs incurred as a result of limiting the provision of advanced services to high potential customers.

Although a municipal FTTH system could theoretically offer more television programming options and greater broadband speeds at the same price as copper-based incumbent service providers, this competitive strategy usually results in lower net revenue and ongoing operating losses, particularly when employed against full-service providers such as AT&T or Comcast.

The only successful example of a municipally operated fiber to the home system in California is Loma Linda, which only provides Internet service – and not television service – to newly constructed or remodeled homes where the developer or property owner has installed empty conduit for the city's use. The City of Loma Linda – which is 4 square miles in size and largely suburban in character – has invested in a fiber backbone network to support this service, but much of the cost of building and operating it is borne by the several colleges and hospitals in town which act as anchor customers.

It is possible for cities in competitive urban markets to build and operate FTTH systems, but it is not reasonable to expect that operating costs and capital pay-back requirements – bond payments, for example – will be met by customer revenue in the near to mid term. Instead, a municipal FTTH operator must expect to subsidize operations for the foreseeable future, via the general fund, grant money, tax increment financing or assessments on property owners or utility ratepayers.

3.4. Municipal examples

Several cities in the Bay Area, as well as elsewhere in California and the U.S., are involved in municipal broadband projects. Some are city-owned and operated, some are public/private partnerships and some are a mixture of both. Goals vary as well. Most focus on improving basic fiber infrastructure for businesses and industrial use, and to provide facilities that independent Internet service providers can use to offer upgraded service to businesses and/or consumers. A few, however, also deliver service to homes.

A summary chart of examples – by no means exhaustive – is below. More information about these initiatives can be found in Appendix D. Markets are broken out into five categories:

Business – standardized, commercial grade Internet service for small and medium-sized businesses.
Industrial – high capacity, customised service and facilities used by large enterprises.
Public uses – government agencies, schools, hospitals.
Amenity WiFi – publicly available, limited capacity WiFi access points.
Homes – standardized residential service.

A question mark in the table indicates that the providers (Google and Sonic in the examples below) have not disclosed availability or terms for a type of service.

Municipal broadband matrix

		Markets Served				
City	**Ownership**	**Business**	**Industrial**	**Public uses**	**Amenity WiFi**	**Homes**
Alameda	Formerly public, now private; revenue bond funding.	•		•		•
Austin, TX	Google Fiber, private.	•	?	•		•
Benicia	Private with public funding via transportation grant.	•	•			
Brentwood	Conduit developer funded & city-owned; private system operator.	•	?	•		•
Kansas City	Google Fiber, private.	•	?	•		•
Loma Linda	Conduit developer funded; city owns & operates system.	•	•	•		•
Lompoc	City owned & operated, funded via electric utility. WiFi only.			•	•	•
Pacific Grove	Private, city funding undefined.	•		•		•
Palo Alto	City owned & operated, funded via electric utility. Dark fiber only.	•	•	•	•	
Provo, Utah	Built via city utility revenue bonds; sold to Google for $2; ratepayers still liable.	•	?	•		•
San Francisco	CCSF owned; operated as an ad hoc service; built with IT budget funds.		•	•		
San Leandro	City owned conduit, partially funded by EDA grant; leased to private company.	•	•	•	•	
Santa Clara	City owned & operated, funded via electric utility. Dark fiber only.	•	•	•	•	
Santa Monica	City owned & operated “lit service”: system built with IT budget funds.	•	•	•	•	
Watsonville	City owned; operated as an ad hoc service; built with IT budget funds.		•	•		

Note: See Appendix D for more detailed information.

4. Berkeley broadband infrastructure

Conduit, fiber optic and copper lines, utility poles and other infrastructure that supports or directly carries broadband services is owned and/or controlled by many different public and private entities in Berkeley. Some assets – conduit, for example – belong to the City or the University of California or other public agencies such as BART. Most, however, belong to private companies, either large, end user-focused carriers such as AT&T and Comcast, or smaller, specialized providers such as Level 3 or Zayo.

4.1. City of Berkeley owned

Downtown

As part of a settlement with the City, in which it approved the transfer of a cable television franchise from AT&T to Comcast in 2003, Comcast agreed to fill gaps in its network, including the downtown area, which required the installation of conduit.

Figure 4.1 – City-owned telecommunications conduit, installed by Comcast in downtown area.

During the course of this work, the City paid to have a second 2-inch conduit system with separate access vaults installed along several blocks of Center Street, Milvia Street, Kittredge Street, Shattuck Avenue, Bancroft Way and University Avenue. It was completed in 2004 (see Appendix B).

This system includes a lateral conduit which enters a utility vault on the U.C. Berkeley campus at Fulton and Bancroft. This vault provides a potential interconnection point to fiber routes used by major inter-city network operators which serve the campus, including AT&T, Level 3 and Zayo. There are several other points where the City's conduit intersects with fiber routes used by those companies, as well as a fiber optic network owned by BART which runs throughout its rail system, but there is no indication in the City's records that physical connections to these other networks were built.

Some of this conduit has been used to support the City's internal data network. Although an engineering survey would be necessary to determine exactly how much capacity is available for third party or City use, given the size of the conduit and its recent construction it is likely it could support additional fiber optic network infrastructure. A survey would also be necessary to determine the exact interconnection path that could be made via the U.C. utility vault and to ascertain if any other interconnection points exist.

Traffic signal conduit

The City's mapping (see Appendix B) indicates that 1-inch conduit has been installed along major arterial streets throughout the City to provide connectivity for the traffic signal system and for internal data networking purposes. This conduit has access vaults at street intersections along the route.

The traffic signal conduit system also intersects, but does not connect with BART, Zayo and Level 3 intercity fiber routes, and is near routes owned by other intercity network operators including Sunesys, and OpticAccess. This system also passes by the U.C. campus. Except for connections to the City's internal data network, this conduit system does not have any interconnection points to external networks.

Figure 4.2 – City of Berkeley conduit.

It is possible that at least one additional fiber cable could be installed in this conduit, in a similar manner to the Lit San Leandro project. A visual inspection of traffic signal conduit access vaults, as well as decommissioned vaults previously used to support the fire alarm system, was conducted with the assistance of the City's Public Works Department on 7 April 2015.

Most of the conduit and vaults surveyed appeared to be in good condition, with room to support at least one additional cable. Given that this inspection was not exhaustive or conclusive, the observations indicate that a technical survey is both feasible and likely to find opportunities for co-location of a fiber optic network. This opportunity could be limited, though, due to the smaller size of this conduit.

Maps provided by the City (see Appendix B) show several conduit routes in the western, northern and southern neighborhoods (and downtown) that are either identified as currently being used by the City for its internal data network or as unused. The condition and capacity of this additional conduit – generally identified as being 1-inch in diameter – is unknown, and some sections are identified by the City as "abandoned". However, if it is useable by third parties or the City, these routes would provide significant extensions to the downtown and traffic signal conduit systems. An engineering survey would be necessary to confirm locations and determine usability.

Streets

The City of Berkeley has plans to resurface and otherwise improve streets over the next three years. Some of this work may involve sufficient digging to justify the installation of empty conduit on an

inexpensive basis. In other cases, there may be an opportunity to install fiber optic cables via micro-trenching techniques ahead of construction.

Based on the map provided by the City (Appendix B), some of this work will happen along routes that could connect to and extend the City's existing conduit inventory, assuming the planned construction work lends itself to opportunistic installation of conduit and/or fiber.

4.2. University of California

The University of California owns and operates an extensive fiber network on the Berkeley campus, and manages connections for associated facilities such as the Lawrence Berkeley National Laboratory (LBNL). It receives external Internet connectivity via the Corporation for Education Network Initiatives in California (CENIC) which provides broadband services to colleges and universities, as well as K-12 schools, throughout the state. The Berkeley campus is a major node on that network.

CENIC owns very little infrastructure itself, instead leasing connectivity from intercity and local access carriers. It provides multi-gigabit service to the campus via BART (see section 4.3) and Zayo.

The U.C. campus also receives service directly from Level 3, AT&T and Comcast. The fiber lines that support this service connect to the on-campus fiber network at several points, but only one – at the intersection of Fulton and Bancroft – is also served by City-owned conduit.

Because of restrictions on the funds used to pay for this bandwidth, its use is largely restricted to educational and research purposes. However, the demand created by the University has attracted these major network operators and resulted in a higher degree of access in Berkeley to intercity fiber routes than in most Bay Area cities.

4.3. Other agencies

BART operates a fiber optic network along its right of way, and makes it available to third party users. This network is used extensively to connect local fiber networks to major data centers and Internet exchanges, such as Digital Realty Trust in Oakland, and several major data centers in San Francisco and Fremont.

Berkeley Unified School District also receives its Internet service from CENIC, and is subject to the same restrictions as U.C. Local school districts, for example in San Leandro, have used federal and state broadband subsidies to purchase service from local providers and create a financially viable business case for building infrastructure.

4.4. Private inter-city carriers

As mentioned above, several intercity fiber companies have installed networks that both pass through and serve customers in Berkeley (see Appendix B). These fiber lines are used to connect local Internet service providers and large users, such as the University, to major Internet exchange points and provide the national and international links that make a single, world-wide network possible.

The most extensive network is owned by Zayo, which either owns or controls fiber running along Claremont Avenue, Shattuck Avenue, San Pablo Avenue, 10th Street and the railroad right of way near the San Francisco Bay shoreline. This network includes lateral connections in the downtown area, and Zayo has indicated that it is building additional laterals elsewhere in the City.

Level 3 also maintains a fiber route along the railroad right of way, and connects to the U.C. campus and the Lawrence Berkeley National Laboratory. Optic Access has a fiber route between San Francisco and Oakland that runs along San Pablo Avenue to the south of Berkeley. Sunesys has built fiber infrastructure in Albany. PG&E has installed fiber along some of its East Bay power line routes – at an Oakland substation serving a data center and along high voltage transmission lines on the east side of the Berkeley Hills – although the extent of this network in and around Berkeley is unknown.

4.5. Local carriers

In the vast majority of residential areas and most business districts, Comcast has reported to the California Public Utilities Commission that it offers its flagship Xfinity service, which it claims delivers up to 100 Mbps download speeds.

AT&T

AT&T has not upgraded its service offerings to a comparable extent. It offers Uverse-branded service which it claims will deliver up to 25 Mbps in some residential areas and business districts, but large areas of the City have not been upgraded and AT&T service is limited (see Appendix B). As a general rule, service is best in and around the downtown and U.C. areas, and degrades the further one moves to the west, south or north. According to the information AT&T has filed with the CPUC, these areas do not meet the minimum standard of 6 Mbps download speeds and service may be as slow as 1.5 Mbps in some neighborhoods.

This pattern of upgraded service in residential neighborhoods with a high potential for combined television, broadband and telephone revenue, and sub-standard service in older industrial and commercial districts is a common one in the East Bay Area, according to the EBBC study. It was first identified in the City of San Leandro, where a detailed study was conducted in 2012[6].

A comparison of the City's conduit and fiber infrastructure map with an updated map using the EBBC methodology and more recent carrier data shows that some city-owned broadband assets are located in areas that have sub-standard broadband infrastructure, particularly on the western side of Berkeley.

Comcast and AT&T are expected to make only limited investments in upgrading broadband infrastructure in the next five to ten years. According to a company statement[7] made in 2012 and subsequently supported on an ongoing basis in statements by executives, AT&T is focusing its

[6] *San Leandro Commercial Broadband Strategy*, Tellus Venture Associates, 16 January 2012.

[7] *AT&T to Invest $14 Billion to Significantly Expand Wireless and Wireline Broadband Networks, Support Future IP Data Growth and New Services*, 7 November 2012.

investment on expanding mobile broadband coverage and on specific fiber builds, particularly to support cell sites and to reach major office buildings in central city business districts, such as in San Francisco. It also has indicated it will increase wireline speeds available to residential and business customers in Oakland, but has not specifically mentioned plans for Berkeley. Details about these upgrades are scarce. So far, most of AT&T's efforts have focused on areas where it faces new competition, particularly from Google Fiber, with the most significant service improvements coming in areas where new residential developments make installation of fiber to the home networks cost effective.

Comcast

Comcast personnel have not discussed plans to upgrade its infrastructure. Conversations with Comcast representatives indicate that the company believes its existing network to be state of the art and no improvements are necessary.

However, Comcast has made exceptions in cases where it faces competition from new entrants into the market: San Leandro is a case in point. When business people in and near the downtown area were surveyed in 2011, many reported being unable to obtain service from Comcast, or only able to do so if they were willing to pay several thousand dollars in installation costs. In 2013, after the Lit San Leandro project was underway, many of these same business people reported that Comcast was now able to provide broadband service and willing to do so without an upfront installation charge.

Sonic.net also provides copper-based DSL service to businesses and homes in Berkeley. Most, if not all, of this service, is delivered using copper lines leased from AT&T.

4.6. Areas of interest

Downtown

As described above, the City of Berkeley owns an extensive conduit network in the Downtown area that appears to be ready for installation of fiber optic cables with little or no preparatory work. It also owns other conduit in the area that could extend the reach and connectivity options of the system. According to the evaluations conducted for this study and for the East Bay Broadband Consortium, broadband infrastructure in the downtown area rates a "D+" grade overall – significantly below the average in California and Alameda County.

Although it is possible for larger companies to purchase high capacity, commercial and industrial grade Internet service from specialty suppliers, the process for obtaining this kind of access is ad hoc. The City's existing assets can be used as the basis for a commercially-focused fiber network, either owned and operated by the City, as in Palo Alto, or by a private sector partner, as in San Leandro. In both cities, the availability of affordable, reliable and easy to access fiber and other broadband resources has contributed to economic growth, and has been particularly attractive to high tech and clean tech start ups. In San Leandro, for example, an underused office and industrial project – the Gate at West Gate Center – saw 60,000 square feet of additional space leased by several new, high tech companies within six months of being connected to the Lit San Leandro system.

West Berkeley

The area between San Pablo Avenue and 6th Street, running from Camelia Street south to Dwight Way has some of the City's best overall broadband infrastructure, albeit with significant gaps. This corridor includes the City's emergency operations center and a library and senior center. West of 6th Street, however, the quality of broadband infrastructure drops off sharply, with residents and business in many locations only able to get minimal service that meets CPUC standards. For the most part, the infrastructure in the area west of 6th Street is "D+" grade, with a few pockets failing completely.

The City owns traffic signal conduit along most of the length of San Pablo Ave. and University Ave., with a few segments on 6th St., Ashby Ave. and Gilman St. The condition and usefulness of this conduit is unknown.

Providing high capacity, reasonably priced broadband service to the commercial and industrial properties in West Berkeley would have the same beneficial effect as in the Downtown area. Traffic signal and internal City networking conduit connects the two areas, making a joint commercially-focused core fiber infrastructure project conceivable.

Neighborhood business areas

Existing service for neighborhood businesses elsewhere in Berkeley depends primarily on the quality of the service that AT&T and Comcast have chosen to offer to the people who live in nearby homes. As discussed below, it ranges from above average to barely passing. The City has fewer options for immediate action, since the City-owned conduit that's been identified to date is of unknown quality and is not systematically located in or near neighborhood business districts..

A two-pronged approach can be taken to develop broadband infrastructure in these areas. First, areas with existing conduit that either passes through or is accessible with relatively little additional work should be identified and considered for inclusion in any Downtown or West Berkeley projects, if feasible.

Second, when broadband development in residential areas is being planned, either by the City or private companies, these business districts can be appropriately prioritized and given the proper consideration when specific facilities are designed.

Residential service

In general, residential broadband service is of average or below average ("C" or "C-") quality in the flatlands east of San Pablo Ave., with the particular exception of the areas north of Cedar St. and south of Ashby Ave, where service is barely passing ("D" and "D+").

West of San Pablo Avenue, the pattern described above for West Berkeley commercial areas holds: except for the corridor between San Pablo Avenue and 6th Street, running from Camelia Street to Dwight Way, service is generally near or at the failing level with "D" grades and pockets of "F" grades.

The service in hillier residential areas, generally east of Shattuck, is significantly worse than in the flatlands, with some neighborhoods receiving average “C” grades, but most getting barely passing “D” grades. The major exception is the area in the northeast corner of Berkeley adjacent to Kensington, where overall neighborhood broadband infrastructure rates above average with a “C+”.

As discussed above, upgrading residential service is more costly and a problem of much greater scope than improving commercial and industrial grade broadband facilities. Options include 1. building a citywide fiber to the home system, either as a municipal enterprise or via a public/private partnership, 2. pursuing a long term, phased approach that uses opportunities created by the city’s ongoing street maintenance program to build out residential service piece by piece, and 3. using the City’s remaining policy options to provide positive incentives to either incumbent or independent competitive Internet service providers to upgrade existing facilities. These incentives could potentially be packaged with infrastructure improvement projects proposed by incumbents, in order to upgrade service in neighborhoods where corporate financial objectives alone fail to provide sufficient motivation.

5. Policy Options and Next Steps

5.1. Summary of current COB policy

In many regards, City of Berkeley policy regarding telecommunications infrastructure meets or exceeds most best practice policy recommendations (see Appendix C). BMC Chapter 16.10 provides for notification and coordination of construction – sometimes referred to as "open trench" and "dig once" policies – and collection of information. Routine implementation of these policies, including the "city-sponsored utility coordination meetings" and information collection procedures provided for in 16.10, would provide a means of ensuring that utility work in general and broadband infrastructure projects in particular are done in such a way as to maximize the public benefit within the constraints of state and federal law.

A number of studies regarding WiFi facilities and telecommunications planning, among other broadband-related topics, have been completed. However, these studies did not result in the adoption of any specific broadband development policies.

5.2. New policies

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

- Formalize a policy, such as that currently being considered by the City and County of San Francisco, requiring entities that do certain kinds of excavation work in the public right of way provide the City with the opportunity to install conduit. Such a shadow conduit policy would, in effect, formalize the City's process for installing its own conduit whenever a suitable excavation by a third party is undertaken. The City has already done this type of work, notably during Comcast's upgrade of downtown infrastructure in 2004 as noted above, and considered formalizing it during the code revisions that resulted in the current version of Chapter 16.10.

- Investigate the feasibility of strengthening the existing requirements in Chapter 16.10 for conduit sharing, joint use of trenches and use of City-owned facilities. Formalize procedures for implementing both new and existing policy regarding street cuts and other types of excavations.

- Establish detailed standards for submitting mapping data in GIS format, for both third party projects and City-owned facilities. Knowledge of where existing fiber and conduit routes are available will provide an opportunity for the City and telecommunications companies to explore the possibility of using existing routes, rather than paying for new construction and bearing the consequences of repeated excavations in public streets.

- Formalize inspection procedures for project work, and collection procedures and requirements for associated documentation, to support the above recommended policies.

- Develop broadband facilities requirements for new or major remodeled construction, either residential or commercial or both.

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

- Establish 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[8] as it evaluated U.S. cities as locations for expansion of its fiber to the home business. It is not necessary to actually 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.

5.3. Next steps

There are several possible objectives to consider as next steps for a City-led broadband development initiative in Berkeley. In increasing order of risk, roughly, these include:

1. Reduce barriers to private sector investment in broadband infrastructure by extending existing policies and considering new ones, as discussed above.
2. Attract new private sector, commercially focused carriers to Berkeley by likewise offering access to City facilities on a partnership basis.
3. Use City resources to try to entice a new or existing private sector carrier into upgrading residential service, particularly by building a fiber to the home system.
4. Build and operate a municipal dark fiber network or a "lit" network offering industrial grade ethernet connectivity.
5. Build and operate a municipal Internet service utility, for residential and/or commercial purposes.
6. Build a municipal network, to any desired extent, and lease it out to a private operator.

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

Appendix A - Infrastructure grades and the EBBC study

Berkeley's grade

In a study conducted for the East Bay Broadband Consortium (EBBC) in 2013[9], 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, in the state: a combination of relatively high speed cable modem and mid-range telephone company DSL facilities.

In the initial analysis, using data submitted as of 30 June 2012, Berkeley (excluding the U.C. campus) received an overall grade of "C+" (2.4), indicating the quality of broadband infrastructure was just above the statewide average. A second analysis of Berkeley data was performed in March 2015, using the most recent carrier reports available, which were submitted as of 30 June 2014 (see below for a more complete description of the methodology used). The result was a drop in Berkeley's grade to "C-" (1.7), which is below both the California (2.0) and Alameda County (2.0) averages.

Although the second analysis showed that there has been a small drop in the relative quality of broadband infrastructure in Berkeley in the past two years, the primary reason for the lower grade was a re-classification of Sonic.net's reported data. This independent Internet service provider uses a mix of its own facilities, and lines and other equipment leased from other companies, primarily AT&T. Its service areas are much smaller than the two dominant incumbents in the region – AT&T and Comcast – and including its service reports in the analysis was, on the whole, considered more useful than distorting since it highlighted areas where alternative providers have chosen to invest. As result, it was treated as a "core wireline service" provider, as described below.

However, Sonic has a much stronger presence in Berkeley than in other East Bay cities. This fact was noted in the original report and cited as a reason for the city's relatively high grade (fourth-best in the three county area). In the course of preparing this report, which is specific to Berkeley, the latest data was evaluated and a more detailed analysis was made. It was determined that the reports submitted by Sonic in 2014 showed that it typically uses the same underlying infrastructure as AT&T with little differentiation in service levels. In some areas, though, it has invested in significant facilities upgrades, with a corresponding improvement in service levels.

The determination was made that using the raw data provided by Sonic had skewed the result of the 2013 study. For this study, Sonic's data was only factored into the evaluation where it indicated the presence of improved broadband infrastructure over and above that of the base facilities provided by AT&T. As a result Berkeley's grade dropped to a "C-", and greater comparability – apples to apples – was achieved with neighboring cities.

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

Methodology

The primary data for assessing the quantity and quality of broadband infrastructure in the East Bay region (Alameda, Contra Costa and Solano counties) comes from the California Public Utilities Commission, which collects service level reports from providers throughout the state. 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.

The data collected by CPUC was divided into three categories: core wireline service, commercial broadband service providers and mobile carriers.

Consumer-grade service throughout California was assessed, and used as one of the two primary grading benchmarks, the other being the CPUC's standard for minimum acceptable service of 6 Mbps download/1.5 Mbps upload speed. Upload speed was given equal weight to download speed, even though it's generally less critical for consumers, because upload speed gives a good indication of the capacity of the underlying infrastructure. 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.

Grades were then assigned as follows:

A - Two competing providers, both advertising maximum download speeds of at least 25 Mbps and maximum uploads speeds of 6 Mbps, or 3 or more competing providers offering that standard of service in combination.

B - Competing providers, both advertising maximum download speeds of at least 10 Mbps and maximum uploads speeds of 6 Mbps.

C - Competing providers, one advertising max down/up speeds of at least 10/6 Mbps and the remainder meeting CPUC's minimum 6 down/1.5 up standard.

D - At least one provider advertising speeds that meet the CPUC's minimum standards of 6 Mbps down and 1.5 Mbps up.

F - At least one provider offers service, but no service is available that meets the CPUC's minimum standard of 6 Mbps down and 1.5 Mbps up (meets CPUC's definition of underserved).

F- - No broadband service available (meets CPUC's definition of unserved).

A "C" grade indicates that the consumer grade broadband services, and consequently the underlying core infrastructure, in a given area meets the statewide average. A "D" grade means it meets the

minimum passing service standard set by the CPUC. "F" grades indicate full or partial failure, which also means the area is eligible for infrastructure construction subsidies from the Commission. "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 the three counties. 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:

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

EBBC 2013 report card

East Bay Broadband Report Card

	Grade	GPA
Overall		
Alameda County	C	2.0
Contra Costa County	C+	2.3
Solano County	C-	1.8
EBBC	C	2.1

East Bay Broadband Report Card

	Grade	GPA
Alameda County - Cities		
Berkeley 2013	**C+**	**2.4**
Alameda	C	2.2
Albany	C	2.2
Oakland	C	2.1
Emeryville	C	2.1
San Leandro	C	2.1
Newark	C	2.0
Fremont	C	2.0
Hayward	C-	1.9
Union City	C-	1.9
Livermore	C-	1.9
Dublin	C-	1.8
Pleasanton	C-	1.8
Berkeley 2015	**C-**	**1.7**
Piedmont	D+	1.5
Alameda County - Census Designated Places		
Cherryland CDP	C	2.0
San Lorenzo CDP	C	2.0
Castro Valley CDP	C	2.0
Fairview CDP	C	2.0
Ashland CDP	C	2.0
Sunol CDP	D-	0.7
Rest of Alameda County	D+	1.4
Unincorporated Alameda County (includes CDPs)	C-	1.9

East Bay Broadband Report Card

	Grade	GPA
Contra Costa County - Cities		
Concord	A-	3.8
Walnut Creek	B+	3.4
Pleasant Hill	B-	2.9
San Pablo	C	2.2
El Cerrito	C	2.2
Richmond	C	2.1
Pinole	C	2.0
Martinez	C	2.0
Lafayette	C	2.0
Brentwood	C	2.0
Oakley	C	2.0
Danville	C-	1.9
Hercules	C-	1.9
Pittsburg	C-	1.9
Antioch	C-	1.9
San Ramon	C-	1.8
Clayton	D	1.0
Orinda	D	1.0
Moraga	D	1.0
Contra Costa County - Census Designated Places		
San Miguel CDP	A	4.0
Saranap CDP	A	4.0
North Gate CDP	A	4.0
Castle Hill CDP	A	4.0
Acalanes Ridge CDP	A-	3.9
Shell Ridge CDP	A-	3.9

East Bay Broadband Report Card

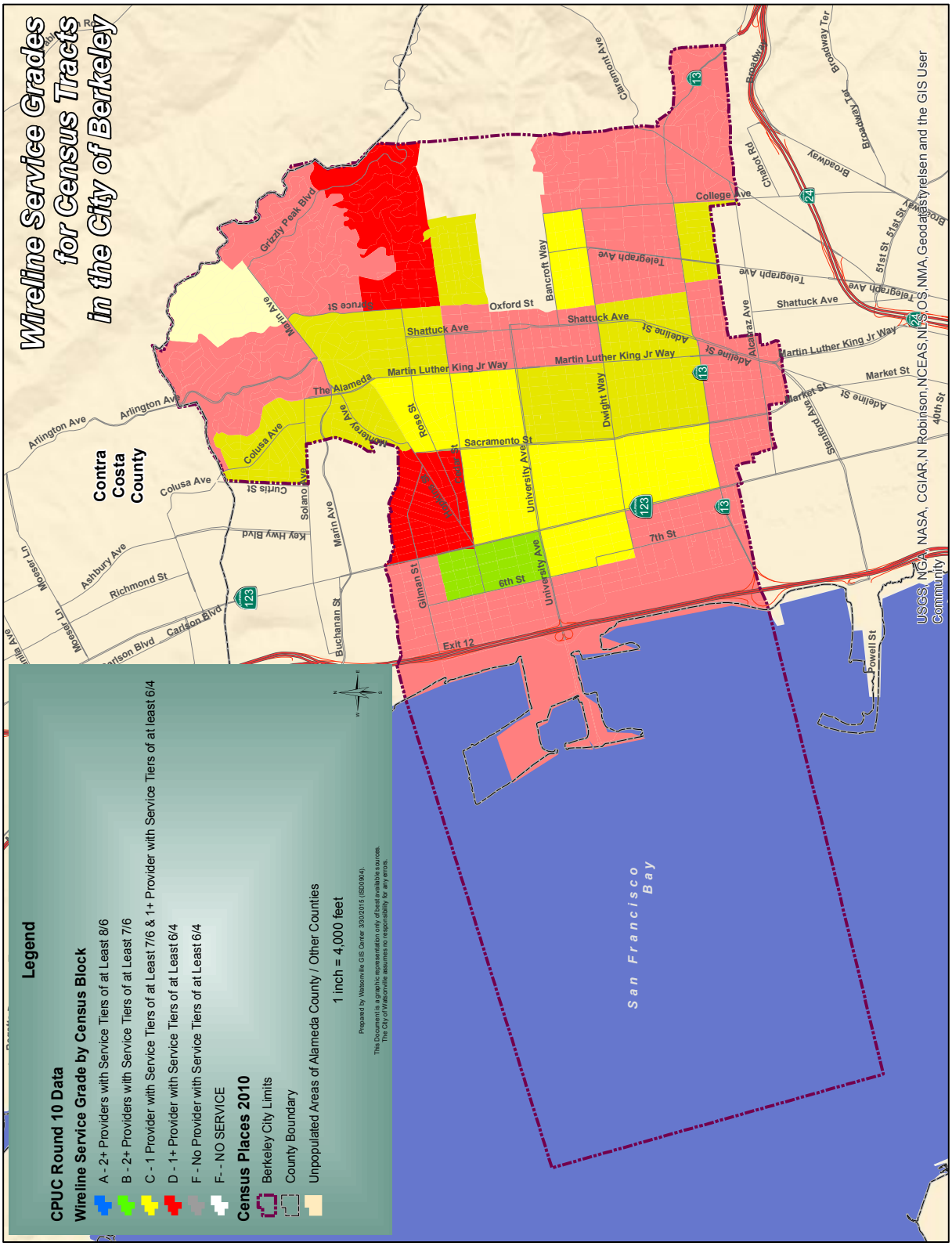
	Grade	GPA
Contra Costa Centre CDP	B	3.2
Clyde CDP	C+	2.5
Mountain View CDP	C	2.2
El Sobrante CDP	C	2.1
Alamo CDP	C	2.0
Rodeo CDP	C-	1.9
Vine Hill CDP	C-	1.9
Kensington CDP	C-	1.8
East Richmond Heights CDP	C-	1.8
North Richmond CDP	C-	1.8
Reliez Valley CDP	C-	1.7
Blackhawk CDP	C-	1.7
Pacheco CDP	D+	1.6
Alhambra Valley CDP	D+	1.4
Discovery Bay CDP	D+	1.3
Camino Tassajara CDP	D+	1.3
Tara Hills CDP	D	1.1
Knightsen CDP	D	1.1
Rollingwood CDP	D	1.1
Bayview CDP	D	1.1
Crockett CDP	D	1.0
Bay Point CDP	D+	1.0
Montalvin Manor CDP	D-	0.9
Norris Canyon CDP	D-	0.9
Bethel Island CDP	C-	0.8
Byron CDP	D-	0.7
Port Costa CDP	F+	0.5
Diablo CDP	F+	0.5

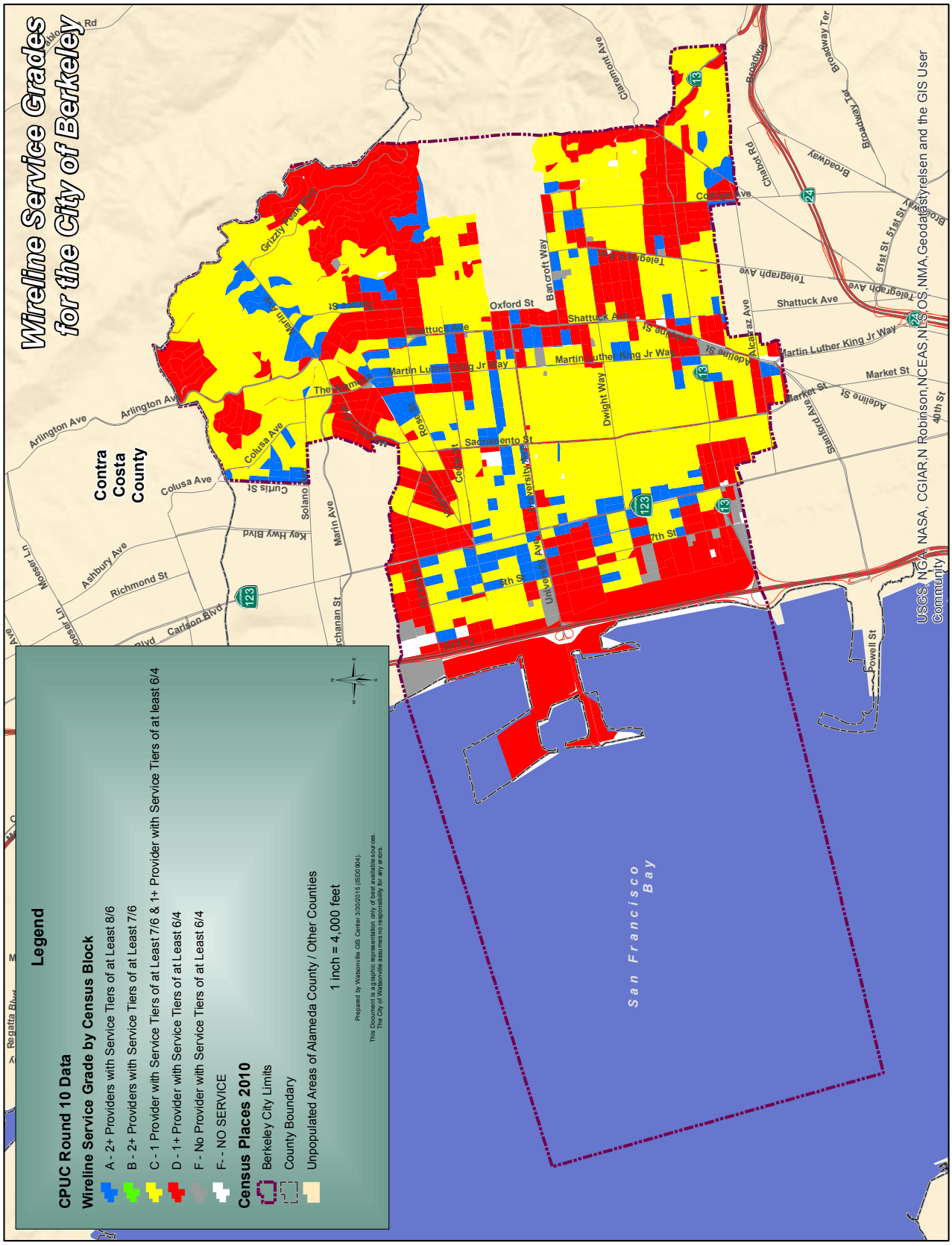
East Bay Broadband Report Card

	Grade	GPA
Rest of Contra Costa County	D+	1.4
Unincorporated Contra Costa County (inc. CDPs)	C-	1.8
Solano County - Cities		
Vallejo	C	2.0
Benicia	C	2.0
Suisun City	C-	1.9
Vacaville	C-	1.9
Fairfield	C-	1.8
Dixon	D	1.1
Rio Vista	D-	0.9
Solano County - Census Designated Places		
Green Valley CDP	D	1.0
Hartley CDP	D-	0.7
Allendale CDP	F+	0.6
Elmira CDP	F	0.0
Rest of Solano County	D	1.0
Unincorporated Solano County (includes CDPs)	D-	0.9

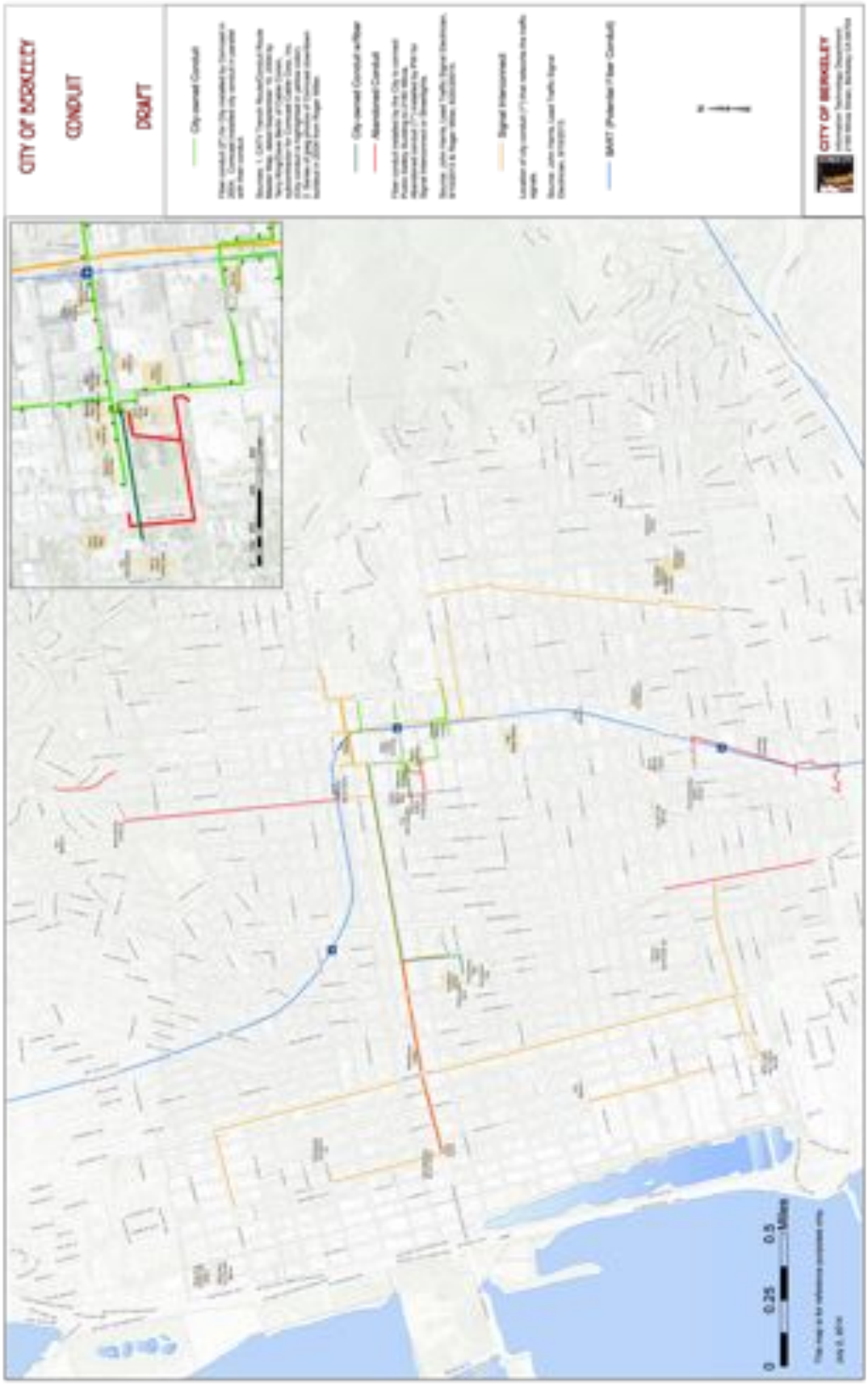
Appendix B - Maps

City of Berkeley broadband report card

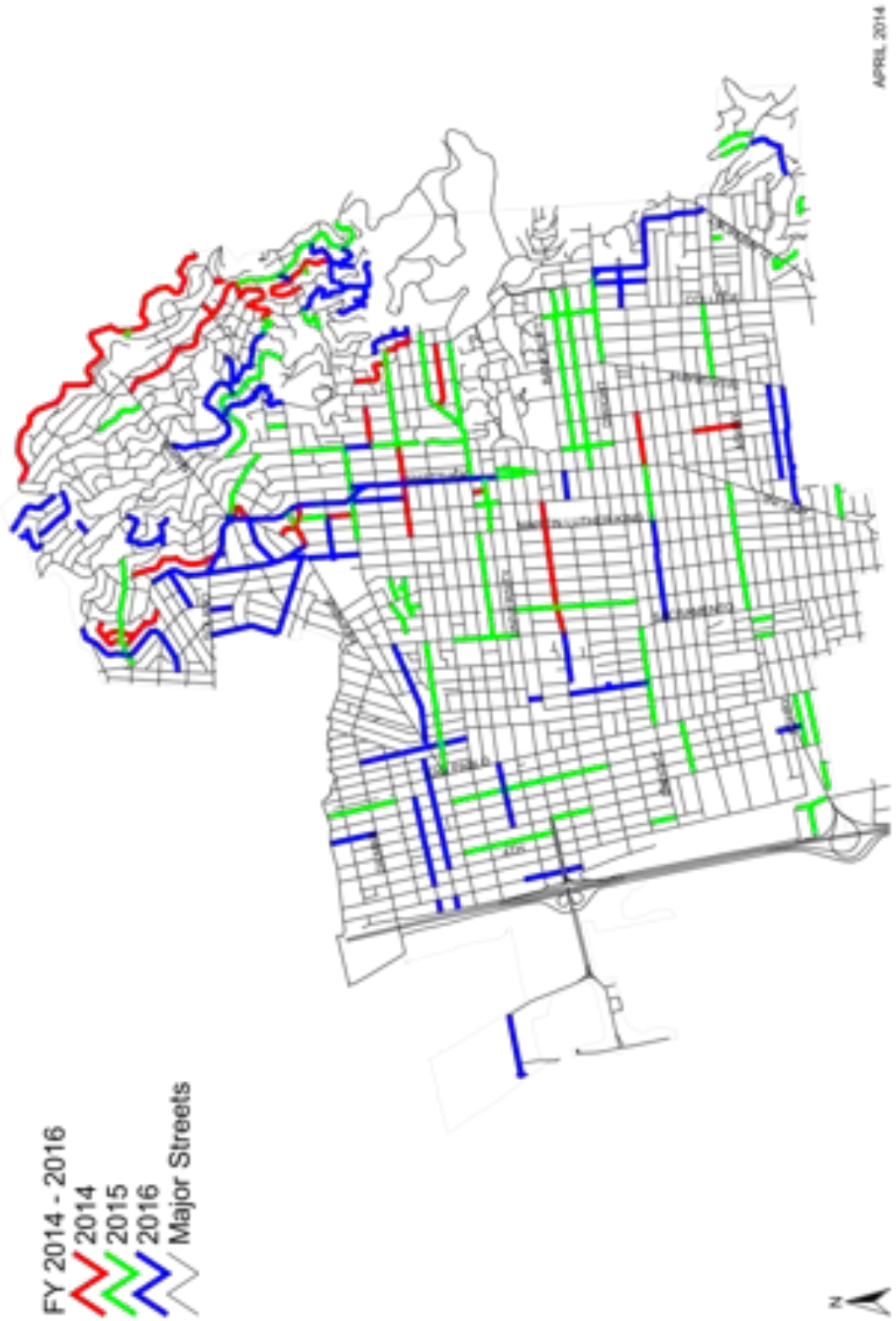



Wireline Service Grades
for the City of Berkeley
Legend
CPUC Round 10 Data
Wireline Service Grade by Census Block
A - 2+ Providers with Service Tiers of at Least 8/6
B - 2+ Providers with Service Tiers of at Least 7/6
C - 1 Provider with Service Tiers of at Least 7/6 & 1+ Provider with Service Tiers of at least 6/4
D - 1+ Provider with Service Tiers of at Least 6/4
F - No Provider with Service Tiers of at Least 6/4
F- - NO SERVICE
Census Places 2010
Berkeley City Limits
County Boundary
Unpopulated Areas of Alameda County / Other Counties
1 inch = 4,000 feet
Contra Costa County
San Francisco Bay
Oxford St
Shattuck Ave
Martin Luther King Jr Way
Sacramento St
Dwight Way
Bancroft Way
Telegraph Ave
Market St
Arlington Ave
Colusa Ave
Ashbury Ave
Richmond St
Carlson Blvd
Key Hwy Blvd
Marin Ave
Solano Ave
Curtis St
Rose St
Cedar St
University Ave
7th St
8th St
Adeline St
Alcatraz Ave
Broadway
Broadway Ter
Broadway Tar
Claremont Ave
Chabot Rd
College Ave
51st St
40th St
Powell St
Grizzly Peak Blvd
Regatta Blvd
USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodastyrelsen and the GIS User Community

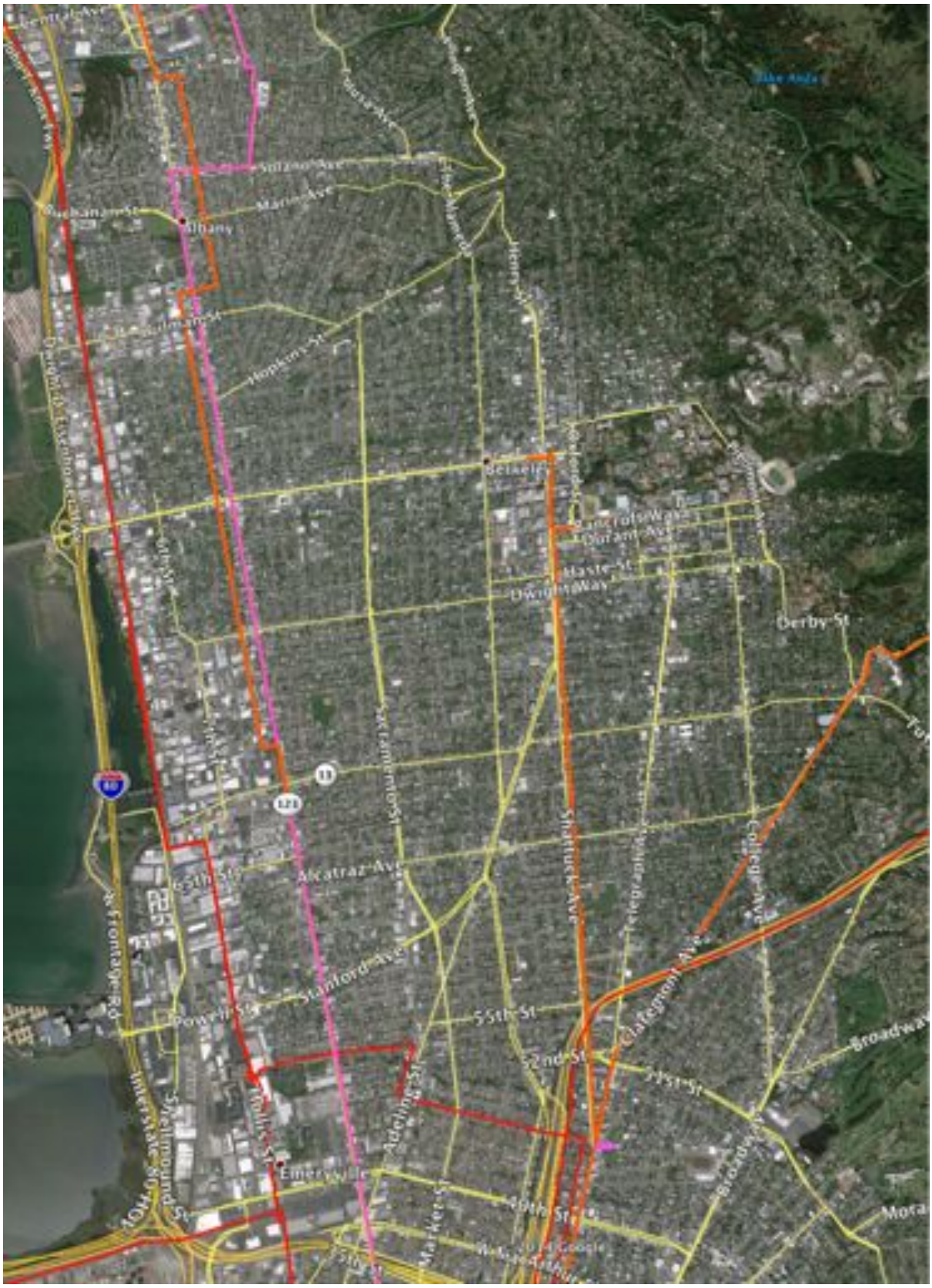
City of Berkeley-owned infrastructure




CITY OF BERKELEY
CONDUIT
DOWNTOWN
DRAFT
City-owned Conduit
City-owned Conduit w/Fiber
Abandoned Conduit
Signal Interconnect
BART (Potential Fiber Conduit)
0 75 150 300 Feet
CITY OF BERKELEY
OXFORD ST
WALNUT ST
TERRAIL PL
SHATTUCK AVE
ADDISON ST
BOWDITCH ST
DURANT AVE
HEARST AVE
MLK JR WAY
MCKINLEY AVE

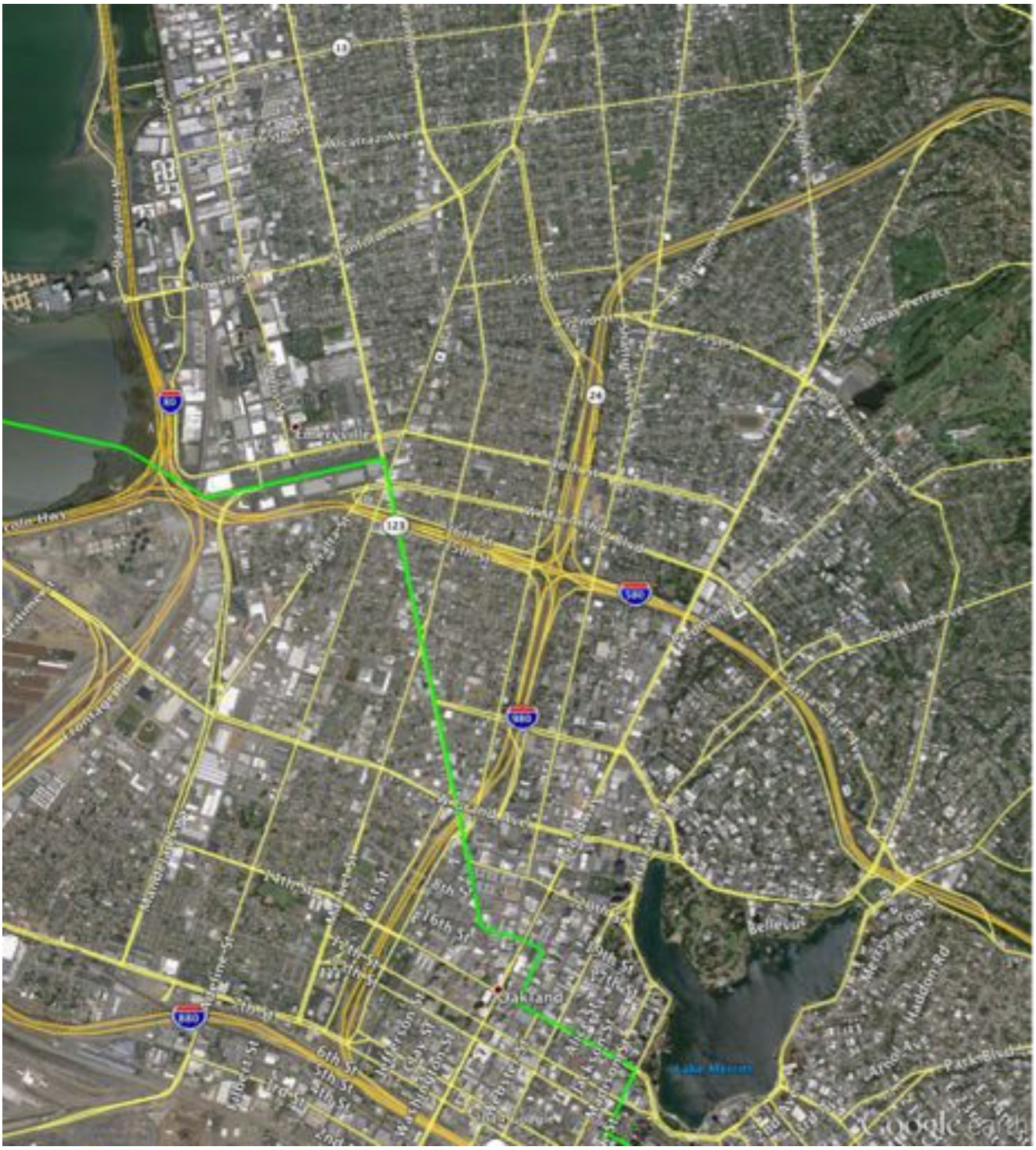

APRIL 2014
FY 2014 - 2016
2014
2015
2016
Major Streets

Zayo fiber

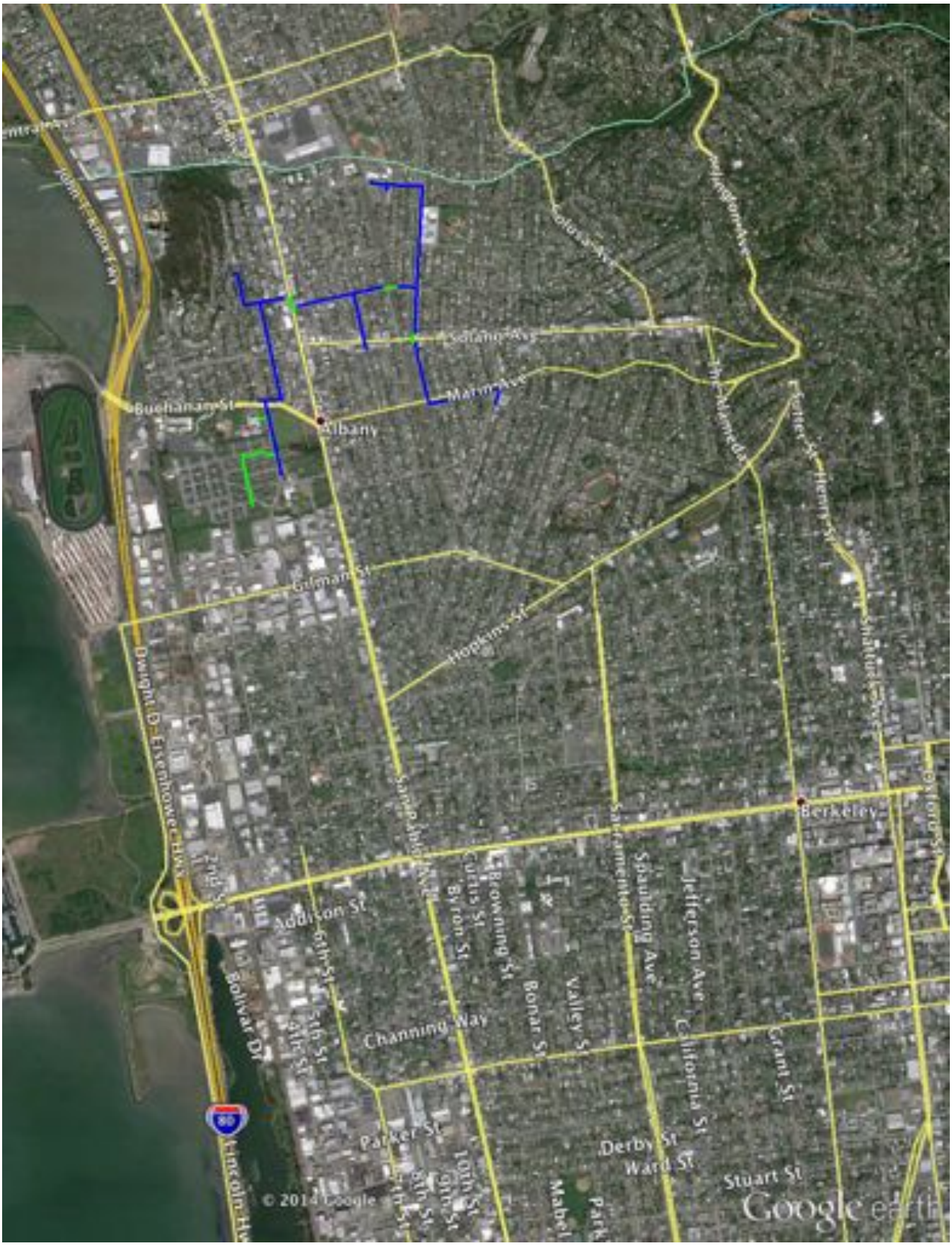

Albany
Marin Ave
Hopkins St
Gilman St
Solano Ave
Henry St
Berkeley
Ashby Ave
Dwight Way
Derby St
Alcatraz Ave
65th St
Stanford Ave
Powell St
55th St
52nd St
51st St
Broadway
Adeline St
Shattuck Ave
College Ave
San Pablo Ave
Frontage Rd
Emeryville
Google

Level 3 fiber

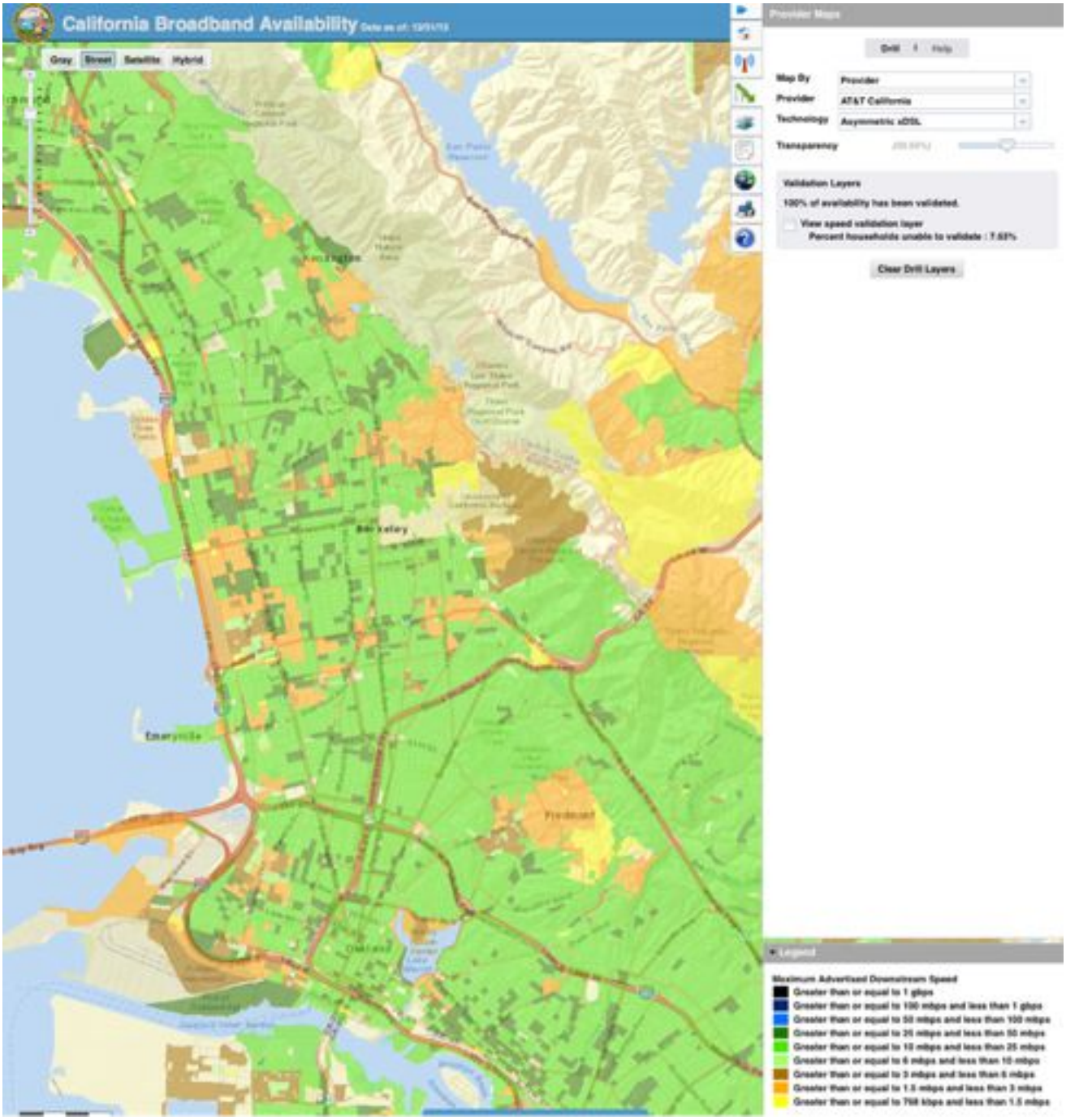
OpticAccess fiber



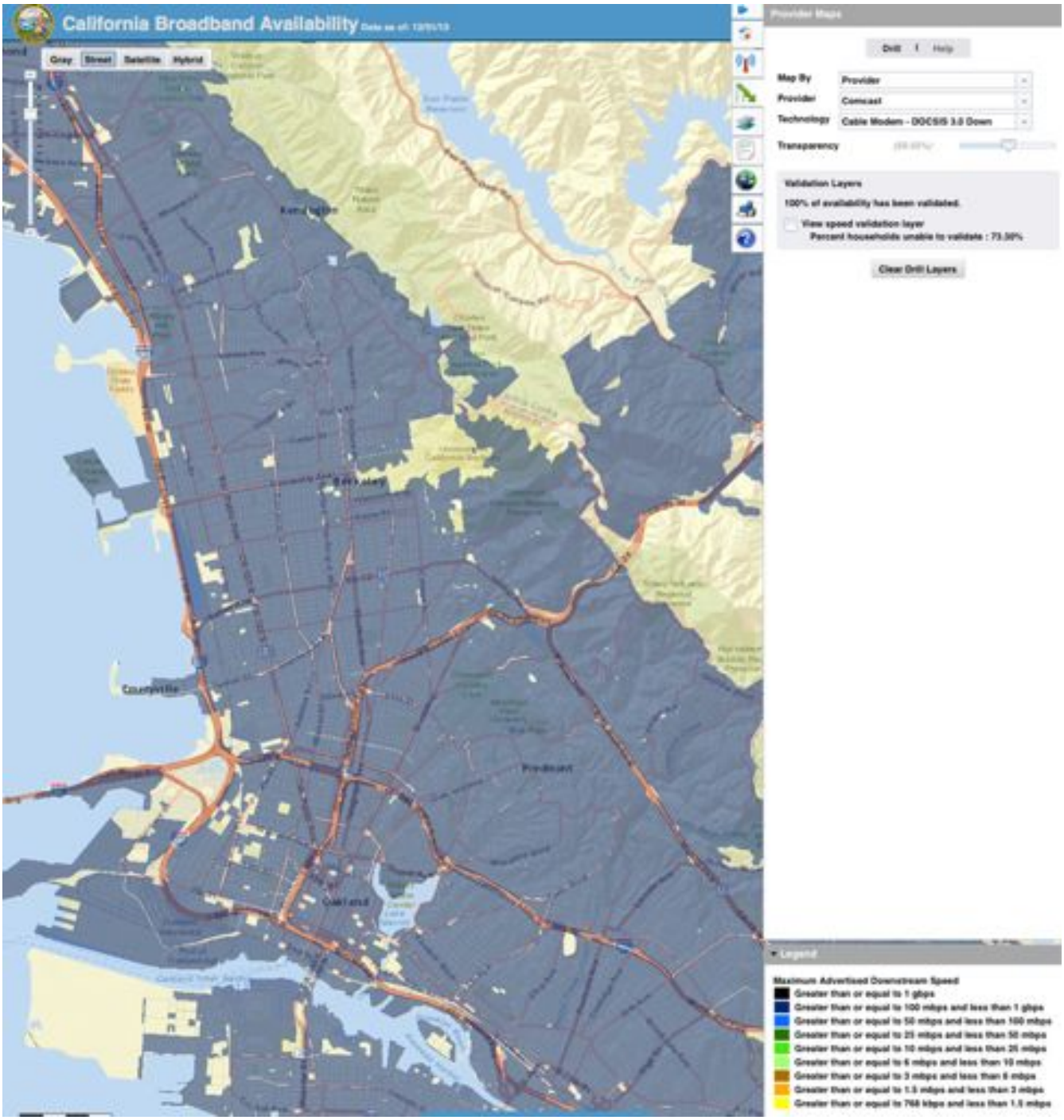
Sunesys fiber



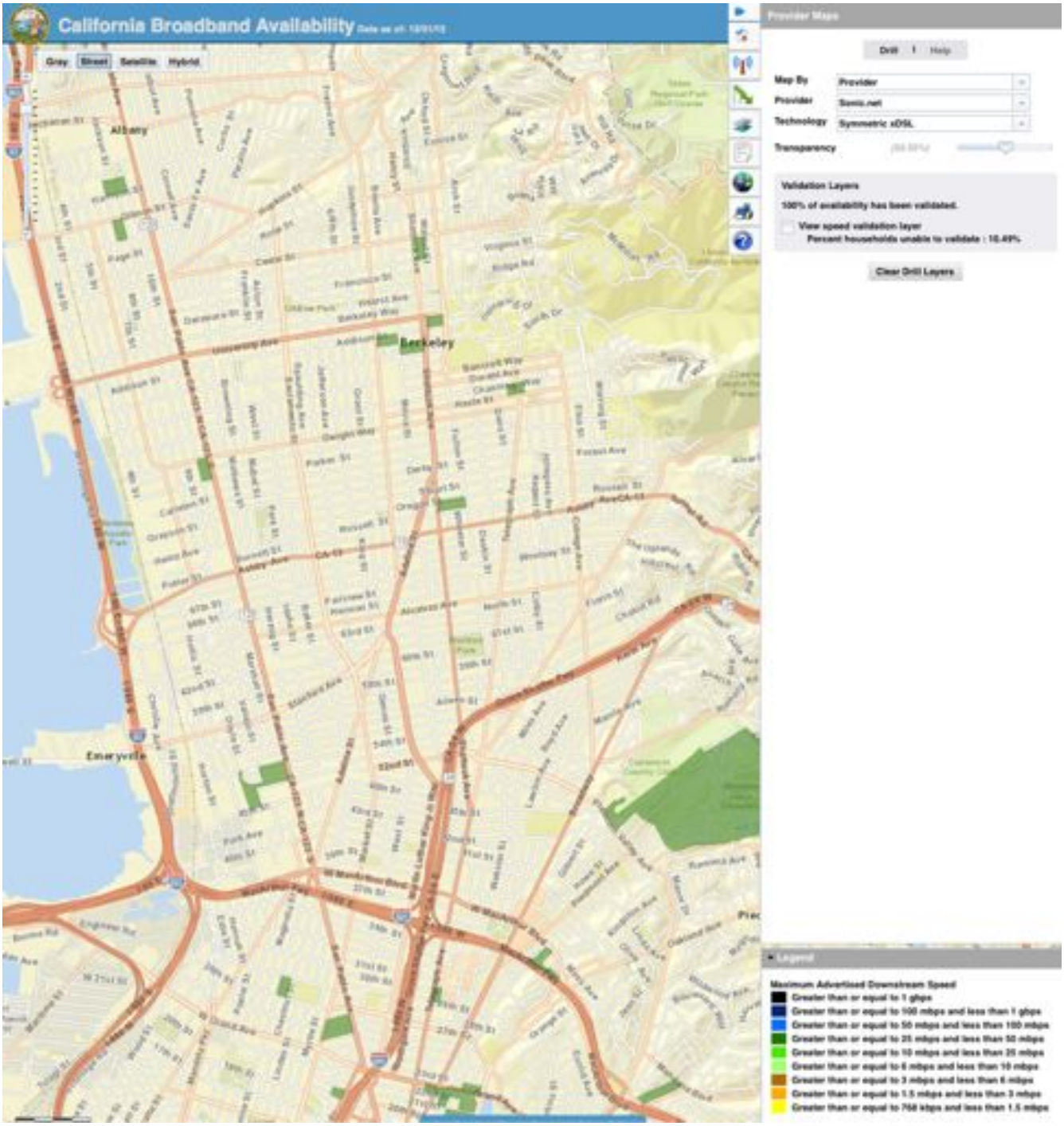
AT&T advertised service levels



Comcast advertised service levels



Sonic symmetric xDSL advertised service levels



Appendix C - City of Berkeley Policy

Berkeley Municipal Code, Chapter 16.10

Title 16 of the City of Berkeley's Municipal Code (BMC) regulates the use of "streets, sidewalks and other public property". Specifically, Chapter 16.10 deals with "excavations for video and telecommunications systems".

For the most part, 16.10 addresses administrative procedures and the practical considerations of any kind of work done in public rights of way, such as traffic control, construction plans and activities, environmental considerations, public notice, and restoration and maintenance. However, some provisions go further and address policy areas that have a greater – and usually positive – impact on broadband infrastructure development. These provisions deal with the excess capacity in conduit, future construction plans, coordination of underground construction among utility companies, and collection of information.

Anyone who applies for a permit to install new conduit in the ground has to first show that there is no existing conduit (or pathway) that can be used instead, including conduit owned by other companies or the City, "whenever sufficient Excess Capacity is available on commercially reasonable terms and conditions"[10]. To a certain extent, California law requires telecommunications carriers to provide access to conduit and pole routes to other carriers. One stumbling block however, is sufficient knowledge of existing conduit.

Title 16 offers several ways to address this problem. First, it requires permit applicants to submit maps in "electronic and/or other form required by the City, and include information describing the proposed facilities"[11]. This map data could include "information regarding any Excess Capacity that will exist in such Facilities after the installation of the Company's Facilities"[12] if requested by the City.

Second, it gives the City broad scope to inspect the work[13] and related documents[14], and to consider the availability of existing conduit capacity in approving or denying a permit application[15]. Finally, it mandates participation in "city-sponsored utility coordination meetings"[16] involving other utility companies, and requires companies to submit "general information regarding any Facilities that the

[10] BMC 16.10.050 K

[11] BMC 16.10.040 B

[12] BMC 16.10.040 C

[13] BMC 16.10.060 F

[14] BMC 16.10.080 G

[15] BMC 16.10.060 B 4

[16] BMC 16.10.050 I

Company plans to apply for permits to install within the [public right of way] in the next six (6) months, regardless of whether a permit is currently sought for those Facilities"[17].

Another provision in Title 16 puts some teeth into coordination requirements, stating "a Company may not excavate any Street that has been reconstructed or resurfaced by the Department or at its direction in the preceding five-year period and shall participate in City efforts to coordinate excavation activities"[18].

Taken together, these provisions can be effective tools for the City to use to encourage the development of competitive broadband infrastructure, or to influence decisions made by incumbent providers. Collecting detailed information about telecommunications infrastructure, making it available in a convenient and useful way, and requiring, to the extent possible, that telecommunications companies cooperate with each other levels the playing field for smaller companies that might want to build new facilities or offer upgraded service. It also gives the City a means of participating – as a regulator or a partner or as a conduit and fiber owner – in the telecommunications marketplace.

Other City policy documents

The City of Berkeley has undertaken several studies relating to telecommunications infrastructure. These studies include:

- A staff report on municipal WiFi systems[19].
- Recommendations from a task force on telecommunications
- Audits of cable franchisees.

No additional policies regarding the development of fiber optic networks that have been adopted by the City Council and are still in effect have been located.

[17] BMC 16.10.040 A

[18] BMC 16.10.080 C 4

[19] *Wireless Internet for the City of Berkeley*, Chris Mead, Director, Information Technology, 25 July 2006.

Appendix D - Initiative options and business models

Initiative options

There are several ways of pursuing any priorities established. Possibilities include:

Evaluate using existing city conduit as the basis for a commercial and industrial grade fiber network. Although costs would depend on a number of unknown factors, such as the condition of some of the city's conduit and the type and extent of the desired network, installing fiber optic lines in existing conduit and building the necessary supporting infrastructure could cost in the millions of dollars range. A network that used most of the city's existing conduit and filled relatively minor gaps with new construction might cost less than $10 million.

Conduct a fiber-to-the-home feasibility study. The cost of building a full, fiber to the home system that serves every Berkeley home and business would be in the tens of millions of dollars range[20], perhaps approaching the $100 million point. A feasibility study can be used to assess such a project, from the point of view of operating it as a municipal enterprise as well as an opportunity to present to potential private sector partners.

Issue an RFP. In line with the priorities set, a request for proposal (or similar) could be used to ask private sector companies to submit ideas for using the City's broadband facilities, and particularly its downtown, traffic signal and other conduit. The request could be structured around a public-private partnership, or a straight lease arrangement, or simply left open.

Develop a broadband master plan. This document could be developed and adopted on a standalone basis, or incorporated into the City's existing general plan. The plan could set out overall policy and establish a roadmap for broadband infrastructure development, for both the public and private sector.

Develop a phased build out plan. There are steps the City can take immediately with its existing conduit and fiber resources, steps that can taken in the near future in conjunction with existing projects, such as street maintenance, and steps that are difficult to implement now but could be done over time. These phases could, if desired, mix municipal and private sector projects, and commercial and residential development.

Assess interest in and capacity for financing broadband infrastructure. Although it can be difficult to gain approval for bond measures, new legislation enacted last year (Senate Bill 628) gave local agencies the ability to form enhanced infrastructure financing districts and issue tax increment financed bonds with 55% voter approval. These districts can also use incremental property tax gains to pay back other kinds of financing, including private loans. Additionally, Assembly Bill 2292 added broadband infrastructure to list of allowable projects that may be pursued by traditional infrastructure financing districts. It is possible to pursue grant money from both the State of California and the federal government. For example, the California Public Utilities Commission offers grants for the installation and/or upgrading of broadband facilities in public housing.

[20] *Financial analysis of user-financed residential broadband service in Palo Alto*, Tellus Venture Associates, June 2012.

Assess the potential for using existing City funds. This option is likely to be limited in scope, but, for example, the City could be an anchor tenant on new infrastructure built by a private carrier. Even a small amount of guaranteed revenue at the beginning of a capital-intensive project can make a big difference in the attractiveness of the business model to investors.

Investigate mutual use agreements with BART, U.C. and other agencies. Local agencies in the East Bay have been receptive to low cost or no cost agreements to share broadband facilities. The City could enter into such discussions either to develop facilities for its own use, or to make its existing infrastructure more attractive to private sector investors.

Discuss joint fiber ventures with nearby cities. Oakland, San Leandro, Alameda and Emeryville have either pursued or are pursuing municipal broadband projects of various kinds. Hayward and other cities further south are considering joining this effort, and U.C.'s expansion into Richmond could provide an incentive for cities to the north to do the same. Although each city has its own, unique objectives and circumstances, there are commonalities in any kind of broadband development, and significant advantages to be gained from creating economies of scale.

Survey conduit. The City's existing conduit system is well mapped, but its condition and available capacity is unknown. Conducting an engineering survey will increase the specificity, and consequently the attractiveness, of any partnerships or leases that might be proposed. Alternatively, survey work could be determined by the City to be the responsibility of prospective users.

Inventory other City assets. Either in conjunction with any of the studies described above or as a standalone project, evaluate city owned real estate to determine if it might be available to a broadband development project.

Municipal broadband case studies

Some cities, such as Palo Alto, San Leandro, Benicia and Santa Monica, are involved to one degree or another in developing broadband facilities and services for commercial and industrial areas. Other cities, for example Alameda, Loma Linda, Lompoc and Provo, Utah, have pursued broadband projects that are focused on providing consumer-grade Internet service to homes. Still others, such as Santa Cruz, Brentwood, Kansas City and Austin, Texas, have used policy initiatives to attract private fiber-to-the-home projects.

Each city has its own particular set of circumstances, constraints and needs, but all have determined that broadband is an essential twenty-first century utility – as necessary for economic development and social equity as water or electricity – and that there is a public interest in encouraging its development.

Municipal broadband business models include city or county owned and operated networks, partnerships with private companies, and facilitation of the development of completely private systems (see Appendix D for more details).

Examples (in California unless otherwise indicated) include:

City of Palo Alto – the municipal electric utility has installed more than 40 miles of fiber optic cables, which it makes available to business and industrial customers, and is supplementing this coverage with publicly available, amenity grade WiFi access (i.e. intended to meet occasional, on-the-spot needs of tourists and shoppers, for example, rather than daily household, business or educational needs). No residential service is offered. The system generates more than $2 million in surplus revenue a year.

City of Santa Clara - similar to Palo Alto, the city's electric utility provides access to fiber optic lines to businesses, and also uses the smart meter infrastructure it has installed to support amenity grade WiFi service. This system also generates an annual surplus.

City of San Leandro - the city entered into an agreement with a local company, Lit San Leandro, to provide access to city-owned conduit. This private company installed fiber optic lines in the city's conduit, to support commercial and industrial customers as well as public uses. In the second phase of this project, the city applied for and received a grant from the federal Economic Development Administration to install additional conduit in order to extend the fiber network. In exchange, the city receives access to the network for its own use and, eventually, will receive conduit lease revenue. The city incurs costs to support the project and currently generates no direct revenue, but has had significant success in attracting new, high technology businesses.

City of Benicia - the city has awarded a contract to Lit San Leandro to provide industrial-grade Internet service to a local industrial and a nearby redevelopment area. This project is funded via a re-purposed transportation grant, and supported by city facilities such as its corporation yard.

City of Santa Monica - the city's information technology department provides ethernet connectivity between local businesses and nearby data centers, where high capacity Internet bandwidth can be obtained relatively inexpensively.

City of Loma Linda - the city requires newly built and remodeled homes to include fiber optic connections to the city-run network, which offers optional Internet service to residents.

City of Provo, Utah - the city's municipal electric utility built a fiber-to-the-home system using bonds that were to be paid back via the revenue generated. However, the revenue was insufficient to meet bond obligations and a mandatory $5.25 monthly fee was added to residential and commercial electric bills. The system was subsequently sold to Google for a nominal amount, although the bond obligations remain with the city and local electric ratepayers.

City of Alameda - the city's electric utility built a cable system offering video and Internet service which competed for customers with the incumbent private telephone and cable companies. It could not generate sufficient revenue to meet its bond obligations and the system was sold at a loss to the local private cable operator, Comcast. Because the bonds were only backed by revenue from the cable system, and not the electric utility or the city's general fund, bondholders bore the loss. The city was able to successfully defend the subsequent lawsuits.

City of Lompoc - the city's electric utility department built and continues to operate a municipal WiFi utility which was originally intended to provide ubiquitous Internet access to homes and businesses. Although using WiFi to provide primary Internet access to homes proved problematic, the system provides a valuable, albeit low speed, lifeline option for residents and access for visitors. The revenue generated by this service is not sufficient to meet costs, and it is currently subsidized by other city funds.

City and County of San Francisco - a policy is under development to require inclusion of broadband conduit in public projects and to provide an option for placement of publicly-owned conduit in private projects which involve cutting into streets and other right of ways.

City of Santa Cruz - the city council adopted a package of broadband development policies, including a "dig once" ordinance and a master lease template for use of city-owned assets.

City of Watsonville - since the end of local cable television franchising in California, cable companies have begun charging cities for the use of institutional networks – INETs – originally provided at little or no cost. Charter Communications initially wanted to charge the City of Watsonville $150,000 a year for the use of its INET, which connected critical city facilities. Because the city had a policy of routinely keeping an inventory of conduit and other network assets that had been installed on a prospective basis as well as for specific projects over the year, it was able to use conduit routes it already owned to duplicate all but a few segments, totalling a mile, of the INET system. The remaining gaps were connected via conduit installed by the city for less than the cost of two years service from Charter.

City of Brentwood - for the past 15 years, the city has required new home construction to include empty conduits which are deeded over to the city. An agreement has been reached with an independent Internet service provider, Sonic.net, to use the city-owned conduit to install fiber lines and provide fiber-to-the-home service to homes already served by conduit, and extend the system over time throughout the city.

City of Pacific Grove - a contract was approved with SiFi Networks, a U.K.-based company, which provides provide the company with access to city streets, right of ways and sewers in order to build a fiber-to-the-home network. The project is still in the planning stages and the ultimate source of funding is yet to be identified.

Kansas City, Kansas and Missouri and Austin, Texas – local governments have worked with Google Fiber to facilitate construction of privately-owned, competitive fiber-to-the-home systems. This facilitation includes access to government owned facilities, such as right of ways and pole access for fiber installation and real estate leases for equipment huts, as well as a high degree of cooperation in granting permits and carrying out inspections.

Municipal Broadband Case Studies

			Markets Served					
City	Business Model	Municipal Utility?	Business	Industrial	Public uses	Amenity WiFi	Homes	Financial Notes
Alameda	City sold system to Comcast after failure of City-run model.	Yes, broadband & electric	●		●		●	Funded by revenue bonds, bondholders lost money when system was sold at 50% of bond value.
Austin, TX	Google Fiber, no direct city involvement.		●	?	●		●	No direct city investment, provided concessions regarding access to city assets and permits.
Benicia	City partners with private company.	No	●	●				Under development, funded by transportation grant
Brentwood	City partners with private company.	No	●	?	●		●	City requires conduit to be laid in new construction, and then deeded to the city. City leases conduit to 3rd party provider.
Kansas City	Google Fiber, no direct city involvement.		●	?	●		●	No direct city investment, provided concessions regarding access to city assets and permits.
Loma Linda	City provides service to homes and businesses.	Yes, operated by IT dept.	●	●	●		●	Conduit attached to city system required in new & major remodel construction. Service is optional & fee-based.
Lompoc	City provides WiFi-based service on a fee basis to homes.	Yes, broadband & electric			●	●	●	WiFi-only system, funded by 10 year lease-back and subsidized by utility department.
Pacific Grove	City partners with private company.	No	●		●		●	Under development. Either city or private service provider will have to pay monthly fee to company that funds/builds system.
Palo Alto	City provides dark fiber service.	Yes, broadband & electric	●	●	●	●		$2 million surplus revenue/year, initially funded as electric utility infrastructure, now self supporting.

Municipal Broadband Case Studies

			Markets Served					
City	Business Model	Municipal Utility?	Business	Industrial	Public uses	Amenity WiFi	Homes	Financial Notes
Provo, Utah	City sold system to Google Fiber after failure of City-run model.	Yes, operated by IT dept.	●	?	●		●	Sold to Google for $2; rate payers still paying off electric revenue bond obligations incurred to build network.
San Francisco	Ad hoc use of CCSF fiber and conduit by businesses.	Informal		●	●			City conduit and fiber originally installed for public purposes; funded out of agency budgets.
San Leandro	City partners with private company.	No	●	●	●	●		Uses city traffic signal conduit, plus extension funded by EDA grant. City will receive revenue in future years.
Santa Clara	City provides dark fiber service.	Yes, broadband & electric	●	●	●	●		$500K surplus revenue/year, initially funded as electric utility infrastructure, now self supporting.
Santa Monica	City provides "lit" connections between businesses and wholesale ISPs.	Yes, operated by IT dept.	●	●	●	●		System built for public purposes & funded by IT budget. Revenue appears to be at or above break even level.
Watsonville	City provides dark fiber service & conduit access on an ad hoc basis.	No		●	●			Saved the City $150,000/year in telecoms costs, funded by IT budget.

Business Models

California cities have a wide range of choices when considering how to pursue broadband projects. They can work with, or even own, for profit corporations, participate in cooperatives and non profit corporations or they can own and operate a broadband network, either fully or in partnership with a private sector company.

Generally, California cities (and some special districts) can provide telecommunications services within their boundaries with few restrictions. Even if a city provides a service that falls under the CPUC's jurisdiction, it is exempt from CPUC oversight. On the other hand, it is subject to all the controls, restrictions and obligations that pertain to any other municipal function, such as public oversight, open access and Brown Act requirements.

Full City Ownership

A common way of organizing a municipal telecommunications utility is to run it via a separate enterprise fund. Several cities received stimulus grants for the purpose of building publicly available telecommunications networks. Examples given above include the cities of Palo Alto, Santa Clara, Santa Monica, Lompoc and Alameda.

The City of Chattanooga, Tennessee is another example. It received approximately $100 million in grants through the American Recovery and Reinvestment Act of 2009 (ARRA) and, via its municipal electric utility, used it to build a fiber-to-the-home system.

Advantages: City controls operating policy and benefits from any profits generated, most regulatory requirements do not apply.

Disadvantages: City would have to support any financial deficits, could require additional costs such as staff time.

Partial City Ownership

When a city contributes resources to a broadband network project, it can take ownership of specific parts of that network, rather than owning and operating the entire system.

Examples above include the cities of San Leandro and Brentwood. Another example is the City of Monterey. When Comcast installed an institutional network as part of its former franchise agreement, the city paid for extra fiber strands to be installed. Those strands are the property of the city, and are now being used to provide effectively free connectivity between city locations even though local franchise agreements have been preempted at the state level.

Advantages: City gains access to telecommunications resources for its own use and can exercises a degree of control over the operation of a system that it helped to fund.

Disadvantages: Control is only partial. Continued access to the resource may depend on the viability or cooperation of a private sector partner. Care must be taken to avoid exposure to liability or unreasonable ongoing costs.

Corporation/LLC

Limited liability companies and for-profit corporations of various types can do business with few restrictions. Telecommunications companies are potentially an exception. For example, if it is deemed to be a telephone company (CLEC/competitive local exchange carrier) a private company would fall under the California Public Utilities Commission's jurisdiction.

Corporations are owned by shareholders, and different classes of stock can have different voting rights. The assets of a corporation can be sold or assigned to shareholders or others with few restrictions. To a great degree, ongoing governance and control of a corporation can be predetermined by the founders, who can also put requirements and restrictions on how it can do business and structure it to achieve goals they set (and benefit from), within limits.

For profit organizations make money, pay taxes and distribute dividends to shareholders. Individual shareholders can usually sell their stock, although there are ways to limit the ability of new stock owners to control the company. The City can be shareholder of such a corporation.

Examples run from the national organizations (AT&T and Comcast) to intrastate networks (Sunesys, Abovenet, IP Networks) to local companies (Cruzio Internet). Cruzio has agreements with the Cities of Watsonville and Santa Cruz for conduit access and colocation of wireless facilities, and participates with other local government agencies in the three-county Central Coast Broadband Consortium.

Several public-private partnerships were formed to apply for ARRA grants in 2009 and 2010. Examples include the City of Oakland and the City of Watsonville, which did not receive funds.

Advantages: freedom of action, ability to maintain control, able to operate company for the direct benefit of shareholders, able to borrow money and take private investment.

Disadvantages: could bear a regulatory burden, would likely require arms-length dealings with the City, no guarantee that it will always put the public interest foremost.

Non-Profit

A non-profit corporation can do nearly everything a for-profit corporation can do. The major differences are that a non-profit must offer some kind of public benefit, has limits on the amount of cash surplus it can generate from its operations and its governance structure is less controllable by the founders.

Non-profits aren't owned by anyone. The corporation is governed by a board that can be chosen by voting members, named by organizations designated in the bylaws or by the board itself. There are

restrictions on the degree to which board members can act on items in which they have a financial interest.

With self-perpetuating boards and boards chosen by voting members, there is a chance that the organization will take a direction that was not intended by the founders. A board with directors appointed by other people or organizations, for example the founders, is less likely to take an unintended direction but there are limits on the extent to which appointed directors can act in the interest of their parent organization.

A mutual benefit corporation is another type of non-profit, and is similar in concept to a cooperative.

In California, CENIC (Corporation for Education Network Initiatives in California) is a non-profit that runs a statewide broadband network supporting K-12 and higher education institutions. It is a membership based non-profit, controlled primarily by major public and private universities, which in turn are its major customers. Because it is a non-profit serving primarily government entities (as well as a few private non-profit schools) it can more directly serve the needs of its members than it could if its members were for-profit companies.

The Nevada Hospital Association (technically a not-for-profit professional association) received a $20 million ARRA grant to build a public access fiber network throughout Nevada. OneCommunity received a similar grant to build a fiber network in Ohio, as did the University Corporation for Advanced Internet Development, which is working on a national network primarily for higher education use.

Advantage: some freedom of action, less potential for conflict of interest with the City.

Disadvantage: can be difficult to maintain control over the long term, financial and managerial options are restricted.

Cooperative

Cooperatives are not-for-profit corporations that are usually set up to provide some kind of benefit to members. Commonly, cooperatives are set up to pool buying power. Although there can be different classes of membership with different rights, generally governance is on the basis of one vote per member, regardless of the amount of business a member does with the cooperative. Operating surpluses, on the other hand, are usually distributed to members according to how much business they do with the co-op.

The board of directors is chosen by a vote of eligible members. Although there are ways that founders can maintain a large degree of influence, it is possible that other members, representing a majority of votes, can gain control.

Examples:

California Broadband Cooperative. This ARRA grant recipient built and is now operating a 500 mile fiber optic network from Reno, down the eastern side of the Sierra generally along U.S. 395 in California to Barstow.

Plumas-Sierra Rural Electrical Co-op. A rare California example of a traditional rural utilities cooperative. These sorts of organization are common in the midwest and south, and provide telecommunications services as well as electricity.

Mid-Atlantic Broadband Cooperative. Located in rural Virginia, operates a fiber optic network of several hundred miles. Built with tobacco settlement money and ARRA funds.

Advantages: can be run strictly for the benefit of members, has freedom of action and can do business as a private company would.

Disadvantage: can be run strictly for the benefit of members (rather than focusing on public policy objectives), difficult for the founders to maintain control.

Appendix E - Glossary

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.
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. Traditionally, wired networks have been necessary for backhaul, but with 802.16, also known as WiMAX, backhaul via wireless will become even more common than it is with WiFi.
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 data at about 1.5 Mbps. The theoretical maximum for downstream transactions is 27 Mbps and 2.5 Mbps upstream, but the connection is usually much slower because the provider may be hooked to the Internet via a T-1 line.
CDMA	The type of digital cellular phone network used throughout most 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. Unlike competing systems, such as GSM, that use TDMA, CDMA does not assign a specific

	frequency to each user. Instead, every channel uses the full available spectrum. Individual conversations are encoded with a pseudo-random digital sequence. CDMA consistently provides better capacity for voice and data communications than other commercial mobile technologies, allowing more subscribers to connect at any given time, and it is the common platform on which 3G technologies are built.
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 grade	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.
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 comprised 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 (Or FTTB
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: GPON uses a different, faster approach (up to 2.5 Gbit/s in current products) than BPON.
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 grade	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 grade service. A DS-3 or dark fiber strands are examples of industrial grade 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 comprised 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 LATA. 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 comprised 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 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." You must enter the IP address of your router when configuring network settings manually.
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 grade.
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	The idea of providing every home in the United States with basic telephone service.
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.