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Broadband Investment Program Handbook and GIS Report

Prepared for Solano County

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Columbia Telecommunications Corporation

10613 Concord Street • Kensington, MD 20895 • Tel: 301-933-1488 • Fax: 301-933-3340 • www.ctcnet.us

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1 Executive summary

1.1 Overview

Solano County is located on the northernmost part of California's Bay Area and bordering the largest delta waterway system in the state. As of the 2022 census, the County's population was 448,747.[1] Three urban centers—the county seat of Fairfield, the City of Vallejo, and the City of Vacaville—comprise approximately 77 percent of the County's population, leaving vast areas outside the cities sparsely populated.

Solano County's topography and low population density in unincorporated areas make it challenging to ensure full broadband coverage throughout the County. Internet service providers (ISP) may find it cost prohibitive to build out fiber to some of the more remote locations.

Solano County received approximately $86 million in American Rescue Plan Act of 2021 (ARPA) Coronavirus State and Local Fiscal Recovery Funds (SLFRF) Program funds. Of this amount, the County has allocated $2.2 million to broadband infrastructure funding in unincorporated areas of the County and has allocated an additional $1.8 million to digital equity planning.

In 2022, the Solano County Department of Information Technology (DoIT) hired Boston Consulting Group (BCG) to create a Broadband and Digital Equity Strategy and Roadmap.[2] In this study, BCG used 2022 FCC Form 477 data to estimate that approximately 1,800 locations were unserved in the unincorporated parts of the County, with broadband speeds of under 25 Mbps download/3 Mbps upload (25/3). In addition, BCG estimated that approximately 3,900 addresses were underserved, with access to speeds between 25/3 and 100/20 Mbps. (More detail on the BCG report findings can be found in Appendix A.)

In 2023, Solano County DoIT applied for, and received, a grant from the California Public Utilities Commission's (CPUC) Local Agency Technical Assistance (LATA) grant program.[3] Through the LATA program, eligible entities can receive up to $500,000 in grant funding to reimburse the costs of technical assistance for pre-construction expenses in advance of broadband deployment.

[1] U.S. Census Bureau Quick Facts: Solano County, California, https://www.census.gov/quickfacts/fact/table/solanocountycalifornia,US/PST045223 (accessed March 8, 2024).
[2] "Solano Connected: A Broadband and Digital Equity Strategy And Roadmap," conducted by the Solano County Department of Information Technology and Boston Consulting Group, August 2022, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=38196.
[3] LATA awards are designated by the Budget Act of 2021 and Senate Bill 156 (SB 156) in 2021 in the amount of $45 million for local agencies and $5 million for Tribes. SB 156 (Chapter 112, July 20, 2021); Section 35 (Item 8660-062-8506 of Section 2.00) of the Budget Act of 2021 provides: "Funds appropriated in this item may be used to fund projects, distribute grants, or fund support costs associated with the program;" California Public Utilities Commission, Decision Establishing Local Agency Technical Assistance Grant Program, D.22-02-026 (R.20-08-021), February 25, 2022, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M454/K873/454873811.PDF.

Solano County has used this LATA grant funding to further its broadband planning and investment strategies, including the development of this Broadband Investment Handbook.

1.2 Goals and objectives

Through the development of this Handbook, the County seeks to gather updated data to identify areas with the greatest need for broadband investment and to develop a plan for investment that maximizes the impact of future infrastructure spending, achieving full broadband coverage throughout the County.

Given the attributes mentioned above, including significant areas of low population density and wide-open rural spaces, the County will have difficulty ensuring that there will be fiber infrastructure to every location to enable high-speed connectivity. Creative solutions for spending, leveraging grant funding, and using alternative technologies will be necessary to provide high-speed broadband to areas that do not present a strong and clear business case for ISPs to invest in broadband infrastructure.

High-level objectives for this project include:

- Developing strategies to achieve full broadband coverage throughout the County, in both urban and rural areas;
- Planning for future broadband investments—both public and private—to get to full broadband coverage;
- Identifying unserved areas that are less attractive for investment and proposing creative solutions to meet the community need;
- Developing a roadmap for broadband planning for the next five to 10 years;
- Strengthening the County's relationships with ISPs and developing partnerships to help invest in unserved and underserved areas;
- Working with the cities of Vallejo, Fairfield, and Vacaville to leverage their infrastructure for future investment;
- Maximizing the impact of federal and state funding for broadband infrastructure; and
- Educating residents, City governments, and County and City leadership about the importance of high-speed and reliable broadband options and future plans for coverage.

1.3 Purpose of the Broadband Investment Handbook

This Handbook is intended to articulate methodologies and best practices related to the objectives above. It includes:

- Descriptions of broadband technologies that, when combined, can achieve comprehensive coverage of the County;
- Maps demonstrating the current state of broadband coverage in the County and showing the greatest areas of need (i.e., unserved and underserved locations) in the County;
- Maps that show technologies and ISP coverage in the County;
- Maps that show areas with enforceable commitments for infrastructure buildout through funding from state and federal broadband funding programs;
- Discussion of the criteria and identification of areas where fiber buildouts are feasible and areas where alternative technologies may be more suitable;
- Clear delineation of funding opportunities by technology (fiber, cable, and fixed wireless);
- Identification of potential areas of investment for upcoming federal and state funding opportunities such as the Broadband Equity, Access, and Deployment (BEAD) Program and the California Advanced Services Fund (CASF);
- Identification of potential areas of investment by the County in the next five to 10 years to cover locations that may not be eligible for state or federal funding; and
- Recommendations for strategies and opportunities to close broadband gaps in the County.

1.4 Key findings

- **AT&T, Comcast, Cal.net, Valley Internet, and Astound (Wave) Broadband serve most of the broadband customers in the County, and 98.4 percent of all broadband serviceable locations are served at 100/20 Mbps or higher.** In the incorporated areas, 99.7 percent of all locations are served and 74.3 percent are served in unincorporated areas.
- **Fiber coverage in the County is limited to the incorporated areas, as is cable coverage. Fixed wireless is the primary technology in unincorporated areas.** AT&T is the main fiber provider in the County and Frontier has a small coverage area in Rio Vista. Comcast is the dominant cable provider, with Astound covering a small area in Dixon. Valley

Internet provides fixed wireless service mainly in the west and Cal.net provides fixed wireless service mainly in the east.

- **Enforceable commitments based on the Connect America Fund II (CAF II) will enable Cal.net to provide service to 2,243 currently unserved or underserved locations in unincorporated areas.** The CAF II buildouts must be completed by the end of 2025.
- **There were 12 applications for Last-Mile Federal Funding Account (FFA) grants for projects exclusively in Solano County from AT&T, Cal.net, the City of Vacaville, the City of Vallejo, and Comcast, with total requests of over $53 million. There were additionally seven applications that were partially in Solano County that overlapped with neighboring counties.** Solano County was allocated $17 million in FFA funding to support last-mile broadband deployment and awards will be announced by June 30, 2024, according to the California Public Utilities Commission (CPUC), which administers the program.
- **Based on Ookla data, speed tests revealed that certain parts of the unincorporated areas of the County demonstrate download speeds of under 25 Mbps.** AT&T and Comcast show small pockets of speeds less than 25 Mbps adjacent to incorporated areas. Astound shows three blocks of lower than 25 Mbps in the south and in the east. Speed tests for wireless providers show less than 25 Mbps in areas throughout the County.
- **The planned route for the Middle-Mile Broadband Network (MMBN), an open-access middle-mile network established by Senate Bill (SB) 156 in 2021, will cut directly through the middle of the County.** According to the latest route map, the network will follow Highways 80 and 505, offering opportunities for expansion for ISPs to offer last-mile service.
- **Two of the cities in the County have proposed projects for FFA funding, neither of which will cover unincorporated areas.** The City of Vacaville would like to fund a 29-mile fiber network that would be operated by a partner ISP. Vallejo submitted applications for four projects that are focused on multi-tenant housing or trailer parks. Fairfield, Dixon, Elmira, and Rio Vista do not have any current plans for projects.
- **The County has three options to lower costs for its AT&T Switched Ethernet (ASE) network, which connects all County buildings and facilities.** Golden State Connect Authority can potentially build and operate an alternative network based on the MMBN project. Capital and operating costs for this buildout are yet to be determined. Comcast reported that it could take over the operations of this network without downtime and would charge approximately half the cost that AT&T is charging. The County also proposed to AT&T that it reduce its costs of operation so that it can retain the contract.

- **Fiber buildouts in the County will most likely only occur as extensions of existing networks adjacent to incorporated areas; the unserved locations in unincorporated areas will likely need to rely on wireless technology.** An analysis was completed based on population density and existing coverage to identify the unserved and underserved areas of the County where fiber infrastructure investment would be most appropriate. Areas with less than 50 broadband serviceable locations (BSL) per square mile are most suited to wireless deployment, as the cost per passing to serve locations with fiber becomes prohibitive below this threshold.

1.5 Recommendations

For purposes of broadband investment in Solano County, CTC proposes the following recommendations:

- **Fiber will likely not be feasible for deployment throughout the County.** Based on the high cost of building fiber in remote areas of the County and the lack of business case for ISPs, alternative technologies should be leveraged. The analysis assumes that fiber will be extended from existing networks rather than being built as an entirely new network and suggests that the unincorporated areas of the County will be best served by wireless technology.
- **Given the results of the Ookla speed test data, it is not advisable to rely on hotspots for broadband service delivery.** Since the unincorporated areas of the County most often registered download speeds of less than 25 Mbps for wireless providers, it would not be advisable to rely on hotspot service using the cellular network as an alternative to broadband. Though there are certain areas where cellular wireless coverage yielded speeds of greater than 100 Mbps download (for example, Verizon coverage west of Fairfield and west of Vacaville), these speeds are not consistent across unincorporated areas nor are they reliable.
- **The County may find opportunities for funding through CASF.** Since the CASF program has different thresholds than federal funding programs and allows investment in fixed wireless, the County may choose to partner with different ISPs to fill in gaps.
- **The County should continue to monitor upcoming grant programs such as the BEAD program.** The County should stay apprised of the BEAD planning process administered by the CPUC and continue planning with partners once the Extremely High Cost per Location Threshold (EHCPLT) has been determined, as those areas will qualify for non-fiber deployments under this program. As the County has obtained the Tier E CostQuest license, it has access to the National Broadband Map address fabric and therefore is

able to challenge the ISPs' reported data of their service availability through the BEAD Challenge Process.

- **The County may conduct cost modeling in 2024 while BEAD rules are being developed.** A cost model will help determine the potential eligibility of locations for BEAD funding. This cost modeling is a more in-depth analysis than the one conducted for this report.
- **Though the MMBN will intersect the County, it is best leveraged for the County's ASE network rather than last-mile deployments.** The location of the open-access MMBN will still require a considerable number of miles of fiber to be built by ISPs to reach the unserved locations in the remotest parts of the County. ISPs are not likely to invest in this infrastructure as they will not recover the cost to deploy through the revenues from service. The MMBN can be used to build a redundant ASE network through Golden State Connect Authority (GSCA), which is able to finance this effort through tax-exempt bonds.
- **A facilitation model for partnership is recommended.** Since the County does not wish to build, own, or operate its own infrastructure, partnership with the existing ISPs can lead to incentives from the County to improve or build new infrastructure. The $2.2 million in ARPA funds that the County has allocated for broadband infrastructure would be one element of this model.
- **Once the FFA awards have been announced by the CPUC, the County can reassess remaining unserved and underserved locations.** CTC will update this Handbook to include areas where FFA funding will be made available and will adjust recommendations according to this information.

2 Current state assessment

This section outlines the general broadband market, the technologies used for deployment to end users, existing coverage in Solano County, projects that are proposed or in progress, and funding opportunities on the horizon for the County.

2.1 Overview of the broadband market structure

As a foundation for the analysis presented in the remainder of this report, this section briefly describes the structure of the broadband market, including deployed infrastructure, market participants, and customer segments.

The broadband market is divided by types of providers, types of services based on the use of infrastructure, and types of customers served. In larger metropolitan areas, long-haul fiber bridges the distance between cities, often connecting at data centers. The relevant infrastructure for this analysis consists of:

1. **Middle-mile fiber**, which delivers enterprise-level services to large businesses, institutions, and government clients in a local or regional area and connects wireline and wireless last-mile infrastructure with the long-haul network through “backhaul” services.

2. **Last-mile infrastructure** (wireline (e.g., fiber) or wireless), which delivers consumer-grade services to residences and business-class services to small businesses.

Table 1 summarizes the broadband market for middle- and last-mile market segments. The sections below describe the middle-mile and last-mile segments specific to Solano County in more detail.

Table 1: Broadband market overview

	Infrastructure Provider Leverages real estate & infrastructure to support ISPs	Enterprise Service Provider Sells high-end services to sophisticated end users & ISPs	National Incumbent Operates regional networks to serve multiple segments	Local Incumbent Operates local networks to serve multiple segments	Competitor Builds new networks to compete with incumbents
1. Middle Mile (transport & internet bandwidth) ISP customers					
2. Wireless Backhaul Wireless ISP customers					
3. Enterprise Business & institutional customers					
4. Business Class Small/medium business customers					
5. Consumer-Grade Residential & small business customers					

2.1.1 Middle-mile market segment

Middle-mile service providers connect last-mile ISPs (both wired and wireless) to the backbone of the internet at major data centers and other interconnection points. Middle-mile services include the following:

- **Transport** is a service from one point to another over a middle-mile network that enables the buyer to transport its traffic between its local network and a major network hub; this is a high-end service, often with service-level guarantees, that is used by more sophisticated ISPs.
- **Backhaul** is a type of service sold to other ISPs (primarily wireless) to "backhaul" their internet traffic from the neighborhood to the internet backbone; these are high-end services that may be delivered over lit or dark fiber.
- **Commodity internet bandwidth** enables local ISPs to put their traffic on the internet. It can be purchased locally (at the interconnection point with the middle-mile provider), offering simplicity for the local ISP, or at a data center (with transport services then necessary to move the bandwidth between the data center and the ISP's local network).
- **Interconnection services** allow ISPs to connect to the internet backbone and to each other; these include access to data centers or field exchange points; rack space at data centers; and access to splice enclosures or other interconnection elements.

- **Dark fiber** enables sophisticated ISPs to use their own electronics to "light" and operate fiber strands along a middle-mile route; the dark fiber owner offers physical maintenance guarantees and splicing and related services to access the fiber.

A range of entities provide middle-mile services, though remote locations and cost effectiveness may create challenges for different types of last-mile ISPs to connect to these middle-mile providers:

- **Incumbents** operate large networks to support their own last-mile operations, both fixed and mobile; these providers sometimes sell middle-mile services to competitors. AT&T has the largest middle-mile fiber network of the incumbents serving Solano County. Frontier has very limited middle-mile facilities where it serves as the local incumbent last-mile provider.
- **Infrastructure companies** deploy network infrastructure assets and bundle access to those assets including fiber, wireless towers, and "small cells" on street furniture to sell middle-mile services to ISPs. Companies like Crown Castle, CENIC, Extenet, and CenturyLink are considered infrastructure companies.
- **Enterprise ISPs** may or may not deploy their own network infrastructure, but their primary business model is to sell very high-end middle-mile (and last-mile) services to sophisticated users, including last-mile ISPs, multi-location business enterprises, and large anchor institutions. Enterprise ISPs in Solano County include Cogent Communications and Tpx.
- **Platform companies** such as Google and Meta own massive long-haul and middle-mile fiber networks to support their own needs; in limited cases, these assets are also used to deliver services to ISPs.

2.1.2 Last-mile market segment

ISPs offer a range of data services over the last-mile portions of their networks to residences, businesses, institutions—and to other ISPs. Last-mile services and customer types include the following:

- **Consumer-grade internet** services are sold to households and cost-conscious small businesses; these are "best efforts" rather than guaranteed levels of service, which is indicated by advertisements for speeds "up to" a certain level.
- **Business-class internet** services are sold to many smaller and mid-size businesses that require a bit more support than households; these are still "best efforts," but they may include symmetry (i.e., matching download and upload speeds), lower levels of

oversubscription (meaning the infrastructure will be supporting fewer customers), and prioritization at the ISP's network operations center.

- **Enterprise-level services** are the services sold to sophisticated institutions and businesses that require "quality of service" guarantees; these are high-end services that include point-to-point transport and point-to-point dark fiber.

Key last-mile market players include incumbent, competitive, and mobile/fixed wireless providers:

- **Incumbent providers** include "telephone companies" like AT&T offering voice and internet over legacy copper, digital subscriber line (DSL), or (in limited cases) fiber infrastructure, as well as cable companies such as Comcast offering internet over legacy cable TV infrastructure and some newly built fiber infrastructure in core downtown areas.
- **Competitive providers** include fiber-to-the-premises (FTTP) providers like Astound as well as fixed wireless providers like Valley Internet, Cal.net, and DigitalPath. Competitive providers include smaller, niche, and community providers as well as larger enterprises and they market to a mix of residential and business customers. These providers often have to "over-build"[4] the legacy incumbent networks to bring newer technology into the area. In Solano County fixed wireless is a significant portion of the technology used by competitive providers.
- **Mobile companies** such as AT&T, Verizon, and T-Mobile also offer "fixed wireless" services in the last mile, though with entirely different service attributes and utility than competitive providers such as Valley Internet and Cal.net. As these incumbent providers expand their 5G networks over the next several years, and resellers (or Mobile Virtual Network Operators) such as Tracfone market services over those networks, faster and more reliable fixed wireless may become increasingly available.

2.2 Overview of last-mile technologies

There are five options for last-mile broadband infrastructure:

- Fiber to the premises (FTTP)
- Cable (Hybrid Fiber-Coaxial)

[4] Overbuilding in the telecom industry is defined as utilizing an existing telecommunications operator's network (which includes telco and cable networks) to provide service to customers. For example, a fiber network may be built in the same right-of-way or on an aerial pole line where an existing network exists, whether it is copper, coax, or wireless.

- Digital Subscriber Line (DSL)
- Fixed wireless
- Satellite

According to federal funding standards for the BEAD Program, satellite and cellular service is not considered "Reliable Broadband Service," which is defined as fiber, cable, DSL, and terrestrial fixed wireless with licensed spectrum only or a combination of licensed and unlicensed spectrum.[5] The Federal Communications Commission (FCC) has repeatedly noted that mobile service is an inadequate substitute for fixed broadband services;[6] however, an estimated 15 percent of U.S. adults continue to rely on their smartphones and mobile data plans as the only source of home broadband connectivity[7]—a trend that is more common among young adults and low-income households.[8]

For a full description and comprehensive analysis of last-mile technologies, see Appendix C.

2.2.1 FTTP

Fiber with Passive Optical Network (PON) architecture is considered the most "future-proof" of last-mile technologies. The quality and speed of an internet connection varies based on the capacity and limitations of the last-mile technology used. FTTP is regarded as superior to all fixed wireless broadband technologies—including wireless technologies that will be developed in the future.

Though fiber is more expensive to install initially, it has the highest resiliency and lower overall maintenance costs. FTTP is also resistant to environmental conditions such as corrosion, lightning, or radio wave interference. It is also easier than other technologies to upgrade to higher speeds—even up to 100 Gbps. Fiber can support sequential high bandwidth speeds at lower latency than fixed wireless. Fixed wireless components also have a shorter lifespan than fiber, resulting in higher ongoing maintenance and replacement costs.

2.2.2 Cable

Hybrid fiber-coaxial (HFC) cable networks use both optical fiber and coaxial cable. Coaxial cable networks were originally built for video communications. As data capacity needs increased, HFC networks could no longer support high-speed services. Cable operators must now upgrade their

[5] BEAD NOFO, Section I.C.u., p. 15.
[6] FCC Fourteenth Broadband Deployment Report, January 19, 2021, Sections III(A)(10-11), https://docs.fcc.gov/public/attachments/FCC-21-18A1.pdf
[7] Andrew Perrin, "Mobile Technology and Home Broadband 2021," Pew Research Center, June 3, 2021, https://www.pewresearch.org/internet/2021/06/03/mobile-technology-and-home-broadband-2021/.
[8] Andrew Perrin, "Mobile Technology and Home Broadband 2021."

networks with fiber to replace the coaxial infrastructure or make expensive upgrades to network electronics—or do both. One strand of fiber has over 10,000 times the capacity of a coaxial cable. Connection speeds for cable are affected by the number of simultaneous users, so speeds can drop during peak usage hours. Reliability is affected by the end user's distance from the node, so performance can be affected by a customer's location. Cable network upgrades are very costly, which inhibits many operators from doing full-scale infrastructure improvements.

2.2.3 DSL

DSL uses legacy copper lines based on previous telephone infrastructure. Though it was a cost-effective way to repurpose this infrastructure, DSL is limited compared to other types of wireline technology. Speed is based on the length of the copper line from the telephone company's central office equipment to the end user. Performance is limited by the life of the copper line—corrosion of the lines reduces bandwidth and causes interference. Copper is not sufficient for current day or future bandwidth needs, and as a result is being phased out by providers, who are upgrading to fiber or switching to wireless services.

2.2.4 Fixed wireless

In areas where wireline service is either unavailable or too costly to deploy, fixed wireless service can be an option to provide broadband—but it does come with challenges. While fixed wireless has made significant advances in technology and speeds in recent years, it has inherent drawbacks. Some of the notable differences compared to fiber include speed capabilities, reliability, and equipment refresh cycles. Fixed wireless is also not suited to irregular terrain or heavily foliated areas as it requires near line of sight to the point of presence (POP) to receive the signal to meet throughputs exceeding 20 Mbps.

Though fixed wireless may connect areas where fiber will not be deployed, it cannot offer the quality of service offered by advanced wireline technologies. Most wireless equipment requires clear line of sight between antennas, and geographic obstructions or bad weather may affect performance. Wireless equipment must also be replaced every five to seven years, driving up maintenance costs.

2.2.5 Satellite

Satellite-based communication, facilitated by geostationary (GEO) and low earth orbiting (LEO) satellites, provides the distinct advantage over terrestrial communication of nearly ubiquitous coverage of a large area of up to thousands of square miles. For GEO satellites, the high altitude allows a few satellites to cover very large areas, while for LEO satellites, thousands of small satellites achieve similar effects. The mostly unencumbered line of sight with the satellite—apart from local obstructions by vegetation or built structures—means signal loss is low. The large

distance between transmitter and receiver for GEO systems introduces time lags that hamper real-time applications such as video, but LEO systems can theoretically support mobile broadband—although this technology is still in early stages of development.

2.3 Existing providers and technologies

AT&T, Comcast, Cal.net, Valley Internet, and Astound (Wave) currently serve most of the broadband customers in Solano County. Cal.net and Valley Internet primarily provide fixed wireless service with a fiber backbone. Frontier (fiber and DSL), DigitalPath (fixed wireless), and Internet Planet (reseller) have small, isolated footprints in the County. TPx and Cogent (DSL, fiber, and managed services) provide enterprise, data center, and managed services to large business and institutional customers in the County but do not serve residential end users.

The County has been working closely with multiple ISPs that serve different areas, including fiber, wireless, and cable providers both large and small. The County and CTC met with the following ISPs to identify opportunities to participate in the CPUC's Federal Funding Account (FFA) program (discussed further in Section 2.4.2), discuss possible project areas to meet unserved need in the County, and explain potential matching opportunities through the County's ARPA funds allocation.

2.3.1 AT&T

AT&T is the incumbent local exchange telephone company (ILEC) in the County. AT&T's fiber presence in Solano County is primarily in the cities—Vallejo, Vacaville, and Fairfield. It also serves locations throughout the County via DSL using its legacy copper phone network, which will not be upgraded.

The company is interested in extending its fiber network in Solano County and is potentially interested in serving unincorporated areas such as Suisun Valley, Allendale-Hartley, and south Winters. Representatives requested a match from the County's ARPA funding for one of its FFA applications.

2.3.2 Comcast

Comcast currently uses both cable and fiber in the County and serves Fairfield, Suisun, Rio Vista, Vacaville, Vallejo, Travis Air Force Base, and American Canyon. During discussions, Comcast noted that it was considering network buildout in unincorporated areas including Mankas Corner, Elmira, and other industrial areas. Comcast submitted two FFA applications but did not request matching funds from the County.

2.3.3 Cal.net

Cal.net has a presence mainly in the eastern part of Solano County using fixed wireless technology connected by fiber. Cal.net is currently expanding its fixed wireless and fiber network with federal funding from the Connect America Fund Phase II (CAF II) Program and stated that it expects that project to be complete by December 31, 2025. (Projects funded by the program must complete 60 percent of deployment by end of 2023 and 80 percent of deployment by the end of 2024.)[9] CAF II auction winners are required to provide at least one stand-alone voice plan and one broadband service plan in the speed tier designated by the FCC; Cal.net has claimed that it will provide service at a minimum of 100/20 in all CAF II areas.

The company submitted one FFA application and expressed interest in matching funds from the County. Its planned project would include a fiber buildout to comply with the FFA guidelines and would most likely be located east of Vacaville in unincorporated areas. Cal.net stated that it is working with five other counties in California in addition to Solano County.

2.3.4 Valley Internet

Valley Internet positions itself as an expert in licensed and unlicensed fixed wireless technology and states that it has worked with Etheric Networks for fiber buildouts. The company focuses only on rural areas and states that its service offers over 100 Mbps download in the area northwest of Fairfield. The company did not submit an FFA application. Representatives claimed they are considering projects in Mankas Corner, Suisun Valley, English Hills, and Birds Landing.

2.3.5 Astound (Wave)

Astound provides both fiber and hybrid fiber/coaxial services in Solano County. It serves commercial clients in the Winters and Dixon areas and is interested in extending its service to residential customers. The company would like to have a greater presence in the areas between San Francisco and Sacramento and expressed interest in both obtaining FFA funding and a potential County match. It did not submit an FFA application but expressed interest in extending its current footprint to the unincorporated areas in Solano County.

2.3.6 DigitalPath

DigitalPath is a fixed wireless provider that has a presence in 22 counties in California. Its coverage in Solano County is currently limited, with a presence in Vacaville, Dixon, and in the northern portion of the County, as well as Rio Vista and areas in the eastern portion. DigitalPath has a California Advanced Services Fund (CASF) grant application pending for approximately

[9] "CAF Phase II Auction," Universal Service Administrative Co., https://www.usac.org/high-cost/funds/caf-phase-ii-auction/.

$668,000 to cover an estimated 321 households in the areas of Batavia, Elmira, Binghampton, Allendale, and Hartley.

2.4 Funding landscape

There have been unprecedented amounts of funding allocated in recent years at the federal, state, and local level to expand broadband infrastructure and to promote digital equity throughout the U.S. However, the requirements of federal funding programs may present some obstacles to Solano County. Programs including BEAD, FFA,[10] and the Rural Digital Opportunity Fund (RDOF) lead with a "fiber first" strategy and deprioritize fixed wireless projects, which may be more feasible in remote locations of the County.

2.4.1 Broadband Equity, Access, and Deployment (BEAD) Program

The largest source of upcoming federal funding is the Broadband Equity, Access, and Deployment (BEAD) Program administered by the National Telecommunications and Information Administration (NTIA), which provides $42.45 billion throughout the U.S. to expand high-speed internet access by funding planning, infrastructure deployment, and adoption programs.

In June 2023, the NTIA announced that California will receive $1.86 billion in BEAD funding to support a last-mile grant program to deploy broadband infrastructure to all unserved and underserved locations in the state.[11]

The California Public Utilities Commission, which will administer this grant program, conducted extensive state-wide planning in 2022 and 2023 and released three key planning documents setting the policy and strategy for the state's BEAD participation[12]—culminating with California's

[10] The CPUC's Federal Funding Account program primarily relies on federal funds allocated to states by the American Rescue Plan Act's State and Local Fiscal Recovery Fund and Capital Projects Fund programs. As such, the CPUC's FFA program incorporates and complies with the U.S. Treasury rules adopted for these funding sources, including requirements to prioritize fiber. CPUC, "Decision Adopting Federal Funding Account Rules," (D.22-04-055), Order Instituting Rulemaking Regarding Broadband Infrastructure Deployment and to Support Service Providers in the State of California, Rulemaking 20-09-001, April 22, 2022 ("FFA Decision"), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M470/K543/470543650.PDF.

[11] The eligibility of locations for BEAD funding is based on the FCC's Broadband Data Collection, which maps service availability at the address level. States are required to prioritize awarding funding to serve all unserved locations and then underserved locations as identified by these data. See, BEAD NOFO at Section IV.B.7.a.ii and Section IV.B.7.b.1; https://broadbandusa.ntia.doc.gov/sites/default/files/2022-05/BEAD%20NOFO.pdf; and "Broadband Data Collection," FCC, https://www.fcc.gov/BroadbandData.

[12] California Five-Year Action Plan, CPUC, August 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/communications-division/documents/broadband-implementation-for-california/bead/california-bead-five-year-action-plan---final-draft---20230828.pdf; California Initial Proposal Volume 1, CPUC, December 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/documents/internet-and-

Initial Proposal Volume I and Volume II, which the state submitted to NTIA on December 27, 2023. The Initial Proposal outlines the basics of the BEAD program implementation and the principles that the CPUC will use to select grantees for last-mile infrastructure funding.

Through its planning and mapping efforts, the CPUC has determined that this significant investment will not be sufficient to meet the needs of all unserved locations in the state and has proposed a detailed and strict scoring rubric to prioritize projects to maximize the impact of the funding and serve the areas with the greatest need in the state.

Federal rules require states to prioritize BEAD funding for fiber deployment projects except in some "extremely high-cost areas" that may qualify for alternative technologies such as fixed wireless. An Extremely High Cost per Location Threshold (EHCPLT), which determines which areas will be eligible for funding for coverage with technologies other than fiber, will be established by the CPUC. Applicants will be required to make at least a 25 percent match toward project expenses except for in extremely high-cost areas.[13]

In the summer of 2024, the CPUC will be conducting the Challenge Process for the BEAD Program, which allows entities to offer input on whether specific locations will be eligible for BEAD funding. Note that the existence of Broadband Serviceable Locations (BSLs)[14] will not be able to be modified during this process. This is the best opportunity for individuals and entities to request changes to the FCC Broadband Data Map, which is the basis for BEAD funding. Permissible challengers include local governments, Tribal governments, nonprofit organizations and broadband service providers. Though individuals are not permissible challengers, they will have a method to capture evidence related to BEAD-eligible locations and have one of the eligible entities submit them on their behalf.

The Subgrantee Selection Process will likely occur in the fall of 2024. During this process, the CPUC will accept application materials from entities that are seeking BEAD funding. The CPUC will score these applications according to the rules approved by the NTIA, will negotiate with applicants and will announce preliminary award areas. Grant recipients must complete their projects within four years of receiving the award.

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phone/bead-program/draft-cpuc-bead-ipv1-as-submitted.pdf; California Initial Proposal Volume 2, CPUC, December 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/documents/internet-and-phone/bead-program/draft-cpuc-bead-ipv2-as-submitted.pdf.

[13] BEAD NOFO, p. 3, Section L https://broadbandusa.ntia.doc.gov/sites/default/files/2022-05/BEAD%20NOFO.pdf.

[14] FCC Broadband Data Collection Help Center, https://help.bdc.fcc.gov/hc/en-us/articles/16842264428059-About-the-Fabric-What-a-Broadband-Serviceable-Location-BSL-Is-and-Is-Not

2.4.2 SB 156 funding

The California Legislature also allocated significant state and federal funds to support broadband infrastructure deployment through SB 156 in 2021.[15]

SB 156 established the Middle-Mile Broadband Initiative (MMBI) to develop a statewide open-access middle-mile broadband network, allocating $3.25 billion in funding for the project. The network will consist of approximately 10,000 route miles, including new construction and joint-builds as well as leases and purchases of fiber.[16] By providing ISPs with cost-effective access to middle-mile infrastructure on equal terms, the network is intended to help lower the cost of last-mile deployment, particularly in unserved and underserved areas, and support bringing equitable high-speed broadband service to all Californians.[17] The Legislature directed the California Department of Technology (CDT) to partner with a Third-Party Administrator (GoldenStateNet)[18] to orchestrate the build. The design and construction of the network is monitored by the Middle-Mile Advisory Committee (MMAC).[19]

SB 156 also allocated $2 billion to the Federal Funding Account (FFA) Program to provide grant funding for last-mile deployment. The Legislature directed the CPUC to evenly allocate the funding between rural and urban counties,[20] which the CPUC defined and identified based on a formula that uses 2019 data.[21] Using this formula, the CPUC has categorized Solano County as an urban county and allocated $17 million under FFA[22] to fund wireline fiber broadband infrastructure projects located in the County.

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[15] SB 156 (Chapter 112, July 20, 2021), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB156.

[16] "Statewide Middle-Mile Network Map," Middle-Mile Broadband Initiative, https://middle-mile-broadband-initiative.cdt.ca.gov/pages/statewide-middle-mile-network-map.

[17] Middle-Mile Broadband Initiative, https://middle-mile-broadband-initiative.cdt.ca.gov/.

[18] GoldenStateNet, https://goldenstatenet.org/.

[19] The development and structure of the MMAC is designed by SB 156. The Committee has eleven members including representatives from CDT, Caltrans, the Department of Finance, the CPUC, the Government Operations Agency, and four members of the Legislature. Cal. Govt. Code §11549.58(c); "MMAC Meetings," Broadband for All, https://middle-mile-broadband-initiative.cdt.ca.gov/pages/mmbi-advisory-committee.

[20] SB 4, Chapter 671 (October 8, 2021), Section 2 (revised Public Utilities Code Section 281(n)), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB4. The funding is mostly federal funding from the American Rescue Plan Act, including both the Capital Projects Fund and State and Local Fiscal Recovery Funds, as well as smaller contributions of state funds.

[21] CPUC, "Decision Adopting Federal Funding Account Rules," (D.22-04-055), Order Instituting Rulemaking Regarding Broadband Infrastructure Deployment and to Support Service Providers in the State of California, Rulemaking 20-09-001, April 22, 2022, pp. 32-35 ("FFA Decision"), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M470/K543/470543650.PDF.

[22] See, FFA Decision, at p. 35.

Applications for the FFA program were due on September 29, 2023. As discussed in more detail in Section 2.7, the CPUC received twelve applications totaling over $53 million in funding requests for projects solely located within Solano County, as well as an additional seven applications that cross county lines and propose to serve locations within the County. Final awards will be announced by June 30, 2024, and awarded projects must be completed within two years of receiving authorization to construct.

The California Loan Loss Reserve (LLR) Fund was established by SB 156 to finance the municipal network capital expenses through the issuance of long-term tax-exempt bonds. The LLR program allocated $750 million to offer a credit enhancement for localities in financing local broadband infrastructure.[23] The CPUC has started accepting applications for this program beginning in March 2024.

2.4.3 California Advanced Services Fund (CASF)

The California Advanced Services Fund (CASF) provides funding for broadband adoption, infrastructure, service to public housing, consortia operations, line extensions, and technical assistance for California Tribes.[24] The Legislature allocates funding collected through surcharges on residential customer bills to each of the CASF grant fund accounts. Between 2021 and 2032, the CPUC is authorized to collect up to $150 million per year to fund all CASF programs.[25]

For Fiscal Year 2023-2024, the CPUC allocated $32.7 million of the CASF budget for infrastructure grant funding.[26] The CPUC accepts applications for the Broadband Infrastructure Grant Account program once a year and the total amount of grant funding distributed to projects varies each year depending on the mix of applications received.

The CPUC relies on its own data collection and mapping analysis to determine eligible locations for CASF infrastructure funding.[27] Projects are eligible for funding between 60 percent and 100 percent of the costs of construction, and funded projects must deploy infrastructure in unserved

[23] CPUC Loan Loss Reserve Fund, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/broadband-implementation-for-california/loan-loss-reserve-fund

[24] "California Advanced Services Fund," CPUC, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund.

[25] California Public Utilities Code §281(d)(4); See, also, Broadband Infrastructure Grant Account Program Requirements, Guidelines and Application Materials, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/communications-division/documents/casf-infrastructure-and-market-analysis/broadband-infrastructure-grant-account---landing-page/decision-docs/d2211023attachment-1casf-guidelinesw-coverheader053123.pdf

[26] CPUC, Approval of Fiscal Year 2023-24 Budget Allocations for California Advanced Services Fund, Resolution T-17782 (June 8, 2023), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M511/K159/511159823.PDF.

[27] California Interactive Broadband Map, http://www.broadbandmap.ca.gov/.

areas with current speeds of no greater than 25/3 Mbps. The CPUC prioritizes projects in areas with 10/1 Mbps service or lower. Projects must commit to increasing speeds for residential users to at least 100/20 Mbps using either fiber, cable, or fixed wireless technologies. Projects must also commit to offer an "affordable" service offering for low-income customers at $15 or less per month.

At the time that this report was published, there were no approved CASF projects currently being constructed in Solano County.[28]

2.4.4 USDA ReConnect Program

The U.S. Department of Agriculture (USDA) Rural Utilities Service's (RUS) Rural eConnectivity Program, more commonly referred to as ReConnect,[29] funds grants and low interest loans to support capital investment in broadband networks in eligible rural areas. Since 2019, USDA has administered multiple rounds of funding under the ReConnect program and has distributed a total of over $5 billion to connect thousands of locations in rural parts of the country.[30] The application window for the most recent USDA ReConnect opportunity opens in March 2024 and closes in May 2024.

In 2024, ReConnect will fund areas where 90 percent of the households are unserved by fixed wireline or wireless broadband speeds of at least 25/3 Mbps or are only served by satellite or unlicensed fixed wireless.[31] The project area must qualify as "rural," which means that the project cannot be located in an incorporated area with more than 20,000 inhabitants or an unincorporated area that is contiguous or adjacent to a city or town with more than 50,000 inhabitants.[32] ReConnect also uses the population density per square mile of the proposed

[28] "CASF Approved Infrastructure Projects," CPUC, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund/casf-infrastructure-grant/casf-infrastructure-approved-projects.
[29] "ReConnect Loan and Grant Program," USDA, https://www.usda.gov/reconnect.
[30] "ReConnect Loan and Grant Program," USDA, https://www.usda.gov/reconnect; see, "Program Awardees" for a summary of program awards by funding round and lists of program awardees by fiscal year.
[31] "Evaluation Criteria," USDA, https://www.usda.gov/reconnect/evaluation-criteria; See, also, "Notice of Funding Opportunity for the Rural eConnectivity Program for Fiscal Year 2024," notice by the Rural Utilities Service in the Federal Register, issued February 21, 2024, https://www.federalregister.gov/documents/2024/02/21/2024-03484/notice-of-funding-opportunity-for-the-rural-econnectivity-program-for-fiscal-year-2024.
[32] The NOFO utilizes the definition of a "rural area" established in 7 CFR §1740.2, https://www.ecfr.gov/current/title-7/subtitle-B/chapter-XVII/part-1740/subpart-A/section-1740.2. The ReConnect program can update its criteria for eligible funding areas for each round of funding and provides more detailed eligibility criteria in the Notice of Funding Opportunity for each round; USDA provides information about project area eligibility on its mapping tool, available at https://ruraldevelopment.maps.arcgis.com/apps/webappviewer/index.html?id=25591161c5634d49a70290287a1b30e7.

service area in its scoring rubric, giving the highest points to areas with the lowest population density.

Project funds can be used for pre-application and environmental review expenses not to exceed 5 percent of the award. Projects must deliver 100 Mbps symmetrical service to every premise in the proposed service area. Projects that serve low-income and disadvantaged communities as well as those that offer a low-cost service option will be prioritized in the scoring.

Applicants have five years to complete a project from the date funds are first made available to the grantee.

2.4.5 Connect America Fund (CAF) II

The Connect America Fund (CAF) is an infrastructure funding program administered by the Federal Communications Commission (FCC) through its Universal Service High-Cost program.[33] In 2011, the FCC made significant changes to its universal service and high-cost subsidy programs to launch the CAF program and support broadband deployment projects in locations that lacked access to broadband services of at least 4/1 Mbps. Between 2012 and 2015, Phase I of the CAF program provided $438.3 million to serve 637,285 unserved locations across the country with broadband service at speeds of at least 4/1 Mbps within six years of receiving an award.[34]

In 2014, the FCC released Phase II of its CAF funding program. This phase distributed $1.5 billion in funding to ten large incumbent local service providers to extend facilities to 3.6 million homes and businesses in 45 states by 2020. The FCC conducted an auction for the remaining areas in 2018, and the 103 winning bidders have been authorized to spend $1.49 billion over ten years to provide broadband and voice services to over 707,641 locations in 45 states.[35] CAF II recipients committed to serve funded areas with speeds of at least 10/1 Mbps and data allowances of at least 150 GB. Their services must be offered at rates reasonably comparable to urban rates.

As technology has advanced during the implementation of many CAF II grants, grantees have updated their projects to increase speeds and expand service offerings. Many grantees have used their CAF II funding and planning to expand deployments into other surrounding areas.

[33] "Connect America Fund (CAF)," FCC, https://www.fcc.gov/general/connect-america-fund-caf.
[34] "Wireline Competition Bureau Universal Service Implementation Progress Report," WC Docket No. 10-90, FCC, March 18, 2014, https://docs.fcc.gov/public/attachments/DOC-326217A1.pdf.
[35] "Connect America Fund Phase II Auction (Auction 903)," FCC, https://www.fcc.gov/auction/903.

As mentioned previously, Cal.net received a CAF II grant of $50.5 million from the 2018 auction to deploy fiber and fixed wireless services to locations throughout central California, with 2,243 of those locations in Solano County.

2.4.6 NTIA Digital Equity Act Programs

The Digital Equity Act is part of the 2021 Infrastructure Investment and Jobs Act. The Act allocates funding to three grant programs to promote digital equity and inclusion, including $60 million in planning grants for states, territories, and Tribal governments to develop digital equity plans. The California Department of Technology (CDT) is the administering entity responsible for conducting the planning process in California and drafting the state's plan.

These state plans incorporate extensive outreach, partnerships, data collection, and needs assessments to identify solutions to expand digital inclusion and promote the adoption and use of high-speed broadband services. As part of this planning, California will coordinate and complement its investments in digital equity with its plans for broadband infrastructure deployment to support equity, inclusion, and economic development throughout the state, including in rural and underserved areas. CDT issued the California State Digital Equity Plan for comment in December of 2023 and is required to submit the updated Plan to NTIA for review and approval in spring 2024.[36]

Each state's planning and recommendations will be directed toward ensuring that underrepresented and high needs "covered populations" have the skills, capacity, and tools to connect, including aging individuals, incarcerated individuals, veterans, racial and ethnic minorities, people with disabilities, individuals with language barriers, low-income households, and those living in rural areas.

The state digital equity plans set the stage for the $1.44 billion Digital Equity Capacity Grant program.[37] NTIA has not finalized the rules or timeline for the Capacity Grant program, but once the program is launched NTIA will allocate funding to states, territories, and Tribal governments over the course of several years. Under this program, eligible entities will apply for funding to support the implementation of their digital equity plans. States will receive funding based on a legislatively mandated allocation formula. Once received, states will have five years to use this

[36] "State Digital Equity Plan," Broadband for All, https://broadbandforall.cdt.ca.gov/state-digital-equity-plan/; See also, "California Draft State Digital Equity Plan," released for public comment in December 2023, https://broadbandforall.cdt.ca.gov/wp-content/uploads/sites/19/2023/12/Draft-SDEP_For-Public-Comment_12.11.23.pdf.

[37] "Digital Equity Act Programs," BroadbandUSA, NTIA, https://broadbandusa.ntia.doc.gov/funding-programs/digital-equity-act-programs.

federal funding to develop their own digital inclusion projects, including competitive grant programs for activities by state agencies, local governments, nonprofits, and others.

Following the Capacity Grant program, NTIA will implement the $1.25 billion Digital Equity Competitive Grant program in 2025.[38] This direct funding program will award individual grants to eligible entities, including state and local governments and agencies, Tribal entities, nonprofits, and community anchor institutions. Rules and funding priorities are still being developed, but these grants will likely focus almost exclusively on the needs of underrepresented "covered populations" to connect through digital equity and inclusion programs. Funding will likely support programs that address affordability of services and devices, provide education and tools to increase online privacy and cybersecurity, develop digital literacy and technical skills for personal and professional growth, and provide technical support and training for repair and updates to devices.

2.5 Broadband coverage by technology

This section provides an overview of the areas of broadband coverage reported by providers in Solano County, according to the most recent data available from the FCC's Broadband Data Collection as of the development of this Handbook. Section 2.6.7 also identifies locations that are considered unserved according to the CPUC's mapping and eligibility rules for its Federal Funding Account (FFA) grant program—which uses a broader definition of "unserved" than the FCC's National Broadband Map. A full explanation of data sources used for this report is included in Appendix B.

Overall, 98.4 percent of locations are reported to be served In the County at speeds of 100/20 Mbps or greater, according to FCC data. In the incorporated areas, 99.7 percent of addresses are reported to be served. In unincorporated areas, 74.3 percent of addresses are considered served; note that these unincorporated areas account for 5 percent of the total addresses in the County. Counts of served, underserved, and unserved addresses in the County, separated by incorporated and unincorporated areas, are listed in Table 2.

[38] "Digital Equity Act Programs," BroadbandUSA, NTIA, https://broadbandusa.ntia.doc.gov/funding-programs/digital-equity-act-programs.

Table 2: Served, unserved, and underserved location counts[39]

	Locations (may include two or more housing units per address)	Percentage of locations
In incorporated areas		
Served	130,393	99.7%
Underserved	170	0.1%
Unserved	244	0.2%
Subtotal	**130,807**	**100%**
In unincorporated areas		
Served	5,198	74.3%
Underserved	414	5.9%
Unserved	1,385	19.8%
Subtotal	**6,997**	**100%**
All areas		
Served	135,591	98.4%
Underserved	584	0.4%
Unserved	1,629	1.2%
Total locations	**137,804**	**100%**

Table 3: Distribution of total locations

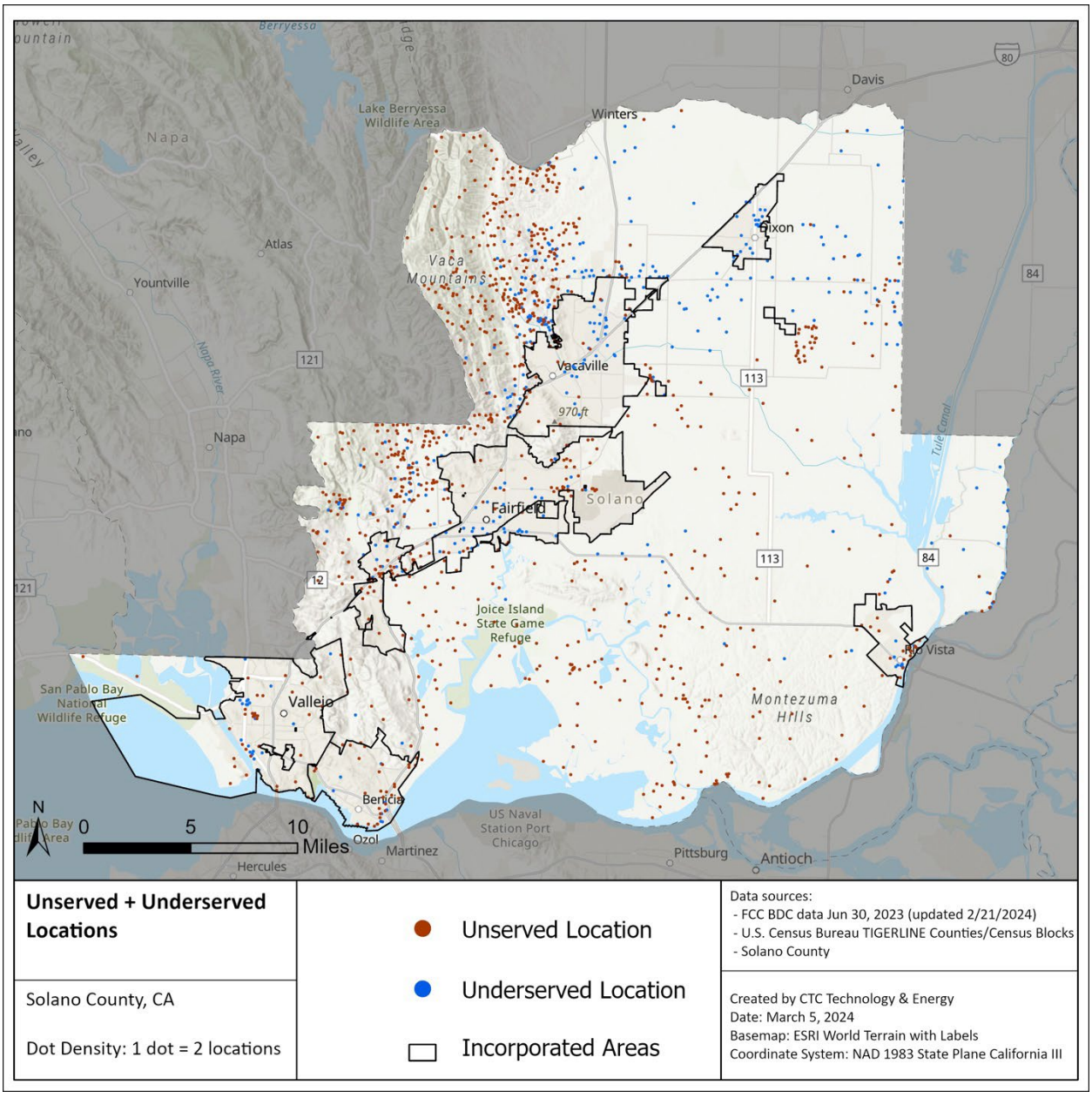
Location type	Percentage of total
% in incorporated areas	95%
% in unincorporated areas	5%

2.5.1 Unserved and underserved locations

Figure 1 shows the unserved and underserved locations throughout the County.

[39] FCC BDC Data, June 30, 2023 (updated February 21, 2024).

Figure 1: Unserved and underserved locations



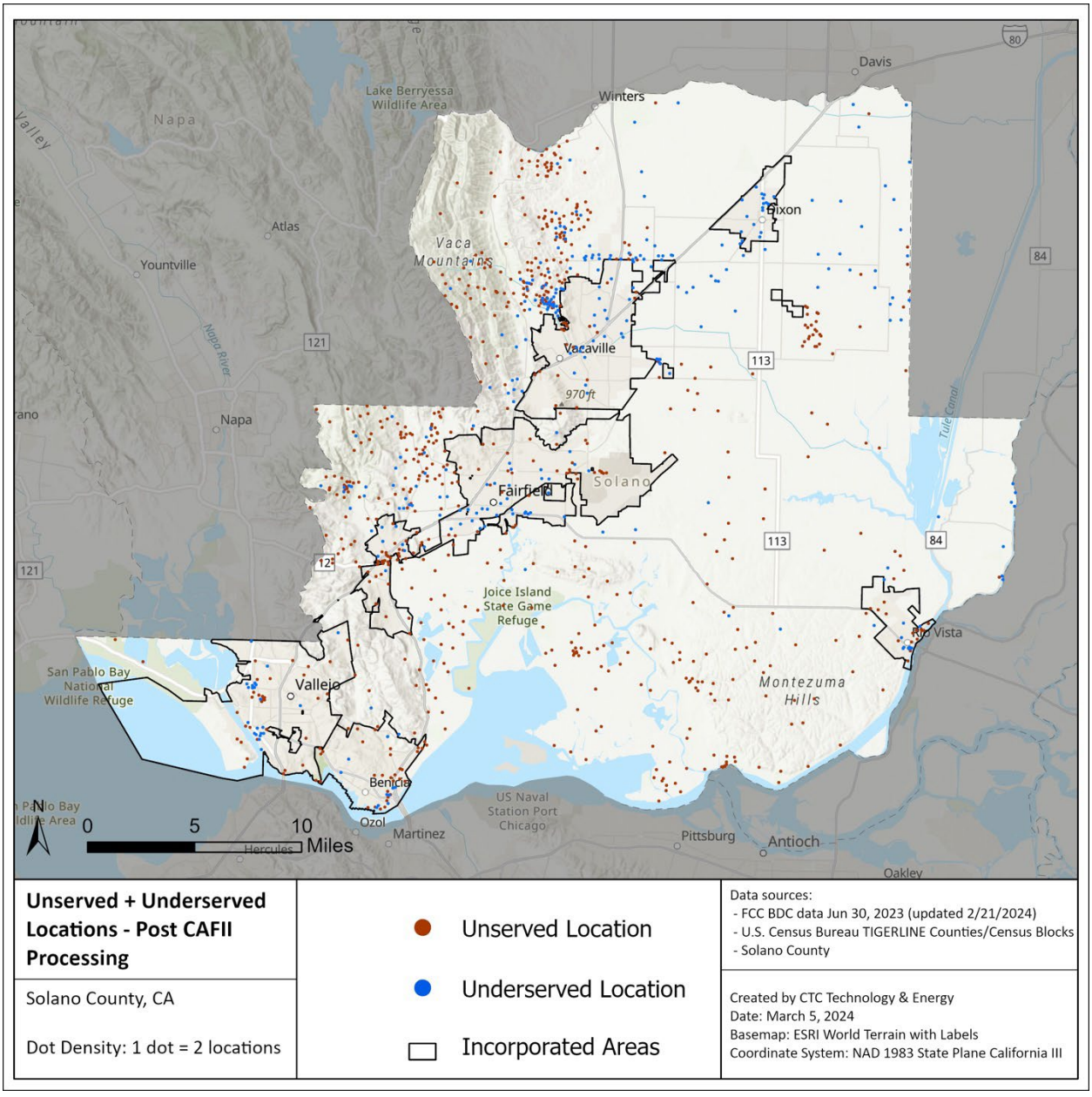
The FCC's service availability data does not consider areas that have received enforceable funding commitments through federal and state grant awards; therefore, Figure 1 does not reflect areas of the County that are pending buildout.

As discussed in Section 2.4.5, Cal.net is obligated to serve 2,243 locations in 44 census blocks in Solano County with funding from the FCC's Connect America Fund II (CAF II) program[40] and is scheduled to complete its CAF II commitments in December 2025.[41] It should be noted that Cal.net plans to ultimately cover over 9,000 locations in Solano County by leveraging its grant-funded locations. Many of these locations are already considered "served." However, there will be locations—particularly in the southern part of the County—that will not be covered by this buildout.

Figure 2 below excludes the 2,243 locations with enforceable commitments for service based on Cal.net's CAF II buildout and shows the remaining unserved and underserved locations in Solano County.

[40] Cal.Net Response to Solano County Dept of Information Technology RFI DOIT 2023-003, August 11, 2023.
[41] "Auction 903: Authorized PN – Authorized Census Blocks Covered, All applicants that have been authorized through 4/4/2023," FCC, available for download at, https://www.fcc.gov/sites/default/files/a903_authorized_pn_through_2023_04_04_0.xlsx. See also, USAC's map of CAF II deployment at, https://data.usac.org/publicreports/caf-map/.

Figure 2: Unserved and underserved locations with enforceable funding commitments excluded



When FFA awards are announced by the CPUC in June 2024, the awarded project areas in Solano County will also be mapped as enforceable commitments.

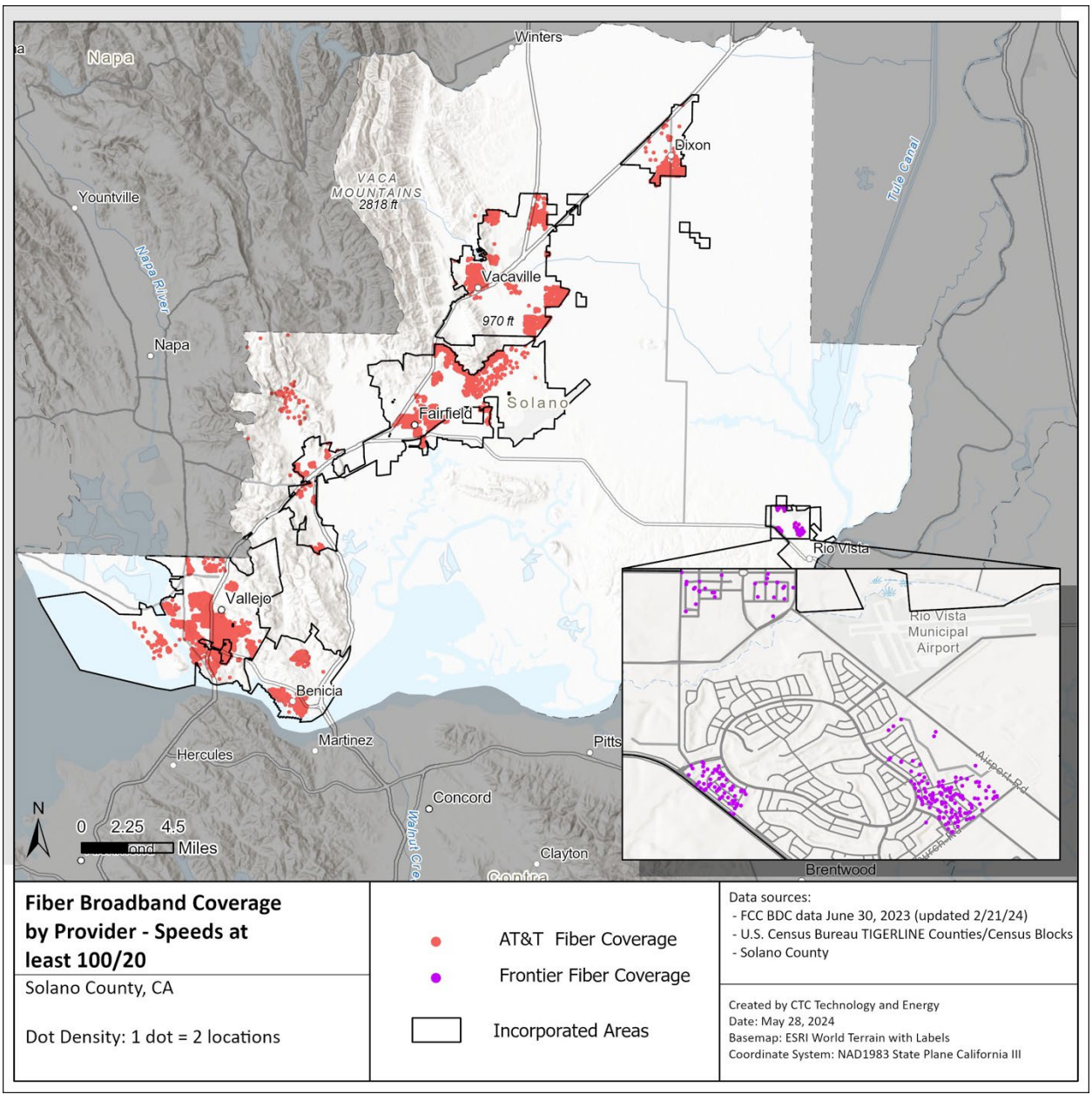
2.5.2 Fiber coverage

Fiber coverage in the County is limited and is concentrated in the larger cities of Vallejo, Fairfield, Vacaville, Dixon, and Rio Vista. Figure 3 below shows the coverage areas of fiber providers with

reported speeds of 100/20 Mbps or higher; as evidenced by the map, AT&T is the dominant fiber provider in the County, with Frontier having a limited presence in Rio Vista only.

For maps showing fiber coverage in areas of the County in more detail, see Appendix B.

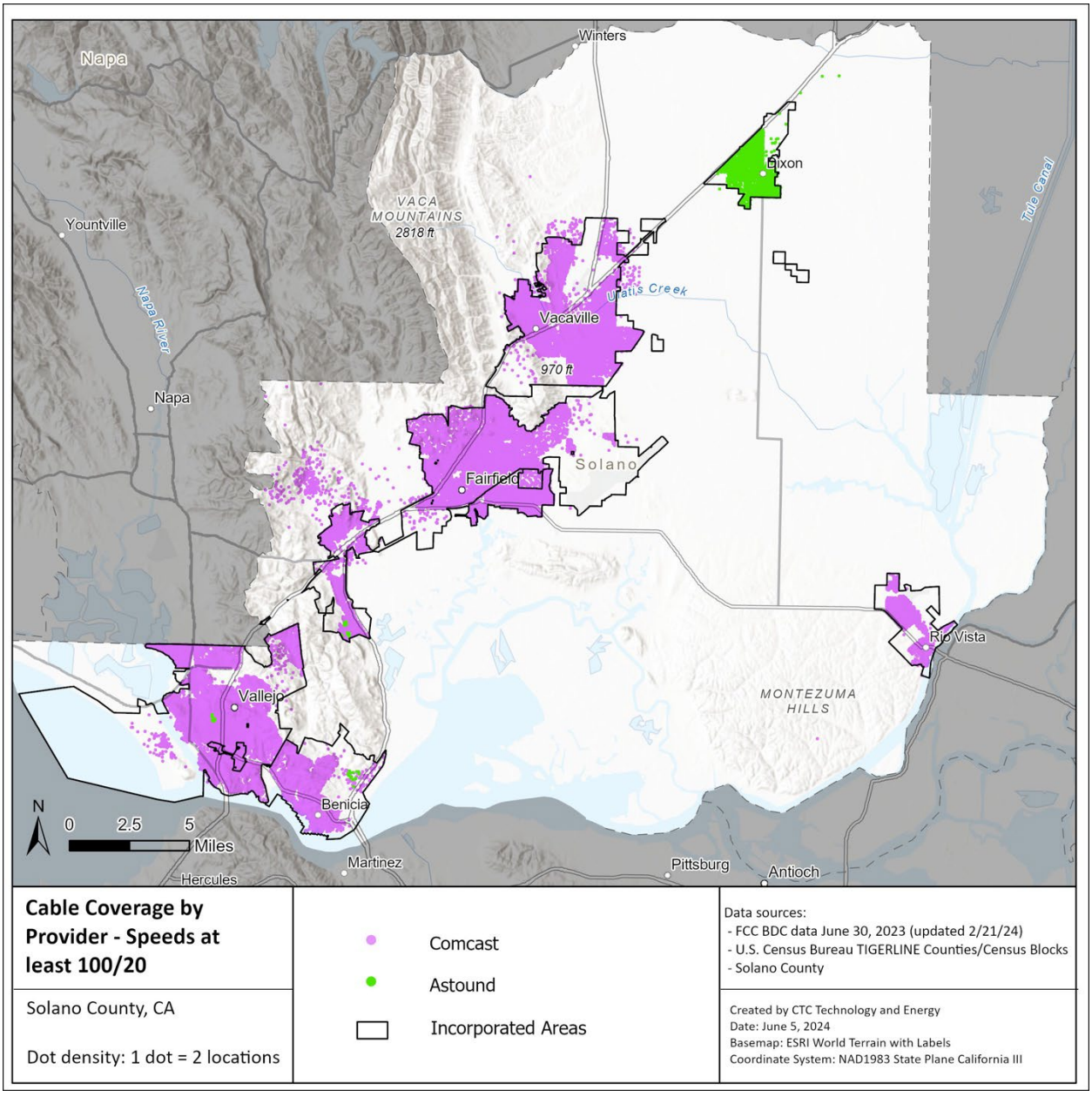
Figure 3: Locations with fiber coverage at 100/20 Mbps or greater by provider



2.5.3 Cable coverage

Like fiber deployment in the County, cable service offerings are clustered mainly around the city centers. Comcast (Xfinity) has by far the largest cable coverage footprint in the County. Astound Broadband (Wave) also covers 220 locations, most of which are in the Dixon area. These coverage areas are shown in Figure 4; this map only includes locations where cable facilities are reported to offer speeds of 100/20 Mbps or greater. For maps showing cable coverage in areas of the County in more detail, see Appendix B.

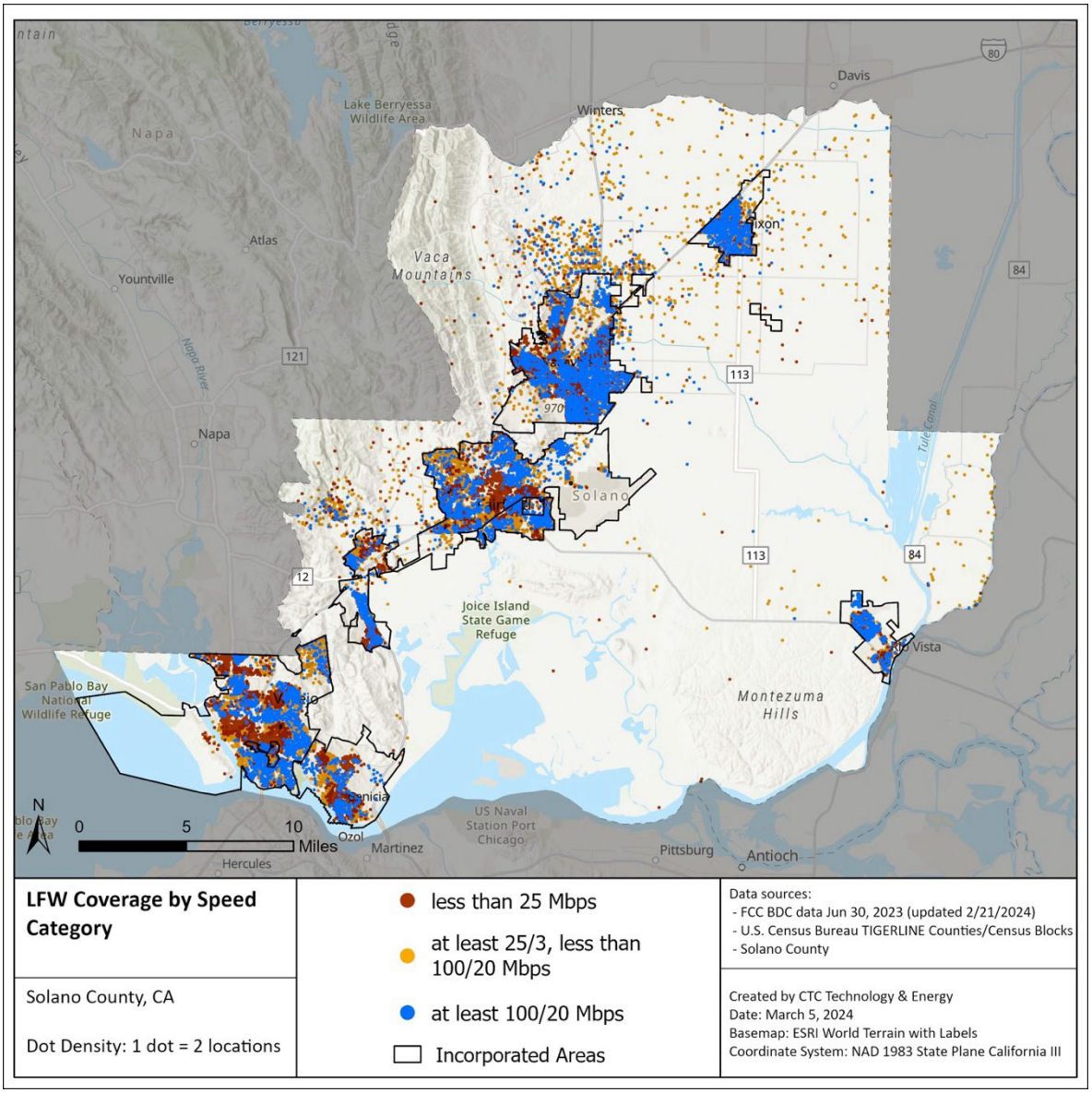
Figure 4: Locations with cable coverage at 100/20 Mbps or greater by provider



2.5.4 Licensed fixed wireless

Outside of the urban areas, the primary option for reported service of over 100/20 Mbps is fixed wireless service. Valley Internet only provides unlicensed fixed wireless service; Cal.net provides both licensed and unlicensed fixed wireless service. For additional details on fixed wireless spectrum, please see Appendix C. Much of the area in the northeastern part of the County is dependent on licensed fixed wireless or mobile broadband as only a few pockets are covered by wireline technologies at served speeds. See Appendix B for additional maps of fixed wireless coverage by provider.

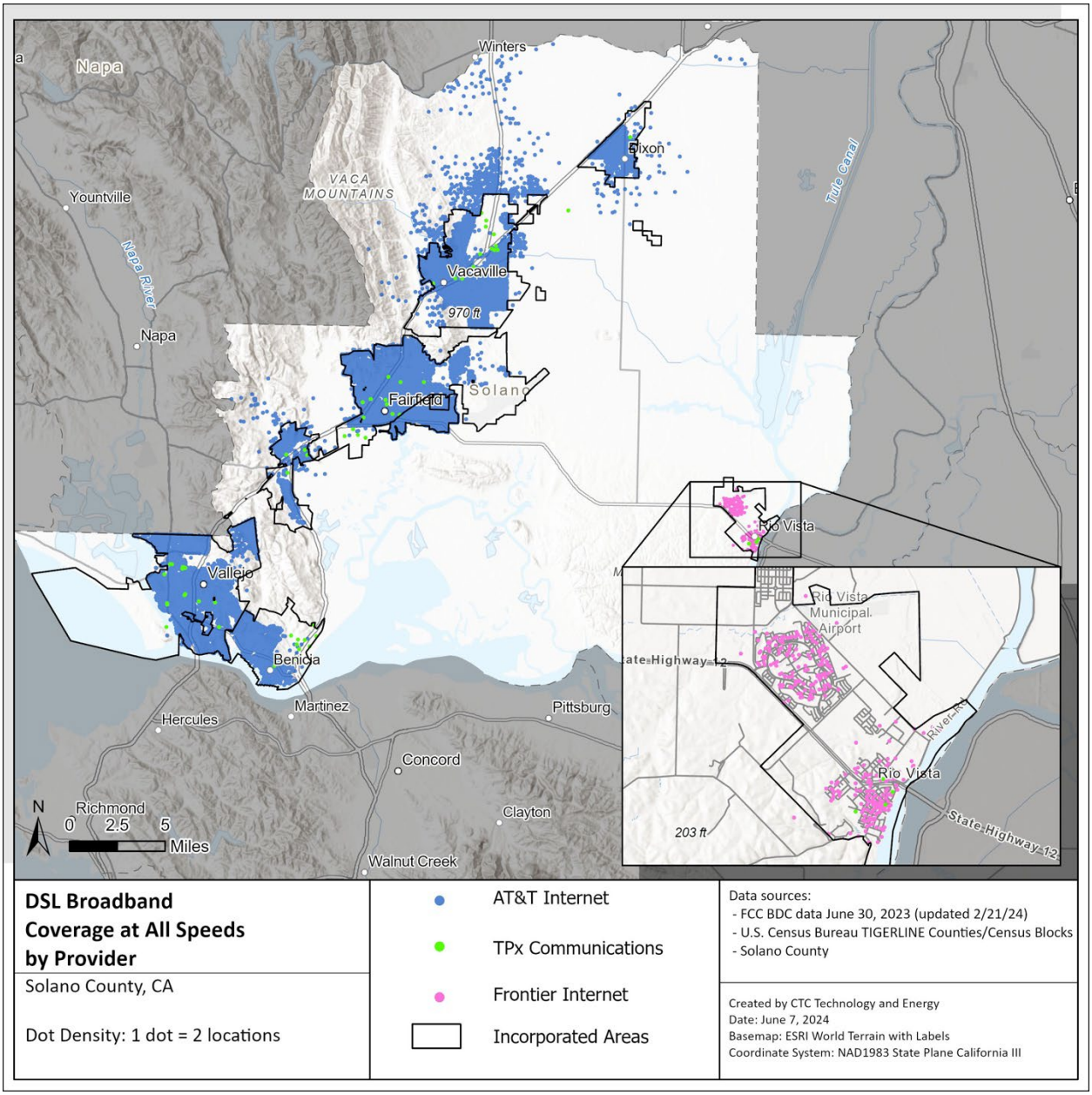
Figure 5: Locations with fixed wireless coverage by speed



2.5.5 DSL coverage

DSL is a legacy technology built on the original telephone service copper network. As the incumbent local telephone provider, AT&T provides DSL coverage throughout the County. Frontier also serves parts of Rio Vista and TPx, a competitive local provider serving enterprise customers, has a limited presence in specific urban centers.

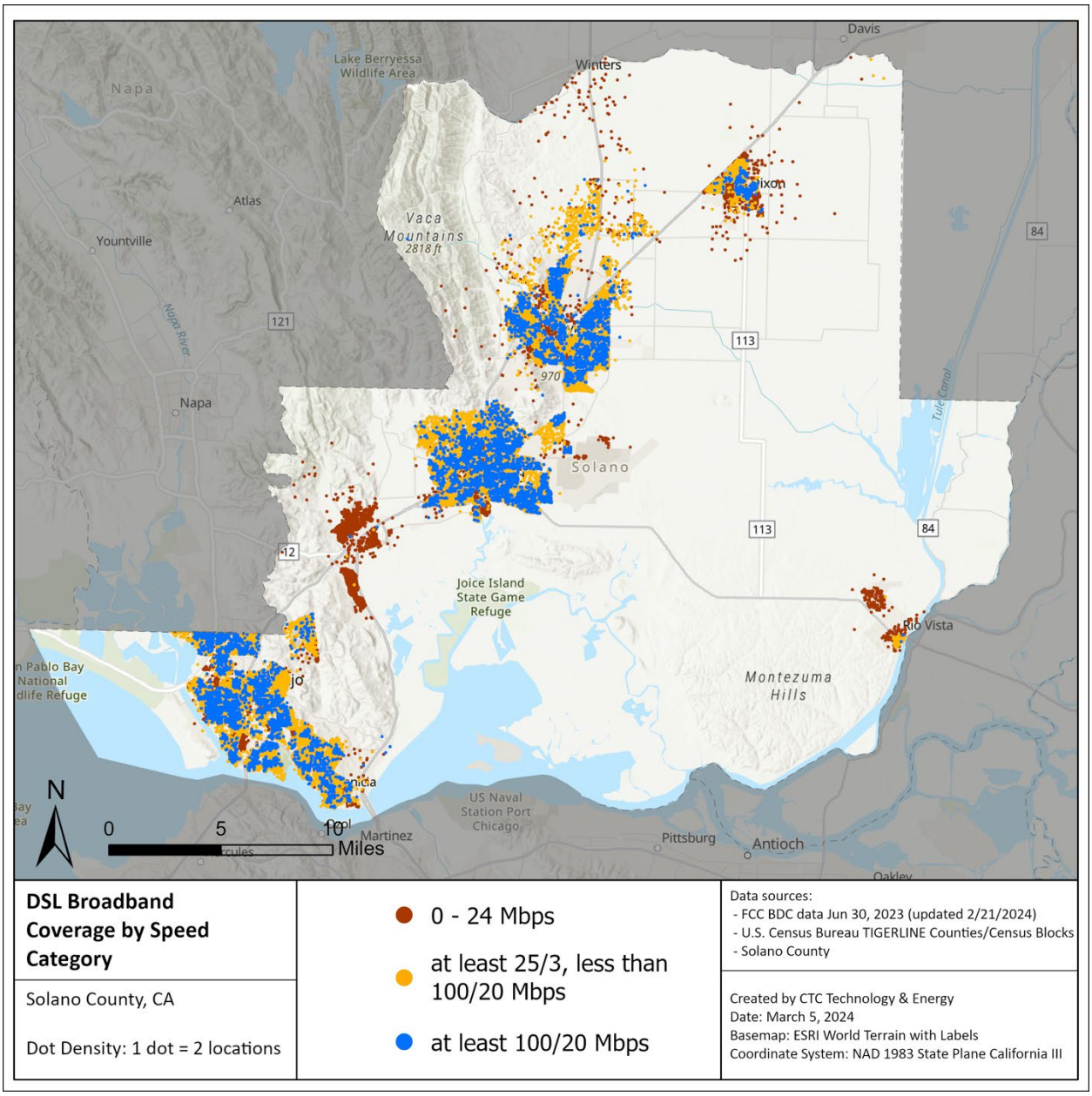
Figure 6: Locations with DSL coverage by provider



Reported speeds for DSL can vary by location based on the distance of the location from the DSL network equipment. While there are many locations in the urban areas of the County where providers report offering 100/20 service, service quality and reliability issues may mean that customers cannot rely on those claims. DSL is generally not a viable option for more remote or rural areas due to the length of the copper line from the customer location to the locations of the DSL equipment at central points in the network, which causes signal loss, slow speeds, and poor service quality.

Figure 7 displays DSL coverage by reported speed. As shown below, only locations within the County's cities are reported to receive speeds of 100/20 or higher for DSL.

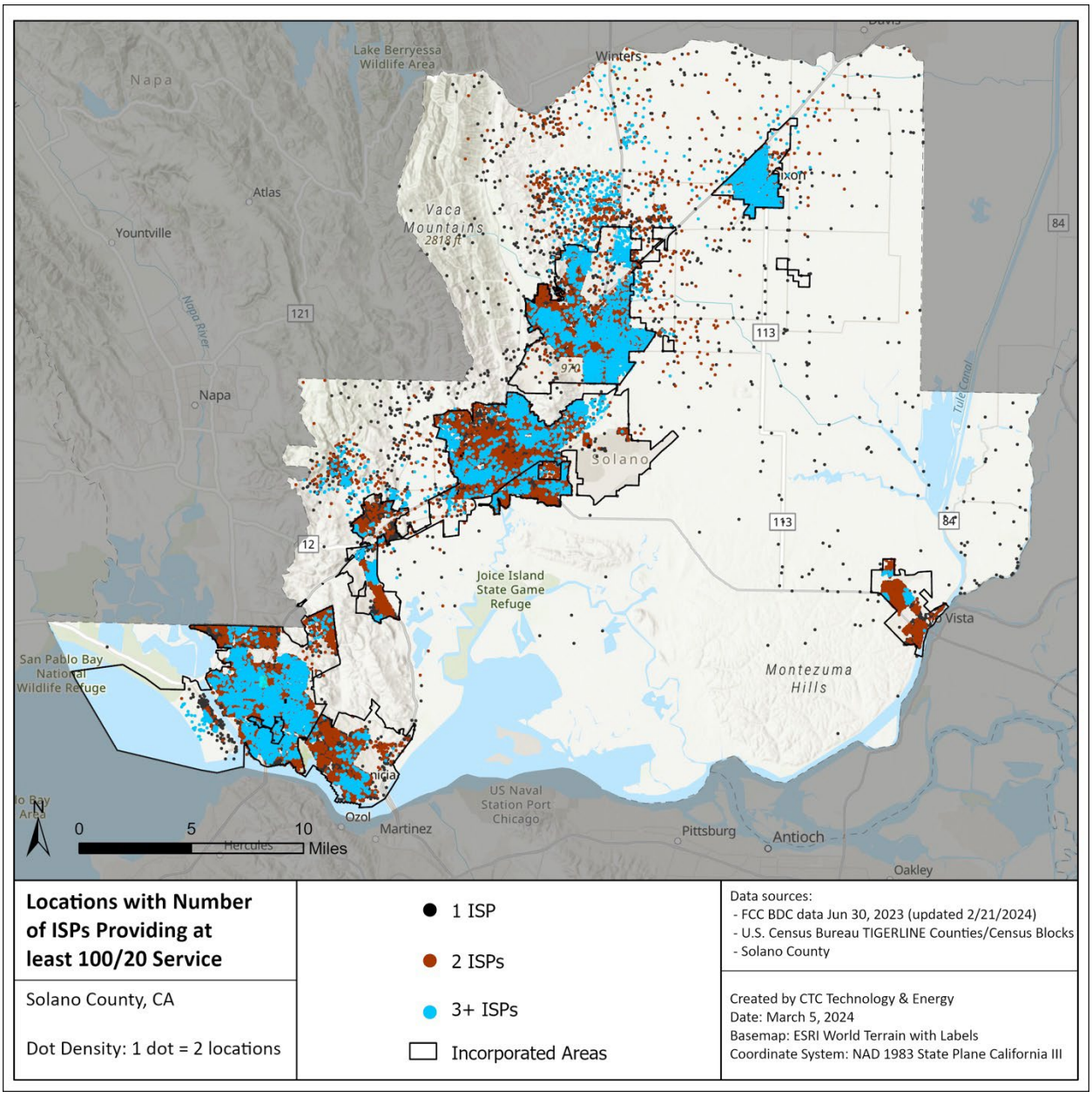
Figure 7: Locations with DSL coverage by speed



2.5.6 ISP competition

While there is a mix of technologies in the County offered by multiple providers, competition among these providers is isolated mainly in and surrounding the urban areas. Figure 8 analyzes cable, fiber, licensed fixed wireless, and DSL coverage to identify locations that have a choice of more than one provider for service with speeds of 100/20 Mbps or greater. As shown in the figure below, the unincorporated areas of the County that are served at these speeds often have access to only one provider.

Figure 8: Locations with competition at 100/20 Mbps or greater



2.5.7 Unserved locations according to the Federal Funding Account Public Map

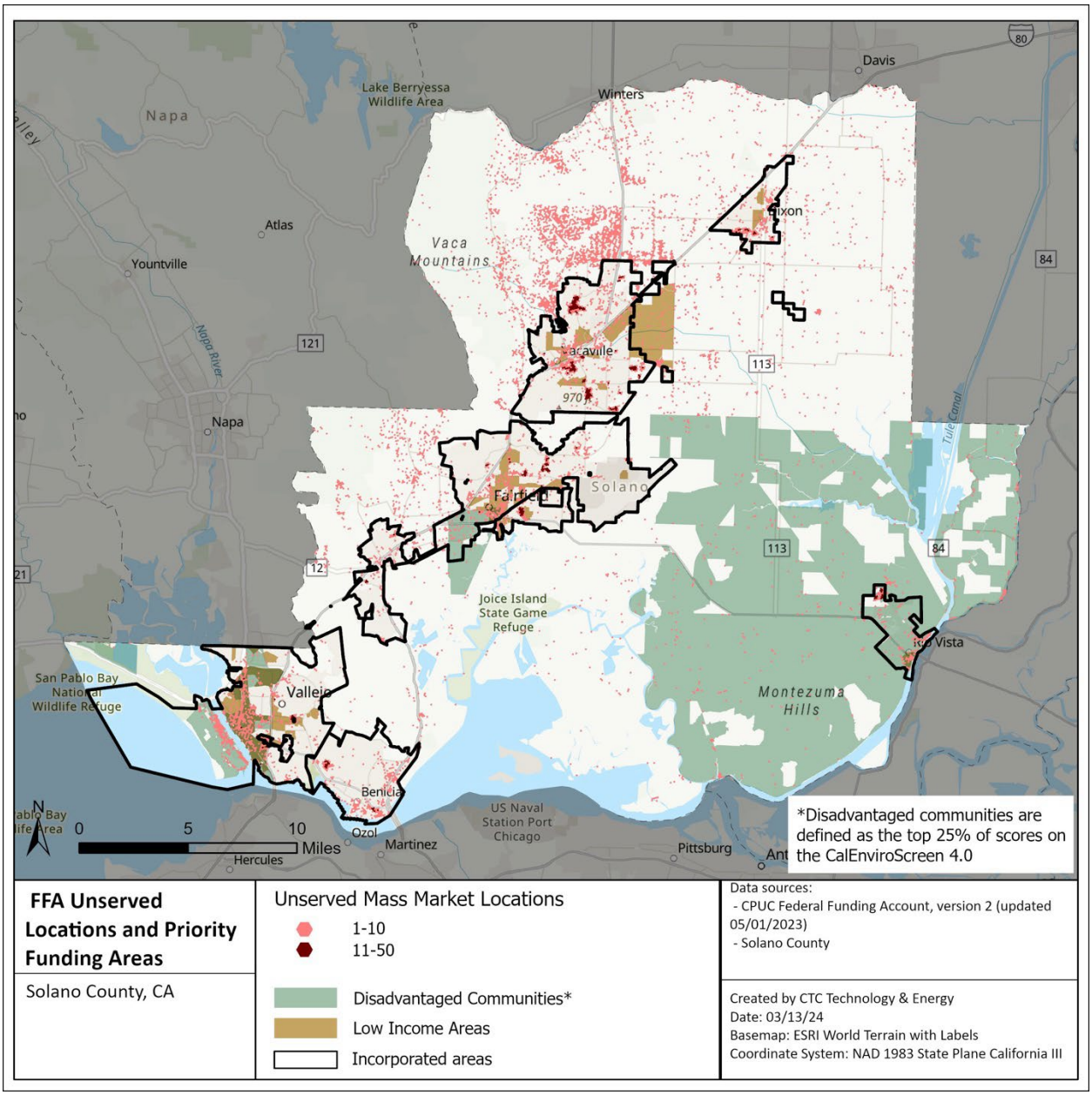
As discussed in detail in Appendix B, the CPUC provides public mapping data of unserved locations that are eligible for funding under its Federal Funding Account grant program, which utilizes different criteria to define "unserved" locations than the FCC's National Broadband Map. The Federal Funding Account Public Map shows "mass market unserved locations" throughout Solano County, which the FFA program defines as those that receive service at speeds of less than

25/3 Mbps or are served by legacy technology (e.g., DSL) or wireless technology—regardless of the speeds reported by ISPs to the FCC.

The FFA map also includes data layers indicating low-income and disadvantaged communities, as the FFA program prioritizes funding for unserved locations in these areas.

As shown in Figure 9, the largest clusters of unserved locations in priority areas according to the FFA map are located in and around the incorporated parts of the County and surrounding unincorporated areas, where the largest population clusters also appear. Disadvantaged community areas are primarily located in the more rural and agricultural areas of the County where there are fewer unserved households and fewer broadband serviceable locations.

Figure 9: Unserved locations and priority funding areas according to the Federal Funding Account Public Map



As shown by the analysis of FFA grant applications in Section 2.7, unserved location counts for an area can vary considerably between the FFA map and the FCC's National Broadband Map due to the FFA program's broader definition of "unserved."

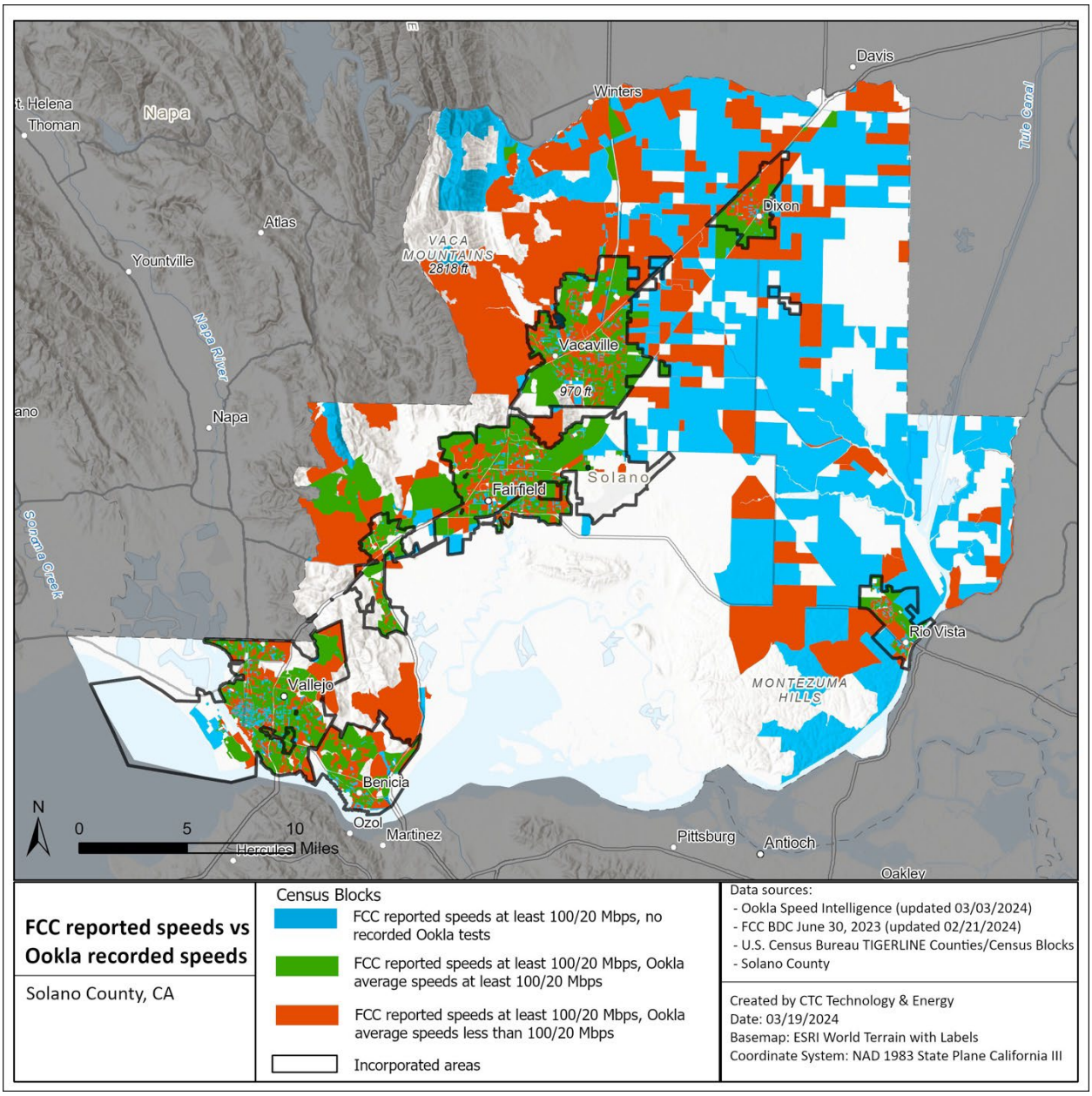
2.6 Actual vs. reported speeds

To compare the speeds promised by providers to actual speeds experienced by customers, Ookla speed test data was analyzed to map average download speeds by provider. The speed test data include all results from August 1, 2022, to February 29, 2024; for a full list of the providers included in the dataset and the number of tests conducted for each provider, see Appendix A.

In Figure 10 below, which compares available Ookla data for wireline and wireless providers[42] to the speeds reported to the FCC by fiber, cable, DSL, and fixed wireless providers in the County,[43] the green areas show where speed tests validate 100/20 coverage in areas of the three cities of Vallejo, Fairfield, and Vacaville. However, the areas shaded orange indicate where Ookla speed test data call into question the FCC data, as speed tests demonstrate results below 100/20 Mbps while service providers report speeds above that threshold. Note that there were insufficient Ookla speed test results to validate the FCC reported coverage in many unincorporated areas in the northern and eastern parts of the County.

[42] The providers included in the Ookla dataset are listed in Appendix B.
[43] FCC reported speeds include the following providers: AT&T, Comcast, Frontier, TPx, Cal.net, Valley Internet, Astound, and DigitalPath; and the following technologies: fiber, cable, DSL, and fixed wireless.

Figure 10: FCC reported speeds compared to Ookla speed test data



2.6.1 Wireline speed tests

Figure 11 shows wireline download speed test results for AT&T—which include both fiber and DSL customers—and Figure 12 shows speed test data for Comcast (Xfinity). Download speeds in excess of 100 Mbps for both providers only appear in the urban areas, which matches the basic footprints of coverage reported to the FCC (see Figure 3 and Figure 4). However, many tests for AT&T yielded results below 100 Mbps but over 50 Mbps. Results for AT&T under 100 Mbps could

indicate locations with DSL but may indicate other cases where promised download speeds for fiber customers are not completely accurate.

As shown in Figure 13, download speed test results of 50 Mbps or higher for Astound Broadband (Wave), which has a smaller cable coverage footprint in the County (see Figure 4), are concentrated in the Dixon area. Download speeds under 25 Mbps were measured from Astound in pockets elsewhere in the County.

Figure 11: AT&T residential wireline download speeds based on Ookla data

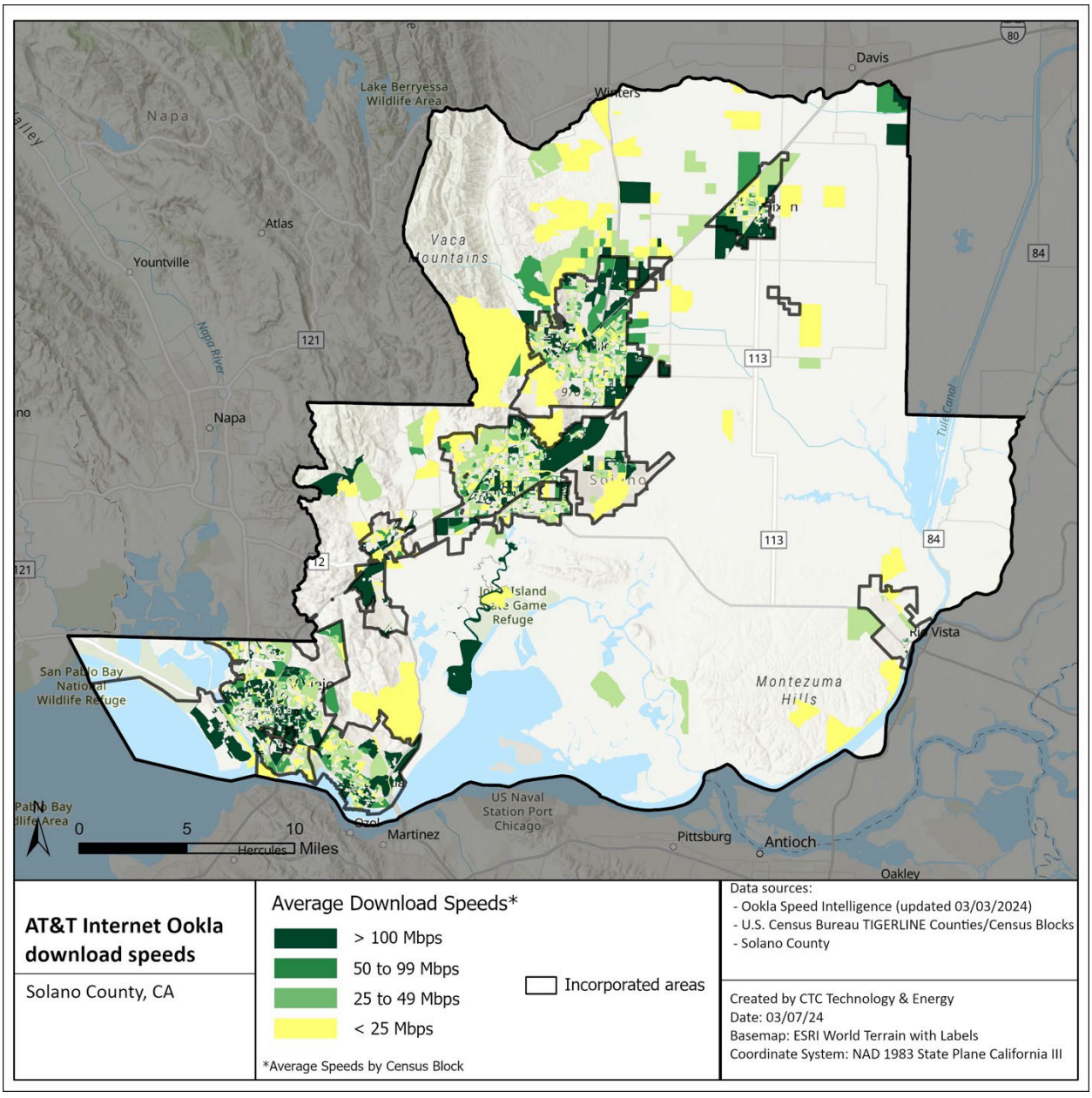


Figure 12: Comcast residential download speeds based on Ookla data

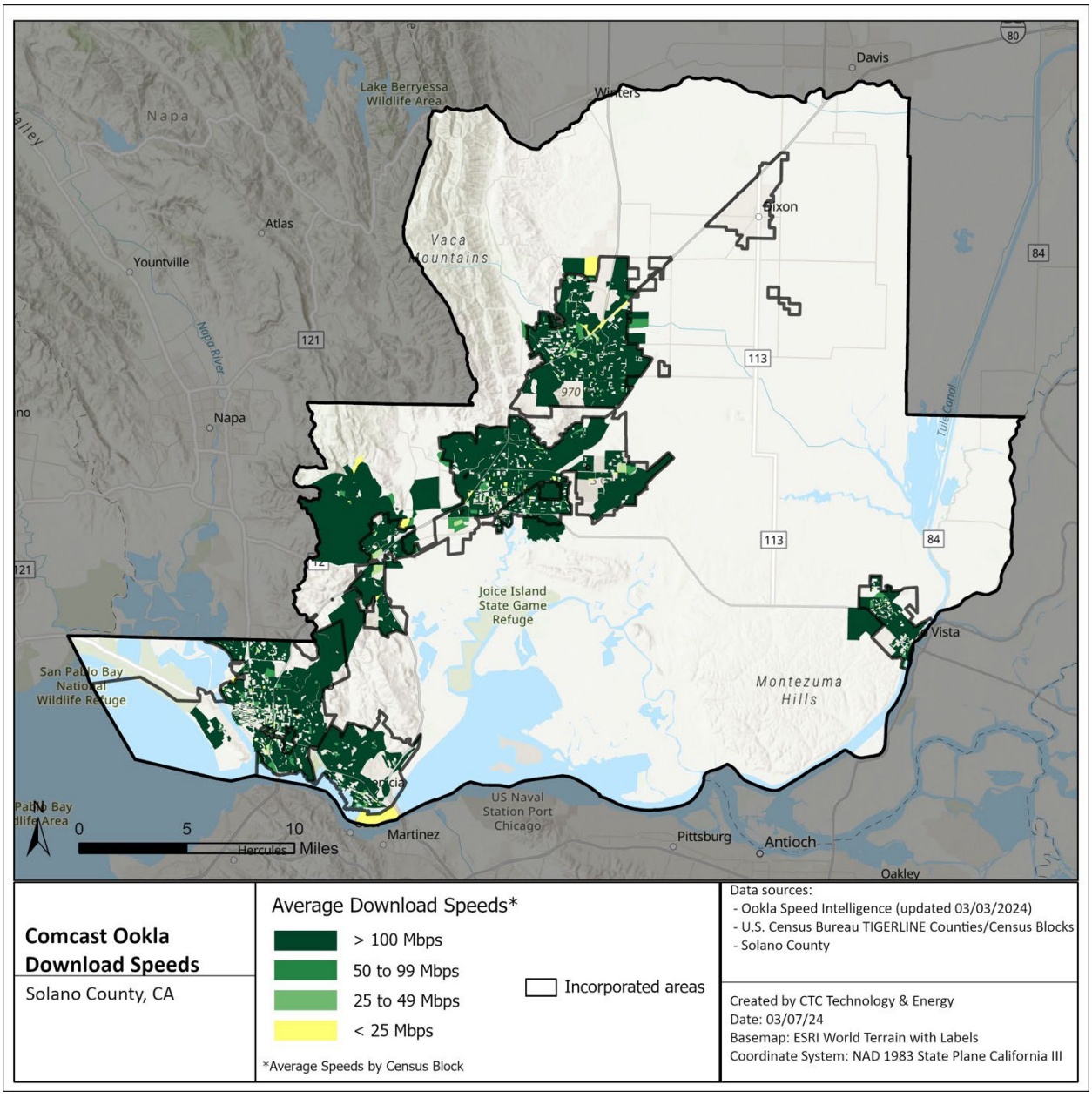
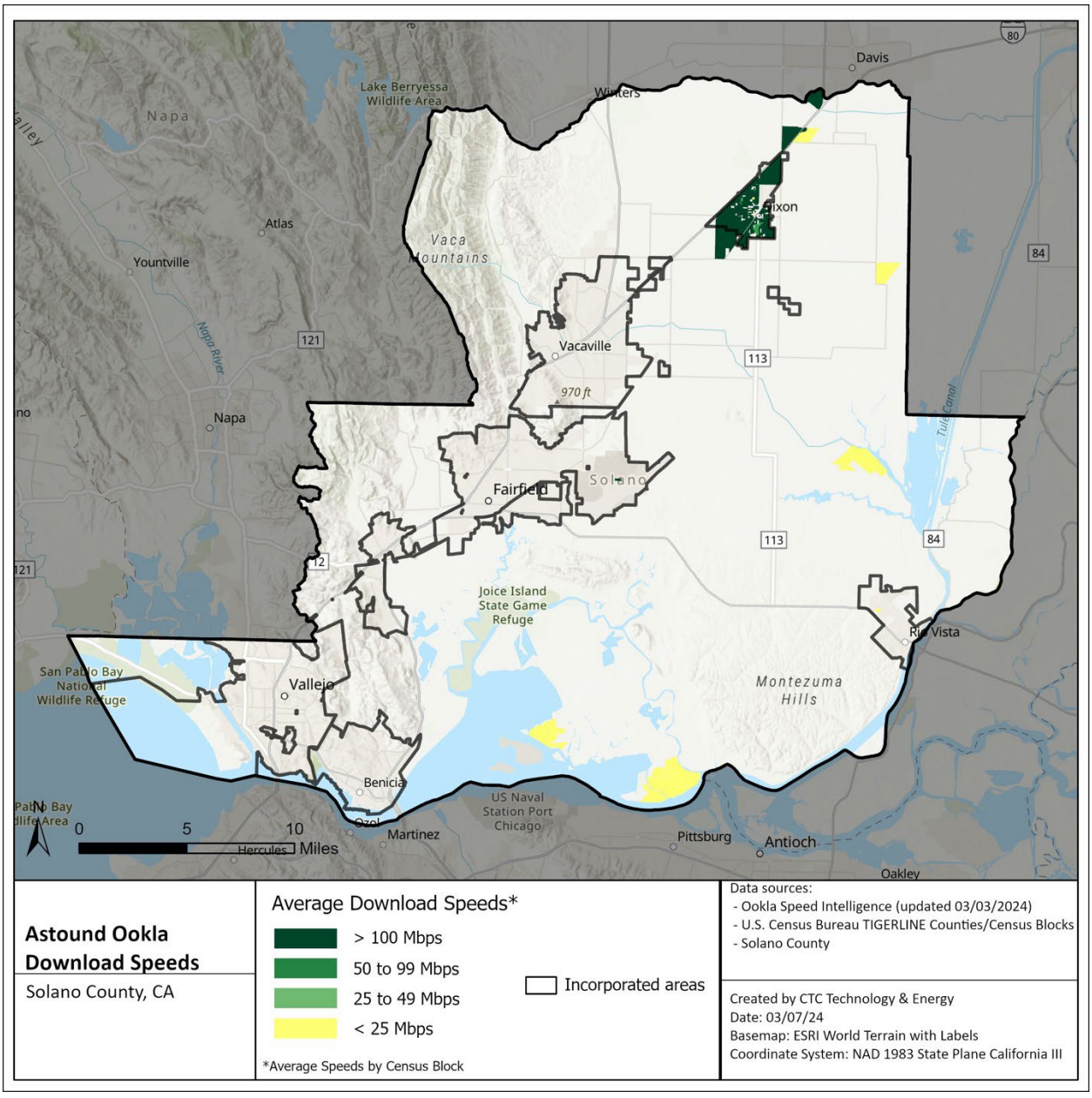


Figure 13: Astound Broadband residential download speeds based on Ookla data

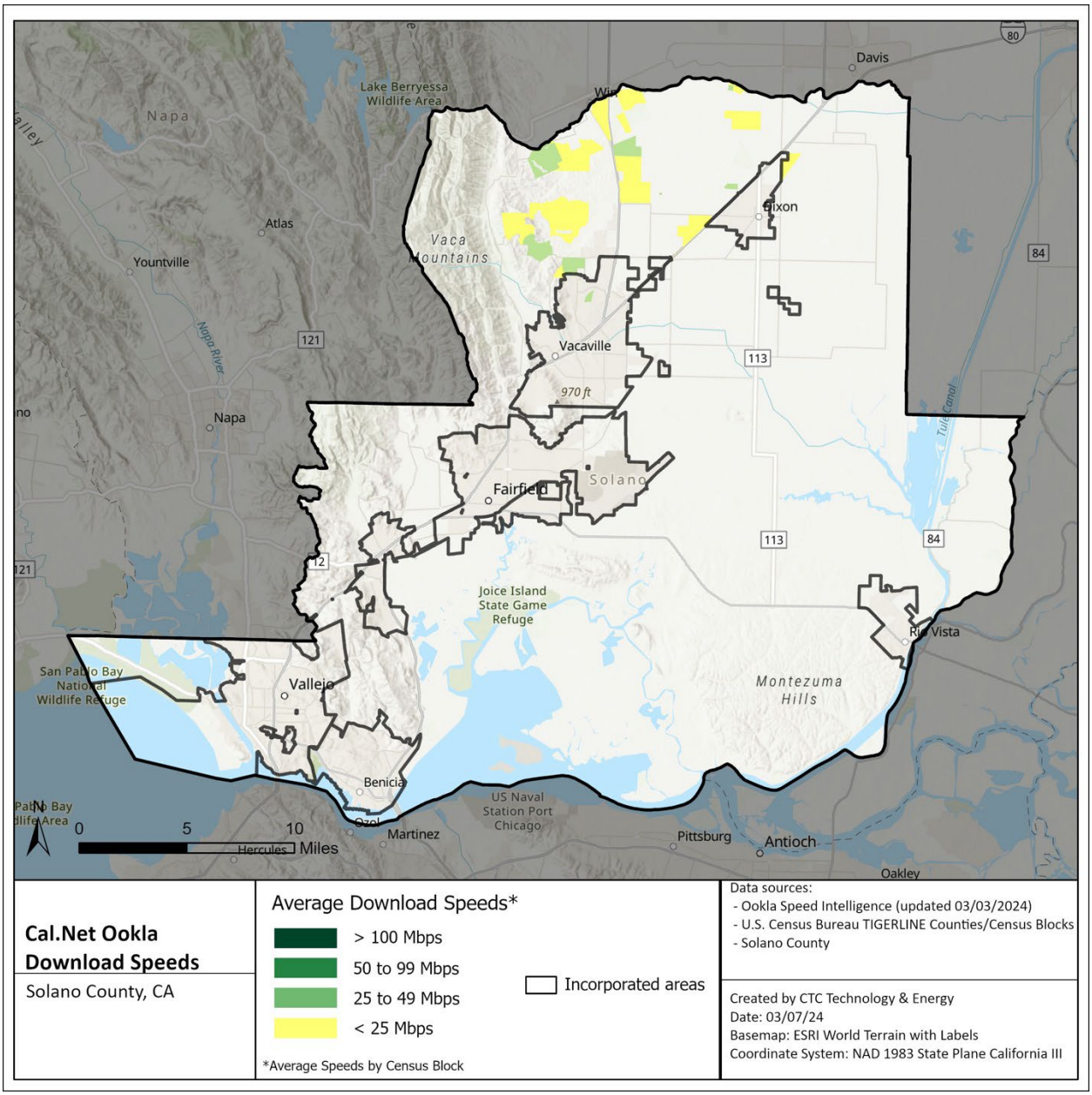


2.6.2 Wireless speed tests

Data obtained for wireless providers through Ookla encompasses both fixed wireless and mobile (i.e., cellular) service providers. Data on fixed wireless providers includes results from Cal.net and Valley Internet, and mobile tests include results for AT&T, T-Mobile, and Verizon.

Figure 14 shows that actual download speeds for Cal.net are far below the 100 Mbps threshold and are often below 20 Mbps. It should be noted, however, that the sample size of speed tests for Cal.net was quite small (only 301 tests).

Figure 14: Cal.net download speeds based on Ookla data



Data for Valley Internet indicate some areas where speeds are higher (i.e., 50 Mbps or above) in the western part of the County and one small area east of Dixon (see Figure 15).

Figure 15: Valley Internet download speeds based on Ookla data

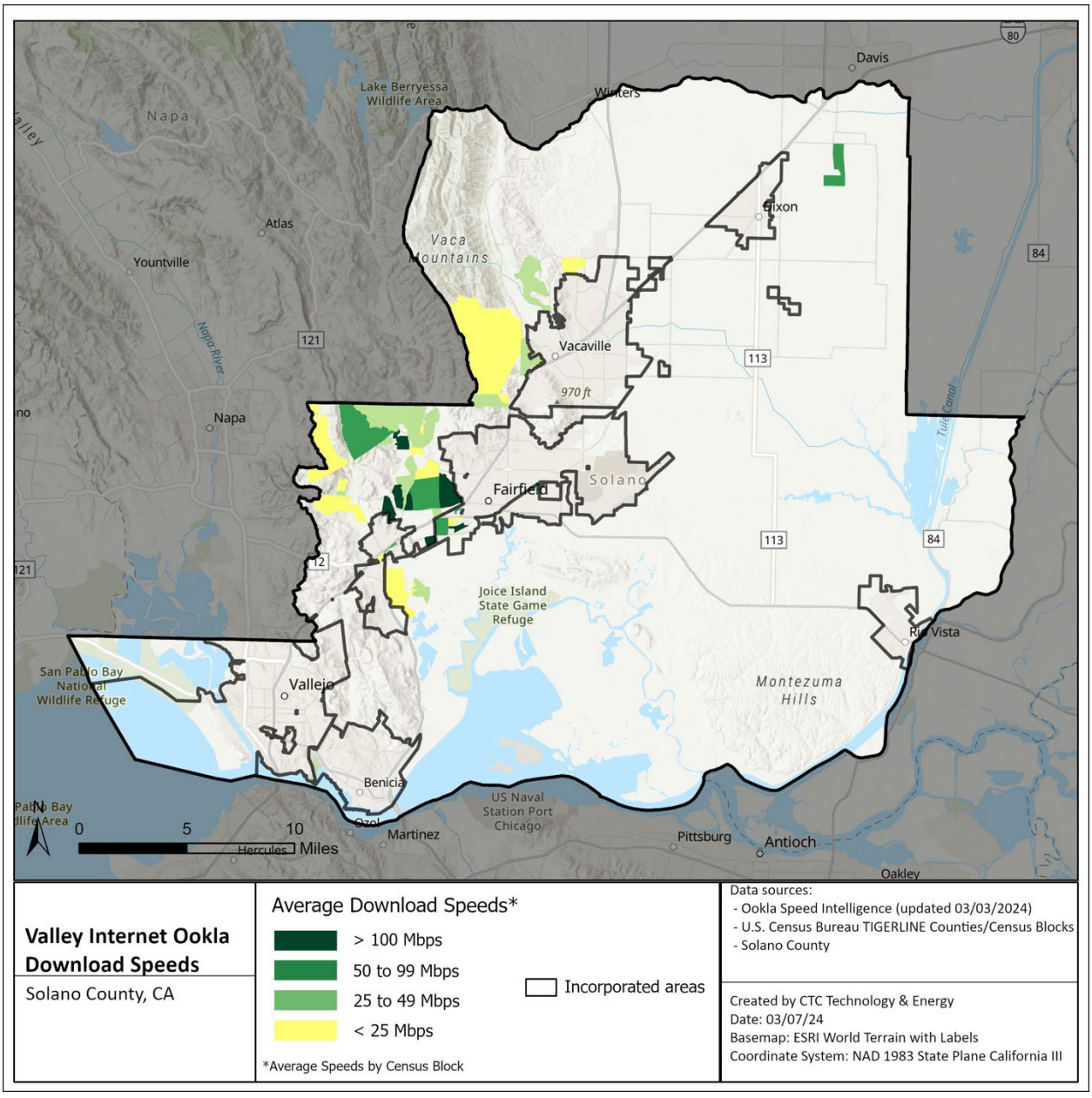
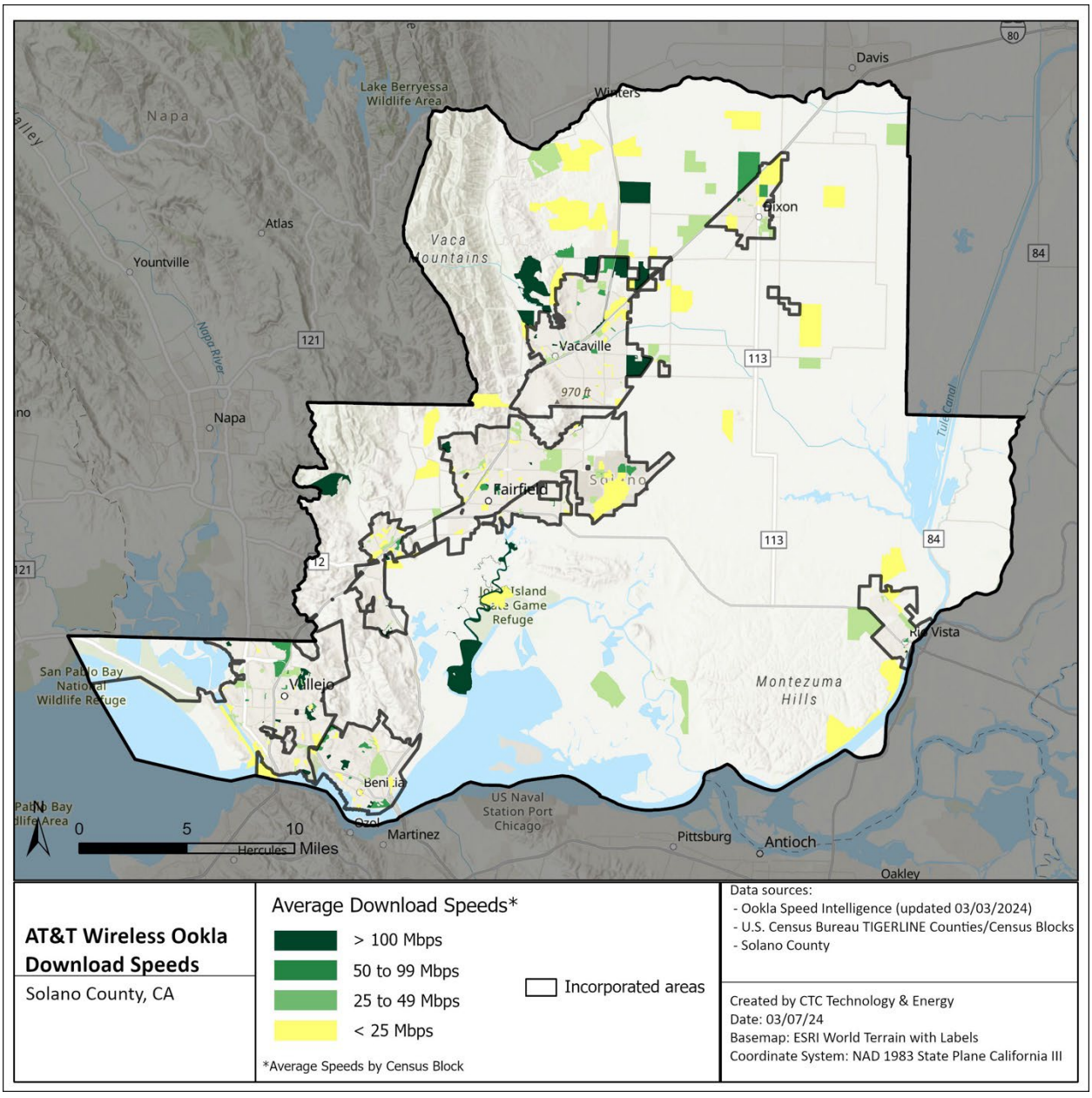


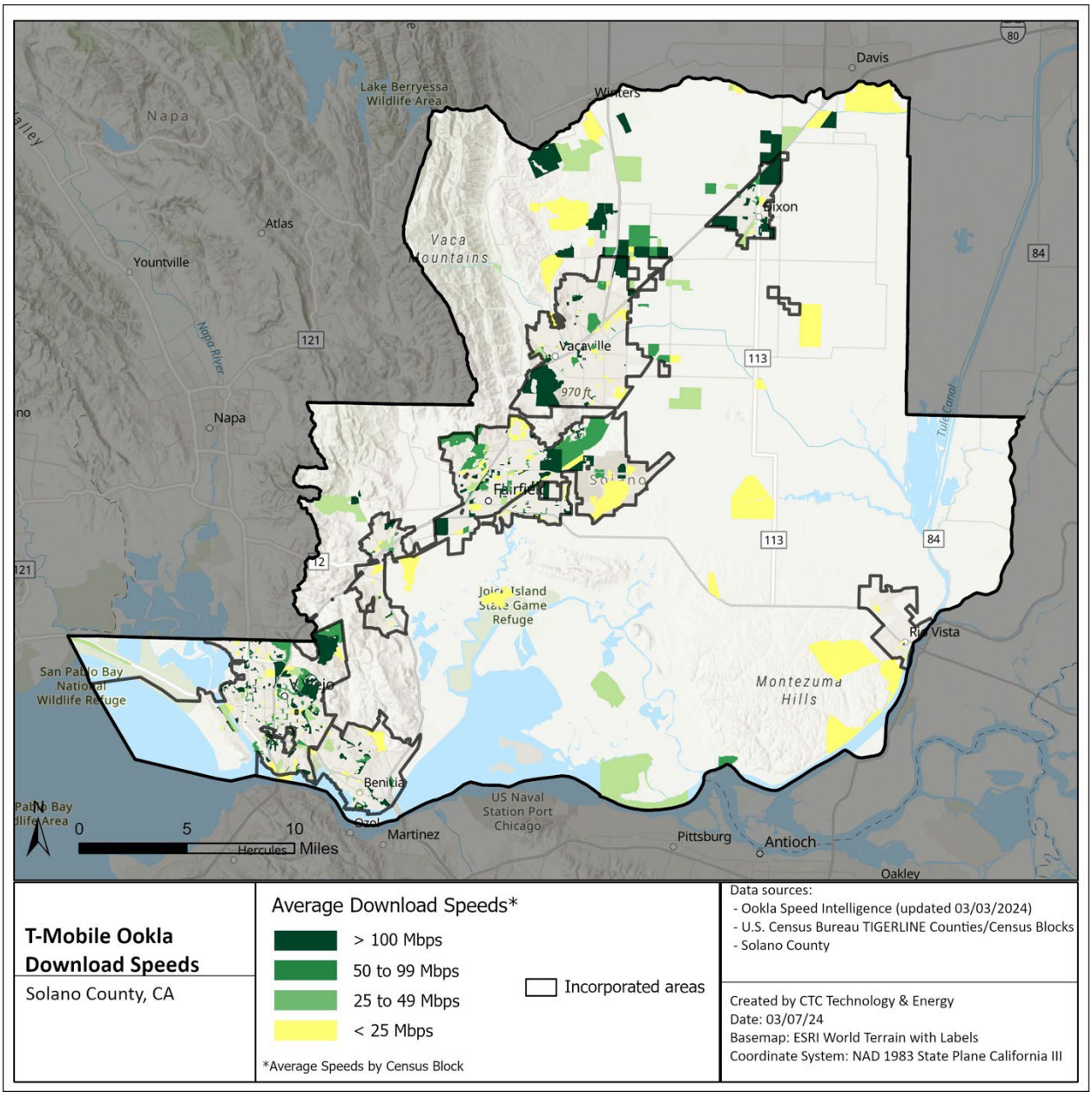
Figure 16 shows speeds for AT&T Wireless service are also often below the 100 Mbps threshold, with only a few areas around Fairfield and Vacaville that exceed 100 Mbps. Other speed tests show that most AT&T Wireless speeds are measured at 50 Mbps or below.

Figure 16: AT&T Wireless download speeds based on Ookla data



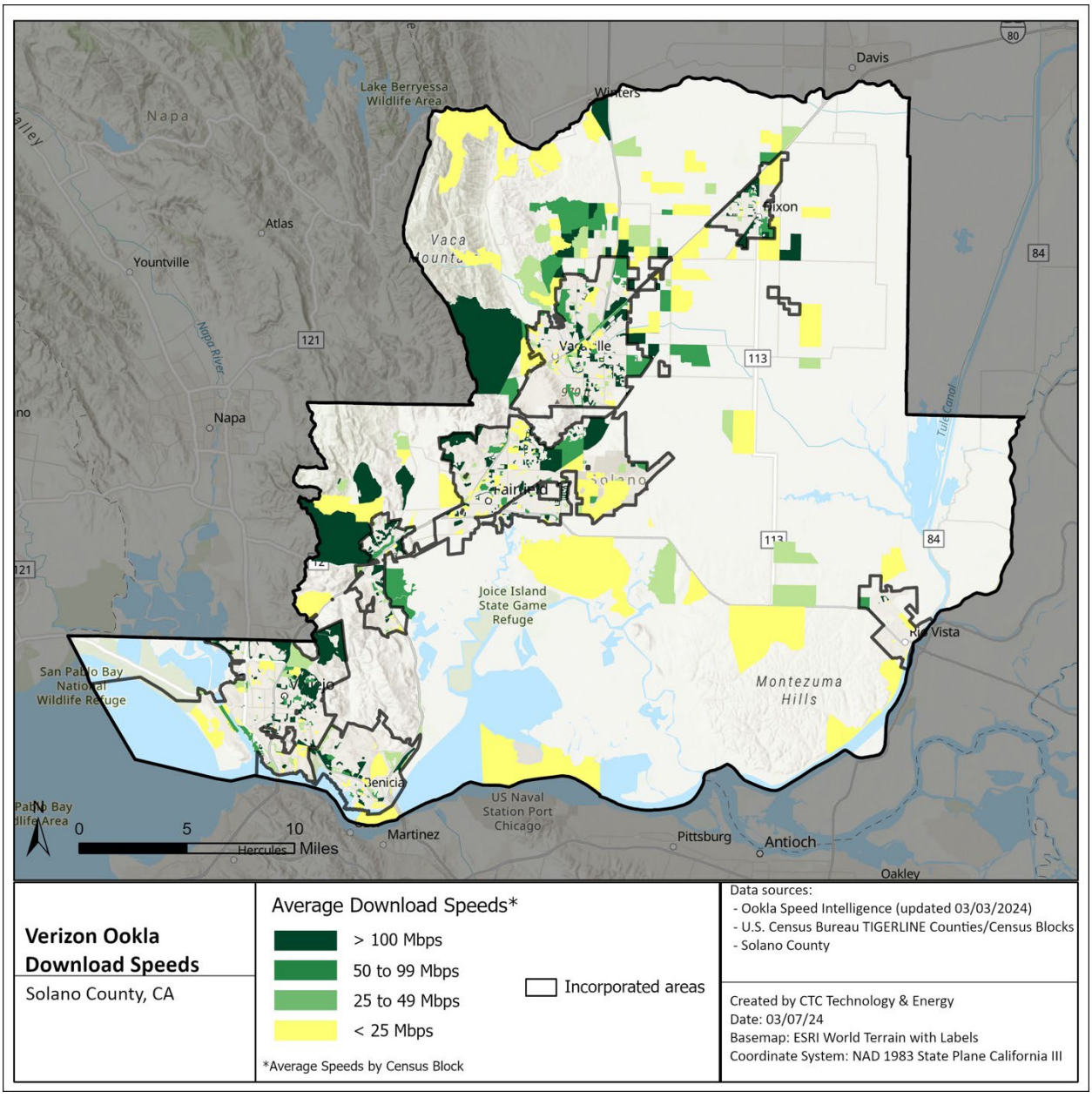
Similar to the results for AT&T, T-Mobile Ookla tests show some pockets around Fairfield and Vacaville that exceed 100 Mbps—as well as areas in Dixon and Vallejo with these speeds. Many areas show speeds of under 50 Mbps (see Figure 17).

Figure 17: T-Mobile download speeds based on Ookla data



As shown in Figure 18, mobile tests for Verizon show more areas than AT&T and T-Mobile with results in the speed tier of 50 Mbps and above, but also few areas with results over 100 Mbps.

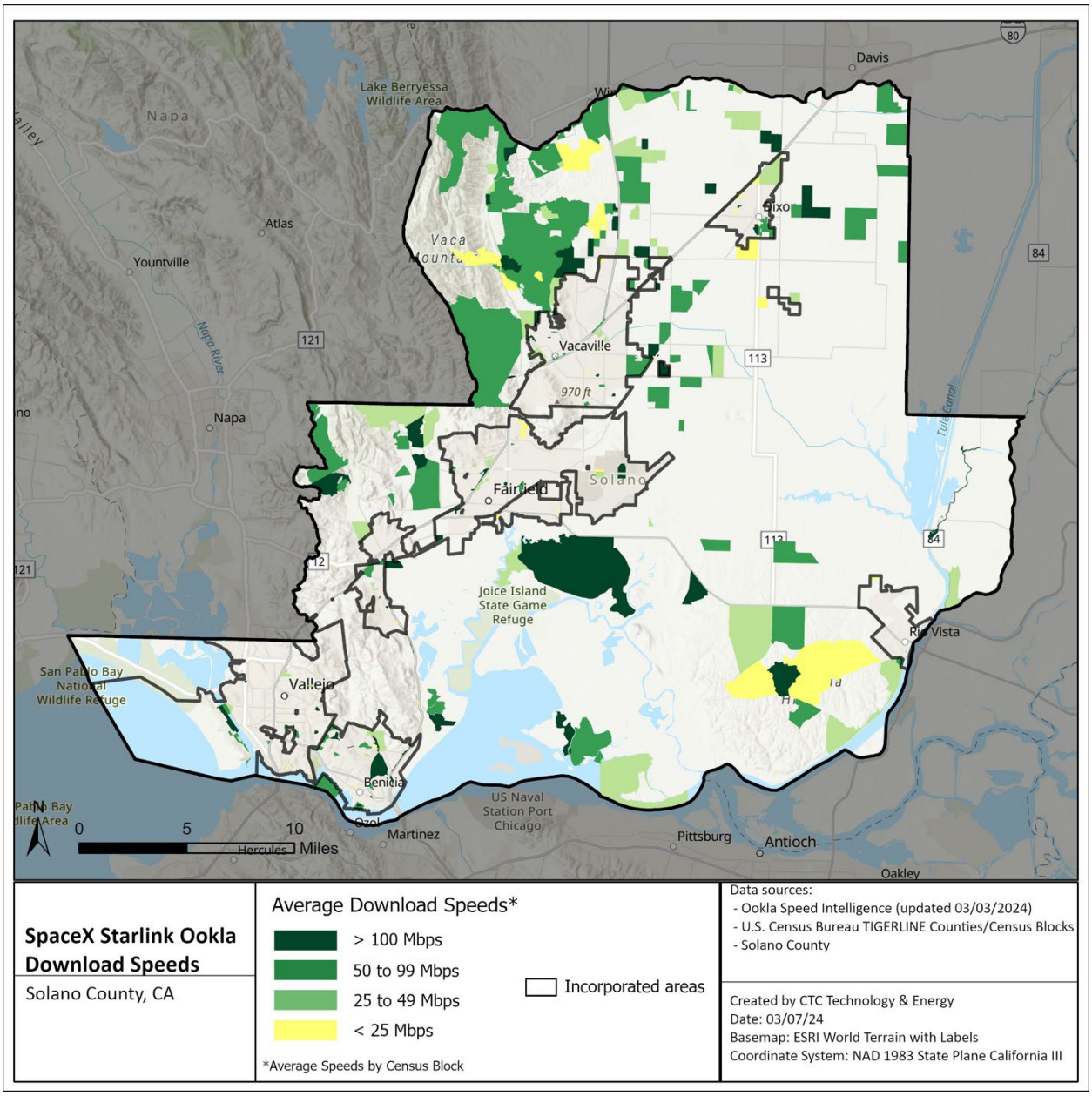
Figure 18: Verizon download speeds based on Ookla data



2.6.3 Satellite speeds

Ookla speed tests for Starlink showed higher download speeds generally than fixed wireless in unincorporated areas, with many test results of 50 Mbps and above (see Figure 19).

Figure 19: Starlink download speeds based on Ookla data



2.6.4 Hotspot usage based on Ookla wireless results

Given the results of the Ookla speed test data, it is not advisable to rely on hotspots for broadband service delivery. Since the unincorporated areas of the County most often registered download speeds of less than 25 Mbps for wireless providers, it would not be advisable to rely on hotspot service using the cellular network as an alternative to broadband. Mobile hotspot data rates can be slow for several reasons. During peak usage times, the cellular network can become congested, leading to slower data speeds for everyone, including those using mobile

hotspots. Also, the strength of the cellular signal significantly affects data speeds. Poor signal strength due to distance from the cell tower, physical obstructions, or being indoors can result in much slower speeds. Mobile networks are typically not designed to have 25 Mbps at the edge of coverage. The coverage edge design criteria are used by Tier 1 carriers is typically an order of magnitude lower throughput than fixed service requires.

Cellular site spacing for most networks was originally determined by the performance of voice only 2G networks built in the 80s and 90s. During these early greenfield cellular builds, new towers were placed to maximize contiguous coverage and minimize interference in the desired coverage areas. The initial strategy to introduce new technologies like 3G, 4G, and 5G is to simply overlay these technologies on existing sites to minimize additional expenses such as site acquisition and site construction. These technological upgrades all have distinctly different link limiting configurations and use different frequency bands, thus resulting in different coverage. Overlay sites to fill in coverage holes are deployed typically only where lack of capacity and coverage drives the business case.

Though there are certain areas where cellular wireless coverage yielded speeds of greater than 100 Mbps download (for example, Verizon coverage west of Fairfield and west of Vacaville), these speeds are not consistent across unincorporated areas nor are they reliable for the reasons cited above.

2.7 Projects proposed for Federal Funding Account funding

Multiple entities submitted applications for the CPUC's FFA funding program (discussed further in Section 2.4.2) within Solano County that could result in additional coverage, depending on the outcome of the awards. The CPUC allocated $17 million for projects in Solano County; the application window for the program closed on September 30, 2023, and the CPUC will announce awards by June 30, 2024.

Applications were submitted by AT&T, Cal.net, Comcast, the City of Vallejo, and the City of Vacaville. These five entities submitted a total of 12 applications for projects located entirely within the County, which request a total of $53,081,407 and propose to cover 7,005 locations. (Note that the City of Vallejo and the City of Vacaville submitted five of these 12 applications.) AT&T submitted applications for seven additional projects that overlapped adjacent counties but included parts of Solano County. Combined, these FFA projects propose to serve thousands of end user customers with speeds of at least 100/100 Mbps and often over 1 Gbps symmetrical.

2.7.1 Overview of proposed projects

Figure 20 shows the proposed project areas throughout the County compared to areas of fiber and cable coverage, according to FCC data at the census block level. Due to the eligibility criteria by the CPUC for its FFA program, many of the FFA applications appear to overlap existing broadband infrastructure.

Figure 20: Proposed FFA project areas compared to FCC-reported coverage

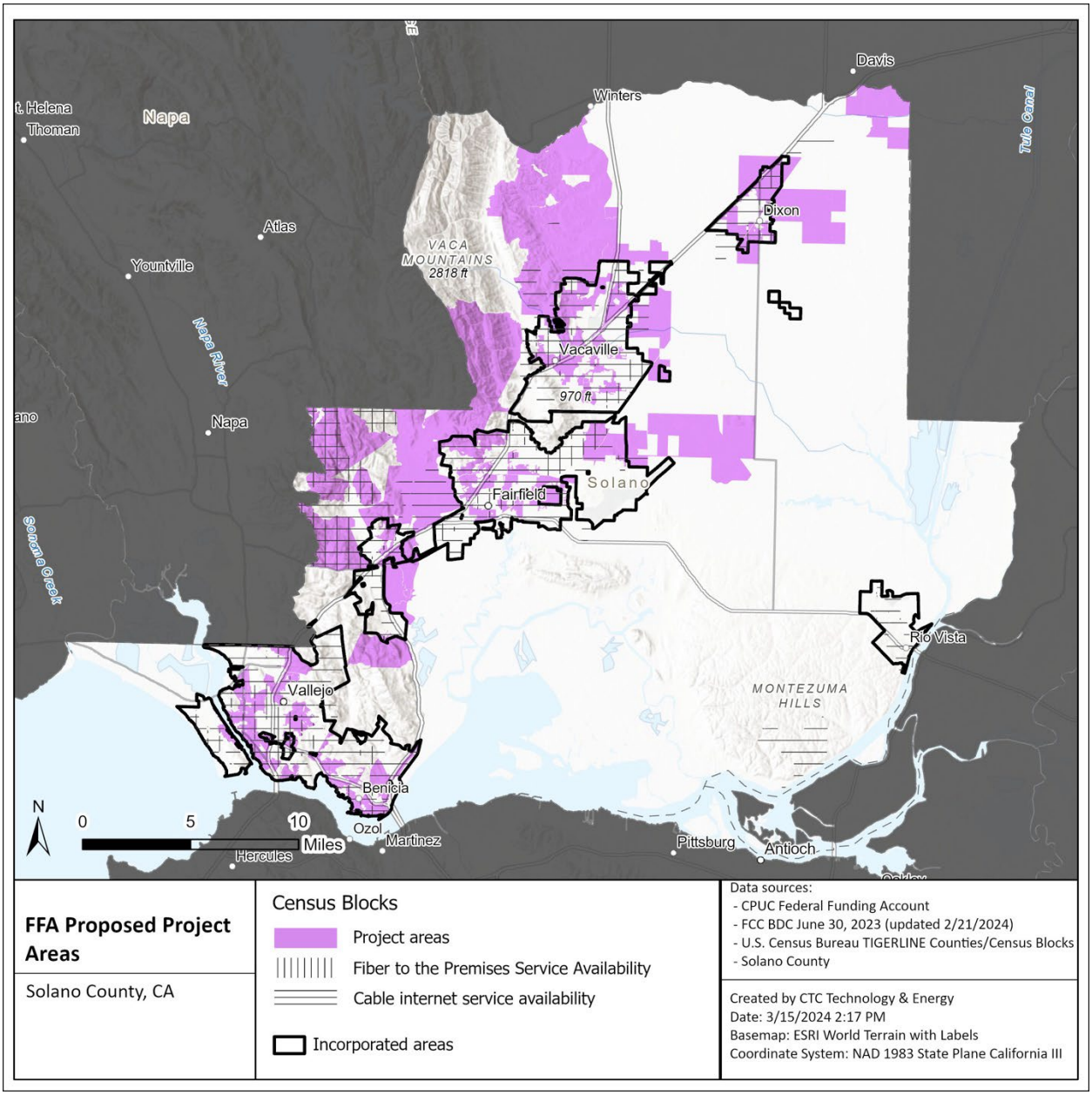


Table 4 breaks down each FFA grant application in more detail and provides the requested funding, median household income in the proposed project area, speeds that will be offered upon completion of the project, and the number of proposed locations to be served by the project.

The table also compares the number of unserved locations within the project area as reported on the CPUC's FFA eligibility map with the number of unserved locations within the same area as reported on the FCC's National Broadband Map. The data illustrate that unserved location numbers vary considerably based on the maps used, indicating the broader definition of "unserved" used by the CPUC's FFA program.

These applications were subject to a public comment and objection period, giving stakeholders (including competing providers) the opportunity to demonstrate that the area is already served by speeds faster than 25/3 Mbps. The CPUC has adjudicated these challenges and has required applicants to revise proposed project areas or withdraw applications in areas where it determines service is being offered over non-legacy technology at speeds greater than 25/3 Mbps.

Table 4: FFA applications cross-referenced against unserved locations according to FCC data

Applicant	Project Name	FFA Amount Requested	Project Cost	Median HH Income	# of currently Served locations (FCC)	# of currently Unserved Locations (FCC)	Max Download Speed Mbps	Max Upload Speed Mbps	# of Mass Market Unserved Locations per Project Area (FFA)
AT&T Services, Inc. on behalf of its affiliate Pacific Bell Telephone Company d/b/a AT&T California	Napa - 1	$7,632,551	$15,265,102	$103,529	7	18	5,000	5,000	1,168
	Napa - 1A	$5,649,233	$11,298,466	$86,576	38	-	5,000	5,000	846
	Napa - 1C	$5,711,250	$11,422,500	$91,429	3	-	5,000	5,000	1,089
	Solano - 1	$5,125,273	$10,250,546	$91,169	1,051	61	5,000	5,000	619
	Solano - 1A	$6,308,993	$12,617,986	$65,101	1,511	90	5,000	5,000	1,098
	Solano - 1B	$8,031,276	$16,062,552	$82,125	1,292	231	5,000	5,000	686
	Solano - 1C	$6,400,000	$13,491,521	$104,044	229	1,337	5,000	5,000	1,396
	SOLANO - PSA	$626,758	$1,253,516	$61,932	769	8	5,000	5,000	333
	SOLANO - XX	$4,540,504	$9,081,008	$101,328	2	2,231	5,000	5,000	2,002
	YOLO - PSA	$98,427	$196,854	$63,875	-	12	5,000	5,000	136
	Yolo -1A	$7,555,881	$15,111,762	$70,331	-	33	5,000	5,000	1,496
Cal.net, Inc	Solano County FFA	$2,834,080	$2,834,080	$86,327	-	411	25	5	411
City of Vacaville	Vacaville Broadband	$10,548,070	$11,042,006	$80,417	726	-	10,000	10,000	729

Applicant	Project Name	FFA Amount Requested	Project Cost	Median HH Income	# of currently Served locations (FCC)	# of currently Unserved Locations (FCC)	Max Download Speed Mbps	Max Upload Speed Mbps	# of Mass Market Unserved Locations per Project Area (FFA)
City of Vallejo	Mare Island Build	$688,892	$688,892	$176,719	85	92	1,000	1,000	177
	N. Sonoma Blvd.	$1,014,322	$1,014,322	$37,375	68	-	1,000	1,000	68
	Porter St to Seaport	$1,680,329	$1,680,329	$67,273	32	-	1,000	1,000	32
	Trailer City Park Project	$475,545	$475,545	$53,854	194	-	1,000	1,000	194
Comcast Cable Communications Management, LLC	Solano Nut Tree	$12,651,291	$15,752,098	$99,297	215	1,077	1,250	1,250	1,103
	Solano Suisun Valley Wine Trail	$6,587,350	$6,587,350	$142,500	50	236	1,250	1,250	239

*Note: Shading indicates project areas shared with other counties

The first round of proposed awards for the FFA Program were announced on June 7, 2024.[44] The Commission will need to approve these awards at their July 11, 2024 meeting for them to take effect. To date, the following amounts were awarded for the following counties. No awards for Solano County have been announced to date. A detailed analysis of the potential impact of the proposed projects is provided in Appendix B.

- $44.1 million for Imperial, Lassen and Plumas Counties
- $44.4 million for Alameda, San Francisco and Sierra Counties

2.7.2 Proposed municipal projects

Two municipalities in the County, the City of Vallejo and the City of Vacaville, submitted applications for FFA funding within their respective city limits. Both cities state that these proposed projects will leverage planned upgrades to their existing infrastructure, as well as the anticipated state-owned middle-mile infrastructure. Taken together, the cities' requests total $14.4 million in FFA funding—over 80 percent of the total available funding for the County—and

[44] Federal Funding Account Recommendations and Awards, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/broadband-implementation-for-california/last-mile-federal-funding-account/federal-funding-account-awards

would serve 1,200 unserved locations. Several parts of these projects overlap with applications submitted by AT&T.

Table 5 shows the amounts requested, number of unserved locations, and cost per location data.

Table 5: FFA applications submitted by the City of Vallejo and the City of Vacaville

	Applicant	County name	Grant amount requested	# of mass market unserved locations	Total project cost	Total cost per location	Grant cost per location
Vacaville Broadband[45]	City of Vacaville	Solano	$10,548,070	729	$11,042,006	$15,147	$14,469
Trailer City Park Project[46]	City of Vallejo	Solano	$475,545	194	$475,545	$2,451	$2,451
N. Sonoma Blvd.[47]	City of Vallejo	Solano	$1,014,322	68	$1,014,322	$14,917	$14,917
Porter St to Seaport[48]	City of Vallejo	Solano	$1,680,329	32	$1,680,329	$52,510	$52,510
Mare Island Build[49]	City of Vallejo	Solano	$688,892	177	$688,892	$3,892	$3,892

If these municipal projects meet the requirements of the FFA program, they will likely have an advantage over the applications submitted by ISPs. The CPUC has strongly encouraged local governments to apply for FFA funding: the CPUC launched a local technical assistance grant program, an outreach and training program, and allows for additional scoring points for applications submitted by (or a network that will be owned by) a local government entity. These projects could receive up to 20 additional points because they are submitted by a local government and up to 10 points because of their purported reliance on the MMBI. However, based on the provided summaries, it appears that there may also be some deficiencies in the cities' applications.

2.7.2.1 City of Vacaville

Vacaville plans to leverage an upgrade of the City's backbone fiber ring network to build a 29-mile fiber network that will be operated by a partner ISP. The application includes four distinct project areas within the city limits, with the majority of the build located directly southeast of

[45] For application details, see, https://broadbandportal.cpuc.ca.gov/a0K3d000002OktHEAS.
[46] For application details, see, https://broadbandportal.cpuc.ca.gov/a0K3d000002cwMuEAI.
[47] For application details, see, https://broadbandportal.cpuc.ca.gov/a0K3d000002cuUqEAI.
[48] For application details, see, https://broadbandportal.cpuc.ca.gov/a0K3d000002cvNfEAI.
[49] For application details, see, https://broadbandportal.cpuc.ca.gov/a0K3d000002csoZEAQ.

Highway 80 in a central part of the city that is mostly residential with schools, parks, and light commercial use. Other areas of the project include neighborhoods with more multi-family and single-family housing. The planned fiber network would be located primarily below grade in conduit[50] and would pass more than 3,300 addresses, allowing a private partner to construct laterals and service drops to residential and business customers.[51]

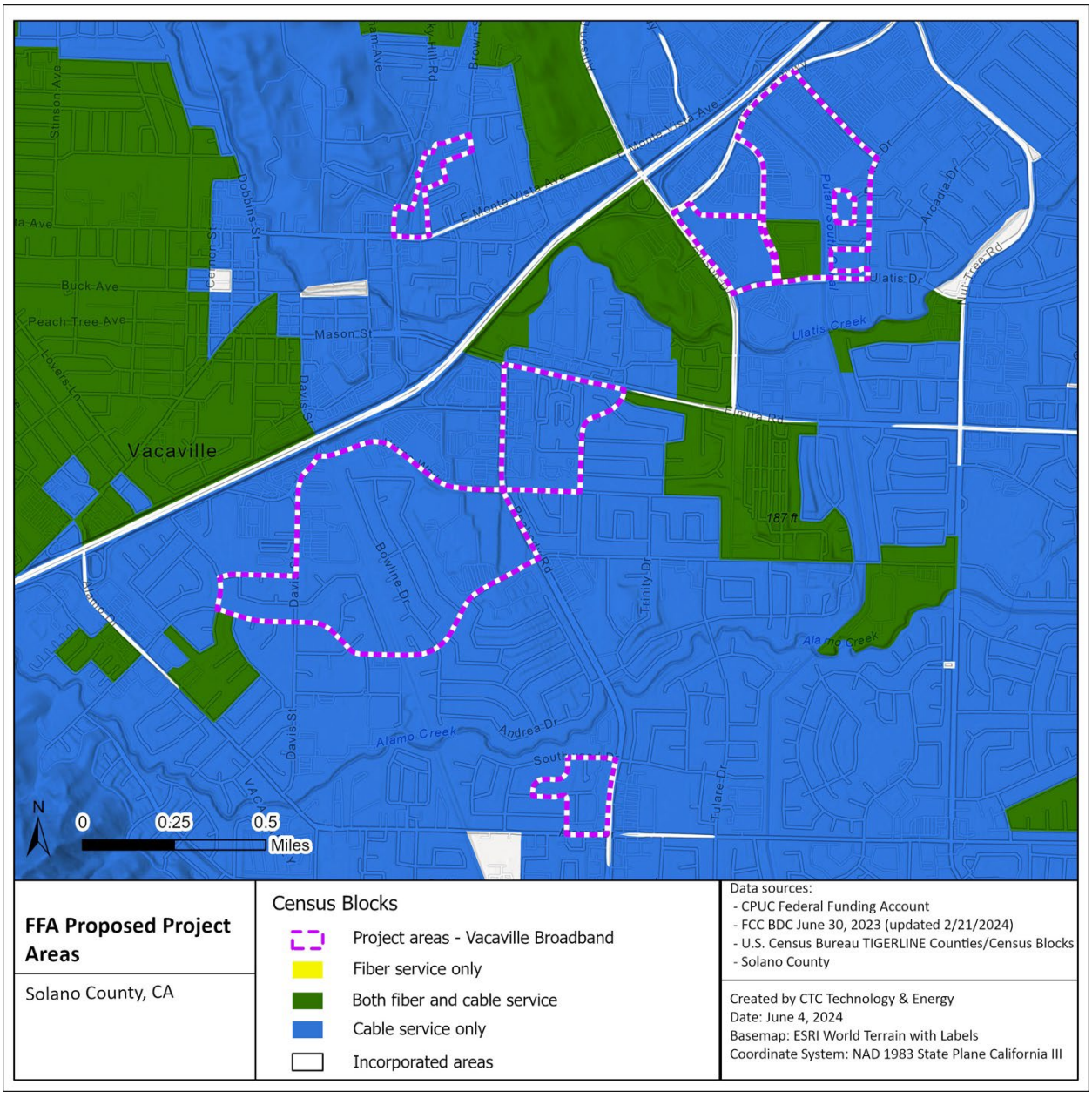
The City states that it has not yet finalized its partnership plans but is in negotiations with "several potential ISP partners."[52]

Although the CPUC requires FFA-funded projects to directly serve end users, it is unclear from the application summary if Vacaville's total project cost includes the costs to build the extensions and serve the customer premises directly, or if the project will only upgrade the City's fiber backbone.

As shown in Figure 21 below, the entire proposed build area for the Vacaville project is in currently served areas, as reported by providers to the FCC for the National Broadband Map.

[50] Just over 80 percent of the build would be microtrenched and just under 20 percent would consist of aerial fiber.
[51] "Application: Vacaville Broadband," CPUC Broadband Portal, https://broadbandportal.cpuc.ca.gov/s/gms-application/a0K3d000002OktHEAS/vacaville-broadband.
[52] See, "Application: Vacaville Broadband."

Figure 21: City of Vacaville, Vacaville Broadband proposed FFA project area



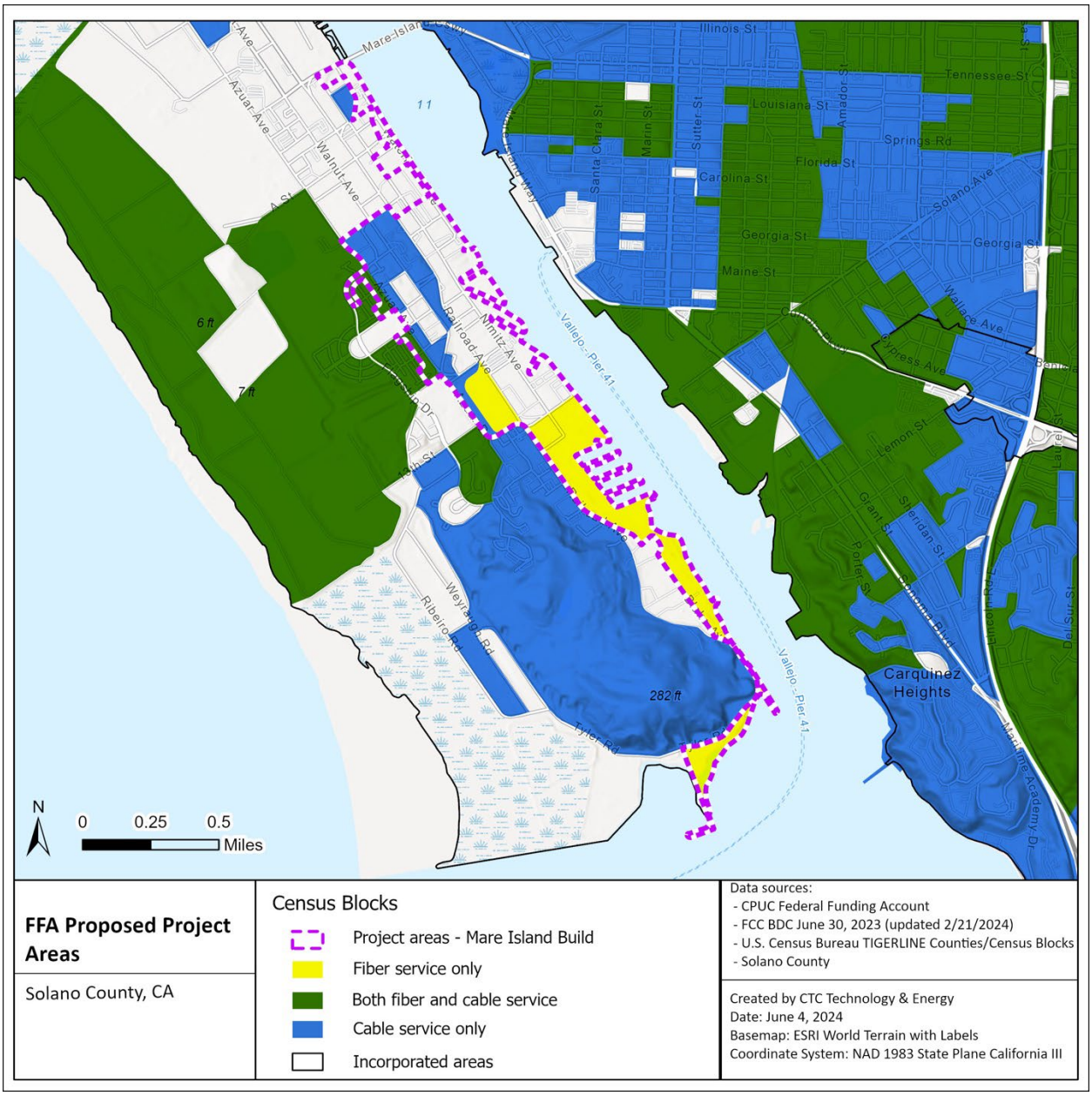
2.7.2.2 City of Vallejo

The City of Vallejo submitted four separate FFA applications, each covering a different project area in the city. The projects will leverage existing facilities owned either by the City or the publicly owned utility company operating on Mare Island. The projects appear to focus on multi-tenant housing and trailer parks, with the exception of the project on Mare Island—which the application states will serve 177 locations but also anticipates future expansion by developers.

However, the Mare Island project excludes several neighboring unserved locations on the island, and the application summaries do not discuss the reasoning behind this omission. In addition, Vallejo's projects do not propose to provide any matching funds. While matching funds are not required for FFA applications, an entity receives scoring preference for providing matching funds; most applications therefore include a match from the applicant, and Vallejo will not gain additional points since the City did not do so.

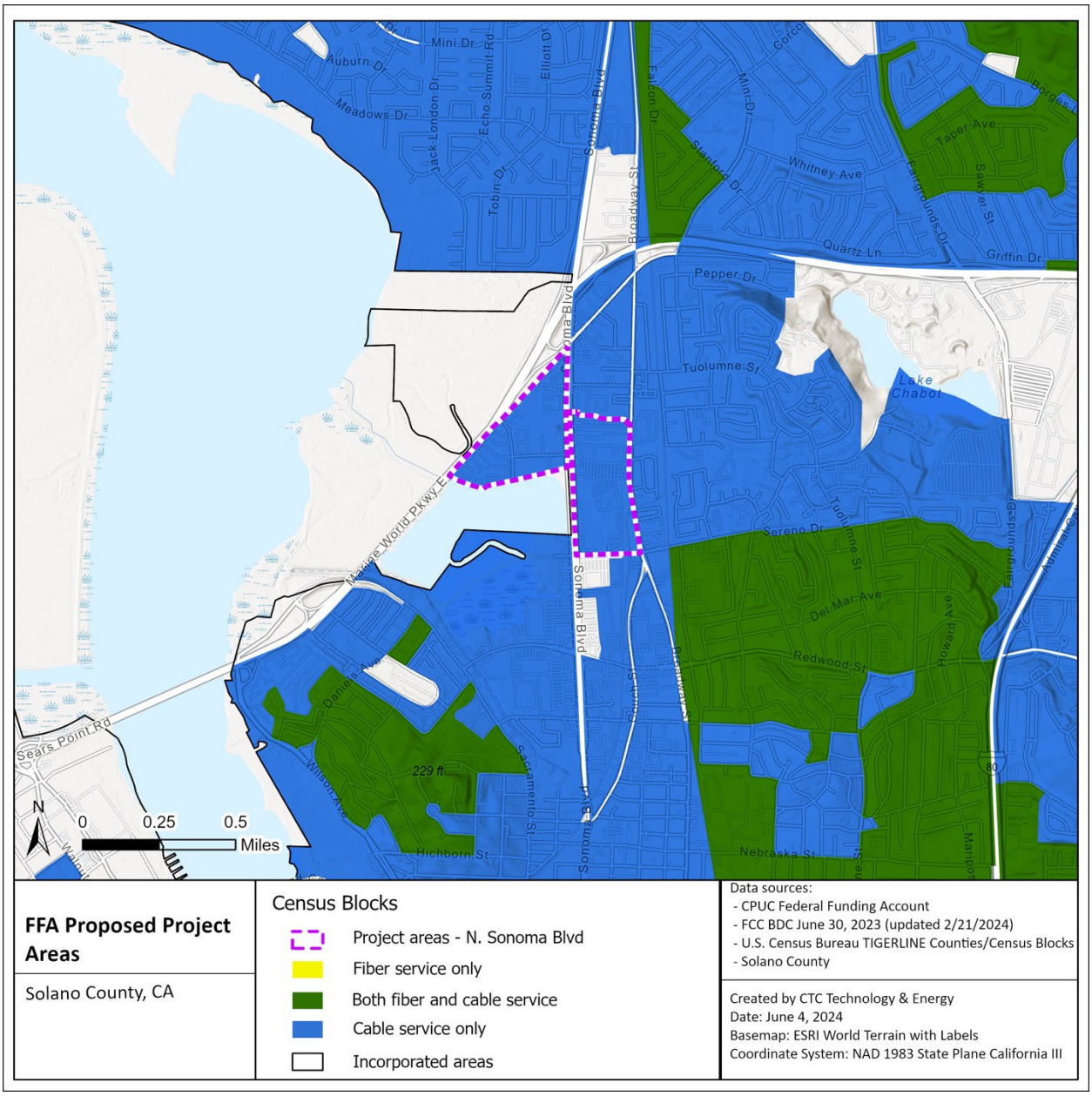
As shown in Figure 22 through Figure 25 below, Vallejo's proposed projects are also located in areas already served by fiber or cable according to FCC map data, with the exception of a few locations on Mare Island.

Figure 22: City of Vallejo, Mare Island proposed FFA project area



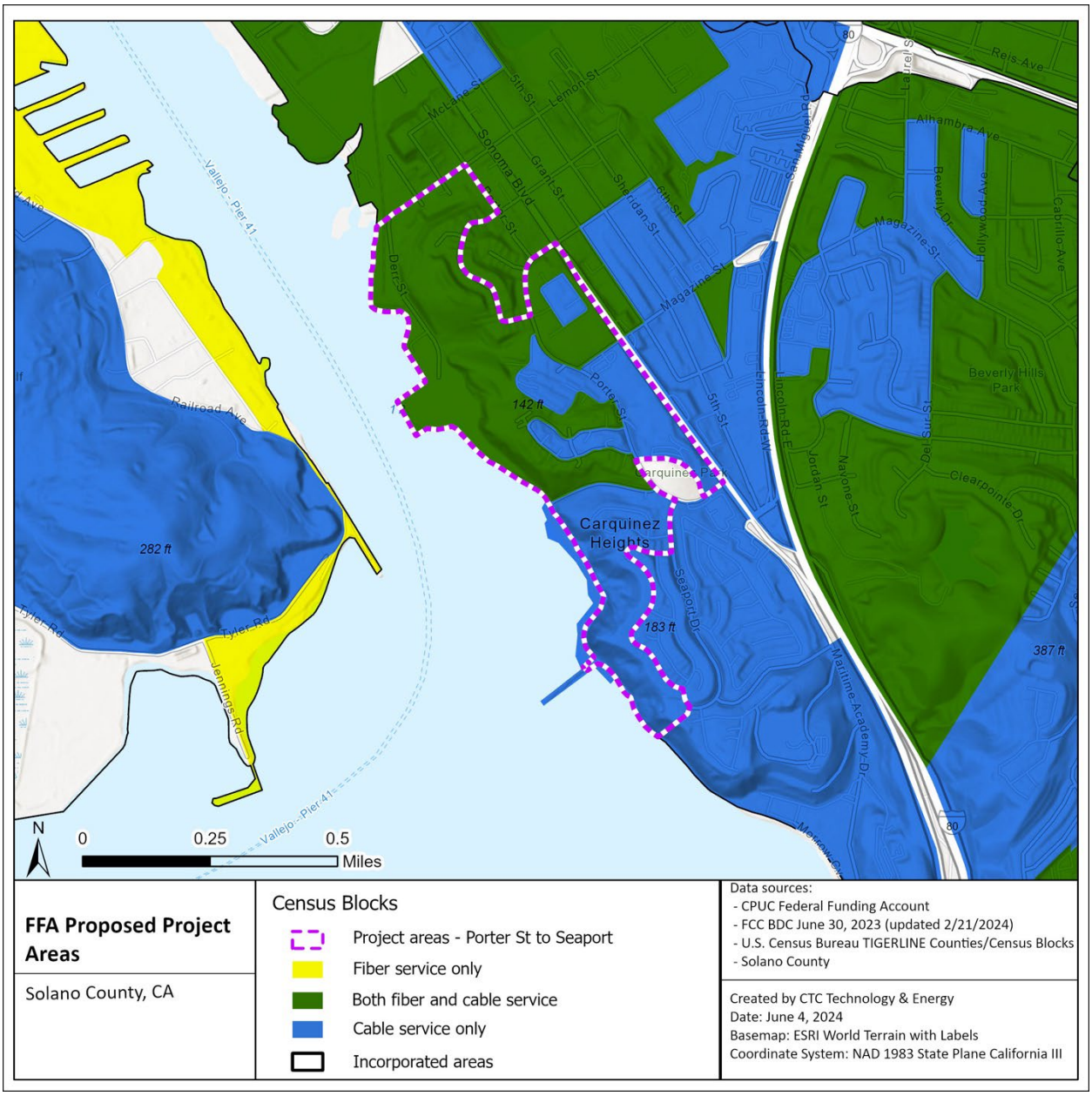
The majority of the project area proposed is already covered by existing fiber or cable.

Figure 23: City of Vallejo, N. Sonoma Boulevard proposed FFA project area



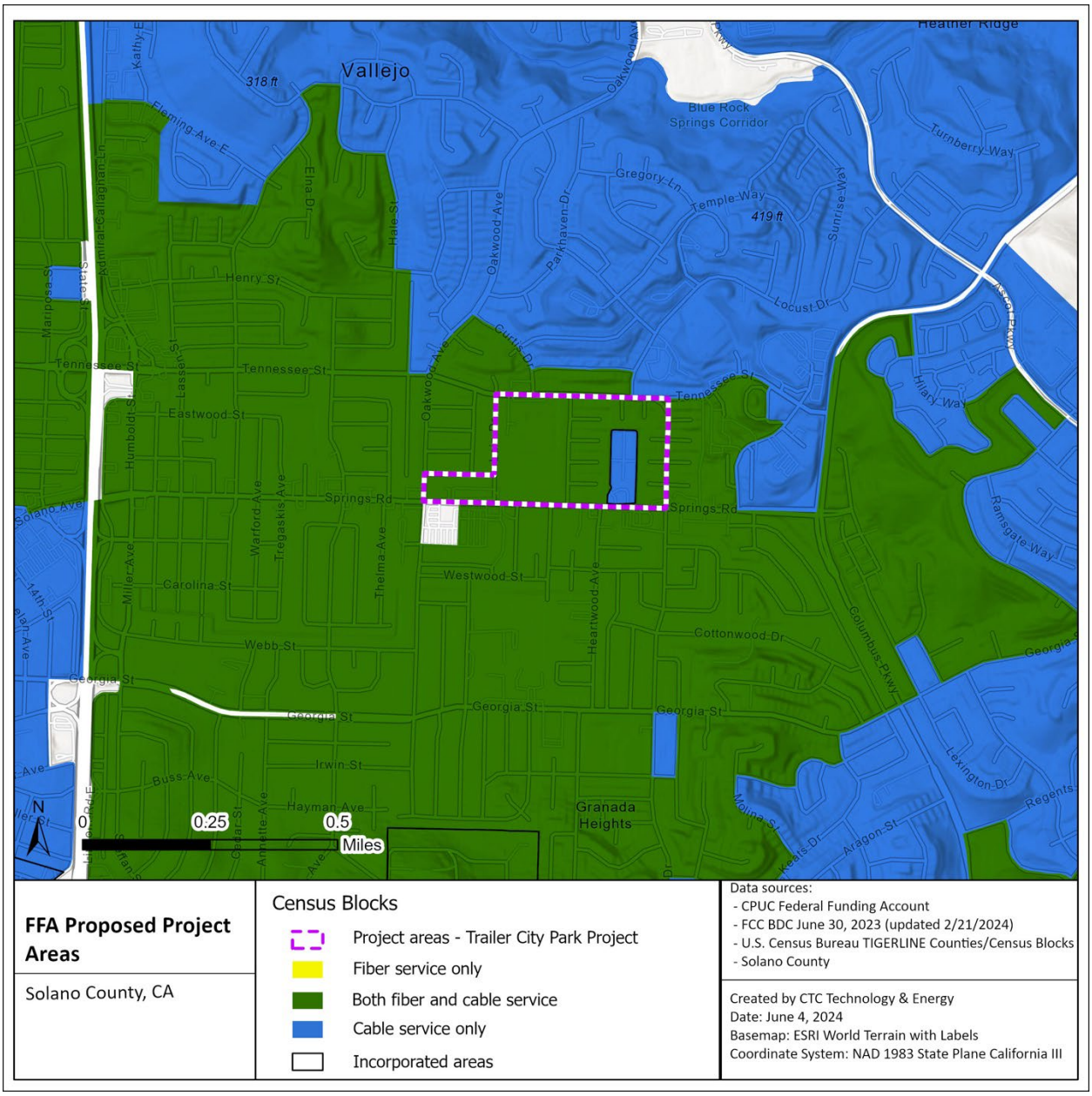
The entire project area proposed is already covered by existing cable.

Figure 24: City of Vallejo, Porter Street proposed FFA project area



The entire project area proposed is already covered by existing cable and/or fiber.

Figure 25: City of Vallejo, Trailer City Park proposed FFA project area



The entire project area proposed is already covered by both existing fiber and cable.

2.8 Efforts currently in progress

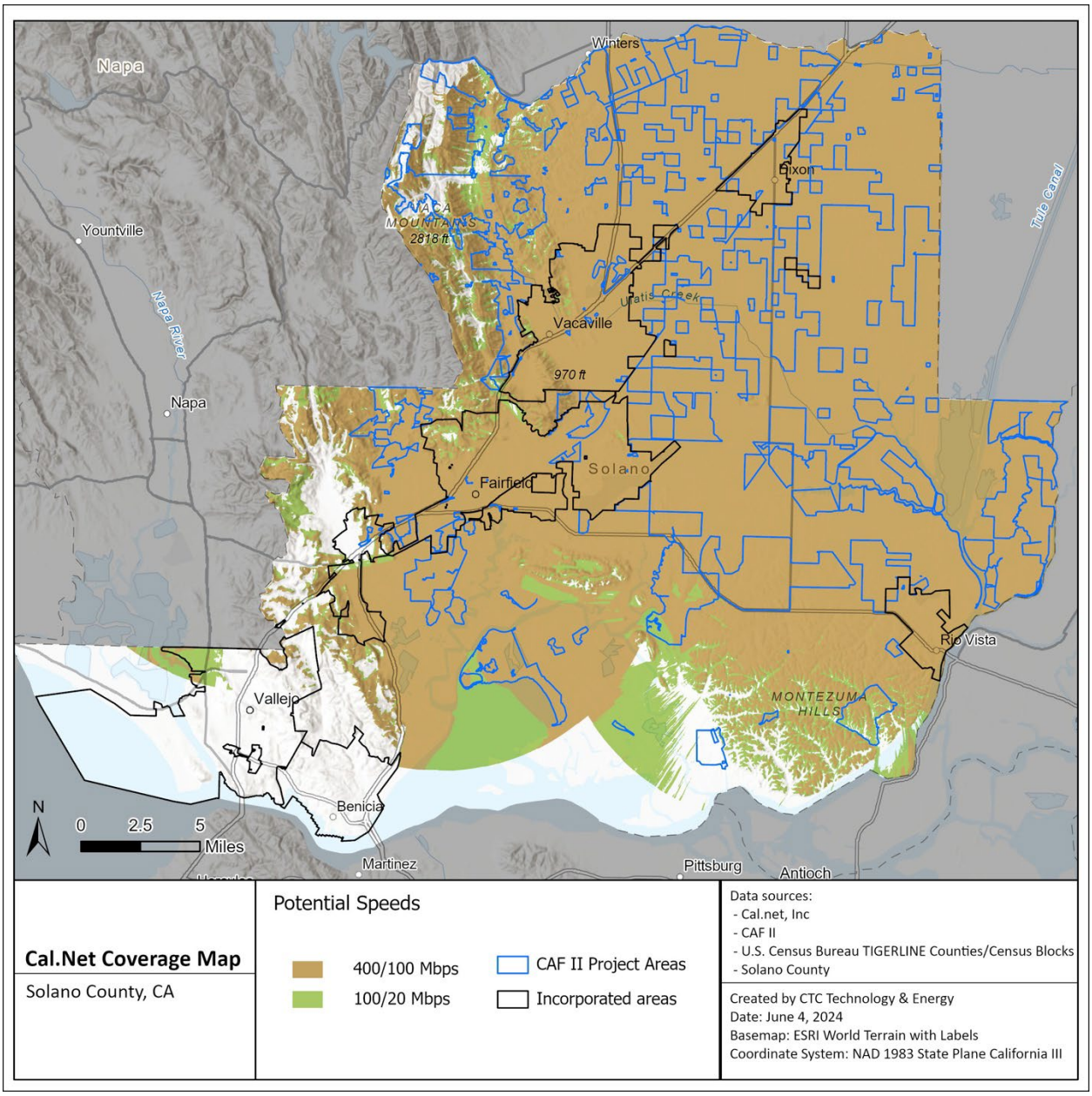
There has been a significant amount of broadband planning and infrastructure development in the County in the past few years. As discussed above, Cal.net is in the process of building out its commitment for CAF II funding, and the cities of Vallejo and Vacaville have also applied for funding for last-mile projects through the FFA program. The MMBI, which is expected to

complete its network buildout by the end of 2026, will also construct middle-mile infrastructure within the County.

2.8.1 CAF II-funded buildout by Cal.net

Figure 26 shows Cal.net's planned coverage for Solano County based on its CAF II funding. According to representatives of Cal.net, the company plans to deploy Tarana wireless technology, which would cover the vast majority of the County at speeds of 400/100 Mbps. It plans to build 14 towers with up to three transmitters per tower. (For more information about Tarana Wireless, see Appendix C.) Cal.net is obligated to serve 2,243 locations in the County by its CAF II funding, but plans to ultimately cover over 9,000 County locations by leveraging these grant-funded locations.

Figure 26: Proposed Cal.net coverage in Solano County by speed[53]



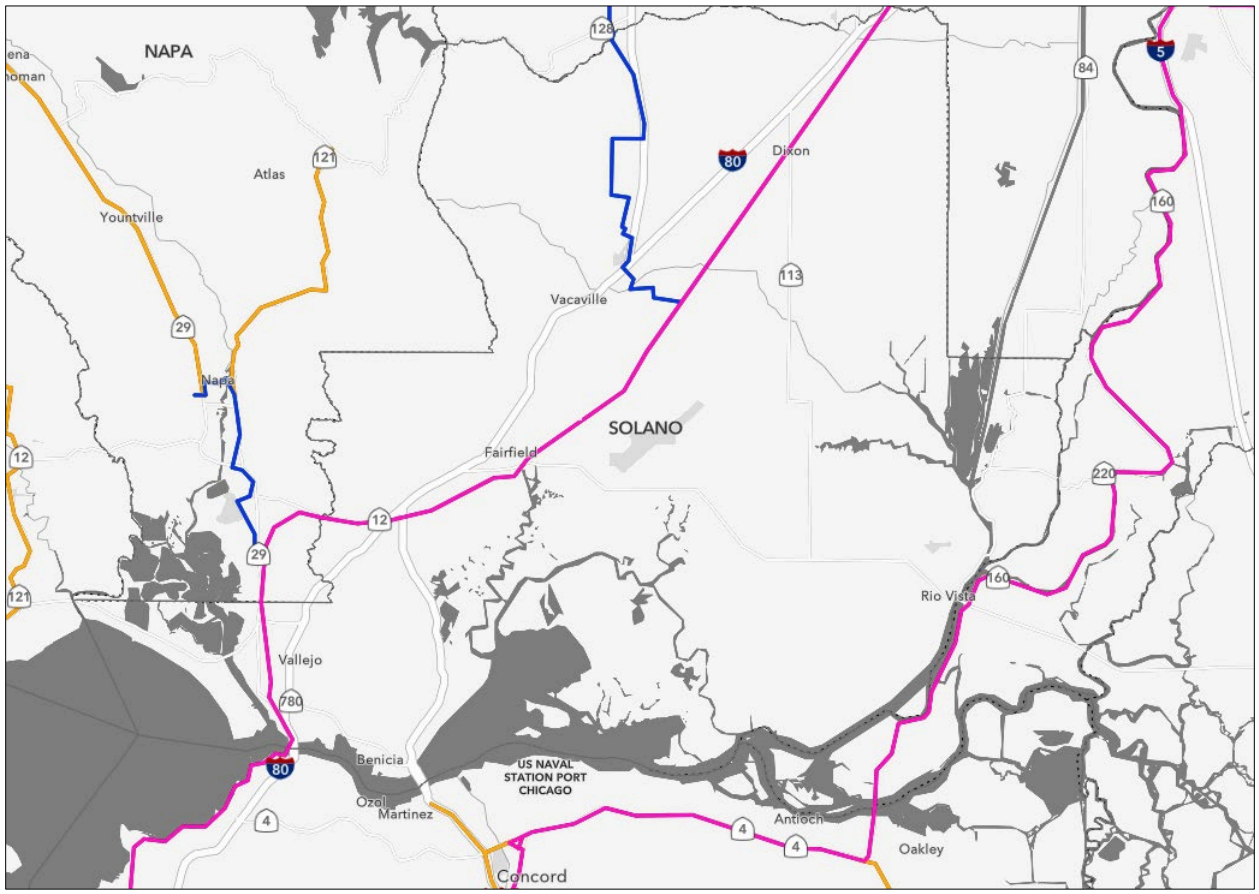
2.8.2 Middle-Mile Broadband Initiative

As discussed in Section 2.4.2, in 2021 SB 156 allocated $3.25 billion in funding for the state to develop a statewide open-access middle-mile broadband network, which will be completed through new construction and partnerships with existing middle-mile network providers.

[53] Data provided by Cal.net on March 11, 2024.

The MMBI will operate 61 miles of fiber in Solano County, which will generally follow the route of the County's two main highways, Highway 80 and Highway 505[54] (see Figure 27). The fiber deployment will consist of 44 miles of joint-build fiber and 17 miles of fiber that will be leased from an existing provider.

Figure 27: MMBI infrastructure in Solano County



2.8.3 County ASE network

Solano County currently has a network to connect all County buildings and facilities. For the past several years, it has contracted with AT&T to run and maintain this network, which costs over $1 million per year. The County was interested in other options that may reduce ongoing costs for running this network.

[54] Statewide Middle-Mile Network Map, https://experience.arcgis.com/experience/e2540ace2ac248ee8c3350aa39395342.

2.8.3.1 Golden State Connect Authority

The County and CTC met with Golden State Connect Authority (GSCA), which is a joint powers authority (JPA) organized by Rural County Representatives of California (RCRC). RCRC has 40 rural counties as members, and its goal is to improve access and choice of affordable high-speed service in rural communities. GSCA was set up to provide technical assistance, funding, and services related to installation and operation of open-access municipal networks.[55]

GSCA discussed the possibility of using the California Loan Loss Reserve (LLR) Fund established by SB 156 to finance the municipal network capital expenses through the issuance of long-term tax-exempt bonds. The LLR program allocated $750 million to offer a credit enhancement for localities in financing local broadband infrastructure.[56] The CPUC will accept applications for this program beginning in March 2024.

GSCA stated that it would use its engineering resources from UTOPIA Fiber to create a network design that includes all County and City buildings and data centers and would enable 100 Gbps symmetrical service for all commercial uses. GSCA would establish a 10 to 15-year agreement with the County, and issue the bonds and manage the financing related to the construction of the network. The network design would leverage the MMBI middle-mile infrastructure planned in the County.

2.8.3.2 Comcast

The County and CTC also met with Comcast to discuss the option of potentially serving as its ASE provider. Comcast representatives stated that the recurring costs of running a similar network would be at least half as much as the current costs, although they did not provide a specific estimate.

Comcast stated that it has an existing network in the area that was developed to serve the Governor's Office of Emergency Services (Cal OES) and is utilized at approximately 40 percent. It currently has a footprint in Fairfield, Vacaville, and Rio Vista but does not serve Vallejo or Dixon. Comcast representatives also mentioned that the network could be switched over to Comcast without downtime, and would be a completely redundant, fully meshed Ethernet network.

2.9 Regional broadband consortia

California is unique in that it has organized groups that coordinate broadband activities on a regional basis. The consortia are formed to facilitate the deployment of broadband infrastructure

[55] https://goldenstateconnect.org/about-us/

[56] CPUC Loan Loss Reserve Fund, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/broadband-implementation-for-california/loan-loss-reserve-fund

in their respective areas by assisting applicants in the CASF broadband infrastructure grant development process.[57] CASF has separate grants that fund the consortia activities. There are 52 counties covered by regional broadband consortia (see Table 6). The only counties not represented by regional consortia are:

- Alameda County
- Contra Costa County
- Orange County
- San Francisco County
- Santa Clara County
- Solano County

The East Bay Broadband Consortium existed at one time and covered Alameda, Contra Costa and Solano Counties, but is currently inactive. The lack of a broadband consortium may be an opportunity for Solano County to initiate a regional group to unify broadband planning efforts that benefit multiple areas.

Table 6: Regional broadband consortia in California

Consortium name	Areas represented
Broadband Consortium of the Pacific Coast	San Luis Obispo County Santa Barbara County Ventura County
Central Coast Broadband Consortium	Monterey County San Benito County Santa Cruz County
Central Sierra Economic Development District/ Broadband Utility	Alpine County Amador County Calaveras County Mariposa County Tuolumne County
Connected Capital Area Broadband Consortium	Sacramento County Sutter County Yolo County Yuba County
Gold Country Broadband Consortium	El Dorado County Nevada County

[57] CASF Rural and Urban Regional Broadband Consortia Account

	Placer County Sierra County
Inland Empire Regional Broadband Consortium	Riverside County San Bernardino County
Inyo-Mono Broadband Consortium	Inyo County Mono County
Los Angeles Digital Equity Action League Consortium	Los Angeles County
North Bay/ North Coast Broadband Consortium	Marin County Mendocino County Napa County Sonoma County
Northeastern California Connect Consortium	Butte County Lassen County Modoc County Plumas County Shasta County Siskiyou County Tehama County
Redwood Coast Connect Broadband Consortium	Del Norte County Humboldt County Trinity County
San Joaquin Valley Regional Broadband Consortium	Fresno County Kern County Kings County Madera County Merced County San Joaquin County Stanislaus County Tulare County
Southern Border Broadband Consortium	Imperial County San Diego County
Tahoe Basin Project	Lake Tahoe Basin
Upstate California Connect Consortium	Colusa County Glenn County Lake County

3 Recommendations for investment

Regardless of the generous federal and state funding available, the County is not likely to achieve 100 percent coverage, and particularly not with fiber. Many of the County's unserved and underserved areas are sparsely populated, have a high cost of deployment, and relatively low revenue potential—making it unlikely that ISPs would have incentive to cover these areas, even with significant federal or state subsidy. The County can consider potential approaches for partnerships with ISPs to facilitate deployment, and alternative technologies, such as fixed wireless and satellite, will likely need to be deployed to reach full coverage.

The County is interested in executing with ISP partners on fiber and fixed wireless projects, potentially in unincorporated areas of the county that have inadequate broadband access to meet community needs but are not competitive enough to be granted funding under the FFA program.

3.1 Recommended technology deployment by geography

CTC conducted an analysis based on population density and existing infrastructure placement to identify the unserved and underserved areas of the County where fiber infrastructure investment would be most appropriate to optimally serve County residents with high-speed broadband services. Remaining areas would benefit from investment in fixed wireless technology offering reliable broadband speeds. Other technologies, such as satellite and mobile 5G data plans can also fill in the gaps where deployment of fixed broadband technologies would be too costly and operation of the network would not be economically sustainable in the long term.

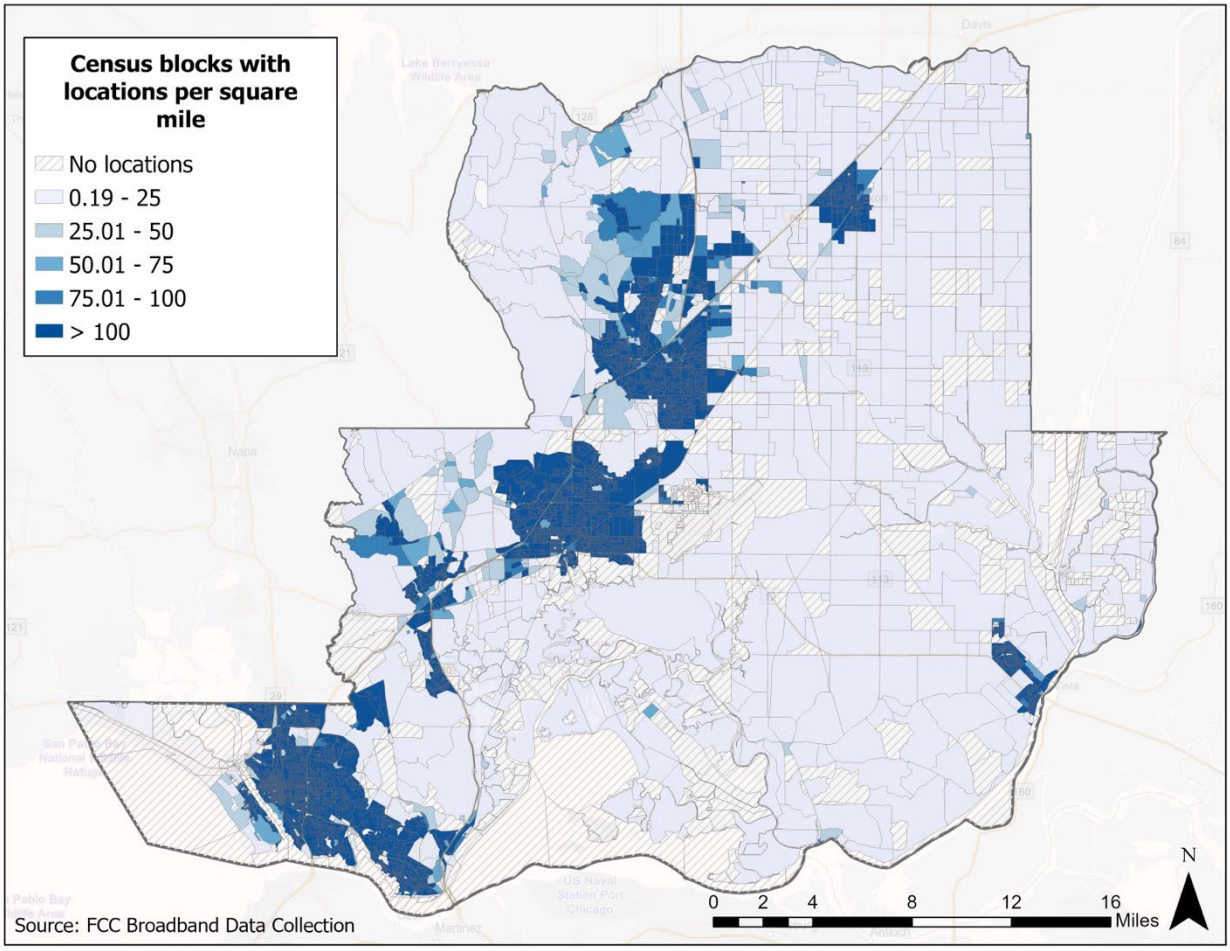
The main determinant in the per-passing cost of fiber optic (or any wireline) broadband construction is the density of passings. Density is almost always more significant than the construction type (i.e., aerial, underground) or the complexity of construction (e.g., existing utilities, right-of-way condition). The per-passing cost of wireless broadband also depends heavily on density; the "sweet spot" of wireless technology from a business case standpoint overlaps with the fiber business case, but generally is feasible to a lower density than fiber construction (although the lowest density areas are still cost-prohibitive for wireless broadband).

Figure 28 shows the density of Broadband Serviceable Locations (BSL)[58] by census block in the County. As shown below, there are many census blocks in the County with no BSLs or with no reported data, and many census blocks have 25 or fewer BSLs per square mile. Note that the

[58] "About the Fabric: What a Broadband Serviceable Location (BSL) Is and Is Not," FCC Broadband Data Collection, updated July 18, 2023, https://help.bdc.fcc.gov/hc/en-us/articles/16842264428059-About-the-Fabric-What-a-Broadband-Serviceable-Location-BSL-Is-and-Is-Not.

figure below shows the density of locations but does not distinguish among served, unserved, or underserved locations.

Figure 28: Broadband serviceable locations per square mile in Solano County



The next step of the analysis determines the threshold of BSLs per square mile at which the per-passing cost to deploy fiber becomes prohibitive for an ISP. In the County, this threshold—which represents a benchmark for investment in fiber infrastructure—is 50 BSLs per square mile. Considering the street mileage in each census block, 50 locations per square mile corresponds to an average of approximately two locations per road mile in the County, which corresponds to roughly $50,000 per passing to serve with fiber. Relying on experience and industry standard practices, this is the cost above which most grant programs seek non-fiber options to ensure the biggest benefits for the most efficient and effective use of grant funds.

While not an exact cutoff, an ISP would be more likely to build fiber infrastructure in areas with a BSL density of 50 BSLs per square mile or higher considering the costs for a fiber extension

project, the optimal distance from a new location to an existing fiber interconnection point, existing fiber facilities and equipment in the area that can be leveraged for an extension, and industry standard take-rate forecasts and revenue projections.

This analysis is also based on the following assumptions:

- ISPs will not build fiber networks from scratch, preferring to upgrade existing networks or leverage existing infrastructure to build an extension to save time and costs on planning, permitting, materials, and construction;
- Incumbent ISPs (i.e., AT&T and Comcast) are most likely to build fiber extensions from their existing facilities instead of new fiber installations located some distance away and possibly isolated from their current facilities, thus increasing costs and the difficulty of marketing and sales; and
- Potential new locations for fiber will be focused around more densely populated areas, mainly city centers and surrounding communities, to ensure cost recovery over time and to support healthy revenue projections and economically sustainable projects.

Based on this analysis, the census blocks marked in blue in Figure 29 below show areas in Solano County that are likely cost-effective to serve with fiber. Green areas in this map represent those that would be more efficiently served with wireless or satellite coverage. Note that the figure below does not distinguish among served, unserved, or underserved locations.

Figure 29: Recommendations for fiber vs. wireless or satellite investment by census block

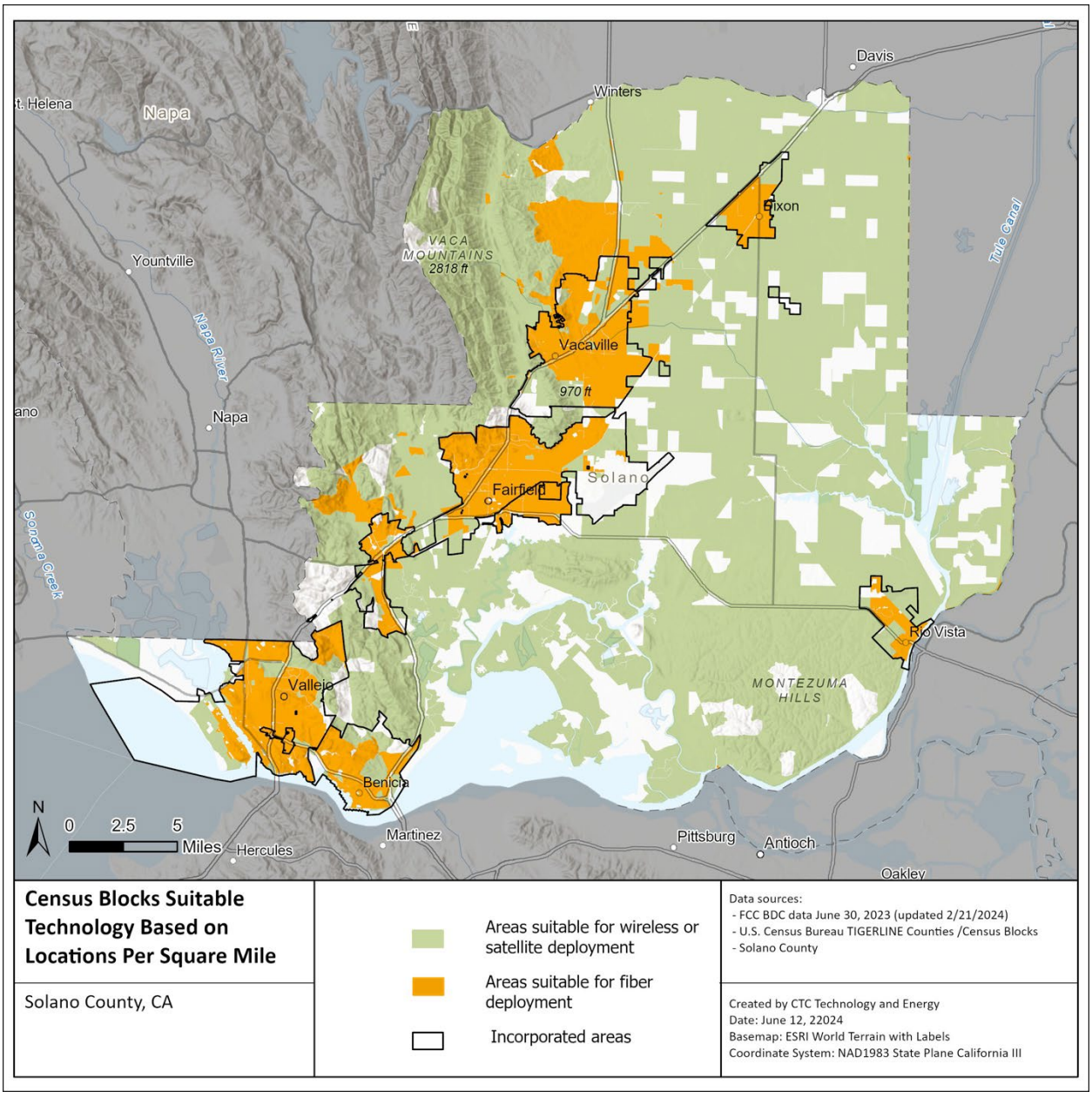


Figure 29 illustrates that areas in and around Vallejo, Vacaville, Hartley, Allendale, Cannon, and Green Valley are most suitable for fiber investment. Under this model, fiber providers can serve unserved and underserved locations using infill from existing wireline infrastructure and expansion from areas served by wireline infrastructure to adjacent areas. 788 unserved and underserved locations, comprising 36 percent of the 2,179 unserved and underserved locations

in the County,[59] are located within these areas optimal for fiber deployment (shaded blue). The metric used for this analysis was the density of locations per square mile: census blocks with 50 or more broadband serviceable locations are designated as those more likely for fiber, whereas census blocks with fewer than 50 locations are more suitable to wireless or satellite.

The one exception to this analysis was a census block containing the majority of the BSLs in the Suisun Resource Conservation District. This census block has approximately 75 BSLs per square mile that are a mix of residential, small business, and District administration buildings. Despite its density of BSLs, this census block is an "island" that is surrounded by census blocks with a lower density of BSLs. This census block is also a significant distance from the closest fiber interconnection point. These issues make it an unlikely candidate for fiber investment due to the extremely high cost to serve. Therefore, this area is excluded from the recommended areas for fiber investment and, instead, is recommended for wireless or satellite service.

To properly determine the number of unserved and underserved addresses, the analysis for optimal long-term investments should consider the enforceable commitments for projects that are in progress but have not yet been completed. As discussed previously, CAF II is the only federal or state funding program with currently awarded grants for new infrastructure in Solano County. Cal.net is required to complete its grant-funded deployment by the end of 2025 (see Section 2.4.5).

For this analysis, the unserved and underserved locations in Cal.net's CAF II funded project were removed. Only those census blocks that will be completely covered by Cal.net's CAF II project were removed, not those with partial coverage. In cases where the CAF II project will only cover a portion of the census block, all the unserved and underserved locations in that census block remain included.

Table 7 shows unserved and underserved location count by proposed technology type.

Table 7: Unserved and underserved locations by proposed technology type

Location count	Location density of census block	Proposed technology type
1,391	< 50 locations per square mile	Fixed wireless

[59] This analysis considered the enforceable commitments for service through the CAF II funding awarded to Cal.net (see Section 2.4.5) and removed those census blocks that will be completely within Cal.net's fiber and fixed wireless project when it is completed in 2025.

788	≥ 50 locations per square mile	Fiber

Figure 30 maps the 788 unserved and underserved BSLs that can potentially be served by fiber in terms of locations per square mile.

Figure 30: Proposed fiber locations by census block

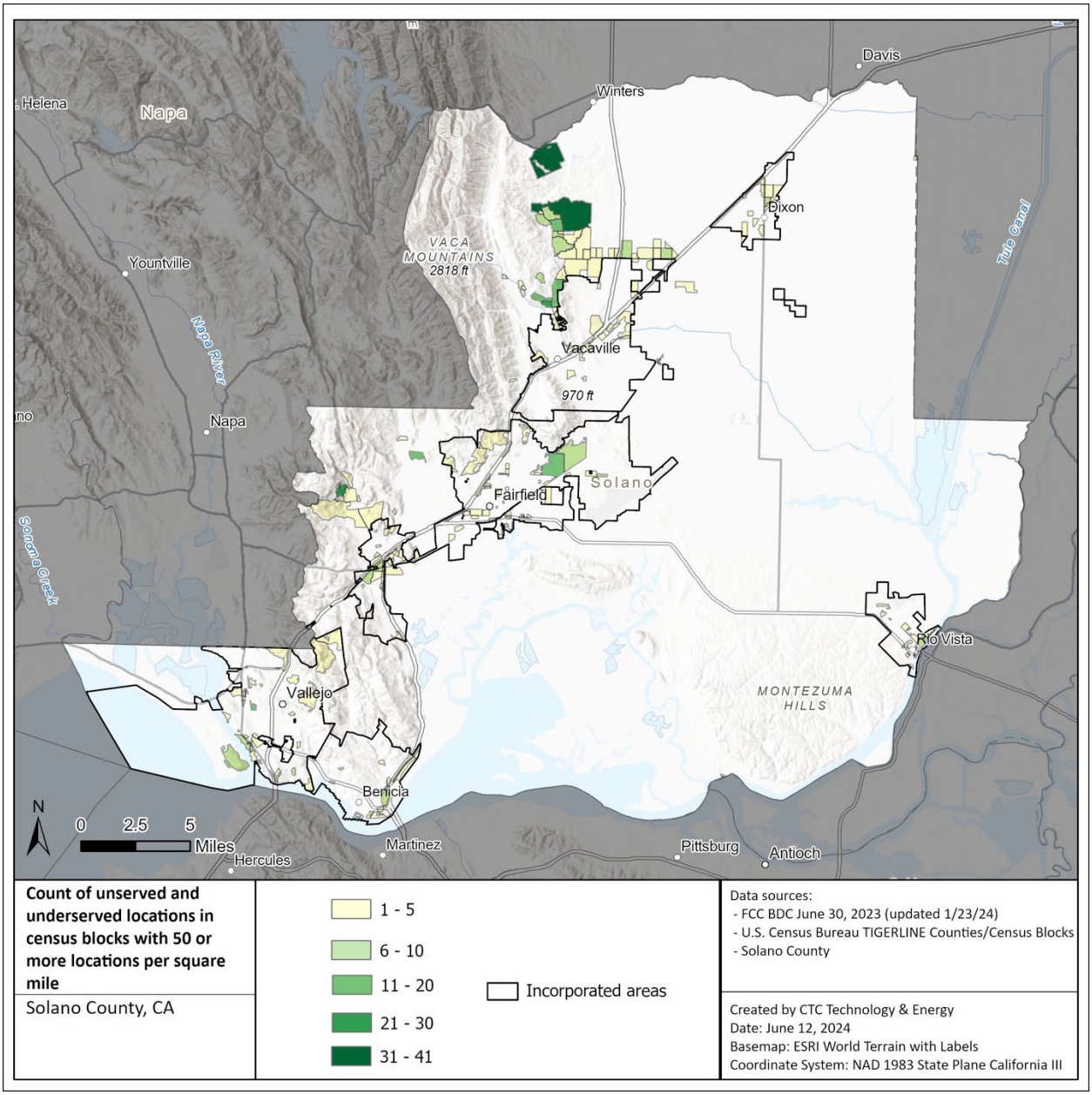
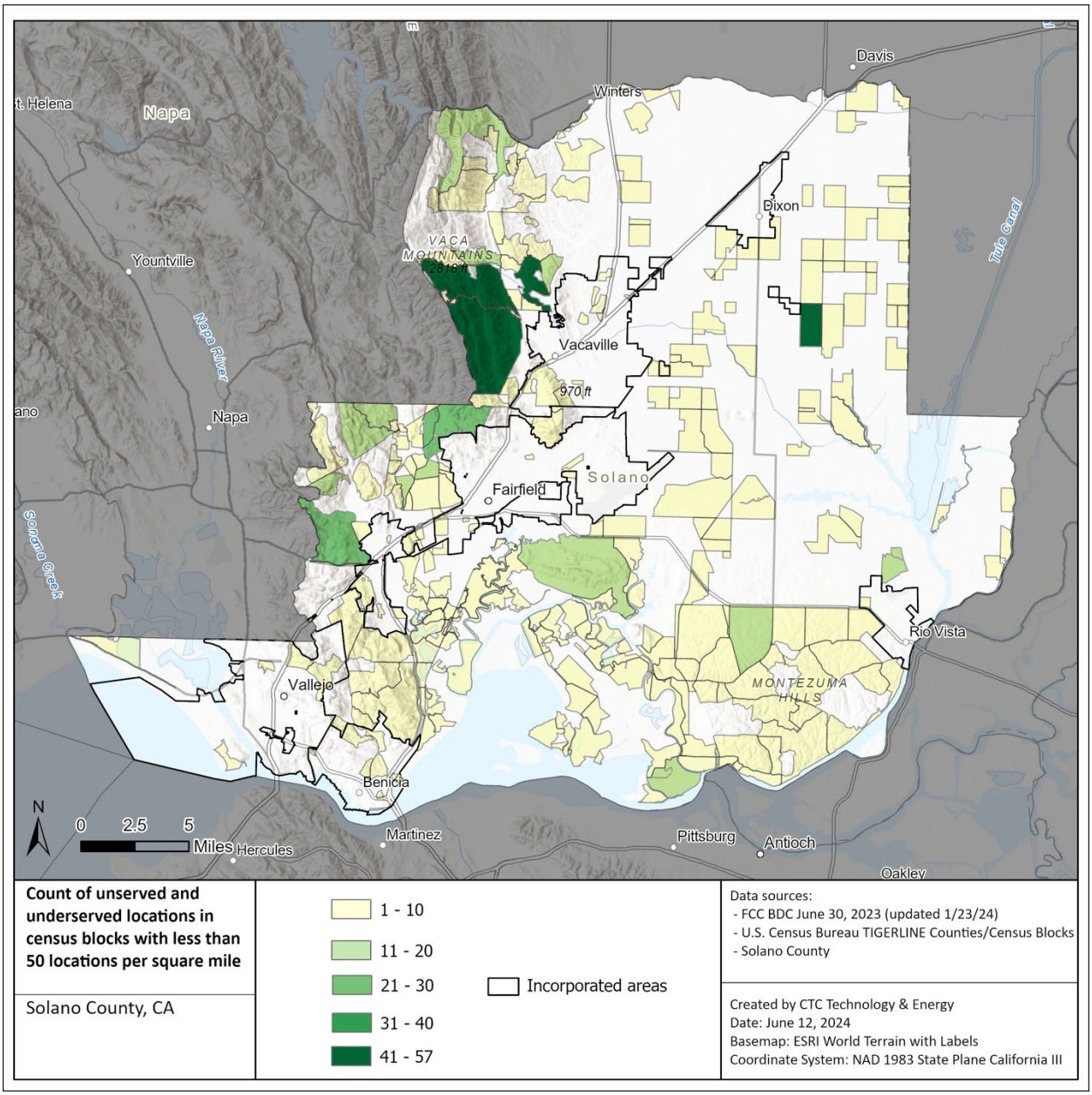


Figure 31 maps the 1,391 unserved and underserved BSLs that can potentially be served by wireless or satellite in terms of locations per square mile.

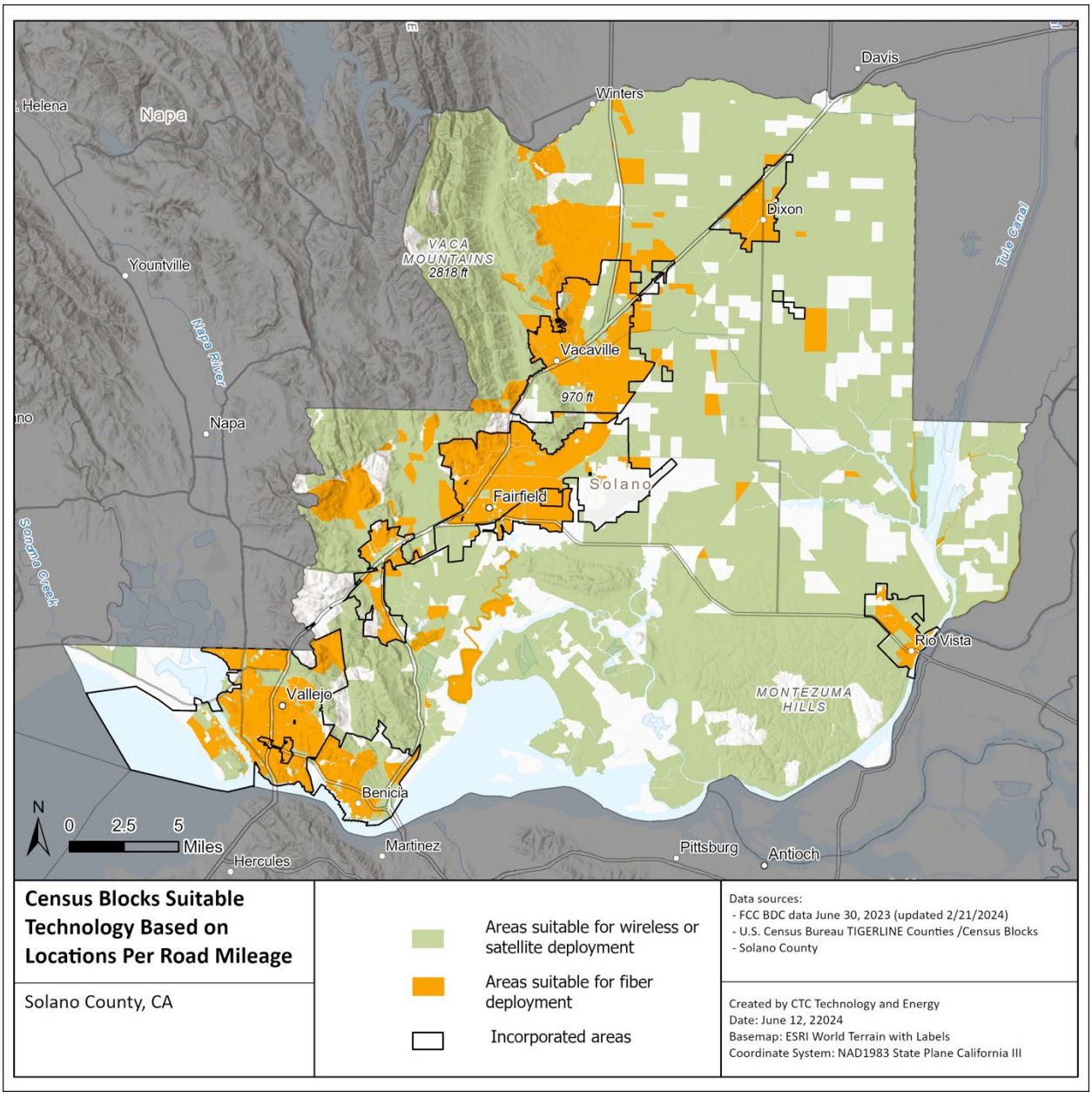
Figure 31: Proposed wireless or satellite locations by census block



An alternative to the above analysis that uses a threshold of locations per road mile, as opposed to locations per square mile (as shown in Figure 29), results in a similar recommended breakdown of areas suited to fiber versus wireless investment (see Figure 32). As discussed previously, the cost per passing to serve locations in the County with fiber becomes prohibitive at a density of

less than two locations per road mile. Areas at or above this threshold, shaded blue in the map below, are likely to be served by fiber; the green areas have less than two locations per road mile and will likely be served by wireless or satellite.

Figure 32: Recommendations for fiber vs. wireless investment by locations per road mile



3.2 Grant-funded investment opportunities

Solano County could consider leveraging upcoming opportunities through state and federal grant programs, including the BEAD, CASF, and ReConnect programs, to help achieve full broadband coverage.

3.2.1 BEAD opportunities

As discussed in Section 2.4.1, California was allocated $1.8 billion in funding under the federal BEAD program and the CPUC is in the process of designing and implementing the state's grant program. The BEAD program's primary objective is to deploy high-speed broadband using a fiber network to unserved locations (those with service of less than 25/3 Mbps), followed by underserved locations (those with service of less than 100/20 Mbps). If funding remains after these last-mile deployments, BEAD funds will be allocated to providing gigabit service to community anchor institutions that are lacking this level of connectivity. Lastly, if funds remain, BEAD funding may be used for adoption and digital equity related programs.

Relevant milestones for this funding opportunity are laid out in the BEAD NOFO as follows, although many dates are still yet to be determined:

Table 8: BEAD funding opportunity timeline

Milestone	Date
Initial Proposal Volume I and Volume II submittal to NTIA	December 27, 2023
Challenge Process	Summer 2024
Initial Proposal Volume I approval	April 4, 2024
Initial Proposal Volume II approval	TBD
Subgrantee selection	Winter 2024 – Spring 2025
Final proposal submittal to NTIA	TBD

3.2.1.1 Prioritization of fiber

If entities within the County are interested in applying for BEAD funds for infrastructure development, it is important to understand the CPUC's implementation of NTIA's requirements and criteria for application. The most important criteria for BEAD is the type of technology used.

The BEAD Notice of Funding Opportunity (NOFO) states: "With respect to the deployment of last-mile broadband infrastructure, the Program prioritizes projects designed to provide fiber connectivity directly to the end user. It also requires all projects to provide a low-cost option to eligible subscribers, requires all states to have plans to address middle-class affordability, and further prioritizes proposals that improve affordability to ensure that networks built using taxpayer dollars are accessible to all Americans."[60]

[60] BEAD NOFO, https://broadbandusa.ntia.doc.gov/sites/default/files/2022-05/BEAD%20NOFO.pdf, p. 7.

In the state's Initial Proposal, the CPUC states that one of its overarching goals is to provide 100 percent affordable connectivity to all Californians regardless of location. Given that the BEAD NOFO prioritizes fiber over other technologies, the state will establish an Extremely High Cost per Location Threshold (EHCPLT) to determine the cost per location at which fiber will or will not be deployed. Locations that exceed the EHCPLT for deployment cost will be eligible for funding for coverage with technologies other than fiber, such as licensed fixed wireless or satellite.[61]

At the time that this report was published, the EHCPLT for California was not yet determined, and therefore it is difficult to identify which unserved locations in the County would be eligible for funding of non-fiber technologies. It is also unknown exactly how the funds will be distributed among qualified applicants as NTIA has yet to approve the state's Initial Proposal,[62] which establishes the methodology for determining the disbursement of grant funding.

Once the BEAD subgrantee selection process is finalized, applications are submitted, and the EHCPLT has been established by reviewing the proposed grant funding amounts, the County may choose to meet with all ISPs and discuss their plans for projects in the County, particularly in the areas where the EHCPLT has indicated that fiber would not be feasible.

3.2.1.2 Grant applications emphasizing affordability

Other requirements that may affect the providers' decision to apply for BEAD funding include criteria around the scoring rubric for subgrantee selection.

In terms of scoring grant applications, the NTIA has predetermined a mandatory minimum of 75 percent of the scoring for three factors: cost, affordability, and labor considerations, as well as at least 1 percent for the factor of time to deploy and, for non-fiber projects only, at least 1 percent for the factor of technology capability. "The primary criteria must collectively account for no less than three-quarters of the total benefits available across all the criteria the Eligible Entity employs in choosing between or among competing proposals."[63]

Therefore, affordability is a key factor for determining which projects will get funded. Potential applicants for projects in the County will have to design and submit projects that can meet the service level requirements, long term economic sustainability, and also demonstrate a strong

[61] California Initial Proposal Volume II, December 2023, https://www.cpuc.ca.gov/-/media/cpuc-website/industries-and-topics/documents/internet-and-phone/bead-program/draft-cpuc-bead-ipv2-as-submitted.pdf, Section 5.10.
[62] "BEAD Initial Proposal Progress Dashboard," Internet for All, NTIA, https://www.internetforall.gov/bead-initial-proposal-progress-dashboard (accessed March 15, 2024).
[63] See, BEAD NOFO, Section IV.B.7.b., p. 43.

commitment to affordability, including commitment to low cost and subsidized service plans and a consideration of the local community's demographics and broadband needs.

3.2.1.3 Number of eligible locations

Based on the FCC data in Section 2.6, there are 1,629 unserved locations and 584 underserved locations in the County that could theoretically be eligible for BEAD funding. Before final determination of their qualification, these locations must be deduplicated with the CAF II approved areas and FFA approved areas. 471 of the unserved locations and 148 of the underserved locations will be served once Cal.net completes its CAF II funded project; data for any FFA projects will be taken into account once the awards are announced.

The County has obtained a Tier E CostQuest license, which gives access to the location Fabric for the National Broadband Map. This license opens the opportunity for local governments, Tribal nations, nonprofits, and ISPs to participate in the BEAD Challenge Process[64] scheduled for March 2024 to June 2024, which will allow them to dispute the eligibility of certain locations for BEAD funding. The County may choose to challenge eligibility of BEAD locations and/or may encourage other entities to do so.

Cost modeling using the more accurate and detailed location Fabric data available from the Tier E license to identify "broadband serviceable locations" may also help the County determine the most promising areas for BEAD investment.

3.2.1.4 Next steps in the BEAD process

As of the time that this report was published, the CPUC announced that the Challenge Phase of the BEAD planning would open on July 8, 2024. The Challenge Process allows permissible challengers (local governments, Tribal governments, nonprofits and broadband service providers) to challenge whether a particular location or community anchor institution on the map is eligible for BEAD funding, including whether that location is unserved or underserved.[65] After the Challenge Process, the state will do a final review of challenges and rebuttals to challenges and will make final determinations of eligibility of locations. NTIA will then review and approve the list of eligible locations for BEAD funding.

Upon NTIA approval of the state's Initial Proposal Volume II, the state will have 365 days to complete the subgrantee selection process and submit a final proposal to NTIA regarding

[64] See, "BEAD Challenge Process Policy," Internet for All, NTIA, https://www.internetforall.gov/bead-challenge-process-policy.
[65] See, BEAD NOFO, page 9, https://broadbandusa.ntia.doc.gov/sites/default/files/2022-05/BEAD%20NOFO.pdf

subgrantee selections. As of the date of this report, the Initial Proposal Volume II has not yet been approved by the NTIA.

3.2.2 CASF funding

Grants through the CPUC's California Advanced Services Fund (CASF) program will continue to be an ongoing opportunity for infilling unserved and underserved areas in Solano County. As discussed in Section 2.4.3, CASF funding is allocated to multiple accounts. Of these, the Broadband Infrastructure Grant Account and Broadband Adoption Account represent potential opportunities for the County.

3.2.2.1 CASF Broadband Infrastructure Grant Account

This grant program accepts applications each year, which are usually due in April. As of February 2024, the CPUC announced that 2023 grant applications would not be processed until June 30, 2024. As the deadline for 2024 applications is dependent on the review and approval of the 2023 applications, it has yet to be determined.[66] For FY2023/2024, the CPUC allocated $32.7 million of the CASF budget for infrastructure grant funding.[67]

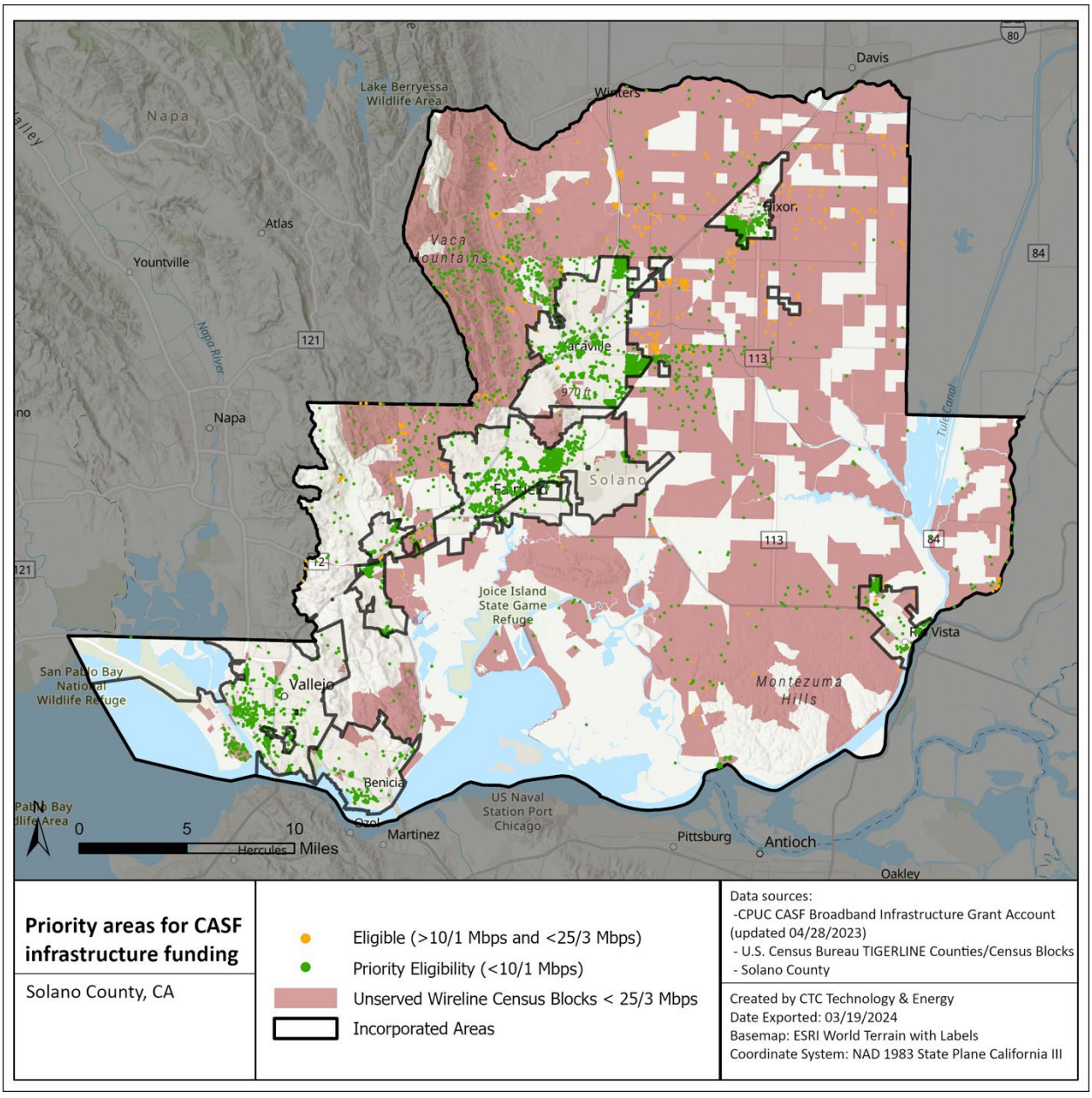
Projects eligible for the CASF Broadband Infrastructure Grant Account program differ from BEAD eligibility in a few key ways:

- CASF eligible projects are determined by the CPUC's California Interactive Broadband Map[68] as opposed to the FCC Broadband National Map;
- "Unserved" for CASF projects is defined as areas with no fixed facility-based broadband provider offering service of 25/3 Mbps or higher, with priority funding for areas with less than 10/1 Mbps;
- Applicants are required to deploy infrastructure that provides service at a minimum of 100/20 Mbps (compared to BEAD projects that must deliver 100/100 Mbps or more); and
- CASF grants do not favor fiber as highly as BEAD grants, and there is no Extremely High Cost per Location Threshold to determine the type of technology to be deployed.

[66] "Postponement of the Deadline for Action on Pending CASF Infrastructure Applications and 2024 CASF Infrastructure Application Deadline," CPUC announcement, February 15, 2024, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/communications-division/documents/casf-infrastructure-and-market-analysis/casf-infrastructure-postponement-letter-2024.pdf.
[67] CPUC, Approval of Fiscal Year 2023-24 Budget Allocations for California Advanced Services Fund, Resolution T-17782, June 8, 2023, https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M511/K159/511159823.PDF.
[68] California Interactive Broadband Map, https://www.broadbandmap.ca.gov/.

Given CASF's different eligibility requirements and parameters compared to BEAD, this program may prove useful to ISPs to build in remote areas of the County where fixed wireless deployments are more fiscally feasible. It may also provide an opportunity to build in areas (with fiber or other technologies) where cable infrastructure is outdated and does not reach speeds of at least 25/3 Mbps. Figure 33 shows areas in the County that are most likely to receive CASF infrastructure funding.

Figure 33: California Broadband Map priority areas for CASF infrastructure funding



3.2.2.2 CASF Broadband Adoption Account

This grant program is designed to support digital inclusion and broadband access projects. $20.024 million is available for FY 2023-24, and applications are due on July 1, 2024, and again on January 1, 2025.[69] After-school programs, training, and public education are all considered

[69] "California Advanced Services Fund (CASF) Adoption Account," CPUC, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/california-advanced-services-fund/casf-adoption-account.

potential uses of this program. "Low broadband access" communities, or those that have lower subscription rates than the state average, are prioritized for this account. Applicants include local governments, senior centers, schools, public libraries, nonprofit organizations, and community-based organizations.[70]

Though the County has expressed a preference to not build or own any infrastructure, it might consider becoming an applicant for the Broadband Adoption Account. Particularly in light of the sunset of the federal Affordable Connectivity Program (ACP)—which provides a monthly subsidy for the cost of broadband service to nearly 150,000 low-income households in Solano County as of February 2024[71]—the County may need funds to conduct outreach to communities in need. Possible uses of a grant may include assistance for previously ACP-eligible households in signing up for ISPs' low-cost programs, such as Comcast Internet Essentials, or funding programs to improve digital skills in the most vulnerable communities.

3.2.3 USDA ReConnect Program

As discussed in Section 2.4.4, the U.S. Department of Agriculture's (USDA) ReConnect Program provides loans and grants for construction or improvement of facilities needed to provide broadband to eligible rural areas. The fifth round of funding for ReConnect opened on March 22, 2024.

$150 million is available for ReConnect 100 percent grants in this funding round, and the maximum award is $25 million.[72] There are also scenarios for 50 percent loan/50 percent grant awards or 100 percent loans. Grantees must provide a matching contribution of cash equal to at least 25 percent of the cost of the overall project.

Requirements for eligibility include:

- At least 90 percent of households in the project area lack broadband access at a minimum of 25/3 Mbps;
- Any infrastructure built must serve all locations in the proposed service area at a minimum of 100/100 Mbps; and

[70] "Broadband Adoption Account Application Requirements and Guidelines," CPUC, May 2022, https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/communications-division/documents/casf-adoption-and-access/adoption_account/information/adoption-account-guidelines-may-2022.pdf.
[71] "Affordable Connectivity Program Enrollment Tracker," Broadband for All, https://broadbandforall.cdt.ca.gov/affordable-connectivity-program/acp-enrollment/ (accessed March 15, 2024).
[72] "Program Overview," USDA, https://www.usda.gov/reconnect/program-overview.

- Proposed service areas are rural, as defined by being in an unincorporated area outside of cities and towns, with a population of 20,000 inhabitants or more, or in an area contiguous to a city or town with a population of 50,000 or more.[73]

The ReConnect mapping tool[74] provides applicants with data and information regarding the eligibility of a proposed project. According to the tool, significant portions of the County are considered "rural" under the ReConnect guidelines and there are small areas near Fairfield and Dixon that are identified as "socially vulnerable" and could earn a project extra points in scoring. However, the FCC BDC data discussed above show that only small, isolated areas of the County meet the eligibility requirement that 90 percent of locations are unserved by broadband speeds above 25/3 Mbps—making it difficult for a ReConnect grant applicant to create an economically sustainable project.

3.3 Conceptual partnership approaches for infrastructure projects

Through its planning efforts, the County has determined that it will not build its own broadband infrastructure to serve last-mile customers. Short of this option, the County can consider business models and opportunities for investment that will effectively and efficiently expand access to broadband service throughout the County. Partners may be able to bring operational economies of scale or existing assets to the table.

This section outlines the possible scenarios for partnership for public entities. Each of the four models discussed below reflects a different role for the County as an investor in broadband and a partner to ISPs and other broadband providers.

[73] "Service Area Eligibility Requirements," USDA, https://www.usda.gov/reconnect/service-area-eligibility-requirements.
[74] "ReConnect Program Service Area Map," USDA, https://ruraldevelopment.maps.arcgis.com/apps/webappviewer/index.html?id=25591161c5634d49a70290287a1b30e7.

Table 9: Business model types

Business model	Funding source	Network operations	Service provision
1	Publicly funded/financed, owned, and controlled	Public entity ISP	
2	Publicly funded/financed, owned, and controlled	Active infrastructure contractor or ISP (one or multiple)	Multiple ISPs/open market
3	Publicly and privately funded/financed; privately owned and controlled	Active infrastructure contractor or ISP (one or multiple)	Multiple ISPs/open market
4	(Largely) privately funded/financed, privately maintained, and operated		

3.3.1 Under Business Model 1, the County or other public entity fully funds, owns, and operates the network

Under this model, the network is fully funded, owned, and operated by the public sector. Under this model the public entity may outsource some of the construction and operating responsibilities, but ultimately remains responsible for the project's success. This is the only business model in which the County would effectively have full control over all aspects of the broadband network construction, operations, and service provision. In this model the County would also fully retain the commercial (revenue) risk and all operating risk. This model also may entail higher operating costs, because the County cannot necessarily achieve economies of scale that are enjoyed by larger broadband providers.

Although this approach is not currently under consideration by the County, it can be part of a long-term planning toolkit as the County considers opportunities for future investment in targeted and focused projects.

3.3.2 Under Business Model 2, the public entity develops and maintains the network infrastructure and contracts one or multiple ISPs to provide equipment and deliver service

This model also assumes that the network is fully funded and owned by the public sector. Here too, the public entity may outsource some of the construction and maintenance responsibilities. However, instead of operating the network and providing services to end users, the County would lease access to the network, including "passive" network elements such as dark fiber and conduit, to one or more ISPs. These ISP partners would deploy their equipment, manage and maintain their portions of the network, and provision service to end users in the County.

The County would have the flexibility to structure the partnerships with the ISPs as a combination of lease fees and revenue sharing agreements to potentially partake in revenue upside scenarios. The County could also use the network for its own business operations, either serving as its own ISP or by negotiating a services agreement as part of the lease agreement with one or more of the partner ISPs.

In this model, the private ISP(s) would assume most of the commercial and operating risk and would be incentivized to provide high-quality service while compensating the County for access to the County's passive infrastructure. However, the County must monitor operations and customer satisfaction, conduct renegotiations of lease agreements, add new ISPs over time, and ensure long-term economic sustainability for the network.

3.3.3 Business Model 3 relies on the County awarding grants and low interest loans to contract with an entity to develop and maintain the active infrastructure

In this scenario, the County would make a grant or low interest loan to one or more ISPs that will make an enforceable commitment to build, own, and operate a network in the County and provide broadband to County residents.

The source of the County funding can be a federal or state program where the County is the applicant for grant or loan funding, or the County may choose to use traditional budget allocation and economic development incentives to provide the investment or seed funding to one or more ISPs. The County could target its grants, loans, or matching funding for projects in high-priority areas of the county or attach specific terms and conditions to the funding.

Through this investment, the County can incentivize ISPs to build high-speed broadband infrastructure in areas that may not have a high return on investment or that would otherwise be an unlikely area for private investment. Under this model, it is critical for the public entity to secure enforceable promises from providers for the location and technology of the infrastructure as well as commitments to affordability, reliability, and matching funds.

The private entity that receives the grant or low interest loan is taking on most of the short- and long-term risk. The County's risk level will vary depending on the size of the investment and the obligations it takes on from the source of the funding. The County will also have some administrative obligations for grant administration, reporting, and monitoring the progress of the project. However, the private entity would be the sole entity responsible for the full scope of its obligation with the City, including the long-term commitment to serve customers and maintain

the network. Under this business model, the County is maximizing its potential for long-term risk transfer through funding conditions and a project agreement with a public/private partner.

3.3.4 Under Business Model 4, the County can facilitate ISP grant projects by clearing barriers and lowering costs while incentivizing deployment projects in underserved and priority areas

In addition to models that involve a direct financial investment in the network infrastructure, the County could encourage and facilitate network infrastructure projects by lowering costs or increasing revenues for the ISP partner.

As the County engages in conversations with ISPs who may be willing to initiate projects, the County can provide a means to facilitate the ISP's plans by adopting several types of small programs or initiatives, including data analysis and asset mapping, coordinating stakeholder outreach, and gathering letters of support for the ISP for any possible grant funding for the project.

Similar to a direct investment of grants or loans to an ISP, the County could target specific areas or types by projects by coordinating its outreach and facilitation efforts with the County's broadband planning and priorities. The County can reduce costs for an ISP or increase revenue by streamlining processes and sharing data or by sponsoring digital literacy and adoption efforts, such as:

- Implementing more efficient permitting processes
- Streamlining the inspections process
- Promoting or sponsoring digital inclusion training and affordability programs through the ISP or other community organizations to support broadband adoption
- Providing access to assets, e.g., fiber, conduit, real estate, and/or vertical assets for placement of wireless facilities
- Documenting and sharing data regarding County processes and assets
- Facilitating meetings, data sharing, and potential partnerships with other County agencies

3.3.5 Since the County is not interested in building or managing infrastructure, a facilitation model is recommended

Based on the County's priority to extend reliable high-speed broadband access to unincorporated areas, the most applicable long-term approach is one of less formal partnership with ISPs. Though

the County currently has $2.2 million in ARPA funds to allocate to infrastructure projects, the County's general assumption is that it would not own or operate any aspect of the new projects. It is also important to consider that there may not be future funding for direct investments in County broadband projects beyond this ARPA opportunity.

The County's interest in partnerships is crucial to providing broadband access to unserved and underserved areas. These areas are generally sparsely populated, have a high cost of deployment, and relatively low revenue potential. Without affirmative efforts to partner with ISPs that may serve these areas—either through available matching funding and seed funding or by applying facilitation methods—it is unlikely that ISPs would have incentive to cover many of these areas, even with significant federal and state funding.

Through these partnerships, the County could incentivize potential ISP partners to commit private investment or to apply for upcoming grants to serve these isolated areas. The County could be a "silent partner" in an application submitted by an ISP through a hybrid approach of small investments and facilitation. These partnerships could include matching funding that would give the service provider priority points in scoring under several state and federal grant programs. It could also include County-owned locations for right-of-way or facilities colocation that could be seen as "in-kind" matching.

The County could also leverage projects that ISPs already have in the pipeline or may be preparing for these funding opportunities, with the County assisting in activities that will help projects meet the needs of the local community and, in doing so, enable the funding and construction of last-mile infrastructure.

Appendix A: Past efforts by the County

The County has done extensive work in the past to ensure widespread broadband coverage. Key efforts are outlined below.

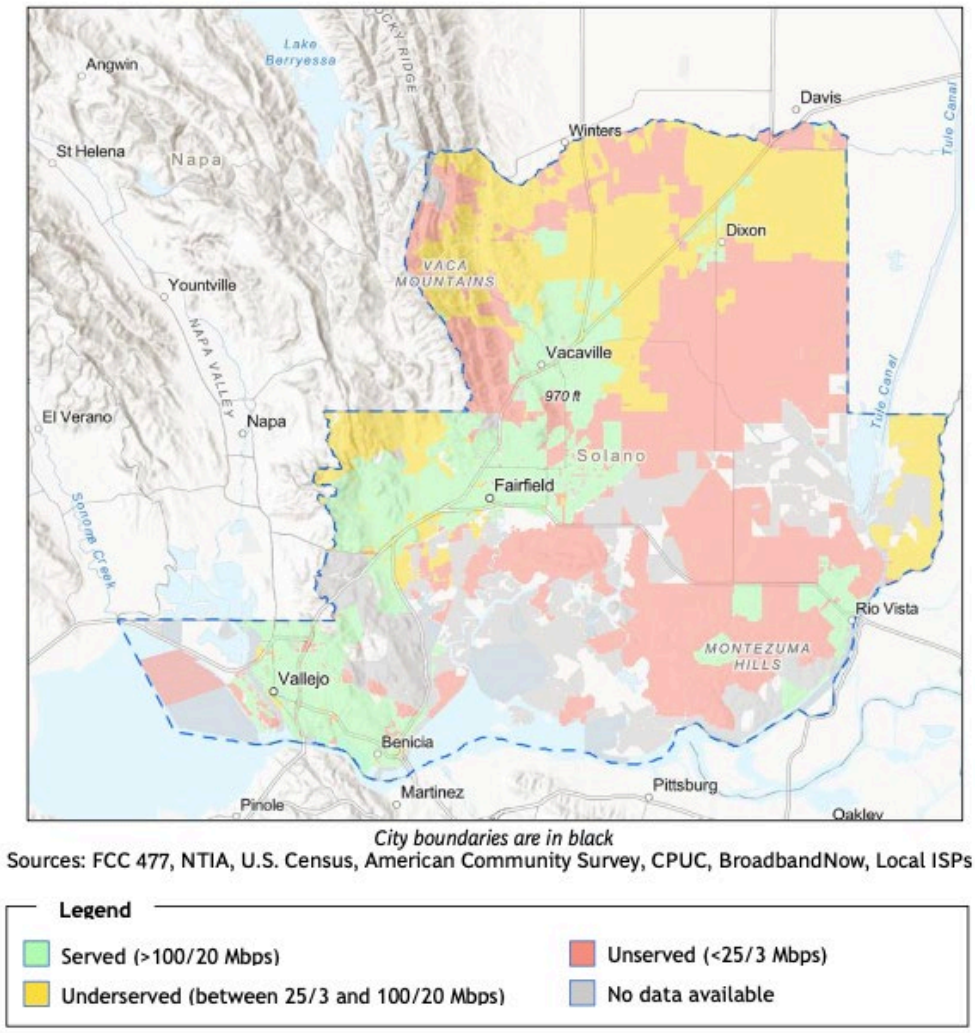
Solano Connected Roadmap

In 2022, Solano County Department of Information Technology (DoIT) hired Boston Consulting Group (BCG) to create a Broadband and Digital Equity Strategy and Roadmap.[75] In this study, BCG estimated that approximately 1,800 addresses were unserved in the unincorporated parts of the County, with broadband speeds under 25 Mbps download, 3 Mbps upload (25/3). In addition, they estimated that approximately 3,900 addresses were underserved, with speeds between 25/3 and 100/20 Mbps. Note that these estimates were made with FCC Form 477 data, which has more recently been replaced by the FCC National Broadband Map.[76] The National Broadband Map location Fabric shows coverage as reported by ISPs at an address level rather than at a census block level. The previous census block reporting was often misleading in that a provider could theoretically serve only one location in a census block and it would appear as "served."

Based on the FCC Form 477 data in 2022, BCG developed the following map showing served, unserved, and underserved areas. Served areas are generally clustered around the urban centers (see Figure 34).

[75] "Solano Connected: A Broadband and Digital Equity Strategy And Roadmap," conducted by the Solano County Department of Information Technology and Boston Consulting Group, August 2022, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=38196.
[76] National Broadband Map, https://broadbandmap.fcc.gov/home.

Figure 34: Served, unserved, and underserved areas in Solano County according to the BCG report



According to the BCG report, the largest unserved area is on the eastern side of the County, south of I-80 and bordering Dixon and Vacaville. This area is largely comprised of farmland, and includes Batavia, Yolano, Libfarm, Bunker, Binghamton, Vale, Dozier, Maine Prairie, and Olcott.

The report also listed recommendations for infrastructure projects in Solano County, which would expand the connectivity to approximately an additional 2,550 locations (see Figure 35).

Figure 35: BCG report recommendations for Solano County infrastructure projects

Supervisor District	Broadband Region *Project Name in parentheses*	Potential Impact (Buildings)
District 5[23]	Elmira (Elmira)	~101 buildings
Districts 1 & 2	Benicia-Cordelia, Jameson Canyon, and Suisun Marsh (Suisun Marsh)	~91 buildings
District 2	Green Valley (Green Valley)	~14 buildings
District 3	Suisun Valley (Mankas Corner)	~220 buildings
District 4	Dixon Rural (Union Pacific Rail to Industrial Ag Services)	~61 buildings
District 4	Allendale-Hartley (505 North of Vacaville)	~435 buildings
District 4	English Hills (English Hills)	~325 buildings
District 4	Olive School and South Winters Unincorporated (Winters Road)	~325 buildings
District 4	Pleasants Valley (Pleasants Valley)	~243 buildings
Districts 4 and 5	Dixon Rural (Dixon Migrant Center)	~388 buildings
District 5	Ryer Island (Ryer Island)	~219 buildings
District 5	Rio Vista Rural (Lambie Industrial Park)	~26 buildings
District 5	Elmira and Dixon Rural (Hawkins Road to Binghamton)	~39 buildings
District 5	Rio Vista Rural (Birds Landing to Collinsville)	~63 buildings
	Total Buildings Connected	**~2,550** buildings

These recommendations were presented to the County Board of Supervisors as the basis for two proposals to apply for CPUC Local Agency Technical Assistance funding for additional feasibility analysis and to allocate matching federal funds from the American Rescue Plan Act (ARPA) for broadband and digital equity projects in the County.

ARPA Local Fiscal Recovery Funds

In August 2022, the Solano County Board of Supervisors approved the allocation of $2.2 million of the County's ARPA funding to support last-mile broadband infrastructure to over one dozen possible areas in unincorporated parts of the County as identified by prior planning analysis funded by the County. [77] At that same meeting, the Board also approved the allocation of $1.8 million for digital equity purposes.

[77] Solano County Board of Supervisors Meeting Agenda, August 24, 2022, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=37819, citing to the "Solano Connected: A Broadband and Digital Equity Strategy And Roadmap," conducted by the Solano County Department of Information Technology and Boston Consulting Group, August 2022, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=38196 .

Eligible uses of ARPA funds

In 2021, the American Rescue Plan Act established the Coronavirus State and Local Fiscal Recovery Funds (SLFRF) Program. $350 billion in SLFRF funding was allocated to state, local, territorial, and Tribal governments to assist in recovery from the COVID-19 pandemic. Solano County received approximately $86 million in SLFRF funds.

Potential uses of these funds include the following:

- "Replacing lost public sector revenue;"
- "Responding to far-reaching public health and negative economic impacts of the pandemic;"
- "Providing premium pay for essential workers;"
- "Investing in water, sewer and broadband infrastructure"[78]

ARPA funding compliance and reporting

SLFRF compliance guidelines state that these funds must be committed before December 31, 2024, and must be expended by December 31, 2026. [79] Therefore, any infrastructure built with these funds would need to comply with this timeline. The County will need to file the following reports for overall ARPA funding:

- Project and Expenditure Report; due annually on April 30
- Recovery Plan Performance Report; due annually on July 31

The Project and Expenditure Report must include the following items: project description; obligations and expenditures (current and cumulative); project status; program income; adopted budget by project; project demographic distribution; subawards, contracts, grants, loans, transfers and direct payments; civil rights compliance; programmatic data for infrastructure projects; and additional programmatic data.

The Recovery Plan Performance Report must include the following and must be posted on a publicly available website: overview of goals and strategy; uses of funds; how funds promote equitable outcomes; community engagement; labor practices for infrastructure projects;

[78] "State and Local Fiscal Recovery Funds," U.S. Department of the Treasury, https://home.treasury.gov/policy-issues/coronavirus/assistance-for-state-local-and-tribal-governments/state-and-local-fiscal-recovery-funds.
[79] "Compliance and Reporting Guidance: State and Local Fiscal Recovery Funds," U.S. Department of the Treasury, Version: 5.4, December 14, 2023, https://home.treasury.gov/system/files/136/SLFRF-Compliance-and-Reporting-Guidance.pdf.

description of evidence-based practices and program evaluation; and performance management for projects.[80]

To meet both FFA and ARPA requirements, fiber is strongly preferred and must meet at least 100/100 speeds. If it can only deliver 100/20, there needs to be a strong justification and the technology must be scalable to 100/100. Fixed wireless may be considered for funding, but the applicant would need to demonstrate that other technologies are infeasible for the proposed locations.

CPUC LATA Funds

The Local Agency Technical Assistance (LATA) grant program was established under Senate Bill 156 in 2021 and is administered by the California Public Utilities Commission (CPUC). The program allocated $45 million for non-Tribal entities and $5 million for Tribes throughout the state for reimbursement of pre-construction expenses related to providing high-speed connections to unserved and underserved communities. Local government agencies and Tribes were eligible to apply.

Expenses that were eligible for LATA reimbursement include:

- Consulting or staff time for needs assessments, environmental and engineering studies, network design and broadband strategic plans; or
- Costs incurred in forming a joint powers authority (JPA) to bring broadband to these communities.[81]

The LATA program was closed on March 24, 2023, for non-Tribal governments after the CPUC received requests of $52.4 million in funding.

Solano County applied for and received LATA grant funding in November 2022 for up to $500,000 for its pre-construction broadband planning. The County has used this funding to develop this Handbook and the accompanying GIS report to develop a strategy for investment going forward.

The County issued a request for proposals (RFP) to consultants on April 12, 2023, to bid on a project for planning broadband infrastructure expansion in unincorporated areas with the intent

[80] "Compliance and Reporting Guidance: State and Local Fiscal Recovery Funds," U.S. Department of the Treasury, Version: 5.4, December 14, 2023, https://home.treasury.gov/system/files/136/SLFRF-Compliance-and-Reporting-Guidance.pdf.

[81] "Local Agency Technical Assistance," CPUC, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/broadband-implementation-for-california/local-agency-technical-assistance.

of using the LATA reimbursement program to fund these activities.[82] The County engaged CTC Technology and Energy (CTC) in June 2023 to assist with this project.

CPUC FFA Program

In 2021 the California State Legislature allocated $2 billion to the Federal Funding Account Program, a new last-mile funding program, to be split evenly between rural and urban areas and to be administered by the CPUC.[83] As part of its statutory mandate, the CPUC designated urban vs. rural counties based on a formula that uses 2019 data.[84] Using this formula, the CPUC categorized Solano County as an urban county and allocated $17 million under the FFA Program[85] to fund broadband infrastructure projects located in the County. The application window for the program opened on June 30, 2023, and closed on September 29, 2023.

The County itself did not apply for funding through the FFA grant program, but worked with ISPs to encourage applications, particularly in unincorporated areas.

About the FFA Program

Last-mile projects funded through the FFA program must be completed within two years of receiving authorization to construct and must provide speeds of at least 100 Mbps download, 100 Mbps upload (100/100).

The following are high-level elements of the program (note that this list is not exhaustive):

- **Eligible organizations:** Broadband service providers, local governments, electric utilities, nonprofits, cooperatives, and Tribal governments may apply. The CPUC intends to prioritize requests from local governments, nonprofits, and cooperatives, with the assumption that these networks have less pressure to generate profits and a stronger commitment to serve communities.

[82] "Request for Proposal (RFP) Number: DoIT 2023-001," Solano County DoIT, released April 12, 2023, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=40705.
[83] SB 4, Chapter 671 (October 8, 2021), Section 2 (revised Public Utilities Code Section 281(n)), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB4. The funding is mostly federal funding from the American Rescue Plan Act, including both Capital Projects Fund and State and Local Fiscal Recovery Funds funding, as well as smaller contributions of state funds.
[84] CPUC, "Decision Adopting Federal Funding Account Rules," (D.22-04-055), Order Instituting Rulemaking Regarding Broadband Infrastructure Deployment and to Support Service Providers in the State of California, Rulemaking 20-09-001, April 22, 2022, pp. 32-35 ("FFA Decision"), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M470/K543/470543650.PDF.
[85] FFA Decision, at p. 35.

- **Eligible areas:** The FFA program determines eligibility based on the current performance of broadband service options in an area, and allows further prioritization based on other key digital equity factors. Non-contiguous projects may be submitted as a single project. Unserved areas according to the Federal Funding Account Map can be found at this link: https://federalfundingaccountmap.vetro.io/map#5.65/37.393/-116.87
- **General eligibility:** Applicants can apply for projects in areas where "no wireline broadband provider reliably offers broadband service at speeds of at least 25 Mbps downstream and 3 Mbps upstream to the entire community" or where a community is served by "legacy technologies" over copper facilities or cable system technology of DOCSIS 2.0 or lower.[86] The CPUC will determine if an area is unserved through a variety of data sources regarding broadband performance and speeds offered by the existing legacy technologies serving the area.[87] An applicant can include locations that show as "served" on the availability map if the applicant can demonstrate that service in those locations is "unreliable."[88]
- **Legacy technologies = unserved:** The CPUC has adopted a "rebuttable presumption" that specifies that areas with only copper facilities or cable system technology of DOCSIS 2.0 or lower are designated as "unserved" and eligible for funding. Incumbent ISPs and network owners will be allowed to rebut this assumption by an evidence-based showing that the network in question offers reliable service to all locations of at least 25/3 Mbps.[89] Additionally, even where the incumbent demonstrates speeds of 25/3 Mbps, the Commission may use its discretion to declare the area eligible for funding if the incumbent ISP cannot show that the network is providing speeds of at least 100/20 Mbps to the subject location(s). In this case, the burden will be placed on the ISP to demonstrate that speeds of 100 Mbps upload are not practicable at those locations.[90]
- **Prioritization:** The CPUC awarded up to 20 points to applicants proposing to serve areas that meet certain socioeconomic indicators.[91] These indicators are:[92]

[86] FFA Decision, at p. 20; FFA Decision, Appendix A, at p. 8 (legacy technology is deemed unreliable, definition of "unserved").
[87] FFA Decision, Appendix A, at p. 8 (definition of "unserved").
[88] See, FFA Decision, at pp. 20-21 (this could include challenging a fixed wireless provider's performance claims of its infrastructure).
[89] See, FFA Decision, at p. 20.
[90] See, FFA Decision, Appendix A, at p. A-21-22.
[91] See, FFA Decision, at p. 20; Appendix A, at p. A-7.
[92] "Frequently Asked Questions: CPUC Federal Funding Account, Last Mile," CPUC, April 2023, at pp. 4-5, https://www.cpuc.ca.gov/-/media/CPUC%20Website/Files/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Communications_-_Telecommunications_and_Broadband/FFA%20Webpage%202023-04/FFA%20FAQs%20V2.pdf.

1. The Disadvantaged Households Index from the CalEnviroScreen developed by the California Office of Environmental Health Hazard Assessment[93]
2. Census Bureau Median Household Income data.[94]

- **Network buildout requirements:** Funded projects must reliably provide service speeds of 100 Mbps symmetrical, have a latency under 100 milliseconds, and must offer services with at least 1,000 GB of data a month (with strong preference for unlimited data). Applicants can include a proposal to build middle-mile infrastructure if demonstrated as necessary to achieve last-mile connectivity. Funded middle-mile projects must be open access with multiple interconnection points. Projects must be complete within 24 months after authorization to build.
- **Service offering requirements:** Projects must cap service prices for five years after project completion at the rates proposed in the application and must waive installation charges. Only adjustments of rates in accordance with the Consumer Price Index are allowed. Applicants must participate in the Affordable Connectivity Program or other analogous low-income subsidies for service.
- **Grant administration:** There are significant quarterly and annual reporting requirements regarding project progress, financial status, and subscriptions; post-closeout reporting will also be required. Payment will be issued upon percentage completion of milestones (10 percent, 35 percent, 60 percent, 85 percent, 100 percent).
- **Scoring Criteria for FFA:** Applicants can receive additional scoring priority by meeting these optional elements:
    1. **Match (up to 10 points):** FFA does not require a match, but a larger match or matches from diverse sources will provide additional points
    2. **Fiber (up to 10 points):** Strong preference for all fiber projects; applicants can justify the use of a different wireline technology with additional evidence and documentation that fiber is infeasible
    3. **Partnership with public, nonprofit, or Tribal entities (up to 20 points):** Networks "owned, operated by or affiliated with" a Tribal entity, local government, or

[93] "CalEnviroScreen 4.0," California Office of Environmental Health Hazard Assessment, https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40.

[94] FFA Decision, Appendix A, at p. 15 (Section 9.5); See also, CPUC Federal Funding Account Public Map, "Median income dataset is from the California Department of Finance's 5-year estimates based from the 2016-2020 American Community Survey, which can be downloaded from https://dof.ca.gov/reports/demographic-reports/american-community-survey/. "

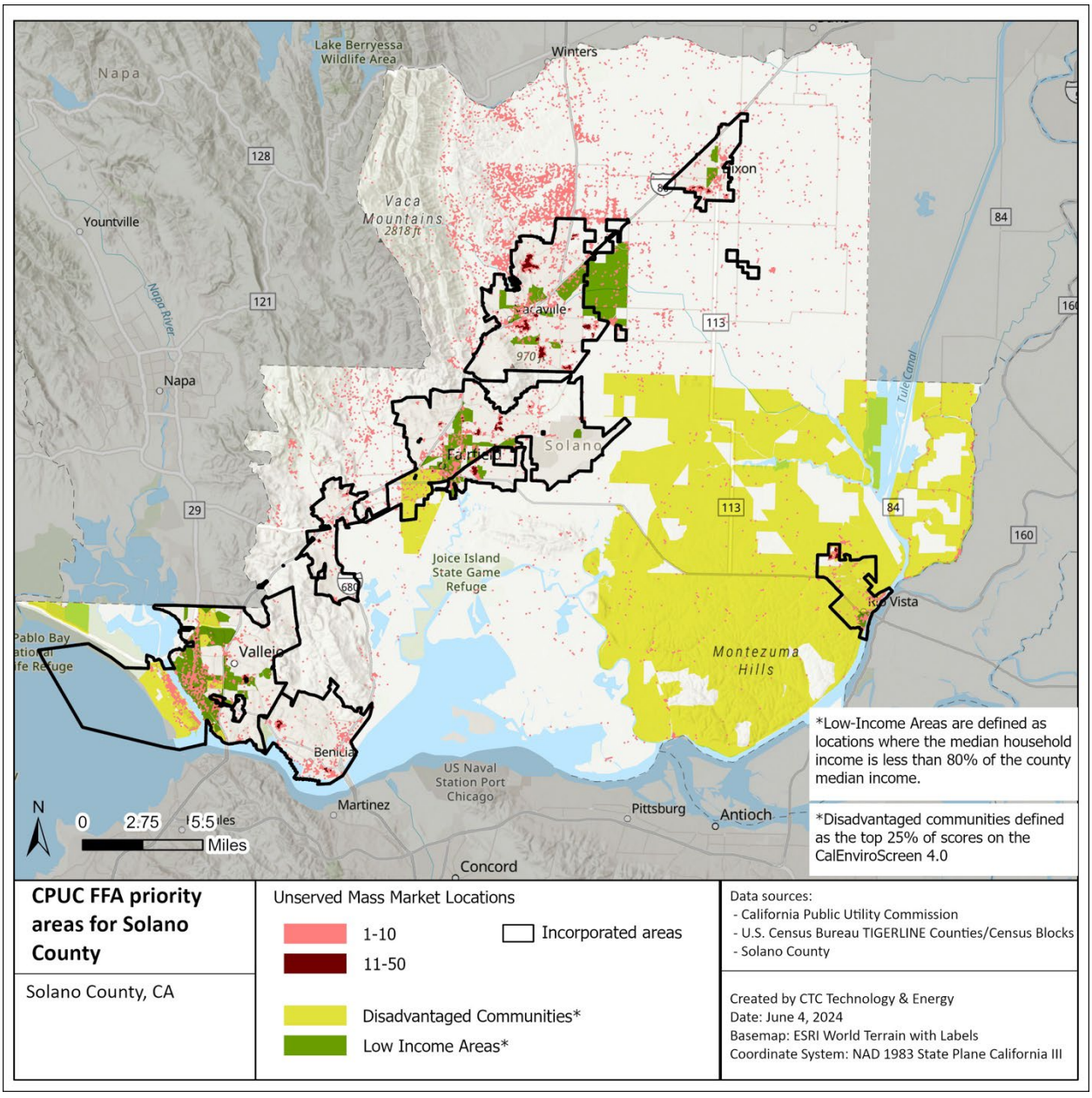
nonprofit will receive additional points; letters of support from public agencies will provide some additional points

4. **Participation in the federal and/or state Lifeline programs (up to 10 points)**
5. **Price freeze for up to 10 years (up to 10 points):** Price freeze of rates for a minimum of five years is required; longer freeze will provide additional point
6. **Low-cost broadband service offering (up to 20 points):** "Low-cost" is defined as no more than $40 per month for 50/20 Mbps
7. **Projects serving disadvantaged communities (up to 20 points):** "Disadvantaged communities" identified with different socioeconomic indicators that appear on the Federal Funding Account Map
8. **Applicant demonstrates financial, technical, operational capacity (up to 10 points):** Applicants must provide three years of financial statements and five years of proforma forecasts

CPUC mapping

As mentioned above, the CPUC determines eligible areas using its own mapping of priority areas. Unlike the FCC National Broadband Map, the CPUC FFA priority areas map also includes layers that show disadvantaged communities according to CalEnviroScreen and locations where household income is less than 80 percent of the County median income. Figure 36 shows the disadvantaged communities and low-income areas as defined by the CPUC in addition to the unserved address-level locations. This map can help prioritize areas for infrastructure expansion, for both ISPs and the County. The shaded areas with the highest density of unserved locations will likely have the highest chance of getting funded from the $17 million overall allocation for Solano County.

Figure 36: CPUC FFA priority areas map for Solano County



Solano County RFI

Purpose of RFI

To support expanding coverage in unserved areas, the County developed a strategy to gauge interest from ISPs and encourage them to apply for FFA funds to defray the costs of new project

buildouts. An additional incentive was provided by the prospect of matching funds from the County of up to $2.2 million, utilizing its ARPA funding allocated for broadband infrastructure.[95]

The County issued an RFI in August 2023 that was designed as the first requirement for ISPs to qualify for matching funding. The RFI was designed to solicit responses from ISPs for potential fiber buildouts (not fixed wireless) to unserved and underserved areas in unincorporated areas for which the County would provide financial support or letters of support. The County's intent was to develop a short list of possible partnerships and projects prior to the FFA application deadline on September 29, 2023. The County also sought to enable FFA grant applicants to provide stronger proposals to ensure as many eligible locations in the unincorporated areas of the County were covered as possible.

The RFI stipulated that 1) ISPs must respond, 2) they must apply for the FFA program, and 3) they must receive an FFA grant to be considered for the matching ARPA funds from the County (not to exceed $2.2 million in total). Since the CPUC does not grant funding to more than one provider in a census block for the FFA program, there would be no overlapping of matching funds. If two ISPs competed for the same area, only the awardee would be eligible for the match. The responses were due by August 11, 2023, and were evaluated by the following criteria: 50 points for experience and qualifications and 50 points for approach and management plan.

All five of the ISPs approached responded to the RFI; however, Astound did not submit its actual project plan. The responses are summarized below.

Identification of potential project areas

The BCG report prioritized the following locations as possibilities for extensions from providers in adjacent areas.[96] This is not an exhaustive list and does not cover every location currently determined as unserved by the CPUC's map broadband data maps or the FCC National Broadband Map.[97] During the County's RFI process for matching funds, ISPs were encouraged to consider these areas as part of a proposed project for FFA funding, but to also look more broadly at County needs.(Please note that only unincorporated areas were considered in this analysis and DSL options were not included.):[98]

[95] ARPA funds may also be allocated to purposes other than FFA matches.
[96] The BCG Report states that its analysis relies on data from FCC Form 477, NTIA – Indicators of Broadband Need, California Public Utilities Commission (CPUC), BroadbandNow, internet service provider (ISP) data, and spatial data stored by Solano County.
[97] National Broadband Map, https://broadbandmap.fcc.gov/.
[98] Solano Connected Roadmap, p. 31, https://www.solanocounty.com/civicax/filebank/blobdload.aspx?BlobID=38196

Table 10: Priority areas identified by BCG report

Unserved location	Service providers in adjacent areas
Elmira	Comcast (cable) AT&T (DSL)
Suisun Marsh	Comcast (cable)
Green Valley	Comcast (cable)
Suisun Valley (Mankas Corner)	Valley Internet (fixed wireless)
Dixon	Cal.net (fixed wireless)
Allendale-Hartley	Cal.net (fixed wireless) DigitalPath (fixed wireless) Verizon (fixed wireless)
English Hills	Cal.net (fixed wireless) DigitalPath (fixed wireless) Valley Internet (fixed wireless)
Olive School and South Winters	Cal.net (fixed wireless) DigitalPath (fixed wireless) T-Mobile (fixed wireless)
Pleasants Valley	Cal.net (fixed wireless) DigitalPath (fixed wireless) T-Mobile (fixed wireless)
Ryer Island	DigitalPath (fixed wireless)
Rio Vista	Comcast (cable) DigitalPath (fixed wireless)

AT&T response

AT&T proposed an FTTP buildout but did not supply maps or specific areas for its FFA application.

The company has a long history of providing internet service through both copper and fiber infrastructure, with fiber deployments for the past 10 years. It has robust marketing and project management capabilities and serves over 19.7 million consumers and over 3 million businesses.[99] The Access from AT&T program offers qualifying low-income subscribers a service option for $30 per month and the company also participates in the ACP.

Comcast response

Comcast also proposed an FTTP buildout that would provide speeds of up to 1 GB symmetrical for the newly served areas. The proposed projects would be completed within 18 to 24 months

[99] Letter from AT&T to Solano County dated August 11, 2023.

of initiation. In response to the RFI, Comcast considered three projects that would cost a total of $55.1 million.[100]

- Suisun Valley Wine Trail / Elmira: Elmira, Green Valley, Mankas Corner
  FFA Subsidy Request: $5.8 million (90 percent)
  Comcast Match: $0.7 million
  324 households, 21 businesses
- Nut Tree: English Hills, Gibson Canyon, I505 N
  FFA Subsidy Request: $20.6 million (80 percent)
  Comcast Match: $5.2 million
  1,335 households, 5 businesses
- Rolling Hills: Winters Rd, Pleasant Valley
  FFA Subsidy Request: $22.9 million (100 percent)
  Comcast Match: $0 million
  486 households, 2 businesses

Comcast actually submitted only two applications: for the Suisun Valley Wine Trail project, requesting $6,587,350 for 239 mass market unserved locations and for the Solano Nut Tree project requested $12,651,291 for 1,103 mass market unserved locations. Comcast did not request matching funds from the County.

The company has over 32.2 million broadband customers to date. [101] Comcast participates in the ACP and has two low-cost service options for qualifying low-income subscribers: Internet Essentials and Internet Essentials Plus.

Cal.net response

Cal.net considered five projects for FFA funding but submitted only one application to the CPUC for three different areas of the County to be covered in fiber. It also considered other projects that were too remote to serve with fiber and would have been feasible with fixed wireless, but since the CPUC favors fiber for this program, those projects were not submitted. Cal.net also considered points at which it could leverage the California Middle-Mile Broadband Initiative. The original project list included the following for consideration:

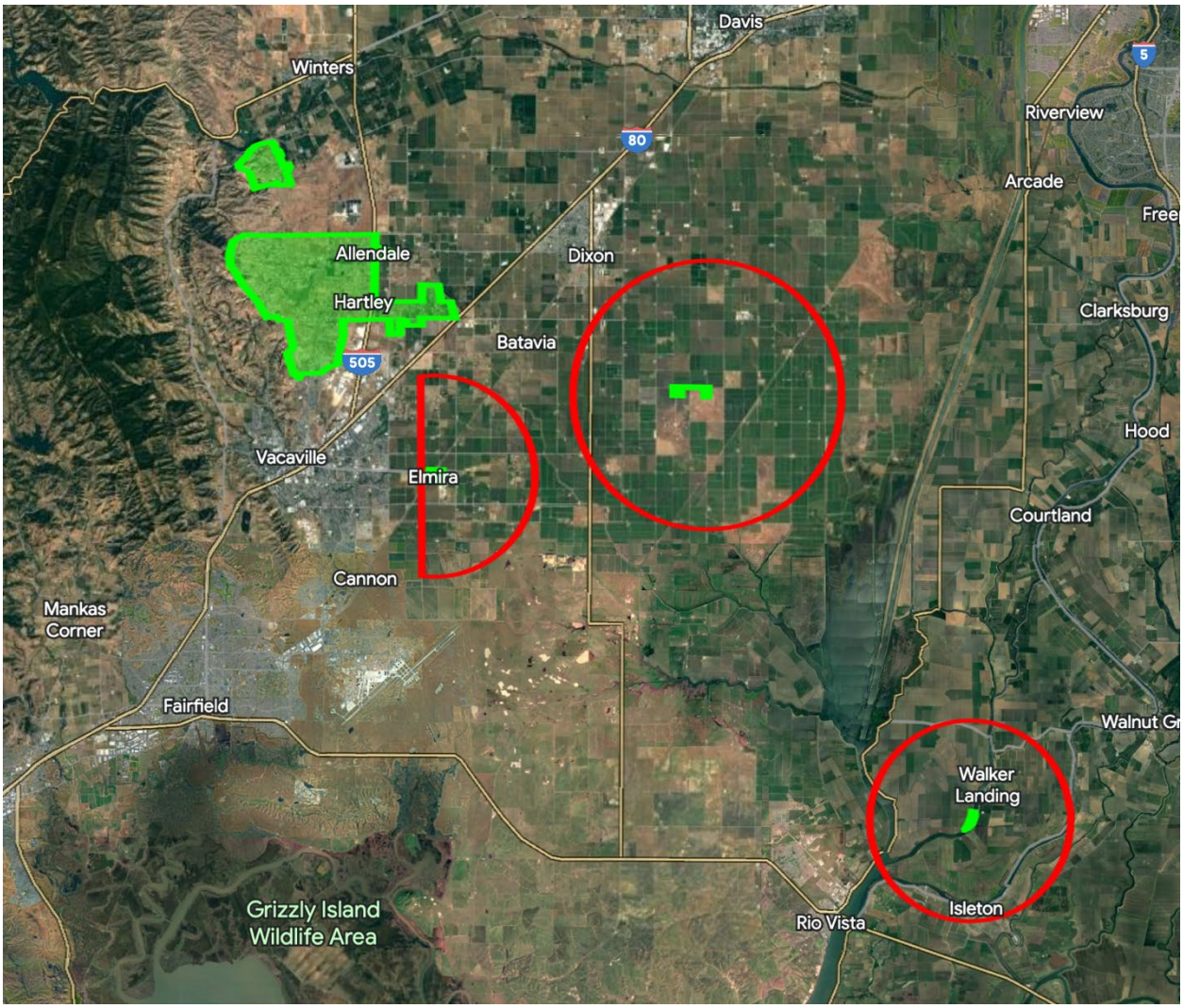
- Elmira, 76 locations
- Dixon Migrant Center, 96 locations

[100] Response from Comcast to Solano County dated August 11, 2023.
[101] Response from Comcast to Solano County dated August 11, 2023.

- Snug Harbor (Ryer Island), 45 locations
- Allendale-Hartley, 1,253 locations
- Olive School Lane/South Winters, 117 locations

The map below shows the proposed coverage area of fiber in green and potential coverage with added fixed wireless within the red border that was submitted with its RFI response to the County on August 11, 2023. Note that Cal.net's actual FFA program coverage area is shown in Figure 37.

Figure 37: Proposed coverage area from Cal.net

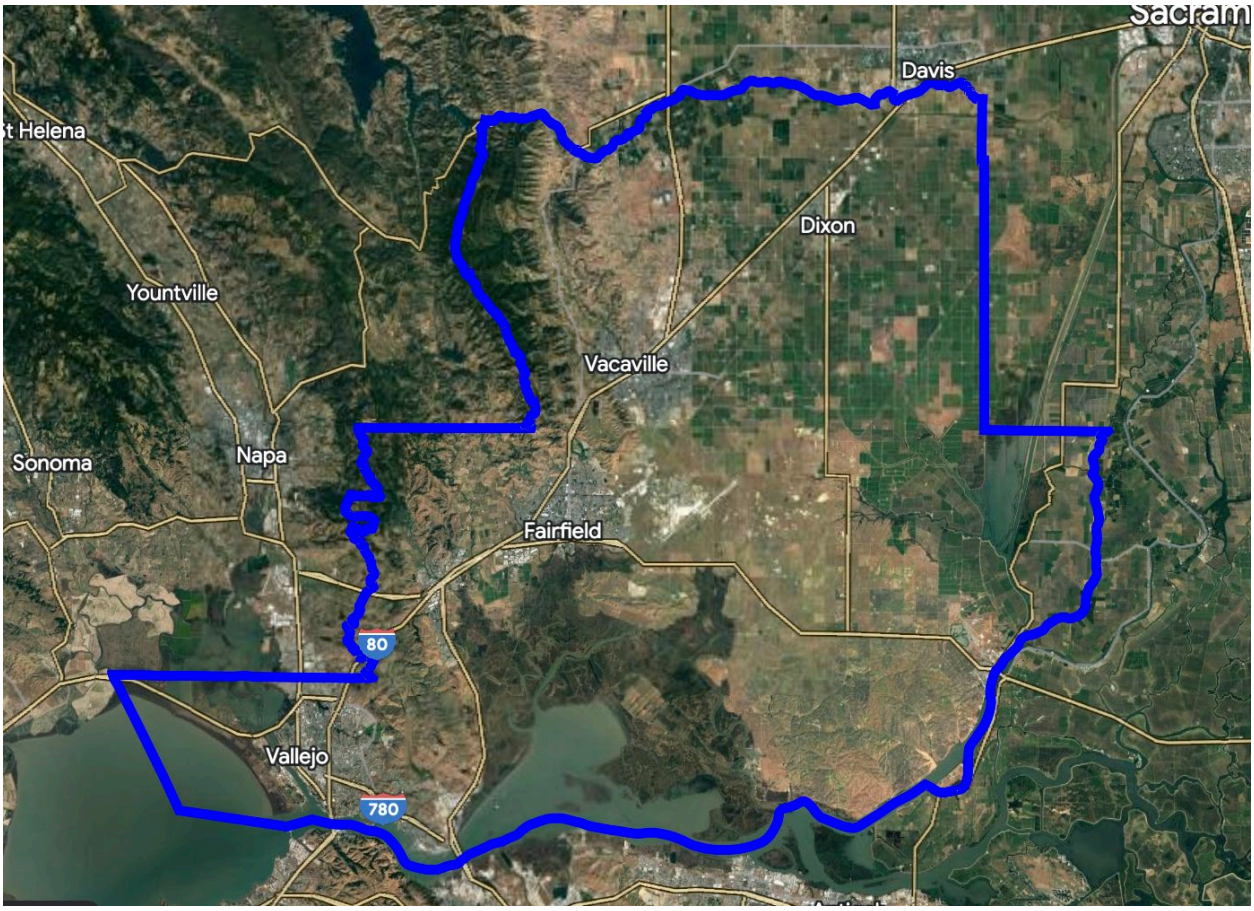


Previously, the company has been awarded a CASF grant, a Connect America Fund II grant, and an NTIA Tribal Broadband Connectivity Program grant.

Valley Internet response

Valley Internet is a fixed wireless provider that has already deployed infrastructure in Suisun Valley. The company claims that the only way to build new infrastructure in unincorporated areas of the County within a reasonable timeframe and budget is by applying a hybrid approach of fiber infrastructure to towers and last-mile fixed wireless to the home. Based on the FFA program's strong preference for fiber and Valley Internet's preference for wireless technology, the company did not apply for FFA funding. Based on discussions with Valley Internet, it could provide broad coverage throughout Solano County as shown in Figure 38 for an approximate budget of $3.075 million with its hybrid technology approach.

Figure 38: Proposed coverage area for Valley Internet



Appendix B: GIS report

Overview of data sources

The broadband coverage analysis in this Handbook utilizes multiple data sources, which are described in more detail below.

FCC and CPUC mapping data

Analysis of the current service availability in Solano County is primarily based on publicly available data, including the FCC's National Broadband Map, the U.S. Census Bureau's American Community Survey (ACS), and the CPUC's broadband service availability mapping data. ACS and CPUC data are updated once a year.

FCC Broadband Data Collection

While there are other public broadband availability datasets, this Handbook relies on the FCC's National Broadband Map as the primary source because it provides the most granular, current, and comprehensive national data regarding broadband services. Wireline and wireless service providers are required to report service availability data via the FCC's Broadband Data Collection portal twice a year to populate the map. The dataset of locations used to build the map is referred to as the Fabric.[102]

The FCC has established an ongoing challenge process for both service availability and location data to refine the National Broadband Map,[103] which may impact the reported coverage in the County. The FCC updates service availability data as challenges are resolved[104] and issues new versions of the National Broadband Map on approximately May 31 and November 30 of each year.[105]

As discussed above, priority areas for federal BEAD funding are determined based on the FCC's mapping; areas with reported speeds of less than 25/3 Mbps on the FCC map are designated as

[102] "Broadband Data Collection," FCC, https://www.fcc.gov/BroadbandData.
[103] For a summary of the challenge process see, "Broadband Data Task Force Seeks Comment On The Broadband Data Collection Challenge Processes," WC Docket Nos. 11-10, 19-195, FCC public notice released January 19, 2024, https://docs.fcc.gov/public/attachments/DA-24-64A1.pdf.
[104] "Broadband Data Collection," FCC, https://www.fcc.gov/BroadbandData; see, "What's on the National Broadband Map?" revised November 30, 2023. Expected release dates for the updated National Broadband Map are on May 31 and November 30 of each year.
[105] Federal Communications Commission, Public Notice DA 23-69, January 25, 2023, https://docs.fcc.gov/public/attachments/DA-23-69A1.pdf (accessed February 20, 2023).

"unserved" and areas with reported speeds of between 25/3 Mbps and 100/20 Mbps are "underserved."

The map utilizes a base Fabric of "broadband serviceable locations" (BSL), which are defined as "a business or residential location in the United States at which mass-market fixed broadband Internet access service is, or can be, installed."[106] BSLs are structures, not addresses. A single structure, such as an apartment building or a small office building, may have multiple units—i.e., addresses—but will be designated as one BSL. Secondary structures such as garages, accessory dwelling units (ADU), or non-residential buildings on a farm are not considered separate BSLs. By counting MDUs as a single BSL, the FCC assumes that all the households or units within a single structure are served by similar levels of broadband speeds and service availability.

Locations that include a single large business or multiple businesses that require enterprise-grade services, such as a manufacturing facility, large office building, or corporate campus, are not counted as BSLs. These locations do not rely on mass-market broadband internet service and are not counted as served or unserved locations. Certain types of community anchor institutions such as libraries, schools, government buildings, and community centers are also considered enterprise customers and, therefore, not counted as a BSL.[107]

CPUC Broadband Mapping

In addition to the FCC maps, this analysis also uses service availability data published by the CPUC. The CPUC publishes two service availability maps based on data reported by ISPs, data from other state funding programs, demographic data, Census data, and socio-economic data built as layers into the maps.[108]

In contrast to the FCC, the CPUC only considers broadband serviceable locations that are unserved by speeds of 25/3 Mbps as eligible for funding through its state grant programs.

The CPUC relies on the California Interactive Broadband Map to determine eligibility of locations for its CASF grant program. This map defines any location or area served by speeds of greater

[106] FCC Broadband Data Collection (updated 7/18/2023), https://help.bdc.fcc.gov/hc/en-us/articles/16842264428059-About-the-Fabric-What-a-Broadband-Serviceable-Location-BSL-Is-and-Is-Not.
[107] "About the Fabric: What a Broadband Serviceable Location (BSL) Is and Is Not," FCC Broadband Data Collection, updated July 18, 2023, https://help.bdc.fcc.gov/hc/en-us/articles/16842264428059-About-the-Fabric-What-a-Broadband-Serviceable-Location-BSL-Is-and-Is-Not.
[108] "CPUC Annual Collected Broadband Data," CPUC, https://www.cpuc.ca.gov/industries-and-topics/internet-and-phone/broadband-mapping-program/cpuc-annual-collected-broadband-data.

than 25/3 Mbps—by any wireline or fixed wireless technology—as served. The CPUC further identifies locations served by less than 10/1 Mbps as "priority" areas for funding.[109]

The CPUC has developed a separate map specifically to support its FFA grant program.[110] The Federal Funding Account Public Map relies on FCC broadband deployment data and data reported by ISPs directly to the CPUC, as well as other demographic and socioeconomic data. This map uses different thresholds and criteria to define areas that are "unserved" than the FCC National Broadband Map or the CPUC's California Interactive Broadband Map.

The FFA Public Map shows a location as "unserved" if the location lacks access to reliable broadband speeds of at least 25 Mbps download and 3 Mbps upload or if the location is served only by "legacy technologies" such as DSL or cable technology utilizing DOCSIS 2.0 or lower. The map also shows any area or location served solely by fixed or mobile wireless to be "unserved." The map determines a location served by legacy or wireless technology to be unserved regardless of the speeds that an ISP may report to either the FCC or the CPUC.[111]

As a result of this broader definition of "unserved locations," the CPUC's FFA Public Map identifies a larger number of unserved locations than the FCC's National Broadband Map or the CPUC's California Interactive Broadband Map. The CPUC allows providers to present an evidence-based challenge to the determination that an area is unserved, including those areas served by legacy technologies.

The FFA Public Map has additional layers that include socio-economic and demographic data, including depiction of "disadvantaged communities" as defined by the CalEnviroScreen 4.0 analysis.[112] The CPUC uses these CalEnviroScreen data to prioritize funding for communities that are in the 25 percent of highest scoring census tracts identified as "disadvantaged."[113] The map also takes into account Census Bureau median household income data and prioritizes areas with median household income at less than 80 percent of the county median household income.

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[109] California Interactive Broadband Map, https://www.broadbandmap.ca.gov/.
[110] Federal Funding Account Public Map, version 2, https://federalfundingaccountmap.vetro.io/map#5.65/37.393/-116.87
[111] See, CPUC, "Decision Adopting Federal Funding Account Rules," (D.22-04-055), Order Instituting Rulemaking Regarding Broadband Infrastructure Deployment and to Support Service Providers in the State of California, Rulemaking 20-09-001, April 22, 2022, pp. 32-35 ("FFA Decision"), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M470/K543/470543650.PDF, at p. 20.
[112] Federal Funding Account Public Map, version 2, https://federalfundingaccountmap.vetro.io/map#5.65/37.393/-116.87.
[113] "CalEnviroScreen 4.0," California Office of Environmental Health Hazard Assessment, https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40.

The FFA Public Map also shows the proposed funding areas for each of the grant applications submitted under the FFA program. As discussed, the CPUC's $2 billion FFA program allocated $17 million to Solano County to fund broadband infrastructure projects prioritizing fiber. During the application window, 12 applications were submitted for projects in the County totaling over $53 million in proposed grants. The CPUC is expected to announce grant recipients under the FFA program in the second quarter of 2024.

Ookla speed tests

In addition to the public broadband availability data from the FCC and the CPUC, this report relies on a dataset purchased from Ookla to obtain speed test results in Solano County. The dataset includes test data from August 1, 2023, through February 29, 2024. Speed tests are broken out by provider and include both wireline and wireless tests.

The number of tests by provider is as follows:

Table 11: Ookla speed tests conducted in Solano County

Internet Service Provider	Number of Tests
XFINITY	64,345
AT&T Internet	25,749
T-Mobile	6,173
Verizon	6,129
SpaceX (Starlink)	4,184
Astound Broadband powered by Wave	3,670
AT&T Fiber	1,588
Cogent Communications	1,548
Comcast Business	1,346
AT&T Wireless	1,141
Valley Internet	471
Cal.net	301
Frontier	202
HughesNet	103
Sonic	94
Succeed.Net	94
TPx Communications	79
Onward	69
Viasat	38

FCC coverage maps

The following maps show areas of fiber coverage in Solano County in additional detail.

Figure 39: Fiber coverage in Vallejo at 100/20 or greater

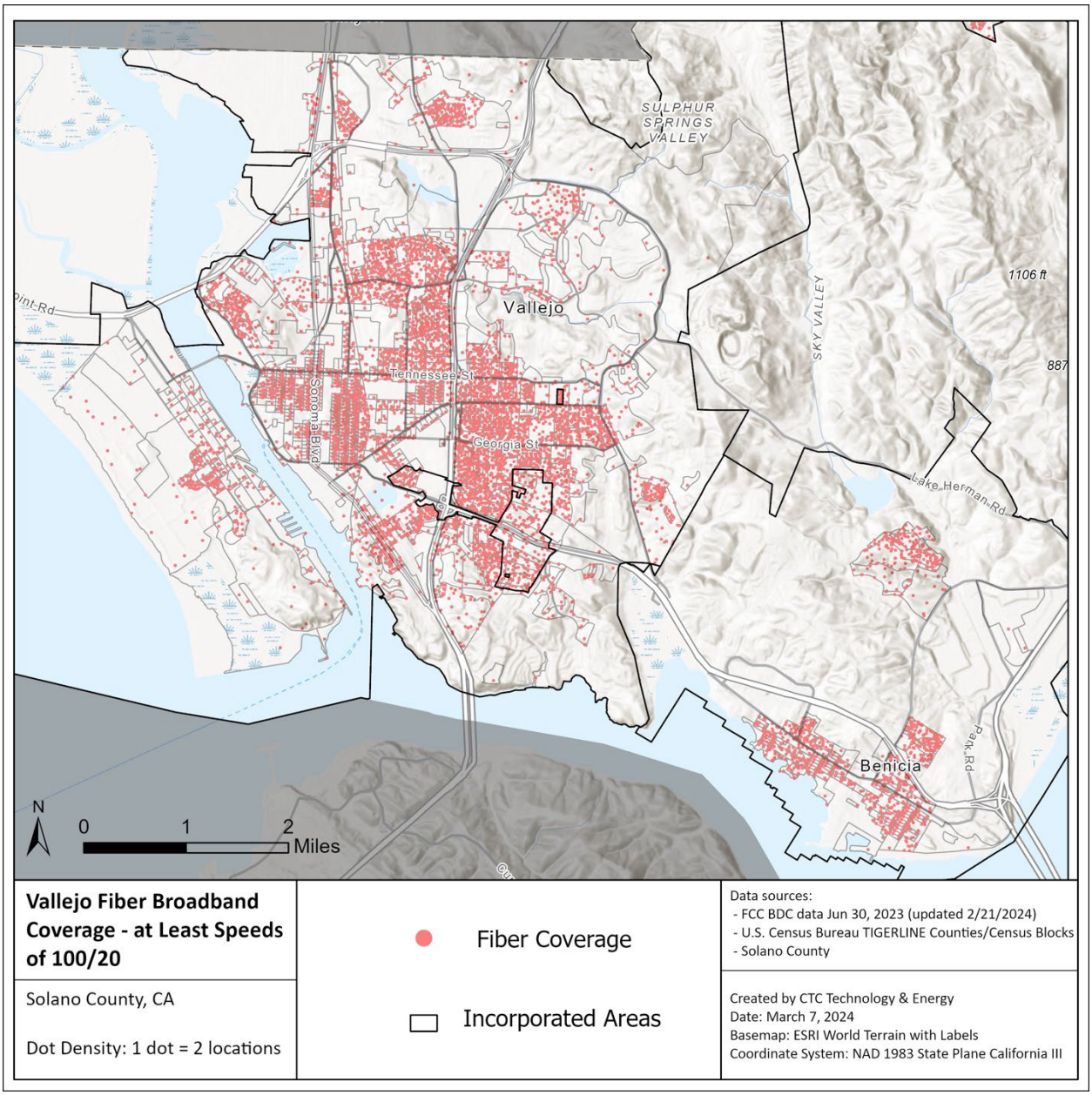


Figure 40: Fiber coverage in Fairfield at 100/20 or greater

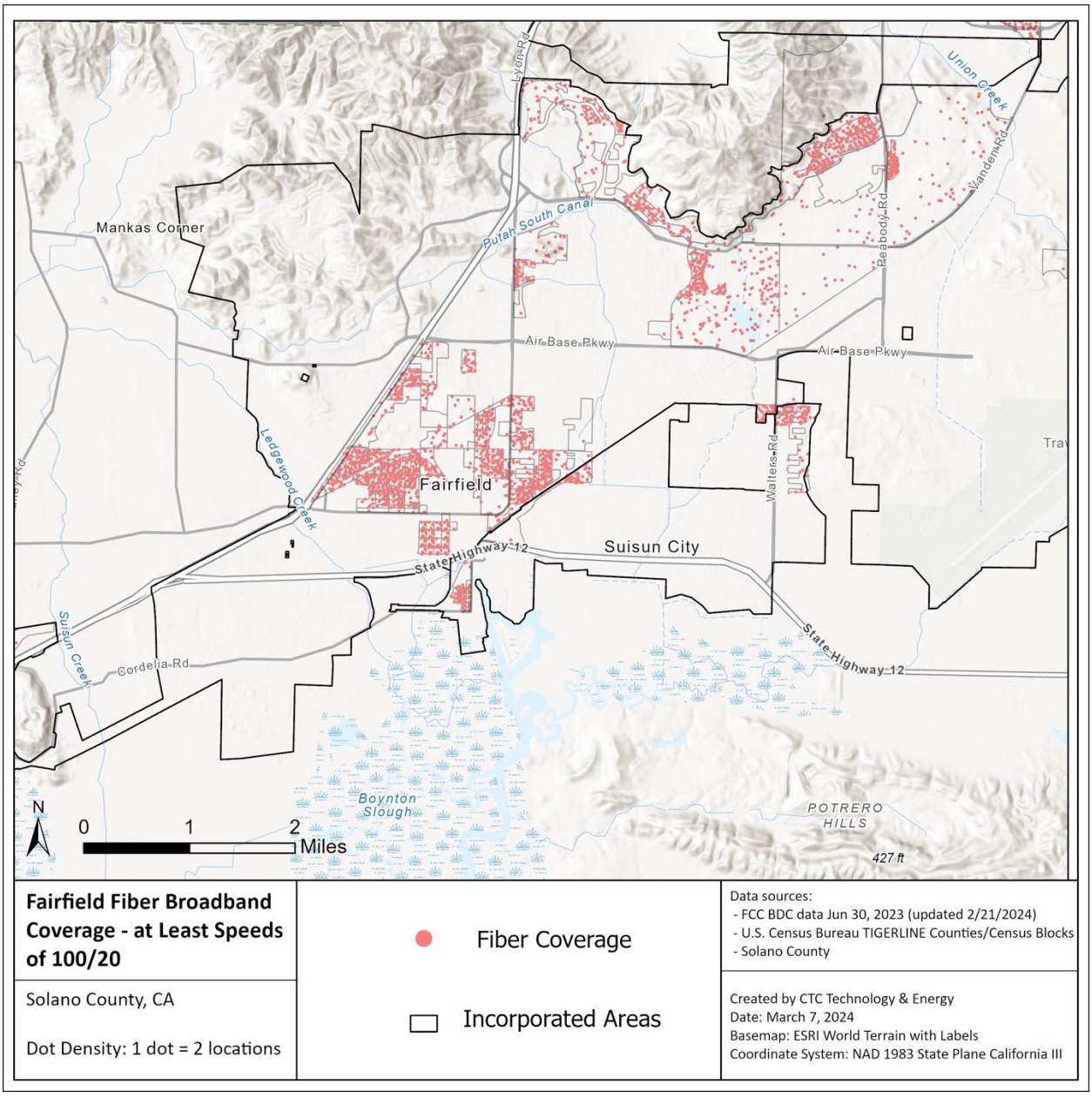


Figure 41: Fiber coverage in Vacaville at 100/20 or greater

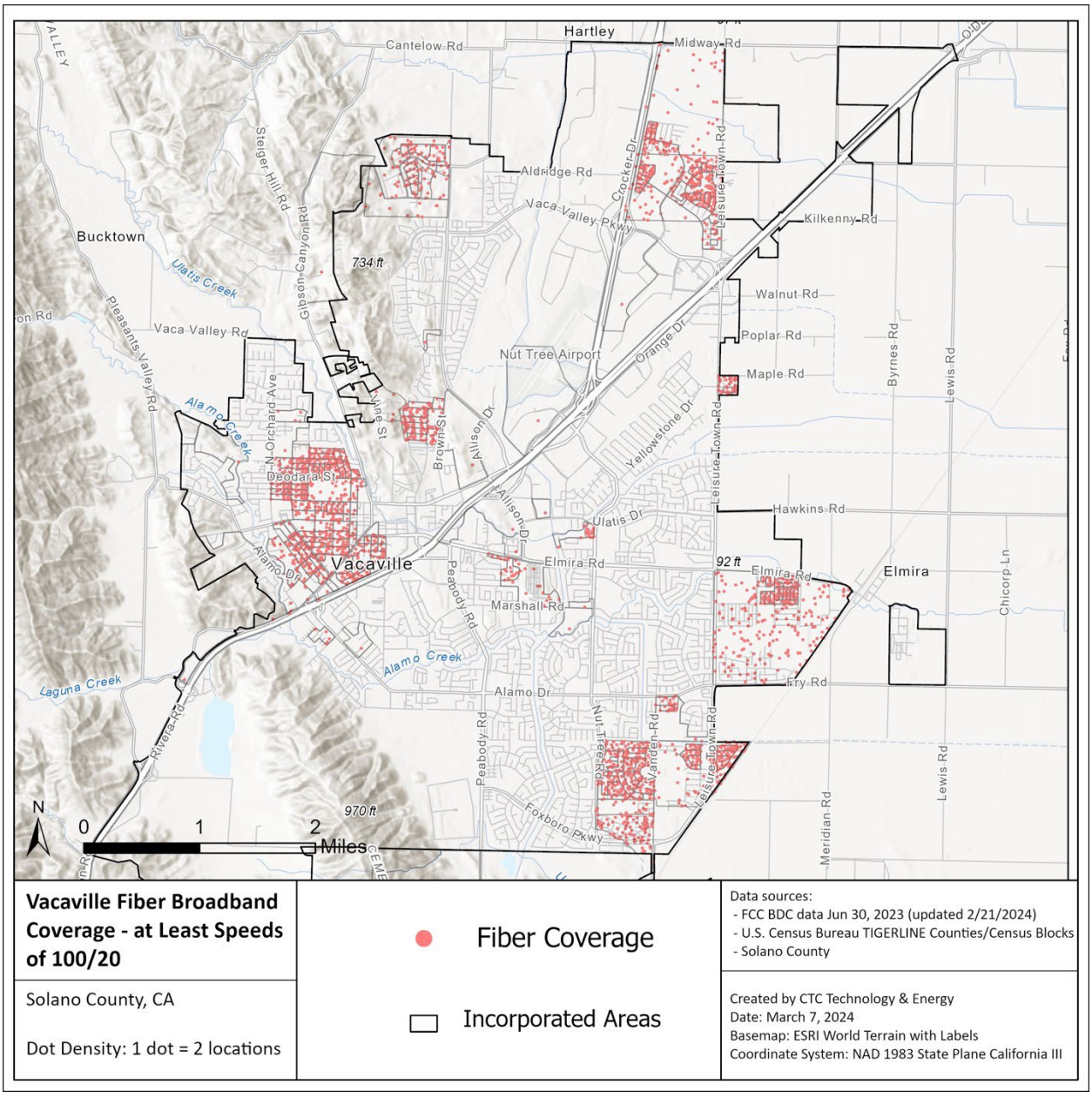


Figure 42: Fiber coverage in Dixon at 100/20 or greater

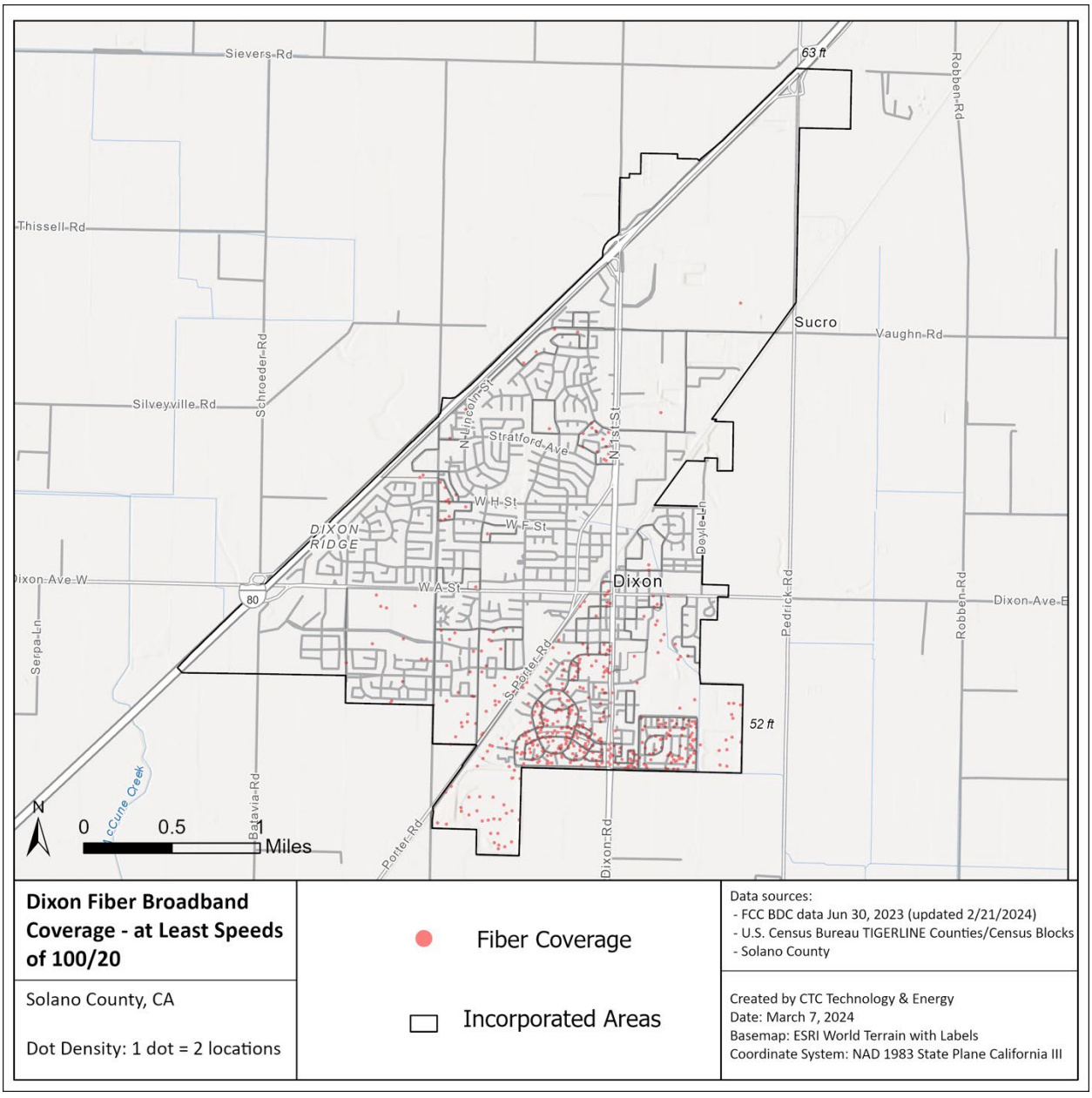
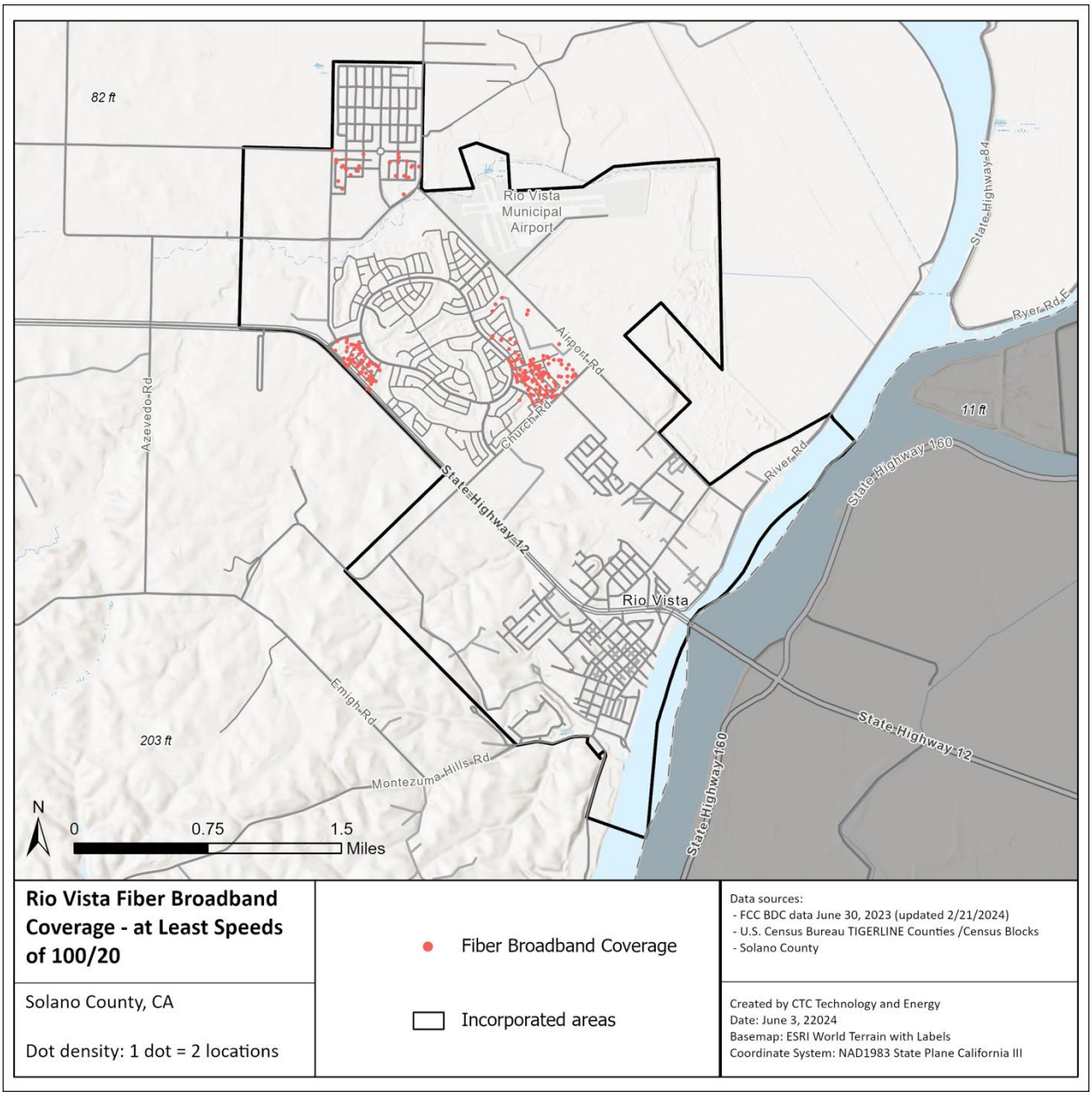


Figure 43: Fiber coverage in Rio Vista at 100/20 or greater



The following maps show areas of cable coverage in Solano County in additional detail.

Figure 44: Cable coverage in Vallejo at 100/20 or greater

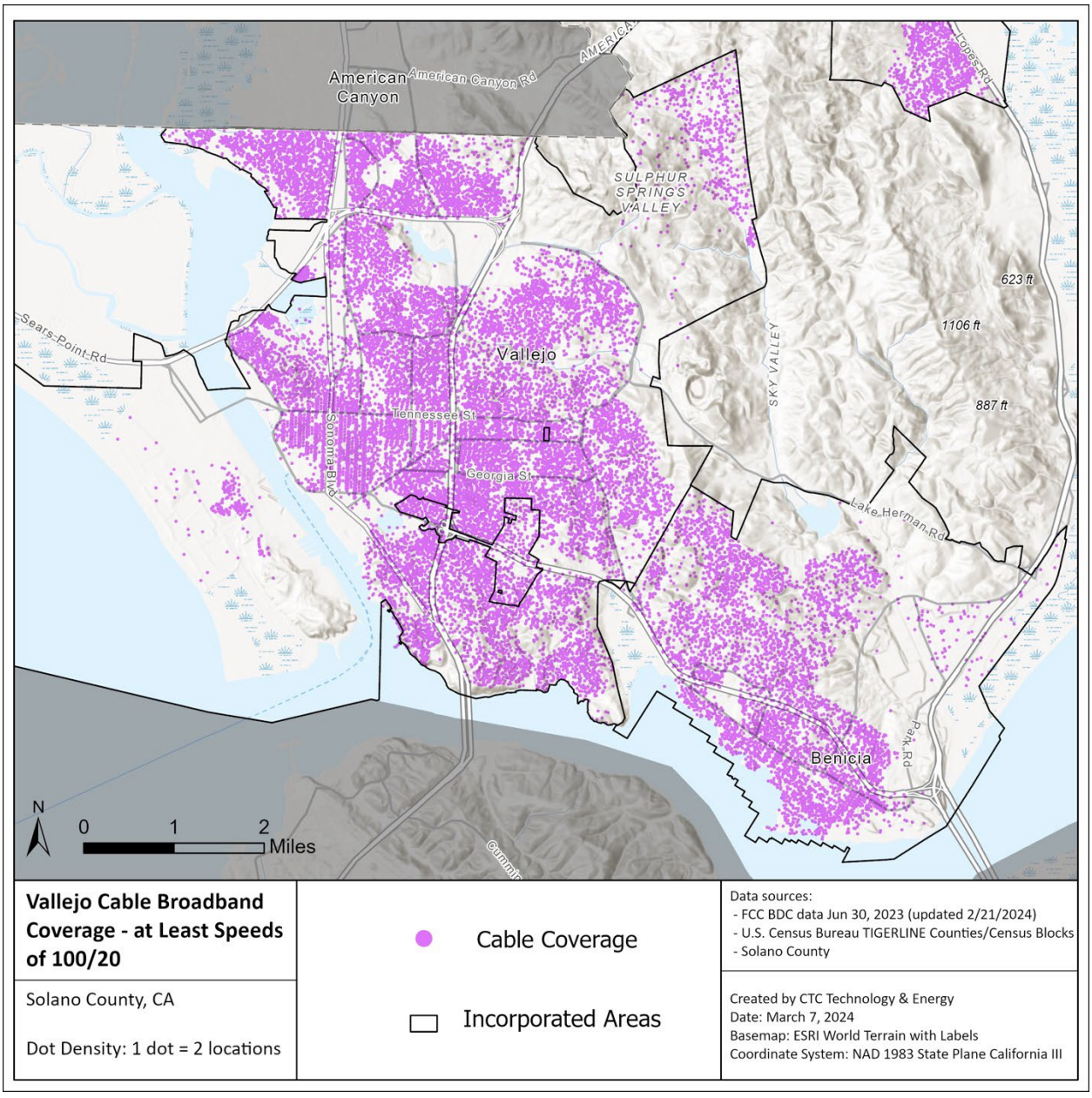


Figure 45: Cable coverage in Fairfield at 100/20 or greater

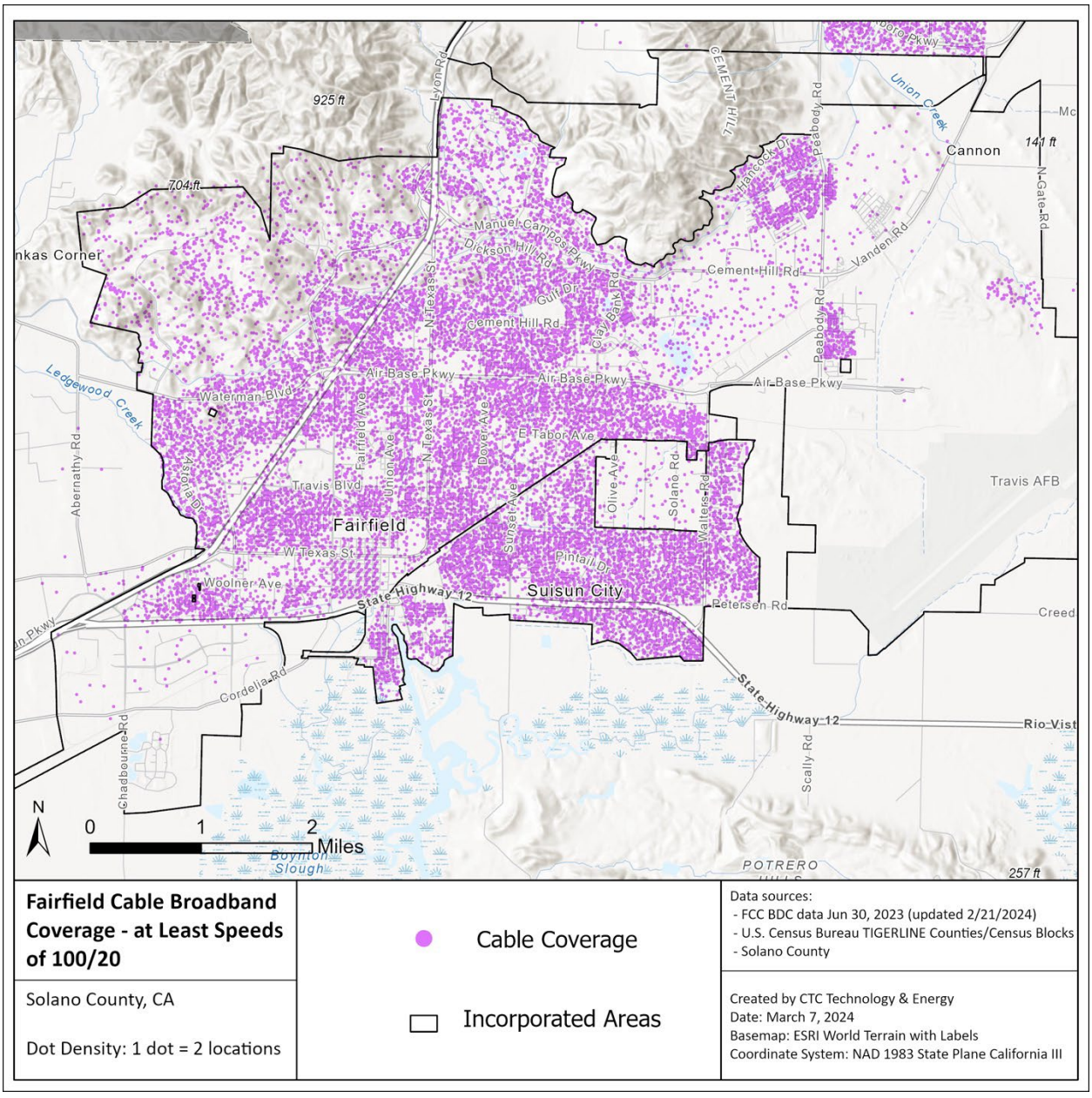


Figure 46: Cable coverage in Vacaville at 100/20 or greater

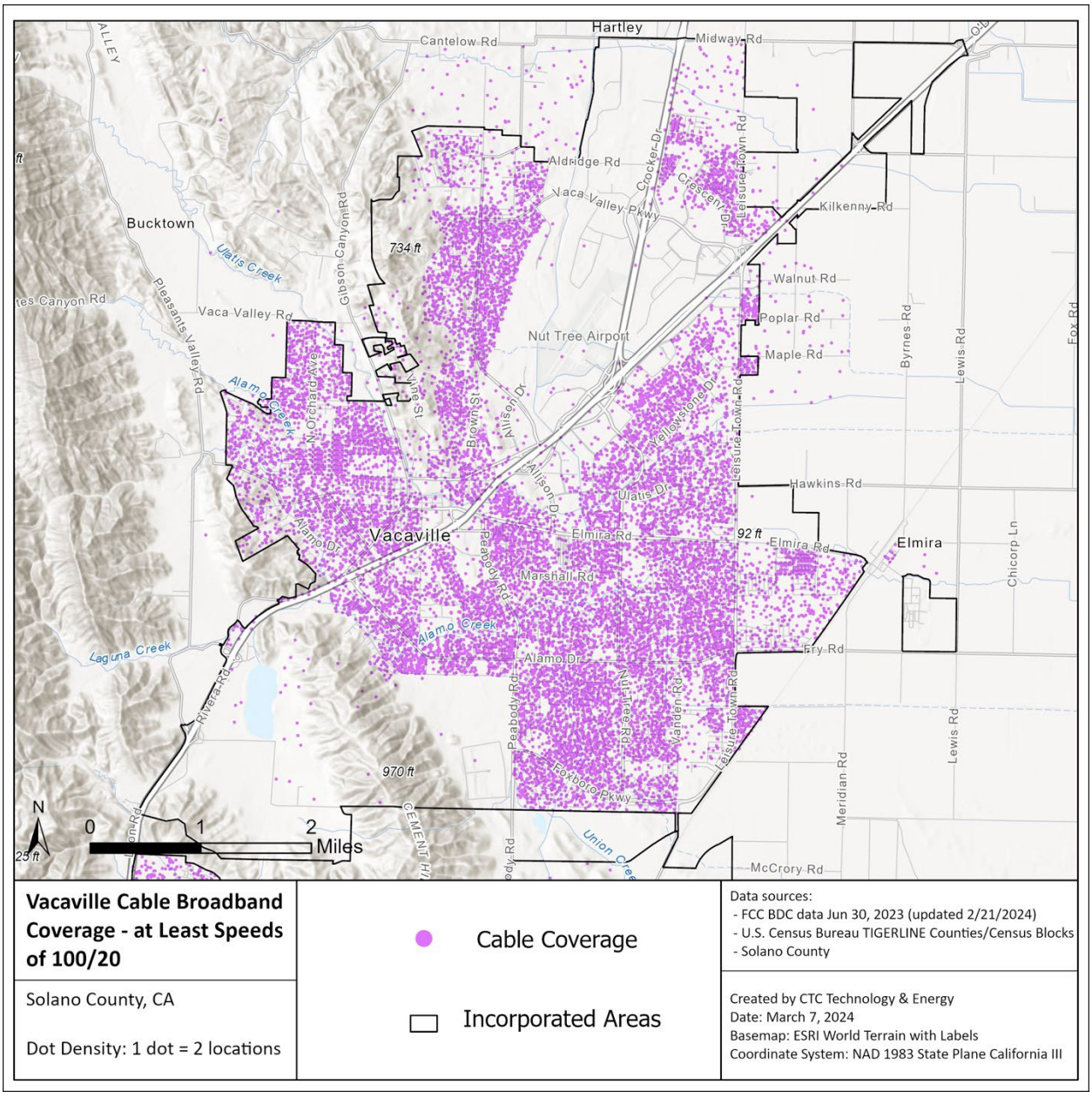


Figure 47: Cable coverage in Dixon at 100/20 or greater

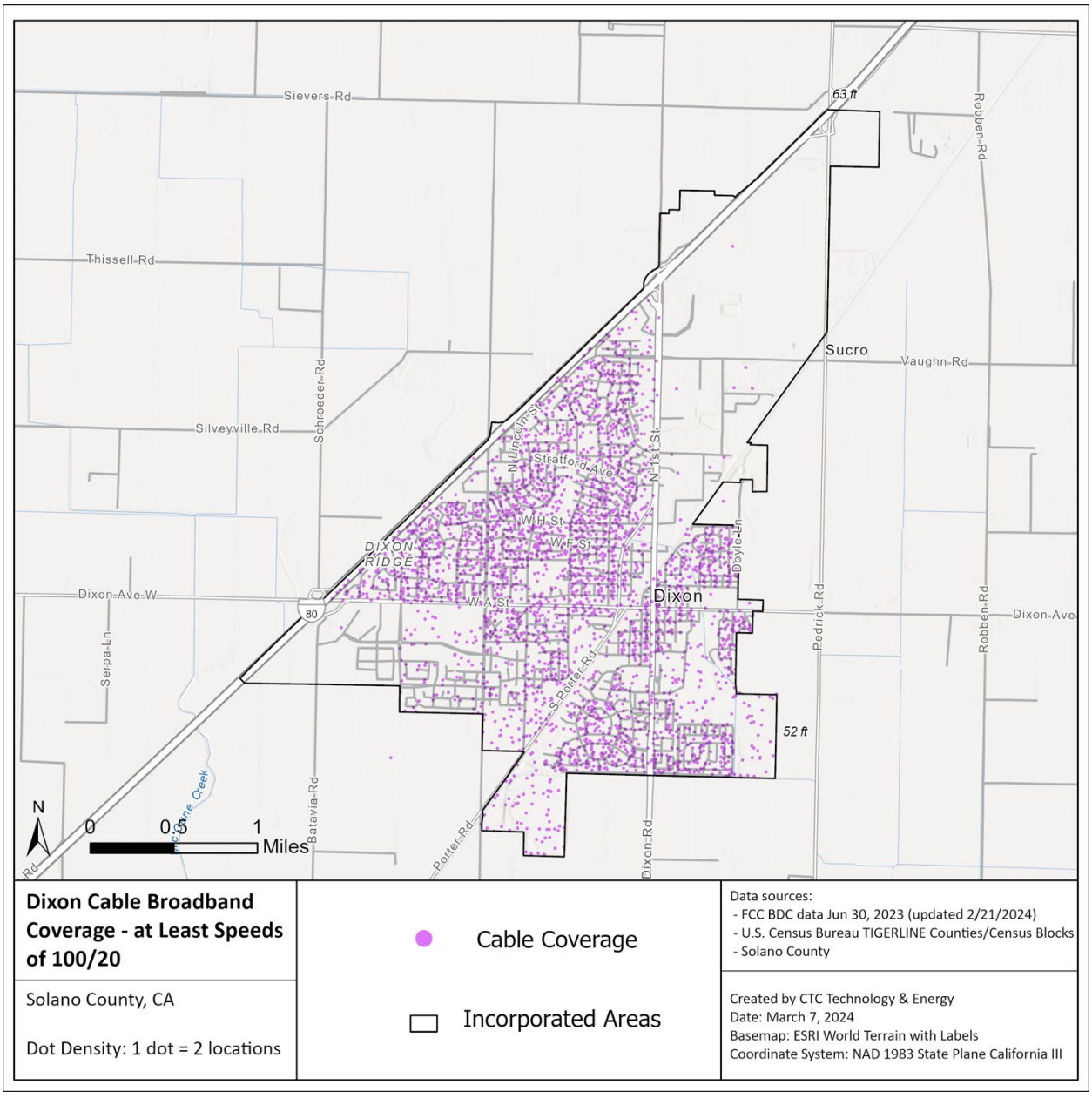
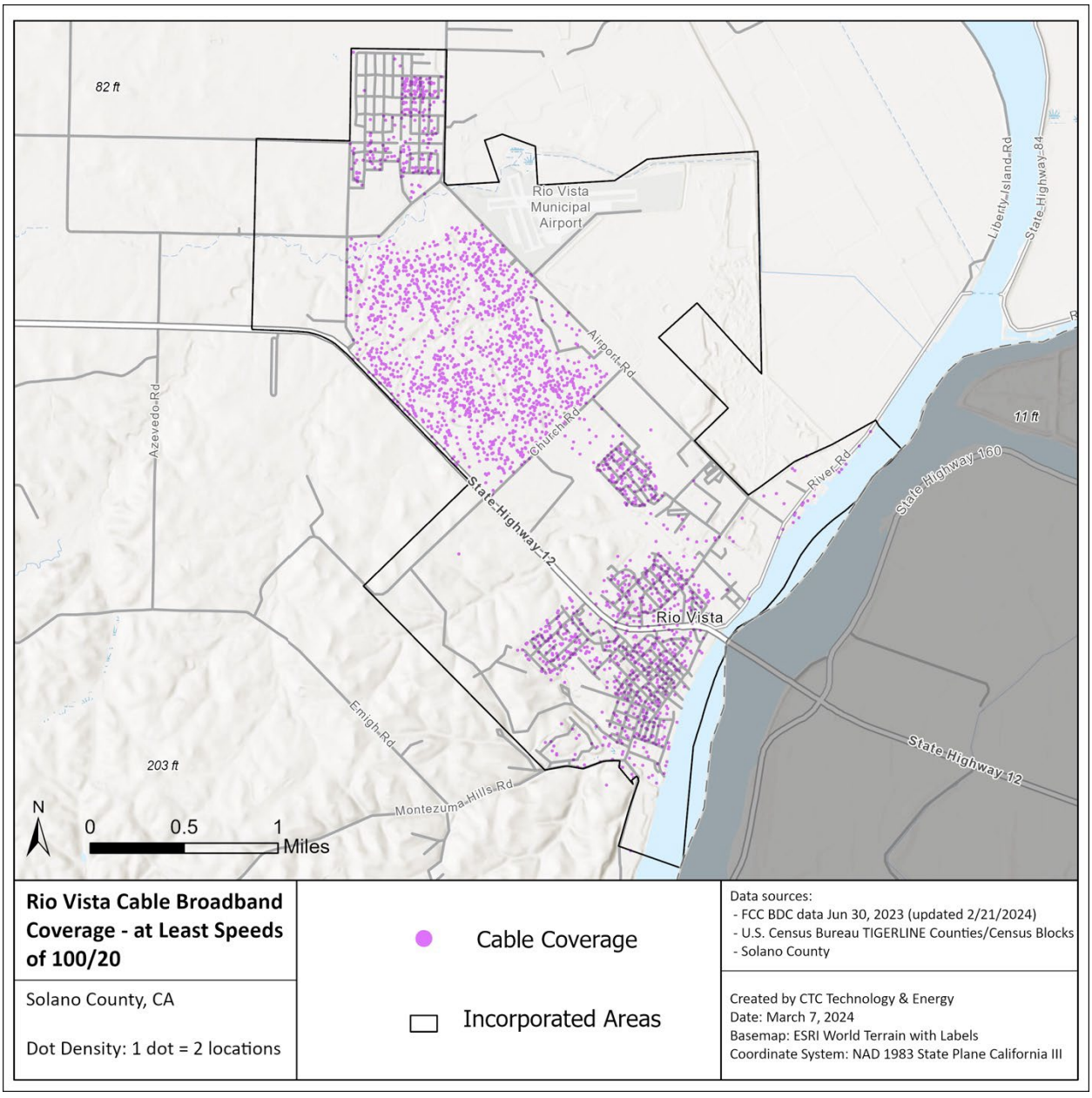


Figure 48: Cable coverage in Rio Vista at 100/20 or greater



The following maps show fixed wireless coverage in the County by provider.

Figure 49: Licensed fixed wireless coverage by Verizon

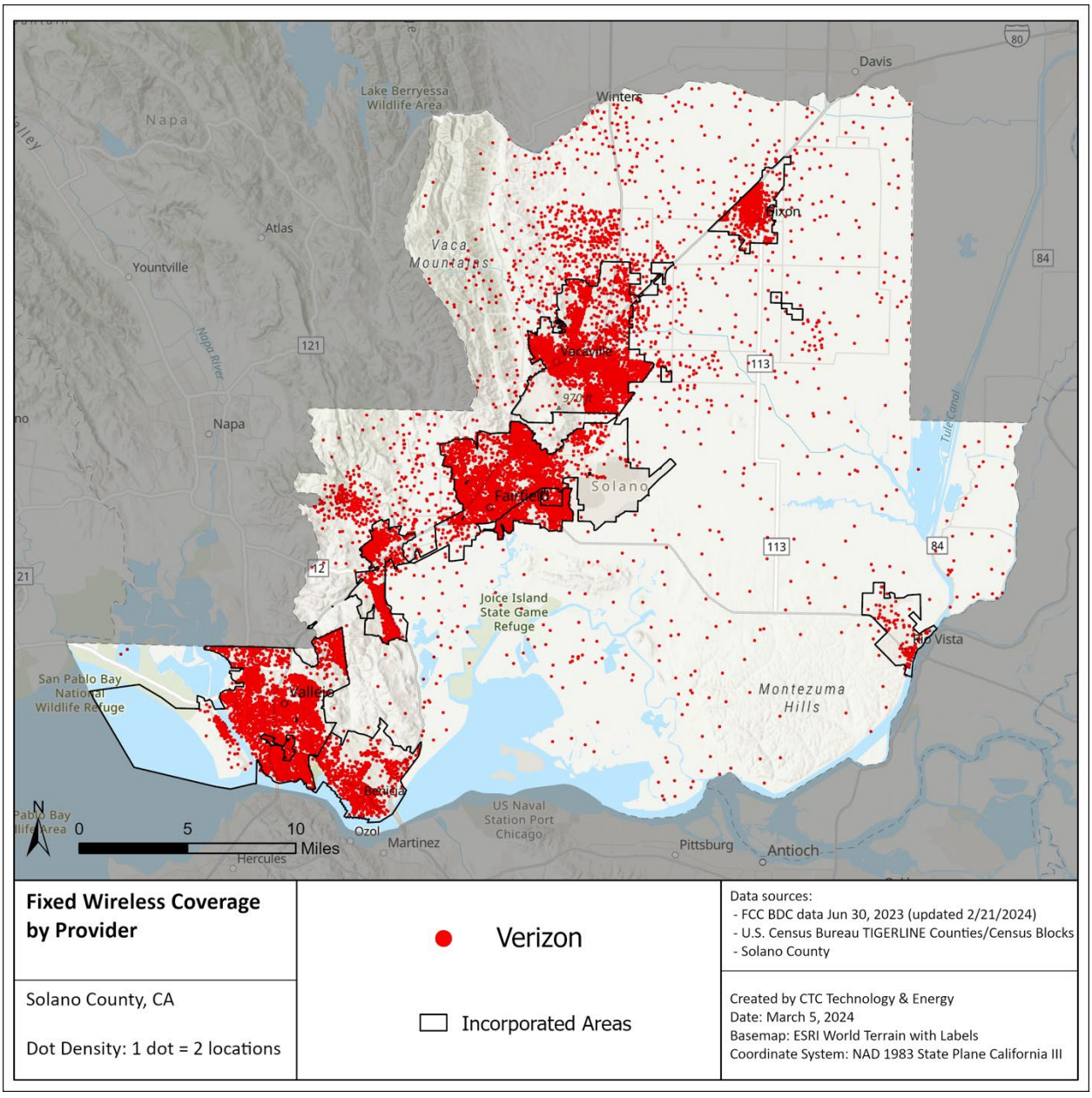


Figure 50: Licensed fixed wireless coverage by T-Mobile

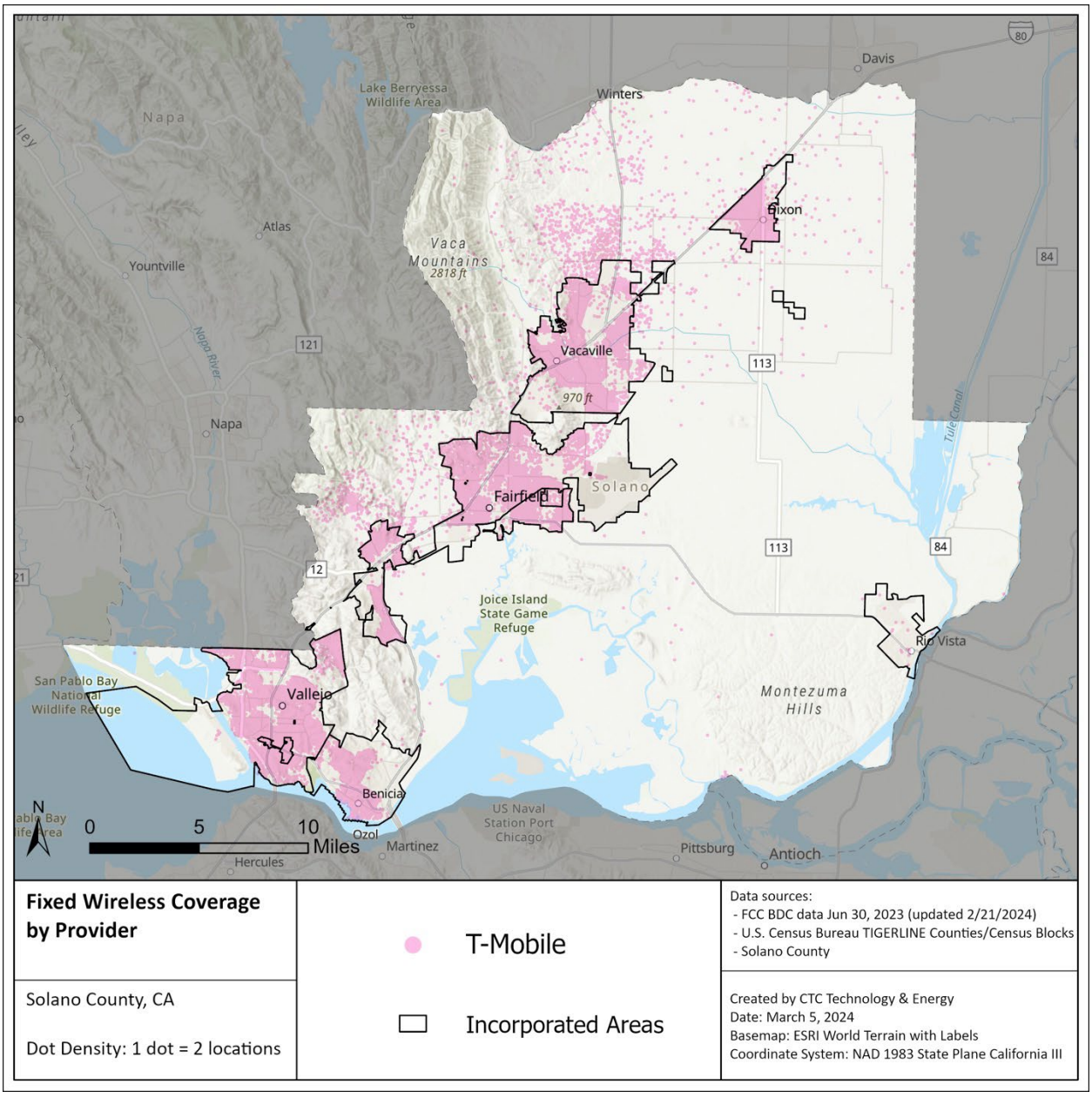


Figure 51: Licensed fixed wireless coverage by Cal.Net

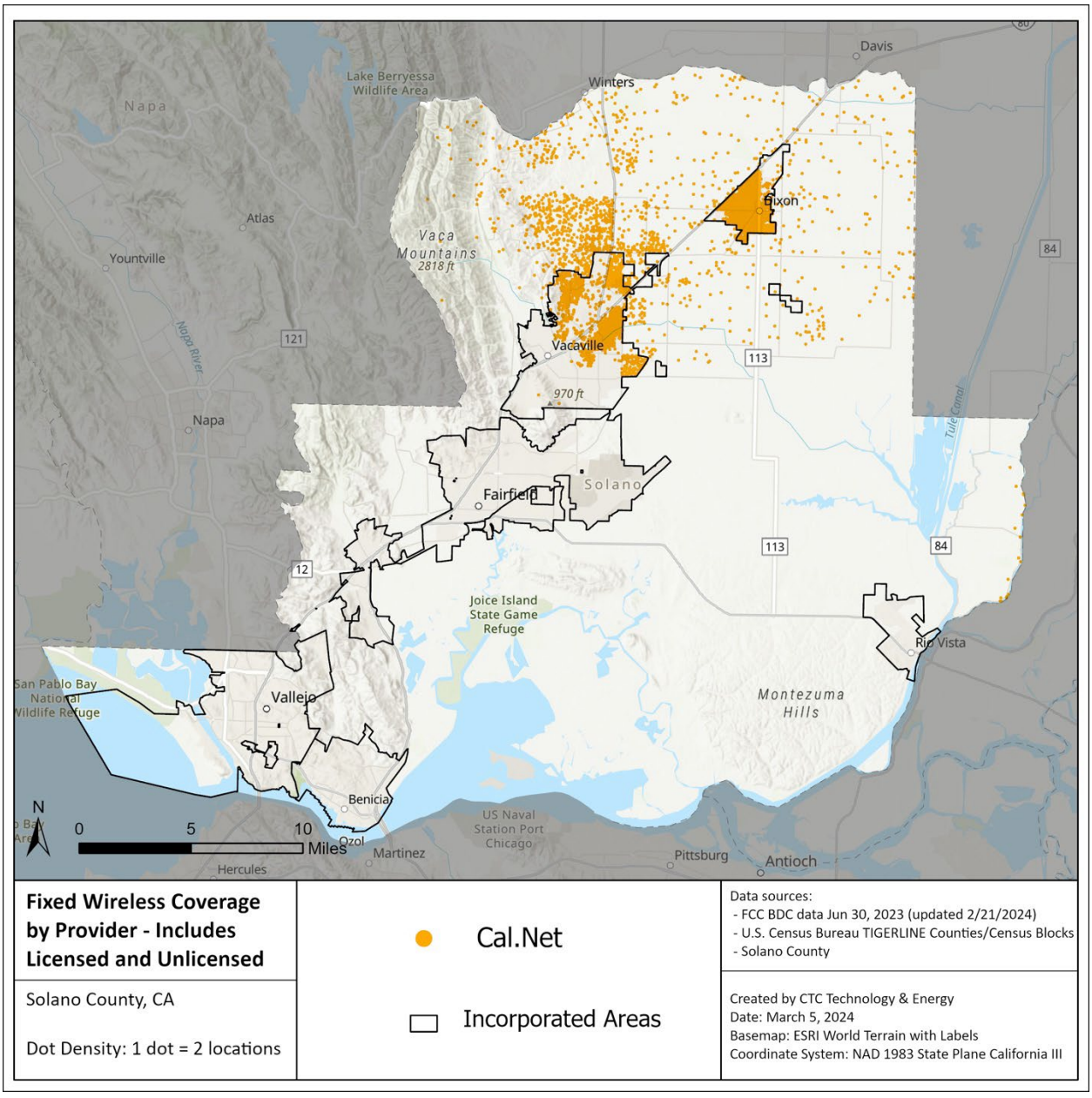


Figure 52: Licensed fixed wireless coverage by Softcom

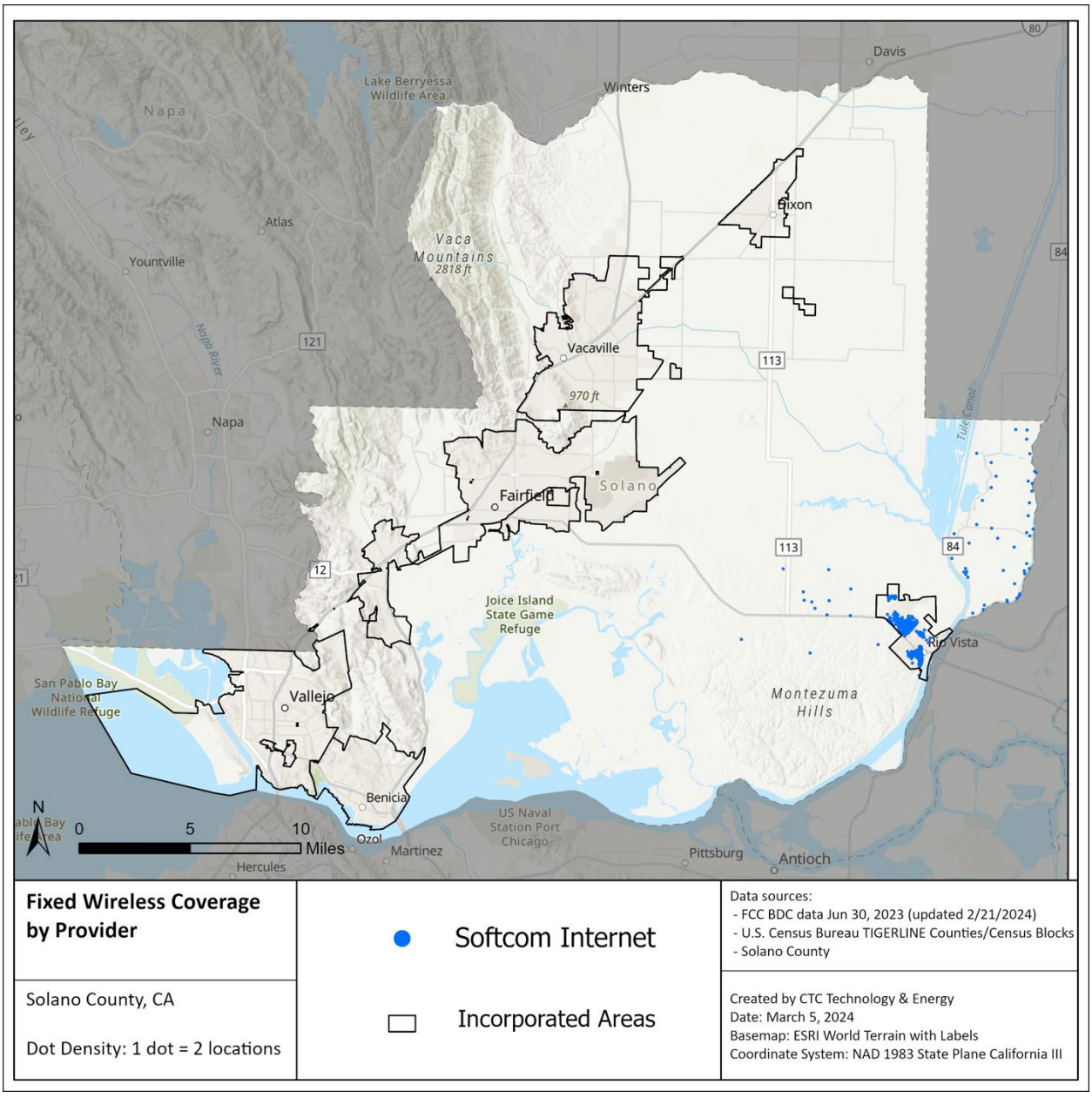


Figure 53: Licensed fixed wireless coverage by Digital Path

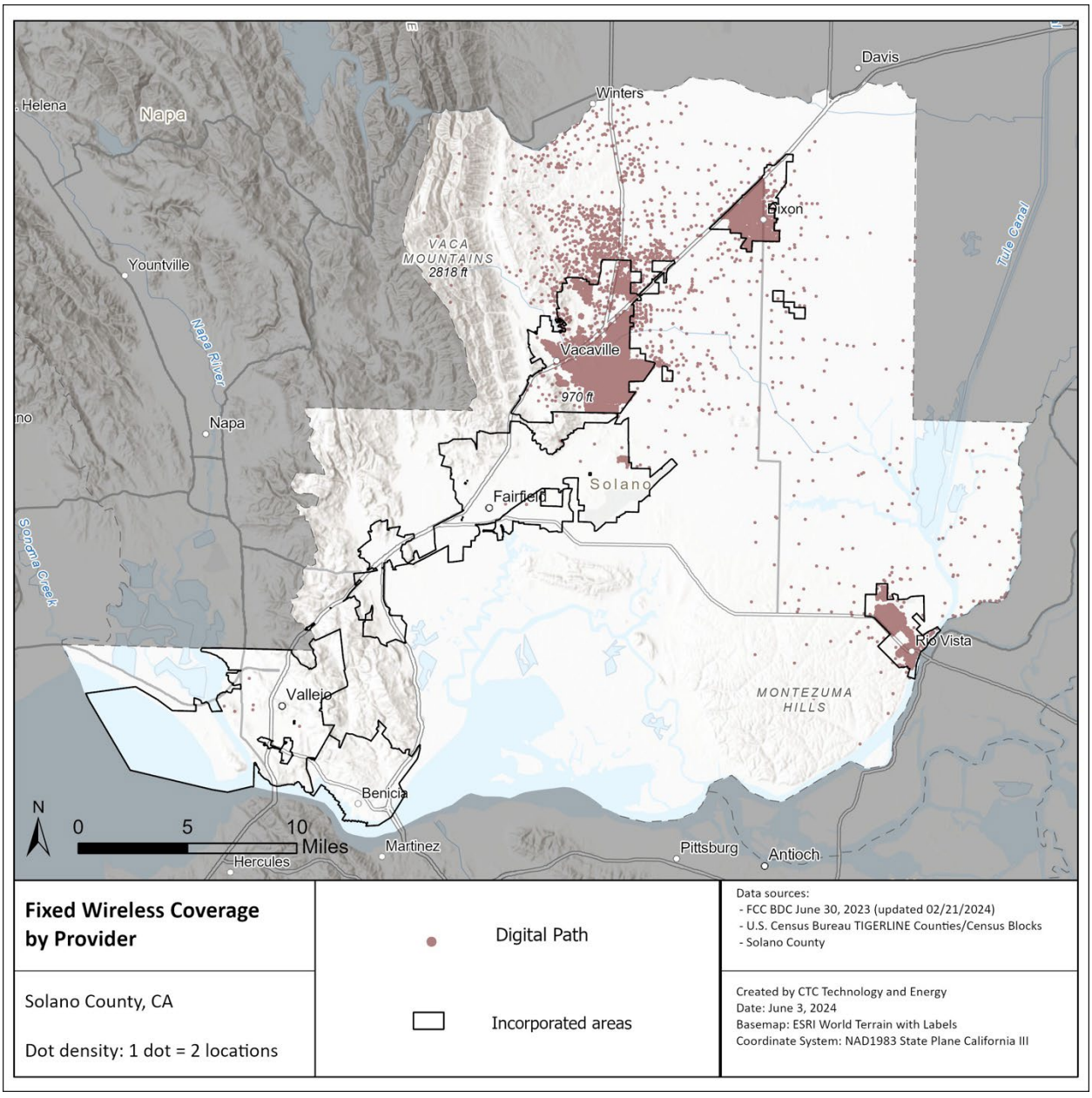
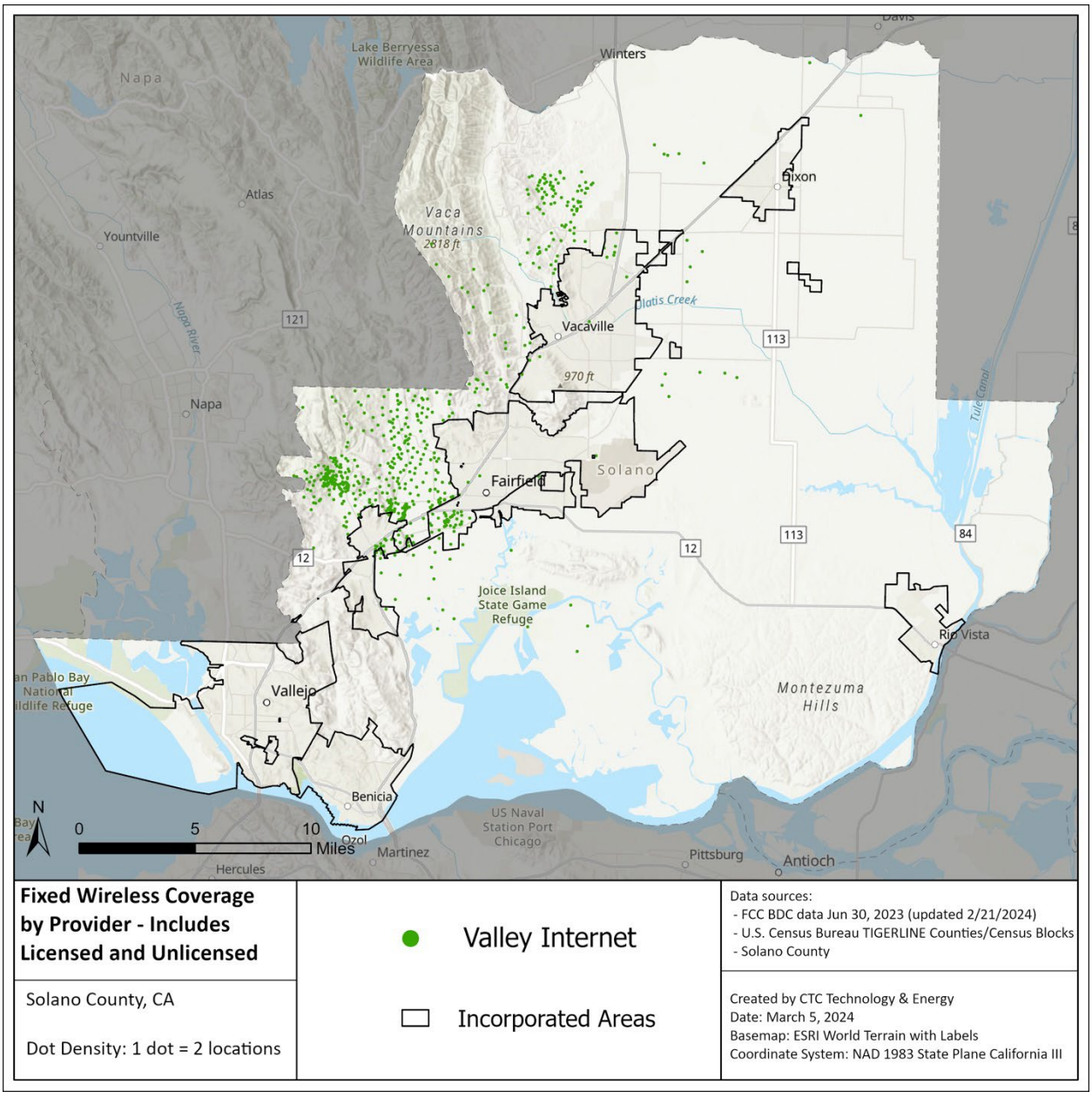


Figure 54: Valley Internet licensed and unlicensed fixed wireless coverage



Analysis of FFA proposed projects

In April 2022, the CPUC adopted rules for the FFA program and allocated $17,007,524 for projects in Solano County that would serve an estimated 7,320 unserved locations.[114]

Overview of applications for Solano County

The CPUC received twelve applications for funding for projects located entirely within Solano County by the deadline of September 29, 2023. These applications request over $53 million, covering just over 7,000 unserved locations in the County as defined by the CPUC FFA map. Applicants include AT&T (4 projects), City of Vallejo (4 projects), Comcast (2 projects), City of Vacaville (1 project), and Cal.net (1 project). See Table 11 for more details on the applications.

There were an additional seven applications that cross county lines and include some unserved locations in Solano County; these applications overlap with Napa and Yolo Counties.

The CPUC held a public comment and objection period that was open until November 20, 2023, to allow the public to review these applications. Applicants had 28 days to respond to objections. The CPUC estimates that it will grant funding awards in summer of 2024.

The tables below link to the applications as they are listed in the CPUC Broadband Grant Portal.[115]

Table 12: FFA applications in Solano County only

Application	County name	Grant amount requested	# of mass market unserved locations	Total project cost	Total cost per location	Grant cost per location	Applicant
Solano - 1	Solano	$5,125,273	619	$10,250,546	$16,560	$8,280	AT&T
SOLANO - PSA	Solano	$626,758	333	$1,253,516	$3,764	$1,882	AT&T
SOLANO - XX	Solano	$4,540,504	2,002	$9,081,008	$4,536	$2,268	AT&T
Solano - 1A	Solano	$6,308,993	1,098	$12,617,986	$11,492	$5,746	AT&T
Solano County FFA	Solano	$2,834,080	411	$2,834,080	$6,896	$6,896	Cal.net, Inc
Vacaville Broadband	Solano	$10,548,070	729	$11,042,006	$15,147	$14,469	City of Vacaville
Trailer City Park Project	Solano	$475,545	194	$475,545	$2,451	$2,451	City of Vallejo
N. Sonoma Blvd.	Solano	$1,014,322	68	$1,014,322	$14,917	$14,917	City of Vallejo
Porter St to Seaport	Solano	$1,680,329	32	$1,680,329	$52,510	$52,510	City of Vallejo
Mare Island Build	Solano	$688,892	177	$688,892	$3,892	$3,892	City of Vallejo

[114] CPUC, "Decision Adopting Federal Funding Account Rules," (D.22-04-055), Order Instituting Rulemaking Regarding Broadband Infrastructure Deployment and to Support Service Providers in the State of California, Rulemaking 20-09-001, April 22, 2022, pp. 32-35 ("FFA Decision"), https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M470/K543/470543650.PDF.

[115] "Objection Page," CPUC Broadband Portal, https://broadbandportal.cpuc.ca.gov/s/objection-page.

Application	County name	Grant amount requested	# of mass market unserved locations	Total project cost	Total cost per location	Grant cost per location	Applicant
Solano Suisun Valley Wine Trail	Solano	$6,587,350	239	$6,587,350	$27,562	$27,562	Comcast
Solano Nut Tree	Solano	$12,651,291	1,103	$15,752,098	$14,281	$11,470	Comcast
Total		**$53,081,407**	**7,005**	**$73,277,678**			

Table 13: FFA applications that cross county boundaries

Application	County name	Grant amount requested	# of mass market unserved locations	Total project cost	Total cost per location	Grant cost per location	Applicant
Napa - 1C	Lake, Napa, Solano, Sonoma	$5,711,250	1,089	$11,422,500	$10,489	$5,244	AT&T
Napa - 1	Napa, Solano	$7,632,551	1,168	$15,265,102	$13,069	$6,534	AT&T
YOLO - PSA	Solano, Yolo	$98,427	136	$196,854	$1,447	$723	AT&T
Yolo -1A	Solano, Yolo	$7,555,881	1,496	$15,111,762	$10,101	$5,050	AT&T
Napa - 1A	Napa, Solano, Sonoma	$5,649,233	846	$11,298,466	$13,355	$6,677	AT&T
Solano - 1C	Solano, Yolo	$6,400,000	1,396	$13,491,521	$9,664	$4,584	AT&T
Solano - 1B	Napa, Solano	$8,031,276	686	$16,062,552	$23,415	$11,707	AT&T
Total		**$41,078,618**	**6,817**	**$82,848,757**			

Impact of applications on priority areas

During the FFA application process, Solano County identified eleven priority areas with significant numbers of unserved locations. Preliminary analysis of the application summaries and mapping data show that most of these areas received at least one application to serve some portion of the locations in the area. These projects commit speeds up to 5 Gbps symmetric through AT&T's fiber projects and slower speeds by Comcast and Cal.net.

There are areas of the County identified as FFA priority areas that did not receive applications for funding, especially in the eastern part of the County in areas such as Rio Vista, Ryer Island, and

parts of the Suisun Marsh. These are areas that the County had previously identified as rural and sparsely populated and unlikely candidates for FFA funding due to its prioritization of fiber projects.

Comparison of project areas to FCC reported coverage areas

An analysis was completed to determine where each of the FFA project areas overlapped with areas that currently have fiber and cable infrastructure offering services at broadband speeds and are thus considered "served" according to the FCC data. It was determined that many of the project areas already have coverage by fiber, cable, or both technologies in the proposed areas for FFA buildout. Detailed comparisons of existing coverage and FFA project areas are displayed in the maps below.

Elmira: In the Elmira area, Comcast and Cal.net submitted overlapping proposals. Both applications serve small parts of unincorporated Solano County and areas within the city limits of Vacaville. The coverage of this area is part of a larger project for both ISPs, so it is difficult to isolate the number of locations served for the Elmira area only.

The Cal.net project is designed to serve 411 mass market locations with 12 miles of fiber in South Winters, Midway, and Elmira; however, the mapping shows that it will serve very few locations in the Elmira section of its project. The application summary states that Cal.net will provide 100/100 Mbps service.[116] Based on FFC data, the Cal.net proposal in Elmira does not include areas currently served by cable or fiber.

One of Comcast's proposed projects also covers Elmira and includes several other areas such as Fairfield and Vacaville. This project has a total of 23.5 miles of fiber and a total of 239 locations receiving service of 1 Gbps or faster speeds. The majority of the locations in this project appear in the Mankas Corner winery area in unincorporated Solano County covering Suisun Valley plus additional locations in Green Valley. This project does include a significant number of unserved locations in Elmira. AT&T also has proposed significant projects in Green Valley and Suisun Valley that compete with Comcast.

[116] Note that the high-level summary of the Cal.net project states that the project will only serve at 25/3 Mbps speeds. This appears to be an error and in the narrative description, the project is described as providing 100/100 Mbps.

Figure 55: Cal.net proposed project areas

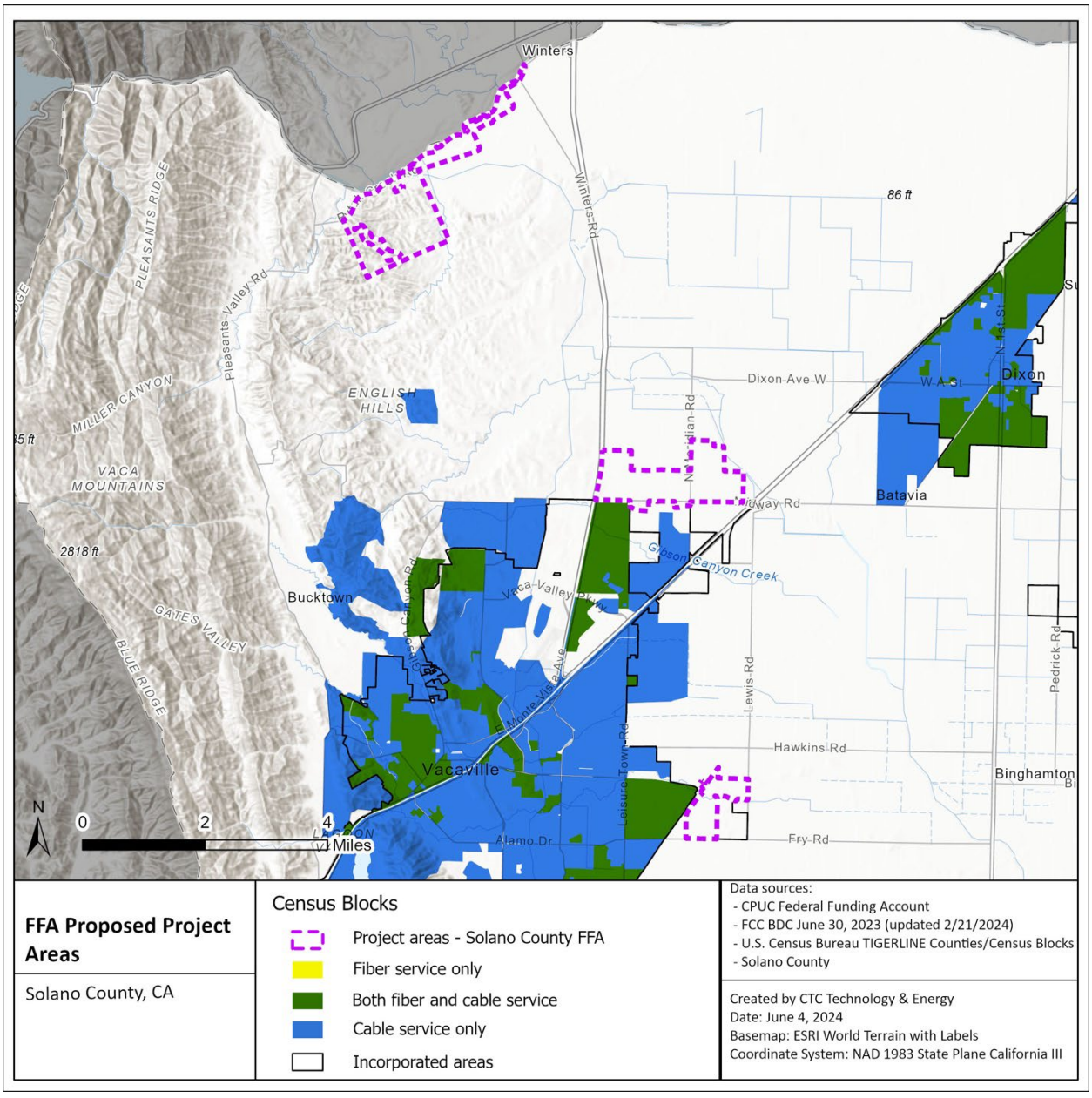
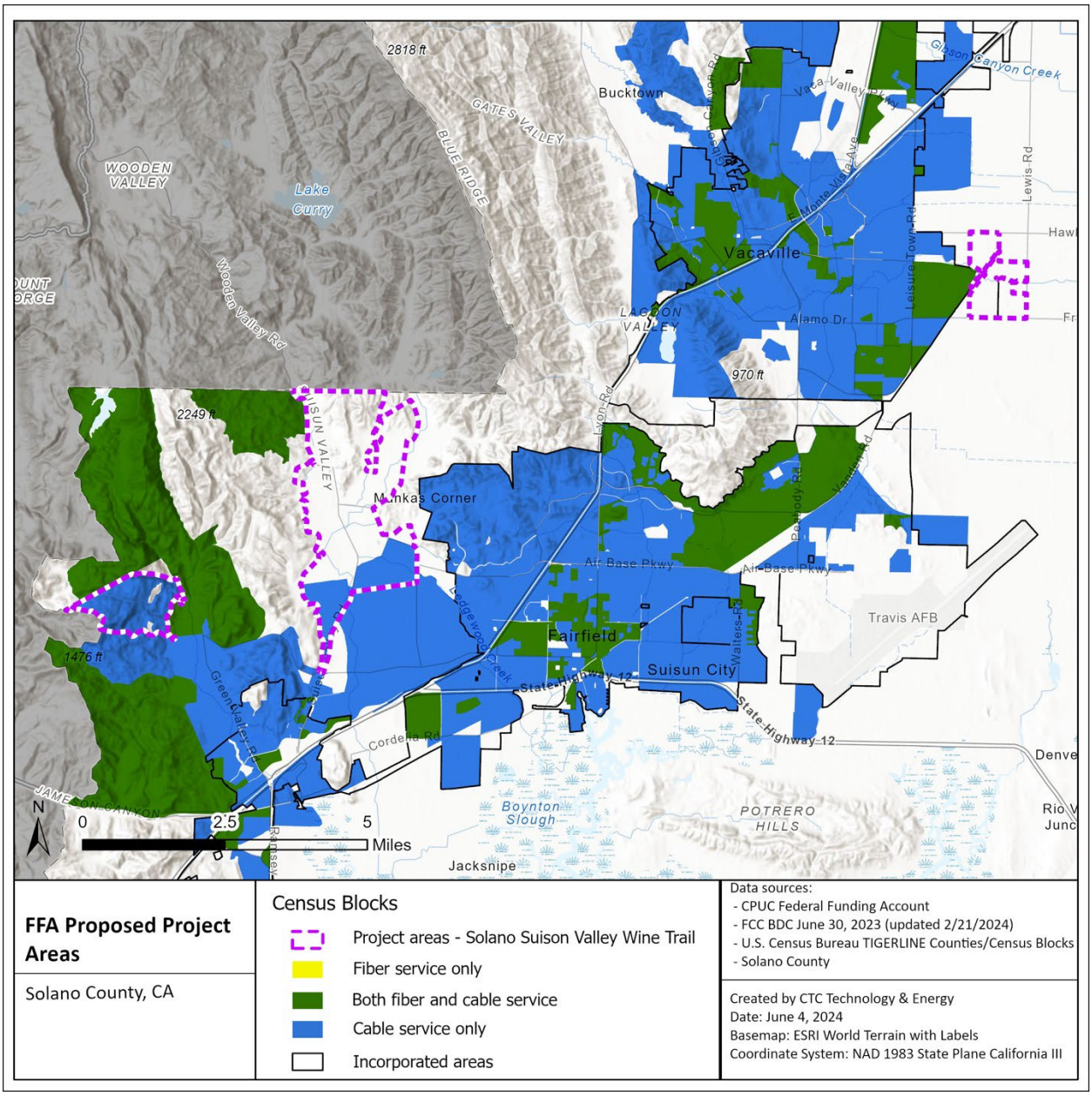


Figure 56: Comcast Solano Suisun Wine Valley Trail proposed project areas



English Hills: English Hills and surrounding areas including the Allendale/Hartley area and the Olive School Road area are covered by several projects proposed by AT&T and Comcast.

Comcast's Nut Tree project proposes to cover a large geographic area with 56 miles of fiber that includes English Hills and runs south. This project will include 1,103 mass market locations and commitments of service speeds of 1 Gbps or higher.

The Nut Tree project, however, is almost completely overlapped by several different AT&T projects, each of which proposes to serve with speeds of up to 5 Gbps symmetrical. The AT&T projects in the English Hills area are estimated to serve approximately 2,000 locations.

Cal.net also proposed a project to serve an area east of English Hills in the Allendale/Hartley area with fiber offering 100/100 Mbps.

Figure 57: Comcast Nut Tree proposed project areas

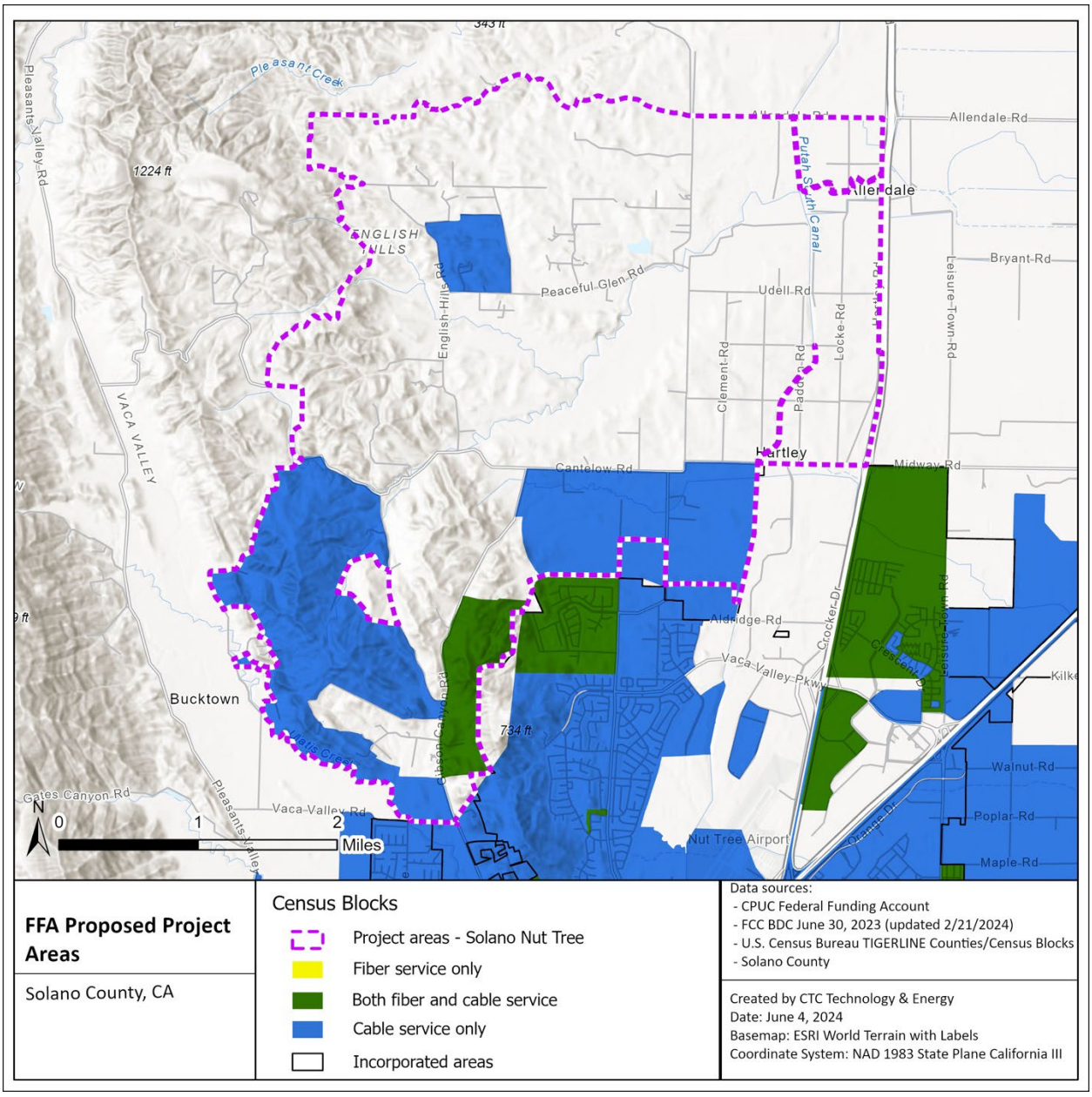
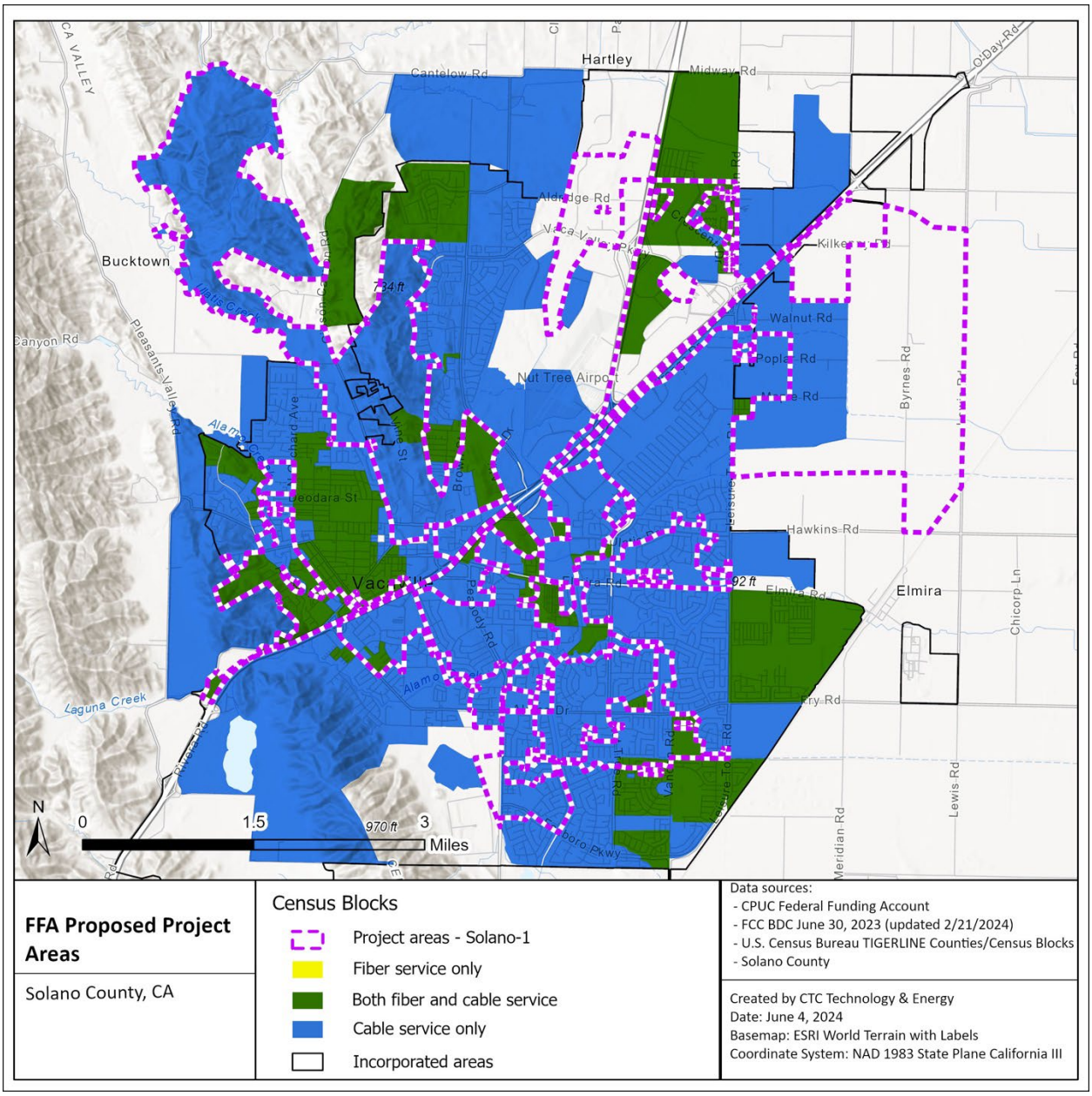


Figure 58: AT&T Solano 1 proposed project areas



Other AT&T applications: The remaining applications submitted by AT&T were located in Suisun Valley, Green Valley, and areas outside the three cities.

Figure 59: AT&T Solano 1A proposed project areas

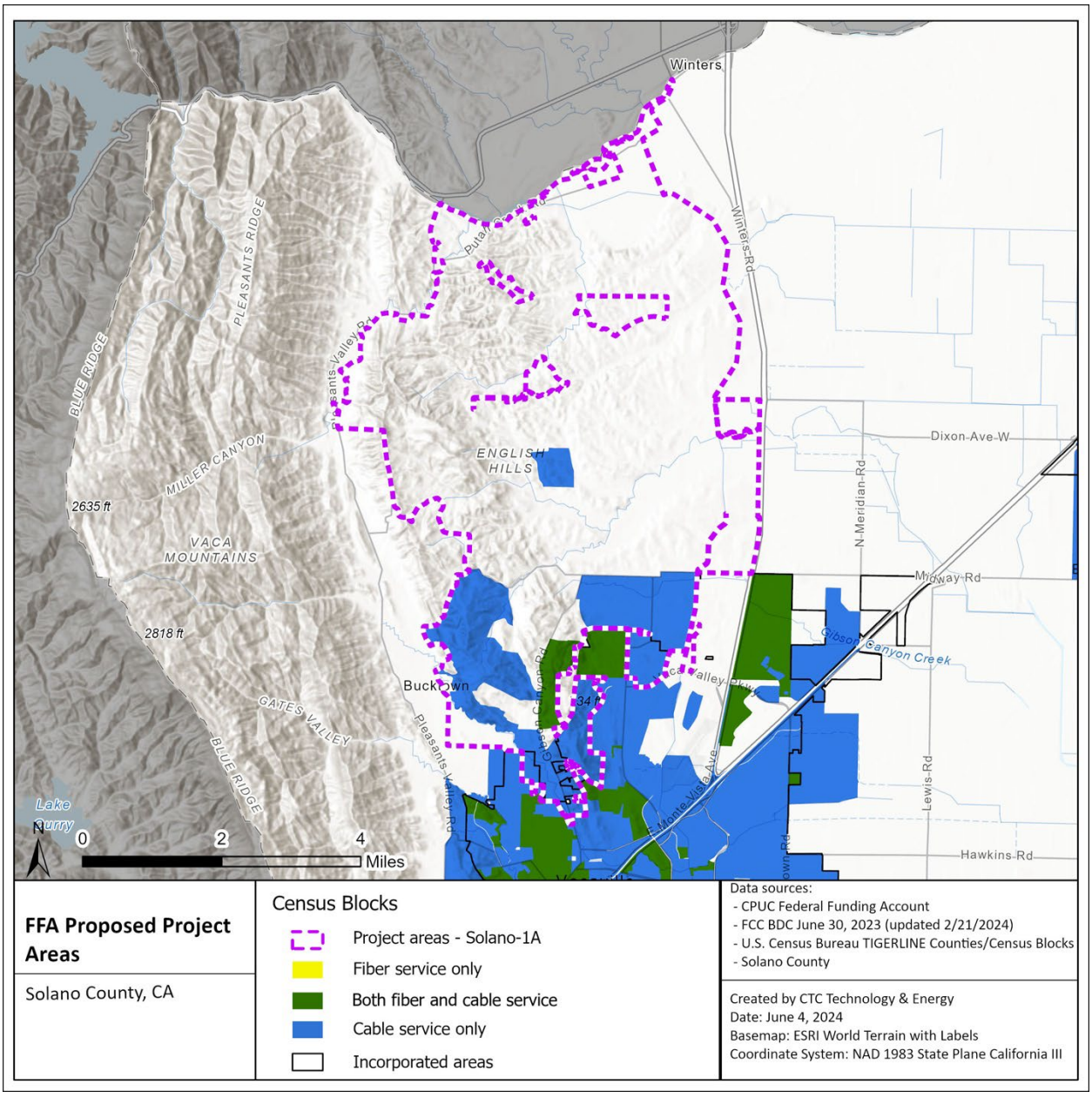


Figure 60: AT&T Solano PSA proposed project areas

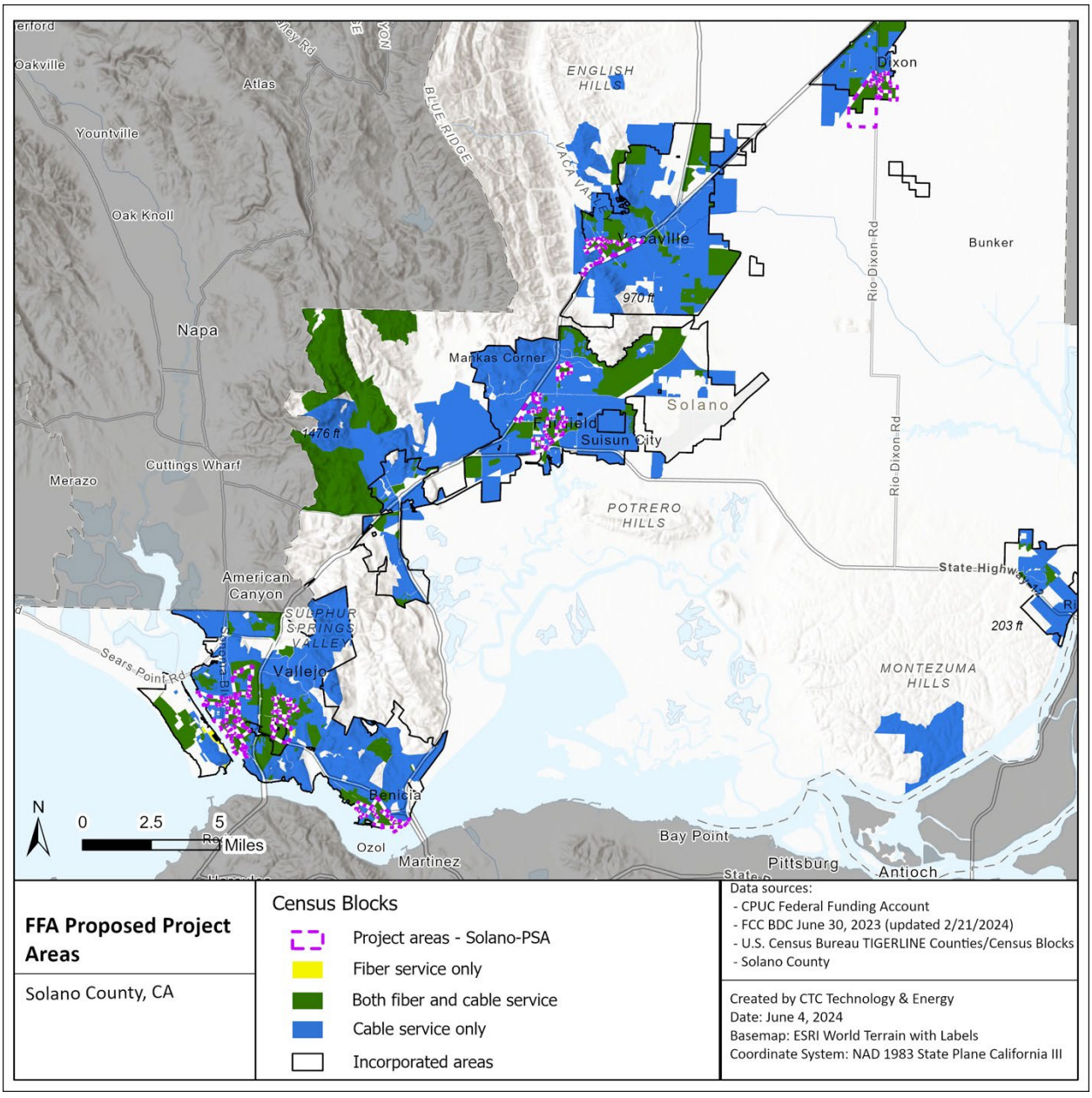
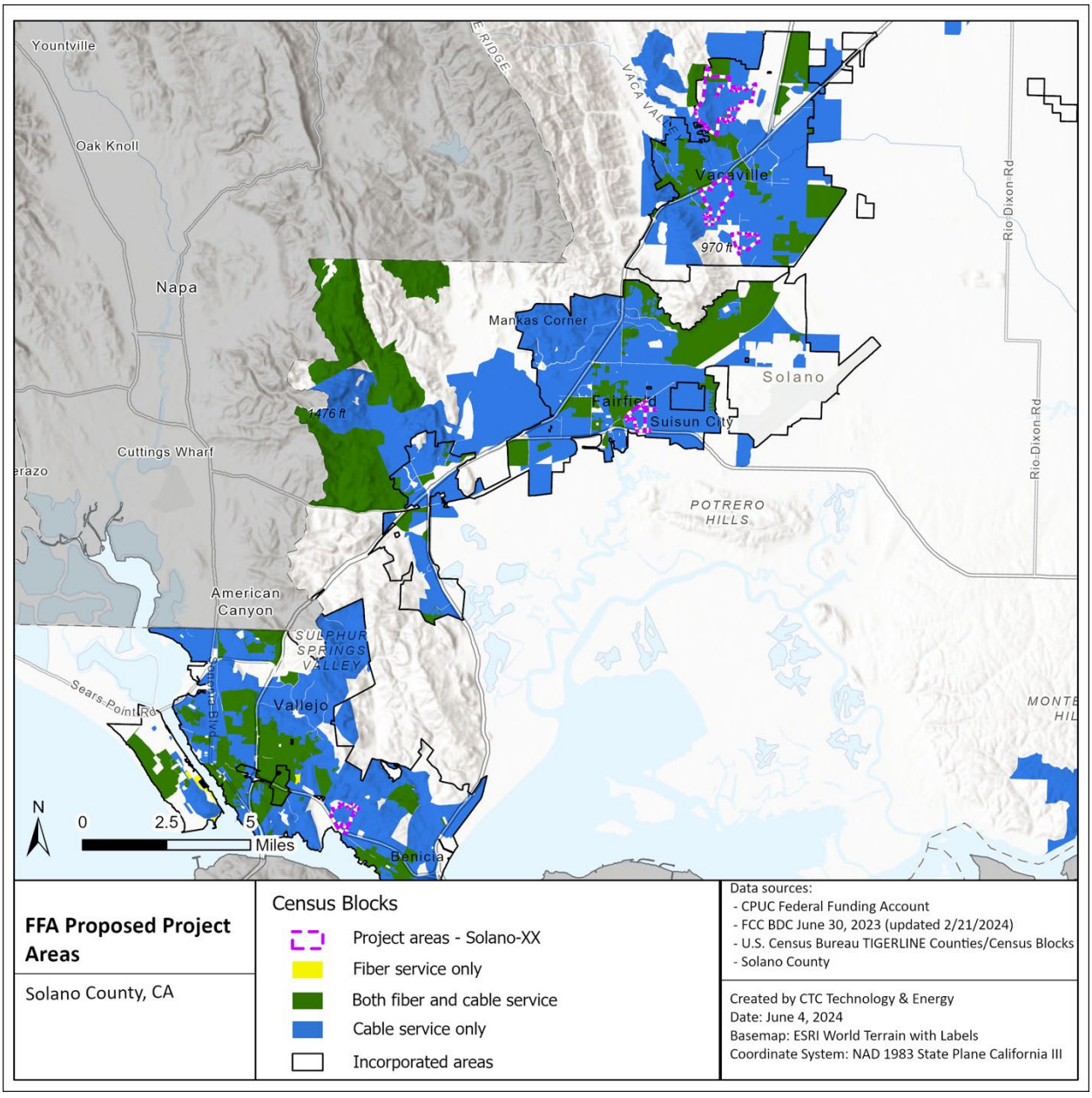


Figure 61: AT&T Solano XX proposed project areas



Appendix C: Technology comparative analysis

This report presents an overview of current and emerging internet access technologies (wired and wireless) that could play a role in sustainable, scalable solutions for filling gaps in the County's unserved and underserved areas.

The quality and speed of an internet connection will vary based on the capacity and limitations of the last-mile technology used. For purposes of capacity, reliability, and scalability, fiber-to-the-premises (FTTP) is superior to all other fixed broadband technologies. FTTP is superior in capacity to even the best of all theoretical wireless technologies.

The unrivaled transmission capacity of optical fibers, combined with a projected lifespan that far exceeds 30 years, makes construction of fiber optic infrastructure essentially a future-proof investment that will meet users' current and next-generation requirements.

In contrast to other wired and wireless transmission technologies, fiber has low operations and maintenance costs. The medium is practically immune to environmental factors such as material corrosion, lightning, or radio wave interference that commonly impact conventional coaxial cable, twisted-pair copper, and wireless transmission systems.

Unfortunately, due to its high capital costs, fiber infrastructure is not ubiquitously available, particularly in areas that are less densely populated. In Solano County, hybrid fiber-coaxial (HFC) cable networks are more prevalent because they developed from the widely deployed cable television networks. As cable providers upgrade their networks by replacing coaxial cable with fiber, those networks are able to scale to broadband speeds that can rival fiber in some scenarios.

For areas that lack fiber and HFC network coverage, wireless communications may potentially be suitable for filling broadband service gaps. While wireless solutions have limitations in terms of bandwidth and reach, the technologies continue to evolve—as exemplified by the proliferation of broadband mobile service. Furthermore, in addition to terrestrial-based fixed wireless network access, new concepts of satellite communications and flying platforms that are in later phases of development or even at early stages of test deployments could become viable communications vehicles for communities where fiber construction is and will remain cost prohibitive.

Wireless connectivity may even be contemplated as a substitute for fiber where the cost of constructing fiber is deemed too high (although analysis of upfront capital costs and long-term operating expenses is required to evaluate the business case for either investment). A wireless implementation also requires a timeline that typically is much shorter than new fiber construction.

Fiber-to-the-premises (FTTP)

Fiber optic cables are the medium of choice for data transfer. They have enormous bandwidth capacity, which enables operators to offer symmetrical download and upload speeds. Fiber is also not subject to interference and does not require amplifiers to carry a signal over long distances.[117] This is why the vast majority of the internet backbone is comprised of bundles of fiber cable strands.

Once a location is connected to fiber, there is no need for significant outside plant infrastructure investment for decades. If more bandwidth is needed, the operator need only upgrade the network electronics, rather than having to replace the cables.

The electronics needed to provide 1 Gbps speed over a fiber-to-the-premises (FTTP) network are already widely available at an affordable price, and the price of the electronics needed to support 10 Gbps connections are declining rapidly.

Technical capacity and limitations

Fiber is one of the few technologies that can legitimately be referred to as "future-proof," meaning that it will be able to provide customers with better and faster service offerings to accommodate growing demand.

The biggest advantage that fiber offers is bandwidth. A strand of standard single-mode fiber optic cable has a theoretical physical capacity in excess of 10,000 GHz,[118] far in excess of the entire wireless spectrum combined, and thousands of times the capacity of any other type of wired medium, which can be symmetrically allocated between upstream and downstream data flows using off-the-shelf technology.

Further, modern fiber can provide extremely low signal loss within a wide range of frequencies, or wavelengths, of transmitted optical signals, enabling long-range transmissions. Compared to a signal loss on the order of tens of decibels (dB) over hundreds of feet of coaxial cable, a fiber optic cable can carry a signal of equivalent capacity over several miles, without amplification, and with minimal signal loss.

Moreover, weather and environmental conditions do not cause fiber cables to corrode over time in the way that metallic components can, which means that fiber has lower maintenance costs.

[117] Maximum distances depend on specific electronics—six to 25 miles is typical for fiber optic access networks.
[118] Conservative estimate derived from the channel widths of the 1285 to 1330 nm and 1525 to 1575 nm bands in G.652 industry-standard single-mode fiber optics.

Factors impacting quality and speed of service

The following factors will determine an FTTP customer's service speed and quality:

- **Network electronics:** Core equipment in an FTTP network is housed at a central office (CO) or video headend office (VHO). If a housing developer builds an FTTP network, core equipment can be placed in a central telecommunications room or closet in a building or in a campus.
- **Network architecture:** Some FTTP operators use passive optical network (PON) technology, splitting the fiber capacity in a neighborhood cabinet to connect up to 64 users. This architecture provides less capacity per user than a direct fiber network (also known as active Ethernet or point-to-point) but is still able to provide 1 Gbps to users. Currently deployed PON networks have a shared capacity of 2.5 Gbps/622 Mbps (GPON) or 10 Gbps/2.5 Gbps (10GPON).

Future capacity and lifespan of investment

Using off-the-shelf electronics, an FTTP network can deliver speeds well in excess of what most customers need today, and service providers can continue to upgrade network electronics to offer improved tiers of service. The outside plant can last for decades with minimal maintenance.

Hybrid fiber-coaxial (HFC)

Hybrid fiber-coaxial (HFC) cable networks utilize both optical fiber and coaxial cable. Coaxial cables were originally designed to provide video services, and HFC networks with fiber built within a half-mile or mile of the home were sufficient in the early years of data communications. However, as demand for data capacity increased, those HFC networks became insufficient to support high-speed services. On an increasingly large scale, cable operators are now deploying fiber into their networks (i.e., replacing coaxial with fiber)—and those operators' new broadband deployments are fiber-to-the-premises. Today, many cable operators choose to build FTTP for so-called "greenfield" builds, where extending service into a new area requires new construction and there are few advantages in extending the coaxial part of the network.

HFC system configurations vary but in many cases will utilize a fiber backbone network that carries data from providers and their broadband equipment to fiber distribution nodes scattered throughout a service provider's area. From there the signal spans the last fraction of a mile via coaxial cables before reaching its destination at a residence or business.

One of the downsides of HFC, especially in comparison to technologies such as fiber optic, is that network performance is dependent on the most limited part of the network. In this case, the

coaxial cable is the limiting factor in an HFC network. A single fiber strand has over 10,000 times the capacity of a coaxial cable, and a typical fiber cable has dozens or hundreds of strands. It is also much more prone to electromagnetic interference, signal loss, power failures,[119] lightning strikes, and equipment failures and a has a higher security risk than fiber. As a result of these performance factors and the relative resilience of all fiber network components, FTTP has lower operating expenditures than that of HFC networks

Technical capacity and limitations

Although there are a number of significant limitations inherent in cable systems relative to fully fiber optic networks, cable system capabilities will increase over the next few years with the deployment of new technologies and the extension of fiber closer to customers.[120]

In an HFC network, headend or hub locations house the core transmission equipment. Fiber connections extend from these hubs to multiple nodes, each of which serves a given geographical area (e.g., a neighborhood). These optical nodes are electronic devices located outdoors, attached to aerial utility lines or placed in pedestals. The equipment in the node converts the optical signals carried on fiber into electronic signals carried over coaxial cables. Coaxial cable then carries the video, data, and telephony services to individual customer locations.

Cable operators have extended fiber optics progressively closer to their subscribers, but for cost reasons have generally stopped at nodes about one mile from the premises. Comcast, for example, typically only constructs fiber to the premises of customers that subscribe to Metro Ethernet and other advanced services.

It is critical to note that these are peak speeds, and that the capacity is shared by all customers—typically hundreds of homes or businesses—on a particular segment of coaxial cable. Speeds may decrease during bandwidth "rush hours," when more users simultaneously use greater amounts of bandwidth. For example, residential bandwidth use typically goes up considerably during evening hours, when more people use streaming video services and other large data applications.

[119] The coaxial portion of an HFC network requires power insertion roughly every mile. Most HFC networks have backup power only for a few hours. In contrast, fiber passive optical networks have power inserted at the wire center or central office, each of which can serve tens of thousands of addresses and host generators that can run indefinitely with refueling. As a result, HFC networks are especially vulnerable to long-term power outages.

[120] Cable is not as scalable "out of the box" as communications systems that were designed from the outset to provide internet-type broadband data services. Issues include coaxial cable's limitations in terms of physical capacity, a physical architecture optimized for broadcast communications, and a significant remaining migration path to full end-to-end Internet Protocol (IP) operations.

Factors impacting quality and speed of service

The following factors will determine a cable broadband customer's service speed and quality:

1. **Bandwidth capacity of cable plant:** Most coaxial portions of a cable network have capacity of 750 or 860 MHz, but they can be upgraded to 1 GHz and beyond. If the cable corrodes, the available bandwidth shrinks, limiting possible connection speed.

2. **Number of customers sharing a node:** Cable capacity is shared among all the users connected to a given node, so connection speeds will decrease significantly during peak usage hours. Cable companies can reduce the number of customers sharing a node by putting fiber deeper into their systems and moving the node closer to the customers.

3. **Proximity of customer to node/fiber:** Another advantage of moving the node closer to the customer is that signals travel less distance on coaxial cable. With progressively shorter stretches of coaxial cable, the inherent problems with reliability and interference decrease.

4. **Standards and protocols:** Cable operators can make faster connection speeds available by dedicating more channels to data services and upgrading their networks to later versions of industry standards. State of the art DOCSIS 3.1 technology that is now in most networks makes more efficient use of available spectrum, freeing up more bandwidth for data download and upload.

Cable operators often offer services with "blast" or "burst" speeds of "up to" more than 100 Mbps. Although a customer may be able to access these speeds on occasion, the actual speeds will probably be significantly lower during peak usage hours.

Digital subscriber line (DSL)

Digital subscriber line (DSL) technology uses copper telephone lines. DSL was a retrofit of copper telephone infrastructure that began in the 1990s. While this was a relatively cost-effective means of getting value from the infrastructure relative to other wireline broadband technologies, DSL is the most limited technology.

DSL operates by using digital modems that use wide, frequency spectrum bands relative to dial-up phone lines and therefore have up to a thousand times more capacity than a single phone line.

Because interference can enter the copper lines, DSL typically require DSL filters to "clean up" the signal on the lines. There are two primary types of DSL that exist today. Asymmetric digital

subscriber line (ADSL) and very high-speed digital subscriber lines (VDSL). ADSL is in older networks and can operate over copper lines up to about three miles in length.

VDSL operates at higher bit rates than ADSL. This is because it uses even higher frequencies and larger channel bandwidths than ADSL. The trade-off, however, is that the high frequencies cannot operate over distances as long as ADSL, so VDSL is typically limited to less than one mile, requiring fiber to be built from telephone central offices to neighborhood cabinets, or nodes.

Therefore, with shorter copper line distances, DSL operators can offer speeds that fit the FCC's definition of broadband of 25/3 Mbps. However, for providers using Digital Subscriber Line (DSL) technologies to offer speeds at 25/3 Mbps or greater, the maximum buffer is a distance of 6,600 route feet from the cabinet to the covered premises.[121]

It is unclear what level of adherence to this standard currently exists as it requires service providers to divulge cabling distances, cabinet locations, and serviced customer premises addresses. It is also unreliable to use the linear distance between DSLAM locations and customer locations to determine cable lengths as the cables are almost certainly not routed in linear fashion to consumers. Conduit carrying this cable often traverses many twists and turns on the way to reaching the customer's premises equipment. It is highly likely that cable could be routed in a very inefficient manner. Based on these concerns, there are likely DSLAMs located over 6,600 routed feet from the customer location. The "served" status of many of the DSL-only locations on the current government maps are therefore likely to fall short of the speeds that are advertised by the service providers.

Technical capacity and limitations

Bandwidth limits on copper cables are directly related to the underlying physical properties of the medium. Higher data rates require a broader frequency range of operation. Twisted-pair copper wire is limited to a few tens of megahertz in usable bandwidth, at most, with dramatic signal loss increasing with distance at higher frequencies.

The main determinant of DSL speed is the length of the copper line from the telephone company central office. In systems operated by large telecommunications companies, the average length is 10,000 feet, corresponding to available DSL speeds between 1.5 Mbps and 6 Mbps. In systems operated by small companies in rural areas, the average length is 20,000 feet, corresponding to maximum speeds below 1.5 Mbps.

[121] Data Specifications for Biannual Submission of Subscription, Availability, and Supporting Data - March 4, 2022, http://www.fcc.gov/sites/default/files/bdc-availability-data-specifications-03042022.pdf.

The fastest copper telephone line technologies widely deployed in outside cable plant in the United States are VDSL and VDSL-2, the technologies underlying AT&T's U-verse and other services. Because these technologies use high frequencies, they are limited to 3,000 feet over typical copper lines and require fiber to the node (FTTN)—much closer than in most HFC systems. Therefore, in order to operate VDSL and VDSL-2, telecommunications companies must invest in large-scale fiber optic construction and install remote cabinets in each neighborhood.

In practice, telephone companies using VDSL-2 over highly upgraded copper lines have been able to provide 25 Mbps over a single copper pair and 45 Mbps over two pairs to the home or business—but it took a significant investment to make it possible for a small percentage of the copper phone lines to temporarily keep pace with cable. Providing even greater speeds will require some combination of even deeper fiber construction, a breakthrough in transmission technology over copper lines, and conditioning and upgrading of the existing copper lines.

The Alcatel-Lucent G.Fast DSL product in development has reached speeds of 500 to 800 Mbps in various environments—but it is limited to 330 feet, requiring the construction of fiber to the curb in front of each home or business—an investment that would be comparable to building a FTTP network.[122] As a result, G.Fast has so far mostly been focused on deployments using telephone wires inside apartment or office buildings—for example, by a provider that brings fiber to the building or high-speed wireless to a rooftop, and then places G.Fast electronics on the copper to extend that service to individual apartments or offices.

Factors impacting quality and speed of service

The following factors will determine a DSL customer's service speed and quality:

- **Length of copper line/proximity to fiber:** The longer a signal travels over copper cable, the slower the potential connection speed.
- **Condition of copper cable:** Copper cable corrodes over time. As it deteriorates, interference increases and the available bandwidth shrinks, limiting the potential connection speed.
- **Number of copper pairs available:** To overcome the inherent limits of copper cable, some operators bundle multiple copper pairs.

[122] Mikael Ricknas, "Alcatel-Lucent gives DSL networks a gigabit boost," *PC World*, July 2, 2013, http://www.pcworld.com/article/2043483/alcatellucent-gives-dsl-networks-a-gigabit-boost.html.

Future capacity and lifespan of investment

It is only a matter of time before the growing demand for bandwidth comes up against the physical limitations of copper as a medium for transporting data. Even if an operator can satisfy present demand using existing copper assets, it is a significant challenge to upgrade a DSL network in a way that the majority of a large-scale network can continue to serve future demand. Many telecommunications companies are minimizing their investment in copper lines, and some are abandoning copper lines for wireless services or migrating to FTTP. New investment in DSL will likely become obsolete within a decade.

Fixed wireless

The high cost of building wired networks in low-density rural areas often leaves rural residents without a wired broadband option. Wireless internet service providers (WISPs) are potentially able to fill these coverage gaps, sending signals from base stations to antennas on or near customer premises. But WISPs are not able to offer connection speeds on a market-wide basis comparable to cable or FTTP built to each premises, and often need to impose data caps on customers to manage limitations on capacity. Accordingly, although fixed wireless service is an important tool to help connect the unconnected, most fixed wireless solutions will not offer the quality of service that the most advanced wired providers can provide. Even as wireless technologies continue to advance, they will still lag behind the performance of fiber optics, simply because of the relative challenge in providing high-capacity connections wirelessly over long distances.[123]

A relatively fixed wireless technology that is gaining traction is Tarana Wireless, a Next-Generation Fixed Wireless Access (ngFWA) technology. Tarana has demonstrated better results in non-line of sight circumstances, such as in areas of heavy foliage. It also has higher capacity and can offer up to 1 Gigabit symmetrical speeds.[124]

Technical capacity and limitations

Smaller WISPs use the same unlicensed spectrum bands as Wi-Fi, which does not have strong long-distance transmission qualities. (This is in contrast to the large mobile carriers like AT&T, Sprint, T-Mobile, and Verizon Wireless, which offer 3G/4G service using licensed spectrum.) WISPs may also use other unlicensed or semi-licensed bands like 3.5 GHz CBRS or 900 MHz, but these also have low data speed capabilities. There are also providers, especially in urban areas,

[123] The analysis of wireless options presented in this report assumes a benchmark capacity of 1 Gbps per location. That is not to say that lower bitrate systems may be insufficient for some locations, nor would it suggest that higher bitrates would not be desirable for others at some time in the future.
[124] Tarana Wireless, https://www.taranawireless.com/our-mission/#the-solution.

who are using advanced millimeter wave wireless technologies. These potentially provide speeds of 1 Gbps over a link, and providers such as MonkeyBrains and Starry have created networks in Boston, San Francisco, and elsewhere that send signals from rooftop to rooftop and distribute the service indoors with a combination of existing copper cabling and Wi-Fi.

Most wireless networking solutions require the antenna at the customer premises to be in the line of sight of the base station antenna. This can be especially challenging in mountainous regions. It is also a problem in areas with dense vegetation or multiple tall buildings. WISPs often need to lease space at or near the tops of radio towers; even then, some customers may be unreachable without the use of additional repeaters. And because the signal is being sent through the air, climate conditions like rain and fog can impact the quality of service.

Some wireless providers in rural areas have begun to use vacant television frequencies called TV white space (or simply white space) to provide service. These TV bands have much better non-line-of-sight transmission qualities than the unlicensed bands; however, because white space technology is still in an early phase of development, compatible equipment is far more expensive than other off-the-shelf wireless equipment.

Wireless equipment vendors offer a variety of point-to-multipoint and point-to-point solutions. Point-to-multipoint solutions are more affordable to implement and are typically used in a WISP environment. However, they limit the capacity of the network, particularly in the upstream, making the service inadequate for applications that require high-bandwidth connections.

Fixed wireless systems built with off-the-shelf equipment today tend to have an aggregate capacity between 100 and 250 Mbps. With innovations like higher-order multiple input, multiple output (MIMO) antennas, and the use of spatial multiplexing, these capacities will likely increase across vendors to as fast as 750 Mbps. It is important to note, however, that this is the aggregate capacity; bandwidth will be shared among up to 200 users connected to a single base station.

Factors impacting quality and speed of service

The following factors will determine a fixed wireless customer's service speed and quality:

- **Wireless equipment used:** Different wireless equipment has different aggregate bandwidth capacity and uses a range of different spectrum bands, each with its own unique transmission capabilities.
- **Backhaul connection**: Although the bottleneck tends to be in the last-mile connection, if a WISP cannot get an adequate connection back to the internet from the tower, equipment upgrades will not be able to increase available speeds beyond a certain point.

- **Unobstructed line of sight:** Most wireless networking equipment requires a clear, or nearly clear, line of sight between antennas for optimum performance. WISPs often lease space near the tops of radio towers in order to cover the maximum number of premises with each base station. In mountainous regions, many premises may not have a clear line of sight to a radio tower.

- **Weather conditions and foliage:** Depending on the spectrum used, weather conditions like rain or fog may cause interference. Also, line-of-sight paths that are clear during the winter may be obstructed by foliage during the warmer months.

Future capacity and lifespan of investment

Wireless equipment generally requires replacement every five to 10 years, both because exposure to the elements causes deterioration, and because the technology continues to advance at a rapid pace, making equipment from a decade ago mostly obsolete. The cost of deploying a wireless network is generally much lower than deploying a wired network, but the wireless network will require more regular investment.

Satellite-based communications

Satellite-based communication, facilitated by geostationary (GEO) and low earth orbiting (LEO) satellites, provides the distinct advantage over terrestrial communication of nearly ubiquitous coverage of a large area of up to thousands of square miles. For GEO satellites, the high altitude allows a few satellites to cover very large areas, while for LEO satellites, thousands of small satellites achieve similar effects. The mostly unencumbered line of sight with the satellite—apart from local obstructions by vegetation or built structures—means signal loss is low. The large distance between transmitter and receiver for GEO systems introduces time lags that hamper real-time applications such as video, but LEO systems can theoretically support mobile broadband – although this technology is still in early stages of development.

Overview of technology and service providers

Satellite communications via geostationary platforms has been offered for years by several companies in North America, most notably by Viasat, HughesNet, and Telesat. Their satellites are positioned at a distance of 36,000 kilometers from earth, orbiting in synchronization with the earth's rotation. The high altitudes provide the ability for coast-to-coast coverage with one or a few satellites.

Viasat, for example, has two satellites in orbit to blanket the U.S. While the service availability is claimed to be nearly ubiquitous with some caveats based on geography, the available data rate is typically in the sub-hundred Mbps range due to the large number of customer access points

the satellite serves and because of the fixed capacity of the transponder electronics in space. A drawback shared by all geostationary communication is the high signal latency, which is approximately 330 milliseconds. Typical data-only applications are not impacted by the delay as much as interactive services or voice communication.

Typical data rates from geostationary satellites range in tiers from 18 Mbps to 100 Mbps downstream and 3 Mbps upstream. The availability of the higher speed tiers is dependent on the subscriber location. In areas of high take-rates (i.e., many subscribers) the user experience tends to be diminished.

In contrast to GEO, LEO satellites have a much-improved broadband potential. As their orbits are at an altitude of 500 km to 650 km, signal delays are an order of magnitude shorter. More importantly, the signal path loss is drastically reduced, allowing greater spectral efficiency—in other words, more data capacity for a given amount of spectrum. Due to the lower orbits, LEO systems provide a smaller wireless coverage area on earth. Unlike geostationary systems that are bound to an equatorial path, LEO constellations can orbit the earth in any direction, thereby forming a contiguous stellar communications network. But because LEO satellites travel at a faster angular speed than the earth's rotation, more satellite stations are required to guarantee continuous connectivity on the ground as the ground receiver is handed off to the next closest satellite.

LEO systems have been in use since 1997 when Iridium launched 66 satellites that have been providing voice and low-speed data service worldwide to handheld devices. The LEO concept has gained renewed and significant momentum in recent years with new entrants that put forward ambitious projects, such as SpaceX with its Starlink program, which started operations in 2019. Further contenders include, among others, the British company OneWeb; Amazon's Kuiper project, which is scheduled to launch in 2023, and Telesat's Lightspeed, projected to go live in 2025.

Starlink currently has more than 3,000 satellites in operation. The company has also received FCC approval for an additional 7,500 satellites in coming years for a total of around 42,000 satellites by mid-2027.[125] With every launch of 60 satellites, the aggregate data capacity is augmented by 1 Tbps. [126]

[125] Akansha Dimri, "Elon Musk's SpaceX to raise $750M at $137B valuation," Tech Funding News, January 3, 2023, https://techfundingnews.com/elon-musks-spacex-to-raise-750m-at-137b-valuation%EF%BF%BC/.
[126] Interview with Rebecca Hunter, Account Manager at SpaceX, private discussion, February 14, 2022.

Residential and small business customers signing up for Starlink service today may receive data speeds of 100 to 150 Mbps downstream and 20 to 40 Mbps upstream. In rarer cases, speeds exceeding 400 Mbps have been measured. The company has stated that its goal is to increase the data rate to 1 Gbps for residential use, although required technologies enabling those bitrates are still in the development and testing phase.

Starlink's Premium service is expected to have higher throughput and allow multiple concurrent sessions. One use case mentioned by Starlink is internet access at community centers or libraries in underserved regions supporting as many as 40 to 60 concurrent users.

The aggregate bandwidth on the subscriber side is undetermined at this time but expected to be on the order of 500 Mbps downstream. Another model is for Starlink to serve as an infrastructure that internet service providers can use – along with terrestrial services,[127] so future arrangements for internetworking Starlink-connected sites with private residents and/or public entities within a rural community may be a possibility, but is only conceptual at this point.

Starlink's residential service is priced at $110 per month and requires the purchase of the antenna and customer premises equipment—for which Starlink charges $599[128], although the equipment has a reported manufacturing cost of $1,000.

Starlink's Premium service subscription is currently priced at $500 per month. The customer premises equipment, including antenna, has a price tag of $2,500.

An interesting use case is for LEO systems such as Starlink to provide direct cellular connectivity to connect to cellphones in areas that are currently dead zones. Unlike the very expensive edge equipment and subscription costs, this would not require any additional equipment beyond existing cell phones as mobile partner providers use existing spectrum they own for this capability. T-Mobile has partnered with Starlink, but Verizon and AT&T have announced similar initiatives with other LEO partners, AT&T with AST SpaceMobile, and Verizon with Kuiper.[129]

[127] Rebecca Hunter interview.
[128] "Starlink Internet Review," Satellite Internet, https://www.satelliteinternet.com/providers/starlink/.
[129] Alejandro Piñero, "Podcast: Rounding up the year in telecom," Fierce Wireless, December 29, 2022, https://www.fiercewireless.com/wireless/podcast-rounding-year-telecom; Scott Moritz, "AT&T CEO Says His Satellite Service Has Lead on Musk's," Bloomberg News, October 5, 2022, https://www.bloomberg.com/news/articles/2022-10-05/at-t-ceo-says-his-satellite-phone-service-has-lead-over-musk-s).

Though LEO systems are promising they face substantial challenges. LEO systems require thousands of satellites. It is not clear that the market is strong or large enough to fund that investment. Even small divergences on expectations of lifespan of the equipment could make enormous differences in financial viability. In short, the biggest problems right now are:

- It is unclear that LEO systems can sustain promised speeds as more customers join the network because there are capacity constraints per satellite and per earth base station.
- There is no indication that the proprietary and expensive customer edge equipment will come down in price. So far, it has increased in price – without industry standards and scale, prices are unlikely to go down.
- There is no indication that the very high cost of monthly subscription will go down in price. So far, it has increased from its initial $99 to $110 per month, and the equipment fee has gone up $100. Starlink has so far pushed back against any efforts to define a more affordable, lower bandwidth pricing tier and does not participate in the federal Affordable Connectivity Program.
- There is no guarantee that the network is sustainable in the long run. It is extremely costly to deploy and maintain, and Starlink is facing competition from other LEO entrants and mobile and fixed broadband providers. Any investment in Starlink equipment and service now may not be of any use a few years from now.

Middle-mile in the sky

Telesat, a Canadian satellite operator of 15 geostationary satellites with yearly revenue of $700 million, is working on Lightspeed, a LEOS-based service with an investment of $5 billion and plans to be operational by 2025. Unlike Starlink and Kuiper, which primarily serve the residential and small business markets, Lightspeed is targeting enterprise customers with data rate requirements from 100 Mbps guaranteed bandwidth to gigabit speeds with carrier-grade availability. Their service is strictly based on a layer 2 connection model in line with a Metro-Ethernet type private network service. In addition, Telesat plans interconnection options with major data centers and carrier connection exchange points. In that role within the communications market, Lightspeed is the equivalent of a middle-mile fiber provider in the sky providing lit point-to-point and point-to-multipoint services, although with lower capacity.

The first 78 Telesat LEOS will be launched into polar orbits to provide coverage of the northern American continent. Ultimately a constellation of 298 satellites with a total capacity of 15 Tbps transmitting in the KA band (26 to 40 GHz) with beam forming antennas will provide what the company calls seamless connectivity to its customers. The company claims high service availability will be achieved through redundancy with inter-satellite free-space optic links. At any

given time, end users' antennas will have at least two satellites in sight, which the company says will translate to an estimated service availability of 99.999 percent.

The customer site will require a 1-meter-diameter satellite tracking dish antenna for a 100 Mbps symmetrical link; 1 Gbps data rates are possible with antennas of 2.4-meter diameter. Satellite communications systems are notoriously expensive; the smaller antenna system will be available at an introductory price of $10,000, while the larger antenna may be as high as $200,000. Telesat estimates that the prices will be drastically reduced once the service gains traction and the antennas and electronics can be produced in large quantities.

The cost of Telesat's service is currently undisclosed. Prices reportedly will vary by sales volume, location, and contract terms. However, Telesat predicts that the cost per megabit will be orders of magnitude lower than the geostationary communication services pricing. On the other hand, Telesat also states very clearly that they do not intend to compete with fiber providers and that they will not be able to match the price of fiber-based services.[130]

At this point, the federal government of Canada is the first and only contracted customer for Lightspeed service.

One can speculate that Starlink, with a fully populated constellation of 12,000 satellites—which the company says will grow to 30,000 spacecraft with a capacity of about 17 Tbps per satellite—will have sufficient bandwidth to entertain different service models (including wireless backhaul with connection speeds exceeding 1 Gbps). When asked about that prospect, a representative of Starlink did not rule out such service plans but was reticent about sharing any vision for the company's plans beyond the Premium service.

High-altitude platform systems

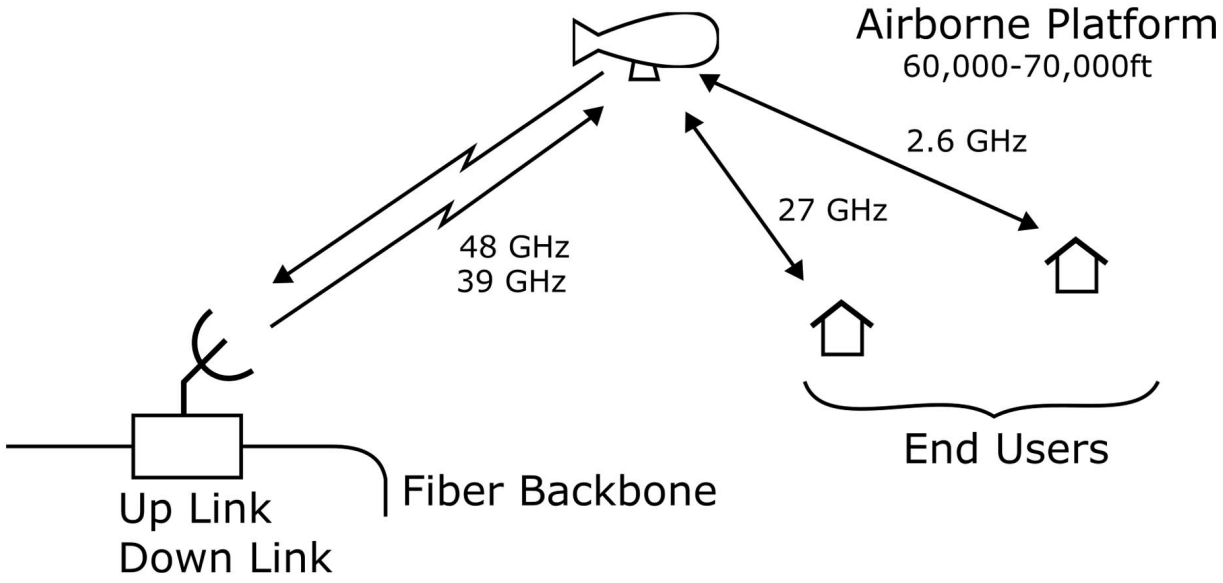
In light of the high capital investments and operations costs of satellite communications, the concept of lower-cost high-altitude platform systems (HAPS) has gained much attention in the communications community in recent years.

HAPS are quasi-stationary airborne communications platforms in the stratosphere outside the commercial traffic airspace between 60,000 feet and 70,000 feet (Figure 63). That altitude appears to be particularly suitable for the positioning of aircraft as atmospheric turbulence is rare

[130] Jeffrey Gardiner, Director of Sales, Telesat, private communication, February 14, 2022.

and average wind speeds are light (5 mph to 40 mph). Air movement is somewhat dependent on the region with lower latitudes typically exhibiting less air movement.

Figure 62: HAPS concept of a wireless communications tower in the sky



Compared to LEOS service the transmitters on HAPS are much closer to the end user, thus reducing the latency to a range comparable to terrestrial wireless communication and allowing for better signal strengths between earth and aircraft. The most significant advantages of HAPS over terrestrial and satellite communications cited by industry experts include:

- Capital investment and cost of operations is expected to be drastically lower for HAPS than for satellite systems.
- HAPS provide flexibility in serving remote areas and in filling terrestrial wireless coverage gaps (white spots).
- Services provided from HAPS may be possible with off-the-shelf customer equipment.
- Signal latency from HAPS platforms of approximately 0.3 milliseconds is comparable to terrestrial wireless communication and therefore suitable for voice communication and interactive applications.

- HAPS have a short deployment time: HAPS can be brought into position within hours, which may be in high demand in disaster recovery scenarios.

- Easy payload and transponder customization allow HAPS to support a variety of service models, including backhaul service.

HAPS concepts are currently in a research and development phase. The idea of using flying platforms for communications purposes dates back to 1996 when the ITU initiated a use case study. The practical exploration and development of suitable prototypes started much later in 2011, when Google launched its balloon-based version of a HAPS, called Loon LLC. Many approaches to HAPS have been envisioned and prototyped since then.

Experimental HAPS have been implemented in the forms of fixed-wing lightweight drones powered by solar cells and blimps of various sizes. The list of stakeholders and participants in HAPS projects today includes well-known names in the communications industry (Google, Facebook, Deutsche Telecom) and aircraft industry (Airbus), among many others, which is evidence of the broad interest in airborne communications platforms.

Most of the ongoing testing has the primary goal of finalizing a design of unstaffed communications aircraft that have the capability to stay aloft for weeks or months, to maintain the desired position, and to be safely returned to earth for maintenance. Several projects initiated in early years have been terminated as the experiments did not yield the results required for practical high-altitude internet platforms. Google's Loon project was eventually terminated after six years when it was concluded that the balloons' positioning by means of altitude control was not feasible. Aquila, launched by Facebook in 2016, was also cancelled just two years later after a failed flight test landing exposed both design and control flaws.

Much of current development efforts of high-altitude flying platforms seem to be focused on aircraft designs, materials, vehicle control algorithms, and the challenging power management associated with solar cell fueled motors. Some contenders are further along than others. In late 2021, Airbus's Zephyr concluded a successful test flight of a solar-powered glider with a flight time of 36 days at an altitude of over 70,000 feet. Thales Alenia's Stratobus blimp prototype is taking shape but will not be available before 2024.

Sceye, a company that has concentrated its efforts on blimp technology development, claims to be close to a final prototype that could be put into service by 2024, assuming that the test flights in the next two years validate the expected long-term integrity of the blimp's skin material, solar

cell capacity, and the flight control system of the airship.[131] The company has developed and tested nine blimp prototypes in eight years. With every subsequent blimp version, lessons learned from previous tests were incorporated in the aeronautic engineering design, material compositions, and remote and autonomous flight control algorithms.

Sceye estimates that their blimps will be able to hold payloads of several hundred kilograms and stay in designated positions for up to a year before they would have to be returned to ground for maintenance.

[131] Alfredo Serrano, VP Marketing and Sales, Sceye, private communication, February 9, 2022.