Chapter

A3

Appendix 3 - Needs Assessment

MEMORANDUM

To: Ellen Talbo, Ben Aghegnehu, Santa Clara County Roads and Airports Department

From: Kim Voros, David Wasserman, Mauricio Hernández, Alta Planning + Design

Date: June 14, 2022 (Updated Deliverable)

Re: Santa Clara County Active Transportation Plan – Active Transportation Network Analysis

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Introduction

This document provides an analysis of existing conditions for bicycling and walking within Santa Clara County, examines network connectivity, and assesses latent demand for active transportation as part of the Santa Clara County Active Transportation Plan (ATP). The findings included in this memo will inform the infrastructure recommendations contained in the final Plan document. These recommendations will focus on improving walking and bicycling infrastructure for users of all ages and abilities. **Please note that the ATP and related analyses focus on county-controlled roadways (i.e., study roads) regardless of whether the geographic area is incorporated or unincorporated**.

The project area is comprised of over 630 miles of county-controlled **roadways,** about 62 miles of which are classified as expressways. The needs assessment discusses the project area (i.e., roadways controlled by the Santa Clara County Roads and Airports Department in unincorporated parts of the county and expressways) in terms of the northern (**urban**) area and the southern (**rural**) area:

- The **urban** area, generally comprised by the northern portion of the County is home to nearly 1.7 million people, 92% of which live in one of the 15 incorporated cities within the County. It is a major employment center and provides over a quarter of the jobs in the region. There are approximately 515 miles of county-controlled **study roadways** in the **urban** area.
- The **rural** area is home to about 136,000 residents and most employment is agricultural. There are 109 miles of County roadways in this southern area of unincorporated 'pockets' of land surrounded by cities in the **rural** area.

Memorandum Organization

The memorandum has been organized in the following sections:

- A discussion of **Existing Bicycle Infrastructure** and an analysis of **Bicycle Level of Traffic Stress** (BLTS) and BLTS stress island analysis.
- A discussion of **Existing Pedestrian Infrastructure** including marked crosswalk spacing, marked crosswalk completeness at intersections, **Pedestrian Level of Traffic Stress** (PLTS) and PLTS stress island analysis
- An assessment of stress-adjusted bicycle and pedestrian **network connectivity**.
- An analysis of **active trip potential** (i.e., Origin and Destination Analysis) to understand the demand for short trips.
- Identification of **Primary Network Gaps** which considers the intersection of areas with high active trip potential and infrastructure gaps.
- The **Summary of Findings** and **Discussion** includes strategies that can be used to identify other infrastructure recommendations to address the primary network gaps.
- The **Appendices** section includes detailed methodologies for each of the aforementioned analyses.

Please note that each section includes a summary of general findings.

Existing Infrastructure Assessment

Bicycle Infrastructure

Bicycle infrastructure includes facilities along roadways and corridors that support people traveling by bike. These include shared-use pathways (Class I) and bicycle lanes (Class II). **At the time of this analysis, the County does not implement bicycle routes (Class III) and separated bikeways (Class IV)** This assessment includes analysis of roadways where these facilities are located, as well as their current conditions. It also provides an understanding of where missing facilities—or gaps—may impact bicycling in Santa Clara County.

There are approximately 9.6 miles of bikeways in or along **study roadways** in Santa Clara County (**Table 1**). This includes 1.7 miles of Class I shared-use paths and 7.9 miles of Class II bicycle lanes. All designated facilities are found in **urban** Santa Clara County and are found on less than one percent of county-controlled roads. It is important to note that as of the writing of this memo, the county does not designate Class II facilities along expressways.

Currently, there are no designated bicycle facilities on rural county-controlled roads. However, based on community feedback, popular roadways among bicyclists include Uvas Road, McKean Road, Monterey Street, Hill Road and Santa Teresa Boulevard.

Table 1. Existing Bike Facility Mileage

Roadway	Bicycle Facility Type	Mileage	Location
San Tomas Expressway	Class I	1.7	Urban
Junipero Serra Boulevard	Class II	2.4	Urban
Foothill Expressway	Class II	2.7	Urban
Page Mill Road	Class II	2.8	Urban

While a number of locally controlled roadways (i.e., city-maintained roadways) include designated bicycle facilities, the majority of county-controlled roadways do not include designated bicycle facilities. Existing bicycle facilities in the **urban** and **rural** areas are shown in **Figure 1** and **Figure 2.**

Field Assessment – Bike Infrastructure

The study team conducted field observations in January 2022 to get an on-the-ground understanding of current conditions and inform the bicycle infrastructure related analyses. While an extensive field inventory was not completed due to the sheer size of the County's roadway network, the following roadways and intersections were selected for field review based on functional classification, existing bicycle facilities, and rankings on the county's High Injury Network (see **Safety Analysis** in **Appendix**). Please note that some cross-streets at intersections are not County-Controlled.

Roadways

- Almaden Expressway
- Capitol Expressway
- Cherry Avenue (City of San José local street)
- Foothill Expressway
- Montague Expressway
- Page Mill Road
- Laumer Avenue

Intersections

- Almaden Expressway and Blossom Hill Road
- Almaden Expressway and Cherry Avenue
- Capitol Expressway and Senter Road
- Capitol Expressway and Story Road
- Montague Expressway and River Oaks Parkway

Figure 1. Existing Bike Facilities Santa Clara County (Urban)

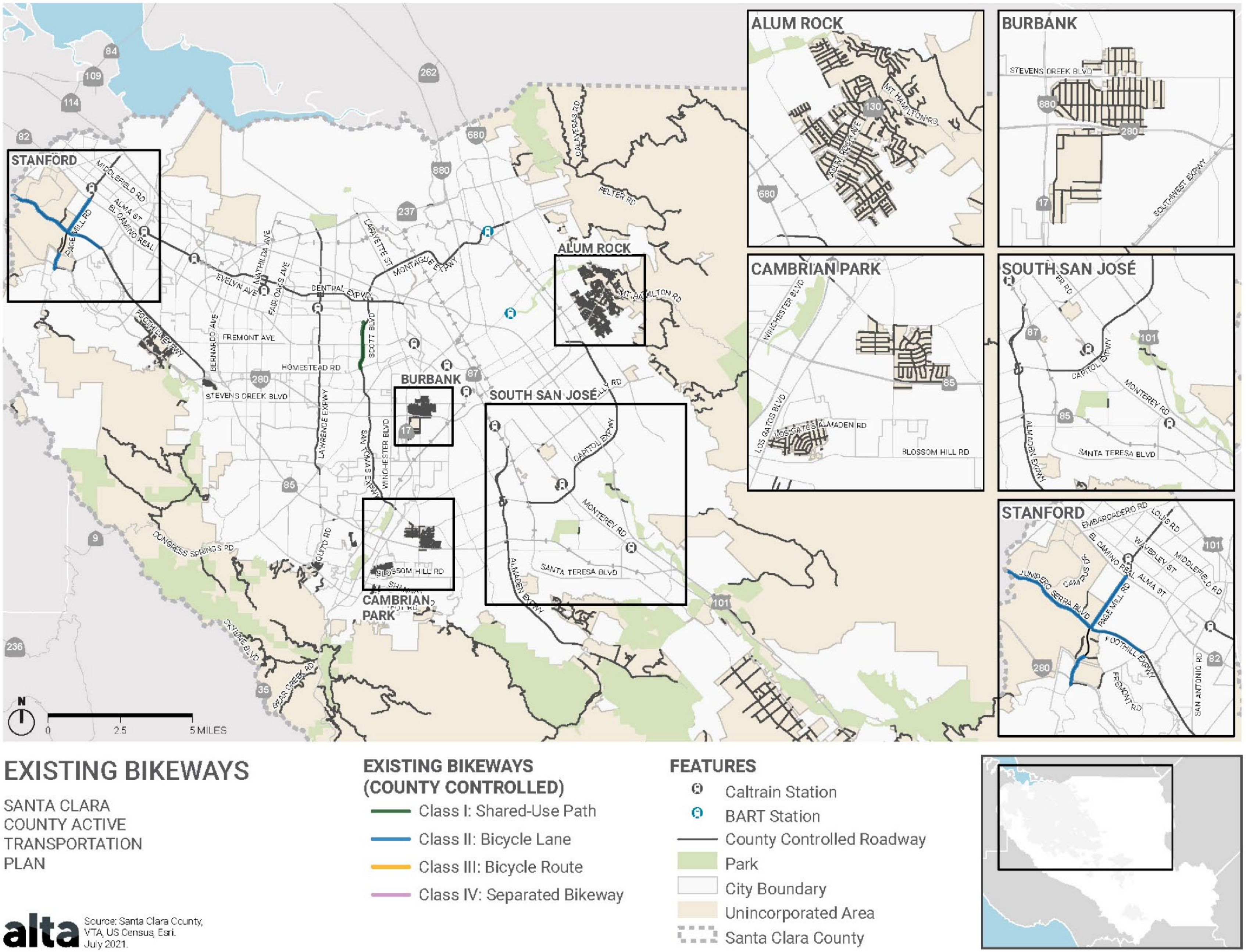
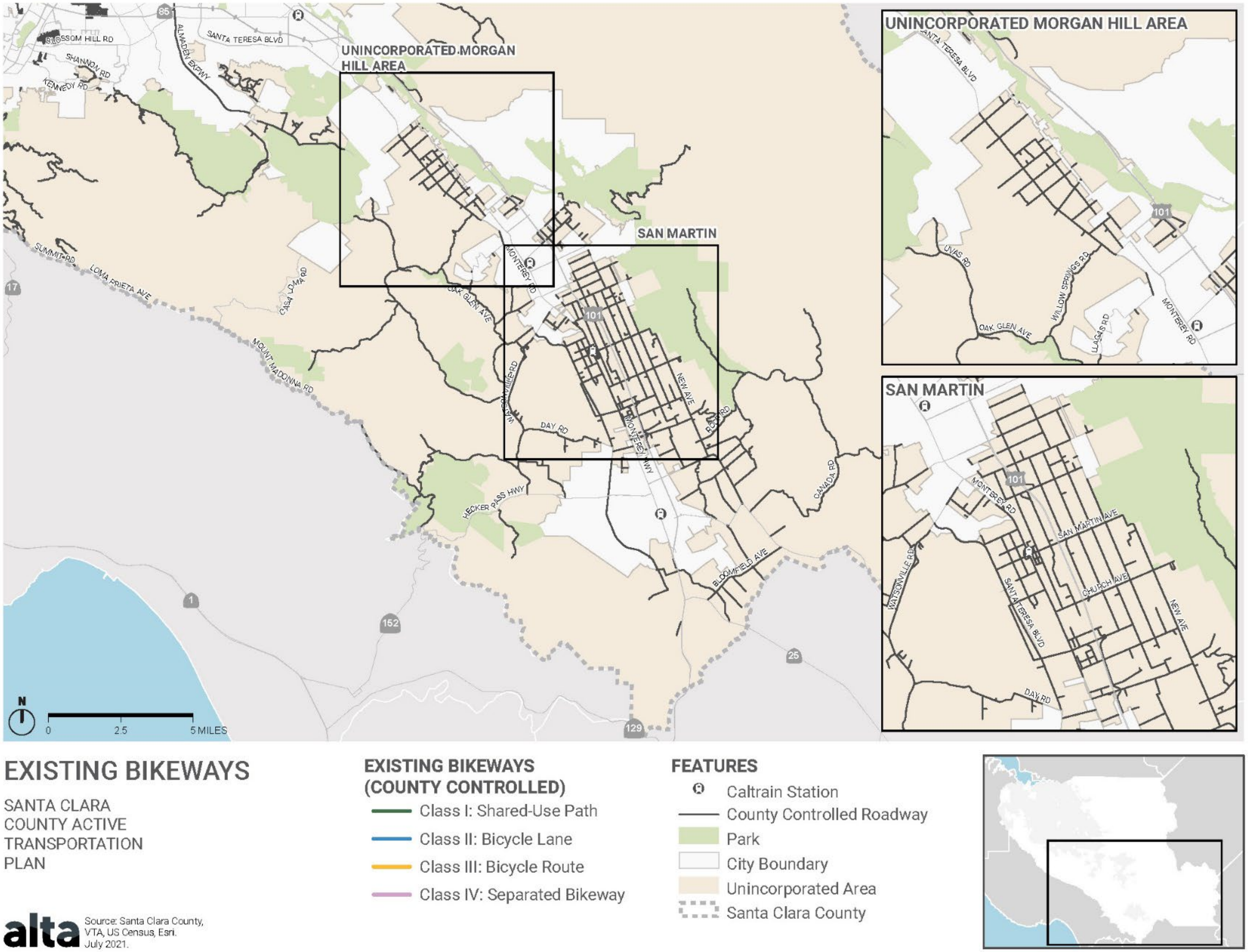


Figure 2. Existing Bike Facilities Santa Clara County (Rural)



Findings

Across Santa Clara County, dedicated bicycle facilities are limited to a small number of roadways. These facilities, where present, are mostly Class II bicycle lanes, although some corridors have parallel Class I trails running along them (i.e., San Tomas Expressway and Thompson Creek). Where designated Class II bicycle lanes are present, they are typically located along wide, high-speed, multilane roadways that represent high-stress environments for most people biking. Perceived speeding is also prevalent, especially along County-controlled expressways where striped shoulders are effectively used as an on-street bicycle lanes (see **Figure 3** below). These multilane roadways with long distances between signals allow drivers to travel above already high (45 MPH or greater) speed limits. In some instances, shoulder areas and travel lanes have been designated as carpool lanes or are used for Santa Clara Valley Transportation Authority (VTA) bus stops (**Figure 4**).

Intersections throughout the County exhibit high-stress characteristics for people biking. In some cases, bike facilities end at intersection approaches to accommodate free right turn lanes (see **Figure 6** below). In other cases, people biking were left to merge or cross a vehicle lane to continue straight through an intersection (see **Figure 5**). Only two conflict areas among the county road network have been upgraded to include green paint to increase awareness of these areas and the presence of people biking. As noted in **Figure 6** some signalized intersections include bicycle detection mechanisms.

Figure 3. Striped shoulder along Capitol Expressway approaching Nieman Boulevard

Figure 4.The bicycle lane on Page Mill Road is only marked with an inner lane marking and shares limited space with bus stops and parked cars. Parking is not allowed, but multiple cars were observed parked in the bicycle lane.

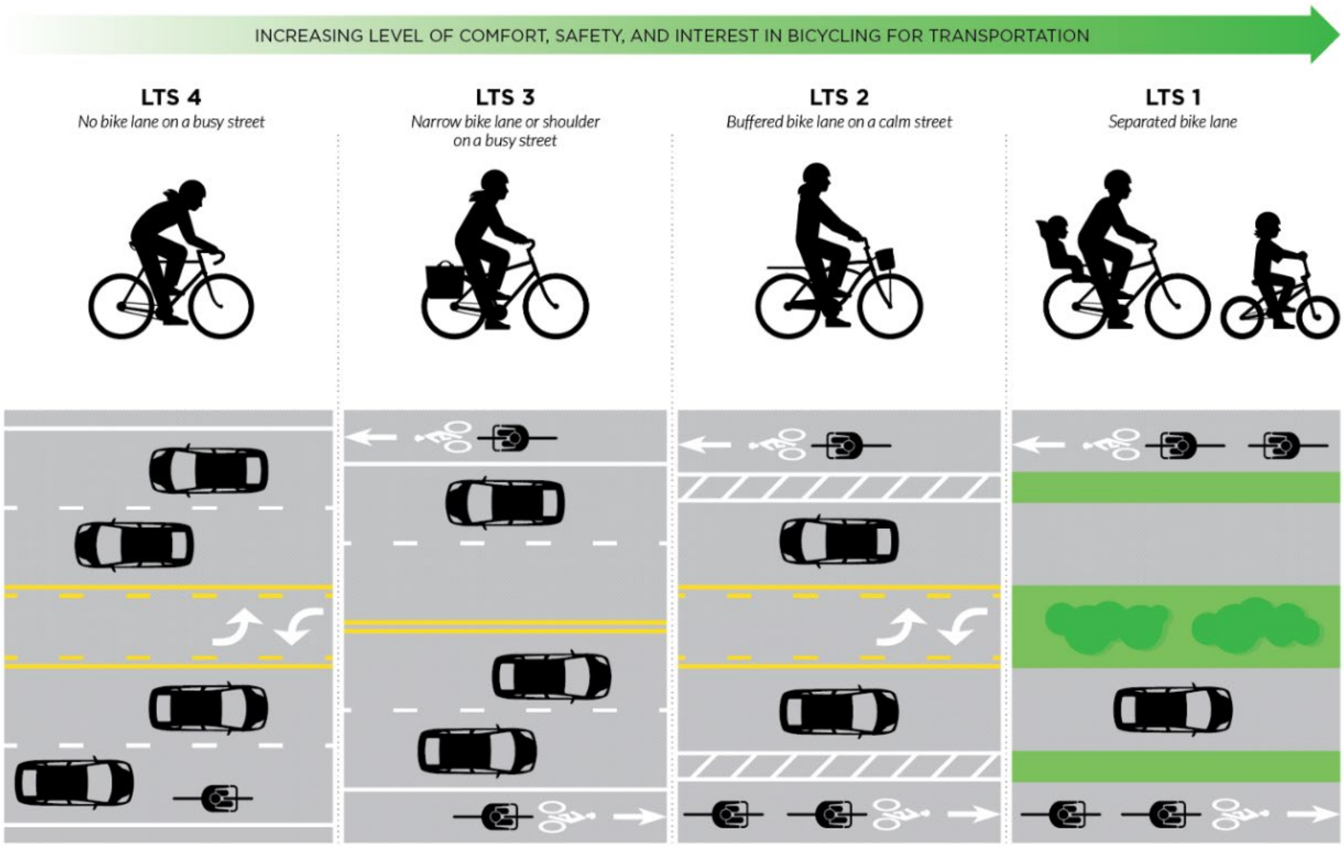
Figure 5. A person biking through the conflict markings on Foothill Expressway, approaching El Monte Avenue

Figure 6. The Capitol Expressway/Snell intersection. People biking must merge left across right turning vehicles in the slip lane to re-enter the bicycle lane approaching the signal (not pictured). The intersection has bicycle detection, but the bicycle lane does not continue across the intersection.

Bicycle Level of Traffic Stress (BLTS)

The study team assessed the bicycle level of comfort using the Level of Traffic Stress (LTS) methodology. The LTS analysis estimates the level of comfort for people biking on a given roadway segment. LTS scores are determined by characteristics of a given roadway segment that affect a user's perception of safety and comfort. **Figure 7** illustrates the level of comfort scores and how they relate to both the type of rider and the characteristics of a roadway. The scores range from Level 1 to Level 4, where Level 1 represents the lowest stress (i.e., most comfortable for all users), and Level 4 represents the highest stress and discomfort.

Figure 7. Bicycle Level of Traffic Stress Illustrated



The BLTS methodology used for this project is adapted from the 2012 Mineta Transportation Institute Report 11-19: Low-Stress Bicycling and Network Connectivity[1]. BLTS is determined by factors including *posted speed limit*, *number of travel lanes*, and the *presence and type of bicycle facility*. The Alta BLTS methodology used relies upon a roadway network derived from Open Street Map (OSM), described in more detail in **Appendix A.**

[1] Mineta Institute. Mekuria M., Furth P., Nixon H. Low-Stress Bicycling and Network Connectivity. 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity

Appendix B includes a more detailed description of the **BLTS** methodology. The combination of this criteria classifies a road segment into one of four levels of traffic stress:

- **BLTS 1** represents roadways where bicyclists of all ages and abilities would feel comfortable riding. These roadways are generally characterized by low volumes, low speeds, no more than two travel lanes, and traffic control measures at intersections. These roadways may have bicycle facilities; separated shared-use paths for bicycles also fall into this category.
- **BLTS 2** represents slightly less comfortable roadways, where most adults would feel comfortable riding.
- **BLTS 3** represents moderately stressful roadways, where most experienced bicyclists would feel comfortable riding.
- **BLTS 4** represents high-stress roadways where only strong and fearless bicyclists would feel comfortable riding. These roadways are generally characterized by high volumes, high speeds, several travel lanes, and complex transitions approaching and crossing intersections.

Considerations:

- The BLTS calculated for **study roads** is based on local county-provided data containing roadway information. The BLTS calculated for other roads is based on publicly available OSM data.
- A BLTS score is calculated for each roadway segment (a roadway segment is defined as the length of roadway between two intersections); the segment score is assumed to apply to both the roadway and the intersection.

Figure 8 and **Figure 9** below show the BLTS findings for the **urban** and **rural** areas of the County. Additionally, total roadway mileage by BLTS for **urban** and **rural** areas is presented in **Table 2**.

Table 2. BLTS by Miles of County Roadway

Rural				Urban				Grand Total
BLTS Level	Arterial[2]	Other[3]	Rural Total	Arterial	Other	Expressway	Urban Total	
1	0.0	99.5	99.5	0.0	139.8	1.7	141.5	241
2	0.0	68.9	68.9	0.4	72.2	0.0	72.6	141.5
3	5.9	22.6	28.5	5.5	27.9	1.0	34.4	62.9
4	14.7	57.8	72.5	0.5	55.3	58.3	115.9	186.6
Grand Total	**20.6**	**248.8**	**269.4**	**6.4**	**295.2**	**61.0**	**362.6**	**632**

[2] Examples of Arterial Roadways include: McKean Road, Santa Teresa Boulevard, Hale Avenue, Watsonville Road.

[3] Other roadways are defined as any road under county control other than a State Highway, Expressway or Arterial. Identified 'Other' rural roads include Metcalf Road, Uvas Road, Monterey Road, Santa Teresa Boulevard, Hale Avenue, Center Avenue, Bolsa Road, East Main Avenue, East San Martin Avenue, Pole Line Road, Santa Teresa Boulevard, and other short roadway segments, mostly in the south county around US 101.

Figure 8. BLTS Santa Clara County (Urban)

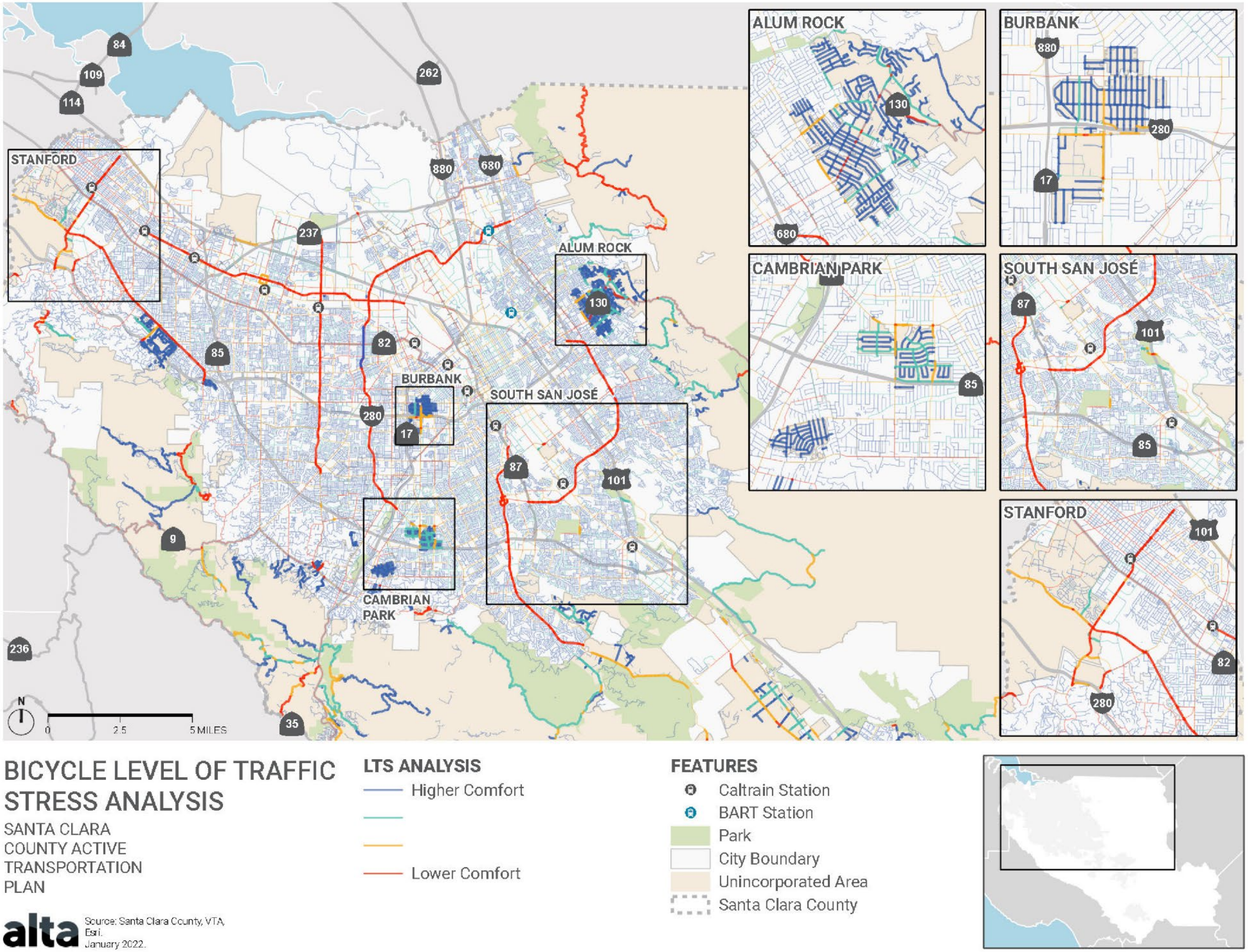
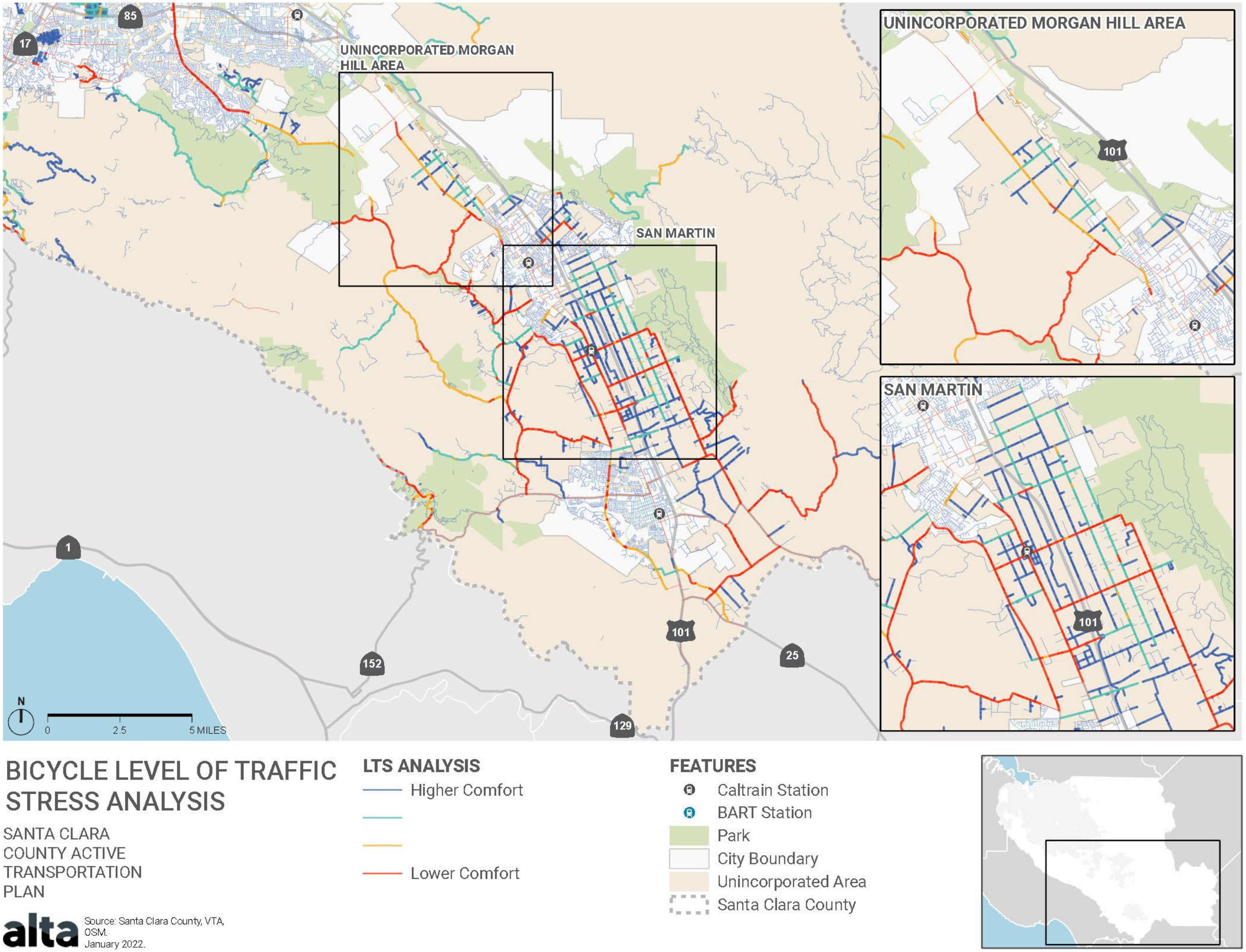


Figure 9. BLTS Santa Clara County (Rural)



BLTS Stress Island Analysis

Figure 10 and Figure 11 show low-stress connectivity islands in Santa Clara County for study roadways and other municipal roadways. The analysis assumes that a higher-stress roadway (i.e., LTS 3 or LTS 4) acts as a barrier for traveling along the corridor and between them (i.e., at intersections). Conversely, low-stress roadways (i.e., roadways experiencing LTS 1 or LTS 2) are assumed to experience lower speed limits, fewer number of traffic lanes. Busier roadways with a lower LTS score (i.e., more comfortable) include dedicated bicycle facilities that that provide separation from motor vehicle traffic. Stress islands are shown in a single color (i.e., blue); smaller islands are lighter and larger islands are darker. Finally, as many destinations are located along major roadways, it may not be possible to access a destination using low-stress routes only.

Findings

The BLTS analysis results indicate conditions along study roadways in both urban and rural areas, with the most common scores of BLTS 1 and BLTS 4. In urban areas there are pockets of BLTS 1 and BLTS 2 roadways in Alum Rock, Burbank and Cambrian Park. Conversely, while there are some roadways with BLTS 1 and BLTS 2 scores in rural areas, these are more frequently bisected by high-stress roadways (i.e., BLTS 3 and BLTS 4) that act as barriers to bicycle travel. Higher LTS scores are typically correlated with major roads like Almaden Expressway, Capitol Expressway, Foothill Expressway, Montague Expressway, San Tomas Expressway and Junipero Serra Boulevard, which provide direct access to schools, parks and employment centers. While designated Class II facilities exist on Page Mill Road, the roadway is still rated as LTS 4 due to the posted speeds over 35 miles per hour and lack of separation between people biking and motor vehicle traffic. Further, collector and arterial roadways without the presence of separated bicycle facilities (ex. Class I or Class IV), experiencing higher speed limits and higher volumes of vehicles were also highlighted as highly stressful and unsuitable for most bicyclists. High-stress routes can also act as barriers to safe and comfortable travel along connecting routes and between low-stress islands. This means that while connecting routes may provide low-stress and comfortable travel opportunities in an area, high-stress crossings effectively limit the reach and connectivity of the route. This is illustrated in the BLTS stress island analysis included in Figure 10 and Figure 11 which show that Santa Clara County is a checkerboard of low-stress islands in both urban and rural areas of the county.

Recommendations

The County should consider developing low-stress connections between existing low-stress islands by providing low-stress bicycle facilities along or parallel to high-stress (BLTS 3 and BLTS 4) roadways. Further, safety improvements to roadways and intersections within the High Injury Network (HIN) identified (experiencing the highest numbers of bicycle collisions) including the Capitol Expressway, Lawrence Expressway and Foothill Expressway should be prioritized. Finally, the County should consider upgrading the existing designated bicycle facilities along major roadways which currently act as barriers including Page Mill Road, to provide for more separation between modes and further improve the comfort and safety of users.

Figure 10. BLTS Stress Islands Santa Clara County (Urban)

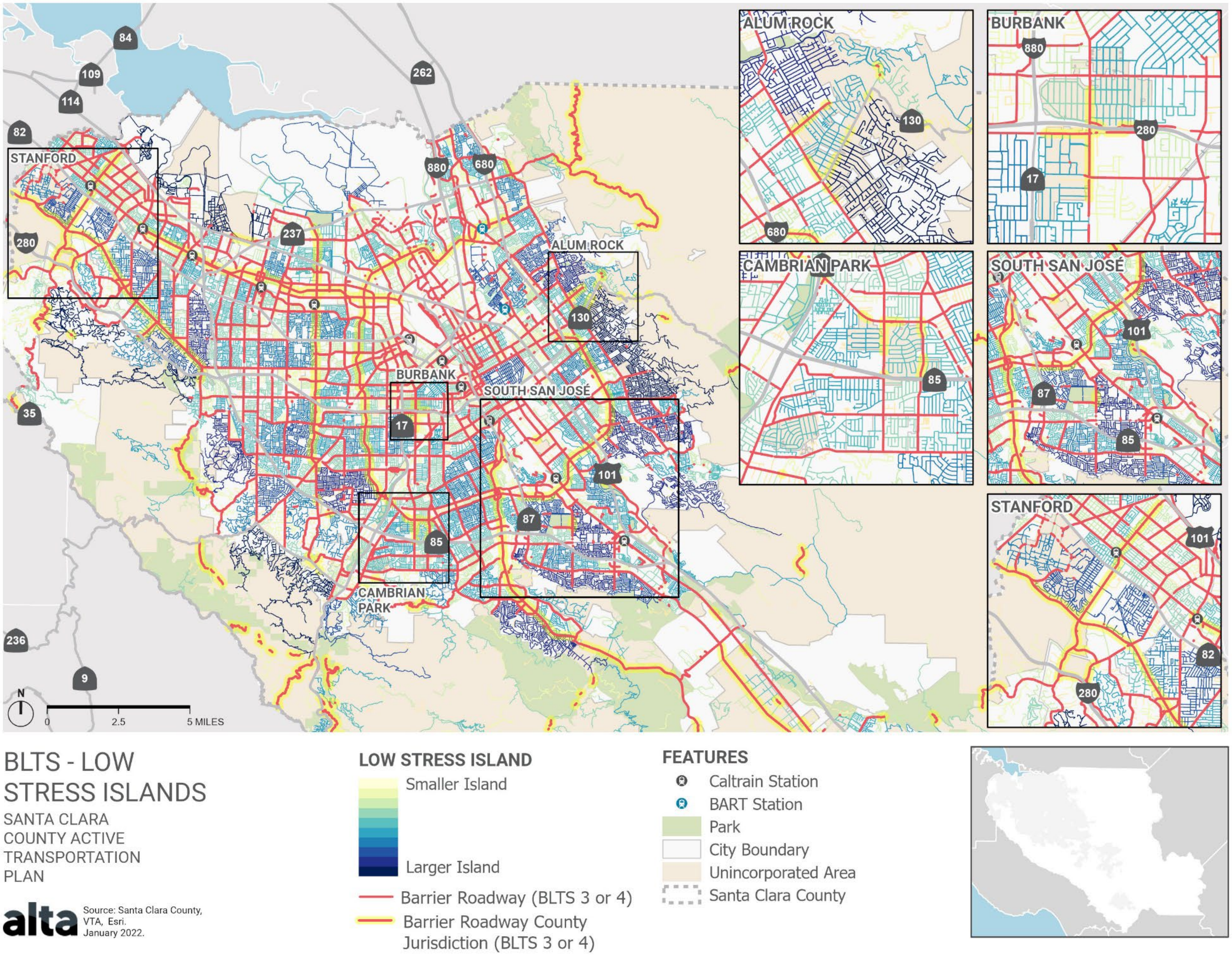
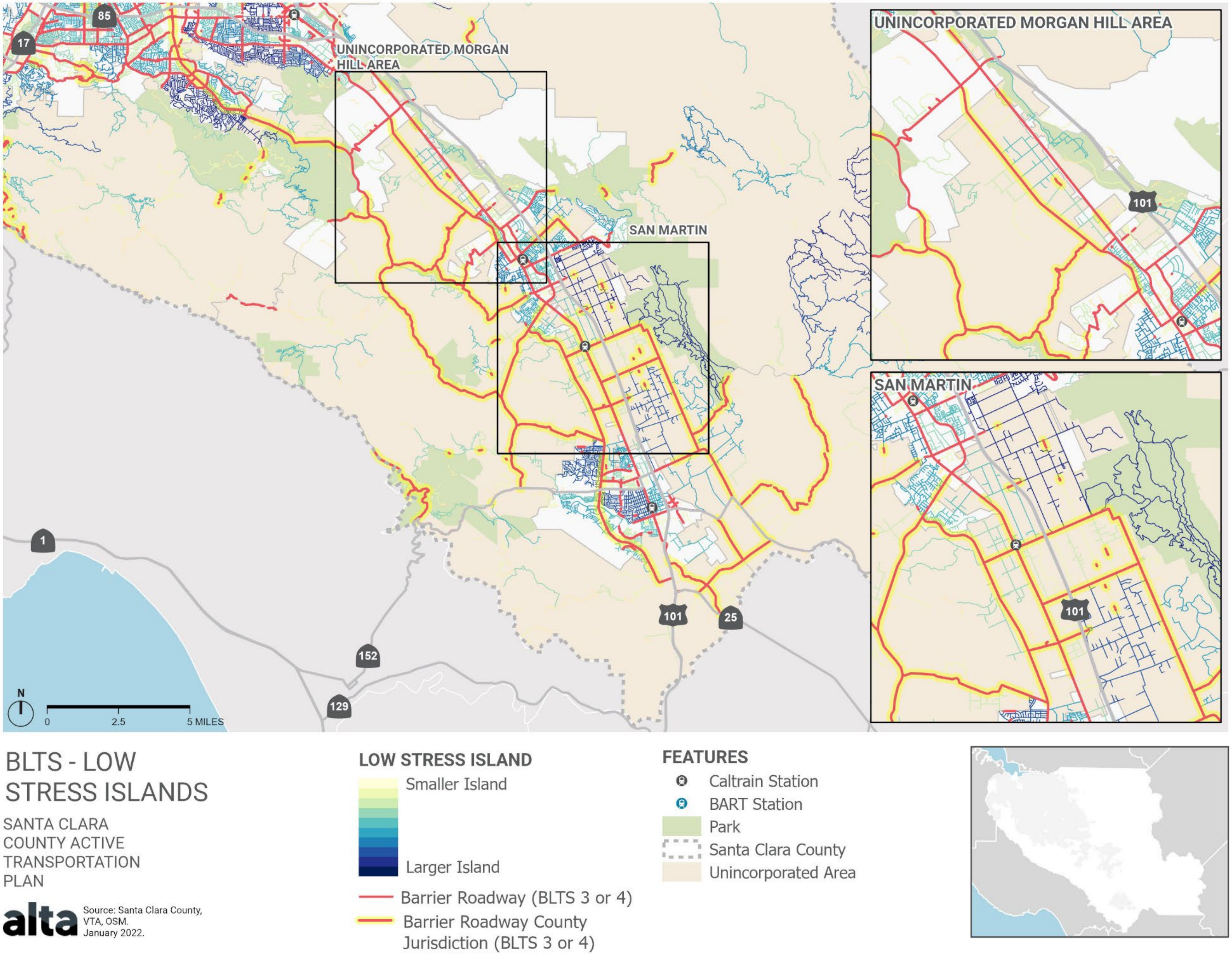


Figure 11. BLTS Stress Islands Santa Clara County (Rural)



Pedestrian Infrastructure

Pedestrian infrastructure includes the facilities that support people walking or using an assisted mobility device such as sidewalks and marked crosswalks. This assessment evaluates both where this infrastructure is currently located as well as their width and provides an understanding of where gaps in the network may impact safe and comfortable travel.

Field Assessment – Pedestrian Infrastructure

The study team conducted field observations in January 2022 to get an on-the-ground understanding of current conditions and inform the pedestrian infrastructure related analyses. While an extensive field inventory was not completed because of the extended size of the County's roadway network, Ecopia data was used to provide information on the location of sidewalks and crosswalks throughout county-controlled roadways. Figures 16 through 22 show where sidewalks and crosswalks are present. Additionally, the study team identified intersections and corridors from the County's High Injury Network (see Safety Analysis) for further review in the field. Field work occurred in unincorporated areas close to Alum Rock and in the cities of Los Altos, Mountain View, Palo Alto, San Jose, Santa Clara, and Sunnyvale. The following roadways and intersections were selected for further field review:

Roadways

- Almaden Expressway
- Capitol Expressway
- Cherry Avenue (City of San José local street)
- Foothill Expressway
- Montague Expressway
- Page Mill Road
- Laumer Avenue

Intersections

- Almaden Expressway and Blossom Hill Road
- Almaden Expressway and Cherry Avenue
- Capitol Expressway and Senter Road
- Capitol Expressway and Story Road
- Montague Expressway and River Oaks Parkway

Findings

Pedestrian facilities primarily consist of sidewalks (where present), crosswalks, and trails. The quality of the facility and comfort level of people using them varies greatly throughout the County. Sidewalks are not consistently present along arterials and expressways. Locations where sidewalks stop, are broken or are obstructed creating accessibility issues for people with physical mobility impairments (see Figure 12). In many cases, especially along and crossing arterial and expressway corridors, the pedestrian experience is more stressful and uncomfortable because of the current streetscape (see Figure 13).

Figure 12. The sidewalk stops on Laumer Avenue and the path of travel is obstructed by a large tree

Crossing arterials and expressways can be difficult for many pedestrians. Many of these corridors include six or more lanes of traffic. In some instances, many roadways widen at intersections to accommodate turning vehicles . For example, at the Almaden Expressway/Blossom Hill Road intersection, the north approach expands from six to ten lanes (7 through lanes, 2 left-turn lanes, and one right-turn slip lane with channelization island). People walking must cross over 150 feet without a pedestrian refuge island to help break the distance (see **Figure 14**).

Generally, most crosswalks are marked at larger intersections with transverse markings at signalized approaches. Some crosswalks across slip lanes are high-visibility. Slip lanes can also be intimidating for some users as fast-moving drivers don't always yield.

Figure 13. There are no sidewalks on this segment of Page Mill Road

Figure 14. Looking across the northern and eastern approaches of the Almaden Expressway/Blossom Hill Road intersection

Figure 15. Intersection of Almaden Expressway and Cherry Avenue. Two people wait at island while another person has just crossed Cherry Avenue (note how they only just made it to the channelization island, and the pedestrian countdown signal already turned)

Pedestrian Infrastructure Analysis

Information on sidewalks and marked crosswalks at and along **study roadways** was captured through an infrastructure assessment completed by Ecopia; a data vendor that extracts roadway infrastructure features, including sidewalk and crosswalk presence, from aerial satellite imagery. This assessment captured data for areas within 500 feet of **study roadways**.

Evaluation of existing infrastructure included two primary assessments:

- **Sidewalk Network** was evaluated based on whether sidewalks were i) present and complete on both sides of the roadway, ii) present and complete on one side of the roadway only or, iii) absent. Sidewalks were classified as incomplete if they were not present along the entire length of the roadway. For example, a roadway that had complete sidewalk on one side of the street and a partially complete sidewalk on the other side of the street would fall into the second category. **Figure 16** and **Figure 17** on the existing sidewalk network along **study roadways**. Results are summarized in **Table 3.**
- **Marked Crosswalk Spacing**, shown on **Figure 20** and **Figure 21**, identifies the location of marked crosswalks along study roadways as well as the distance between them. While a marked crosswalk does not necessarily represent a safe crossing opportunity, especially across high speed and high-volume roadways, findings from this analysis provides insight into potential opportunities for improvement on current unmarked and deficient crossings.

Considerations:

- The sidewalk data is aggregated to facilitate discussion at a Countywide scale
- The crosswalk assessments consider marked crosswalks of arterial roadways but does not consider the presence of traffic signals or other pedestrian infrastructure (ex. curb ramps, Rectangular Rapid Flashing Beacons (RRFBs), etc.)
- The crosswalk assessments do not consider the location of grade separated crossings
- The crosswalk assessment relies upon existing available data and will be verified against aerial photos or a site visit prior to the development of project recommendations

Table 3. Sidewalk Status Sidewalk on Study Roadways (miles)

	Rural			Urban				Grand Total
Sidewalk Status	Arterial	Other	Rural Total	Arterial	Other	Expressway	Urban Total	
Complete Both Sides	0.0	0.3	0.3	0.5	28.2	1.0	29.7	30.0
Incomplete or Missing One Side	1.7	4.6	6.4	2.4	20.9	36.3	59.6	66.0
Incomplete or Missing Both Sides	18.8	243.8	263.3	3.6	246.1	23.5	273.3	535.9
Grand Total	**20.5**	**248.7**	**269.3**	**6.5**	**295.2**	**61.1**	**362.9**	**632.2**

Figure 16. Existing Sidewalks Santa Clara County (Urban)

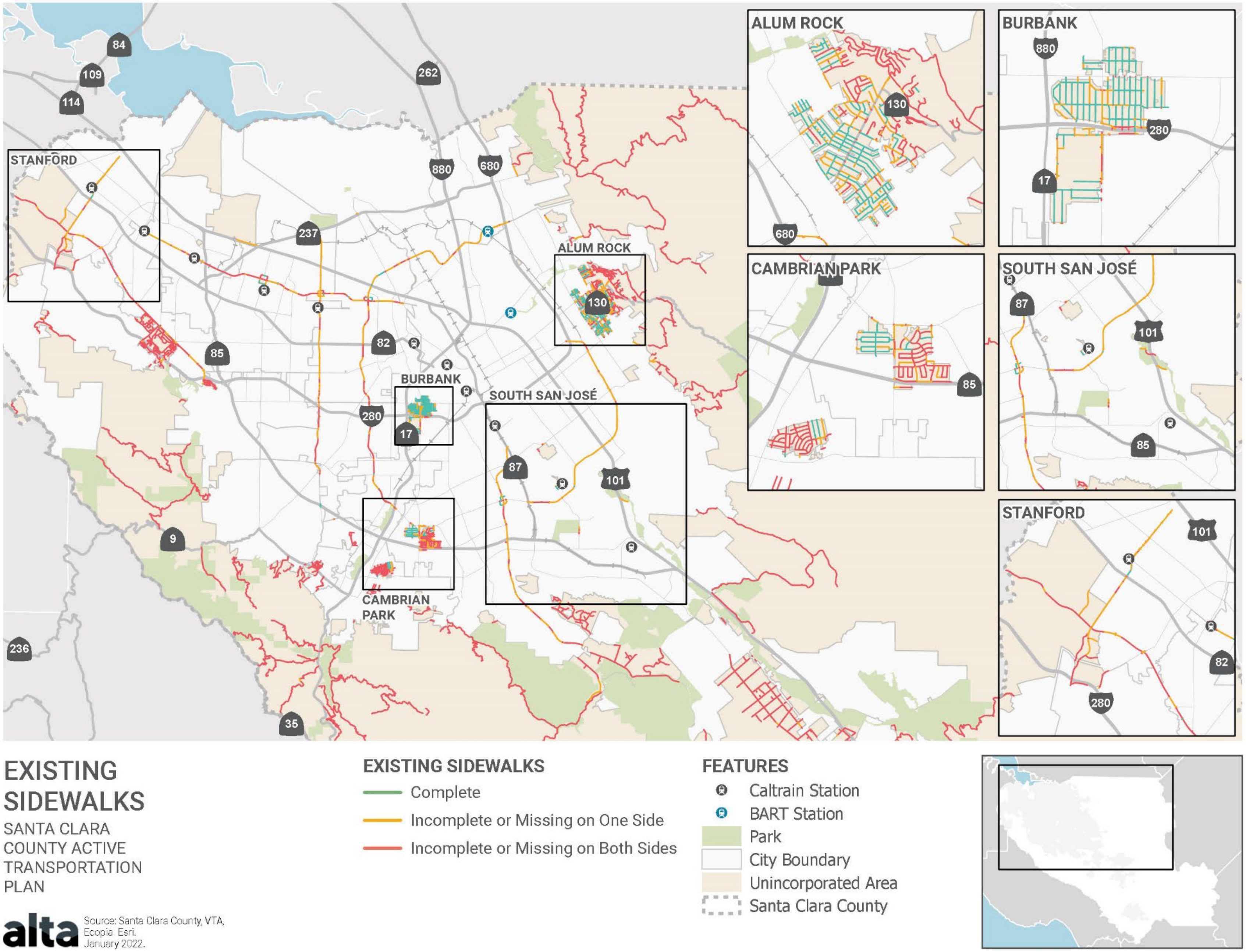
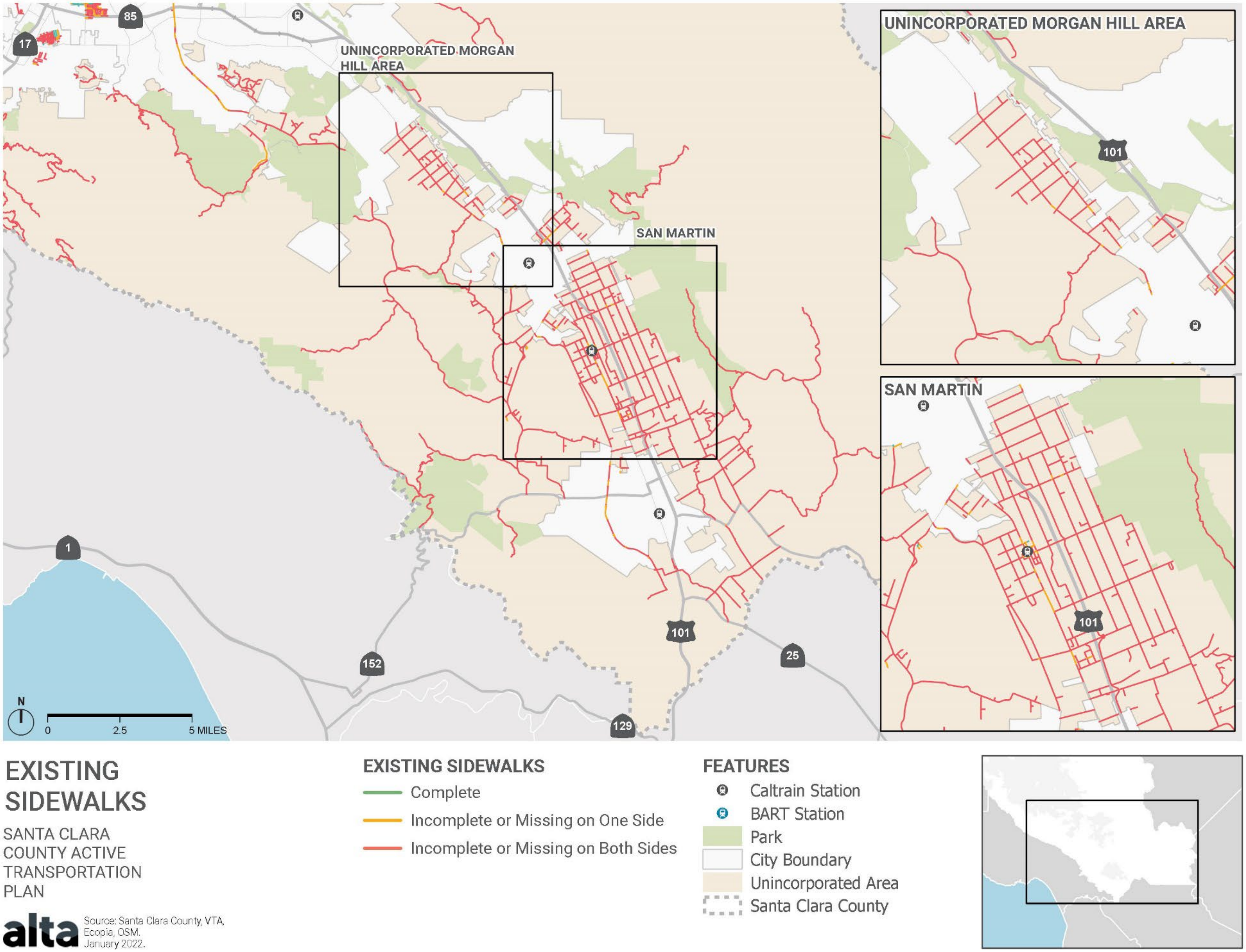


Figure 17. Existing Sidewalks Santa Clara County (Rural)



Sidewalk Assessment

The presence and condition of sidewalks along **study roads** is variable throughout the County. **Study roads** in incorporated areas tend to have a sidewalk on at least one side of the roadway. This is true for roadways like the Montague Expressway, Page Mill Road, and Lawrence Expressway. Other major roadways, like the Central Expressway and San Tomas Expressway, include marked crosswalks but lack sidewalks throughout the corridor. This represents a barrier for people walking and those using a mobility device or have other physical impairments. In **urban** areas sidewalks are present and most complete in Burbank and Alum Rock, while they are missing or incomplete in roadways in South San José, Cambrian Park and Stanford. In these areas, sidewalks widths are more than six feet providing pedestrians with greater separation from motor vehicle traffic along major roadways. In population pockets like Alum Rock and Burbank, sidewalk widths are commonly five feet. Conversely, sidewalks are typically missing on roadways in **rural** areas. Only roadways connecting to the San Martin Caltrain Station and along Santa Teresa Boulevard include sidewalks. In these areas, existing sidewalks are typically five feet or wider.

Recommendations will focus on closing sidewalk gaps in areas with high potential pedestrian demand, specifically around transit centers (ex. BART, VTA and Caltrain stations), parks and schools. Examples of roadways that fit this profile are listed below. Corridors identified as part of the HIN are shown in bold.

Urban Areas

- Bascom Avenue
- Capitol Expressway
- Lawrence Expressway
- Almaden Expressway (urban segments)
- Foothill Expressway

Rural Areas

- Almaden Expressway (through Almaden Valley)
- Condit Road
- Monterey Road

Marked Crosswalks at Intersections, Completeness Assessment

Study roads were also assessed to determine an intersection was complete with crosswalks. Complete indicates that marked crosswalks were present on all approaches. The assessment results are shown on **Figure 18** and **Figure 19** and summarized in **Table 4**. The major intersections along Expressways in **urban** areas typically have marked crosswalks on all intersection legs and are considered to be complete. Intersections marked as incomplete are generally either at the junction of a minor and major roadway or a major interchange where a pedestrian is unable to cross without grade separation (e.g., US 101 and the Lawrence Expressway). In the **urban** pockets like Alum Rock and Burbank, most of the intersections are minor roadways that provide local access and may not realize a significant benefit from a marked crosswalk. However, missing marked crosswalks along arterial roads like South Bascom Avenue in Burbank may benefit from the addition of marked crosswalks and the other associated infrastructure that may be required to create a safe roadway crossing. In **rural** areas most of the roadway intersections are minor and may not benefit from marked crosswalks. However, there are incomplete intersections in Unincorporated Morgan Hill and San Martin that may benefit from additional marked crosswalks, specifically in areas that are expected to serve pedestrian trips. For example, East San Martin Avenue and Depot Street.

Table 4. Marked Crosswalk Completeness Assessment, County Controlled Roads

Marked Crosswalk Status	Road Type	Rural	Urban	Grand Total
Complete	Arterial	4	14	18
	Other	10	14	24
	Expressway	3	101	104
Complete Total		*17*	*129*	*146*
Incomplete	Arterial	52	71	123
	Other	300	613	913
	Expressway	0	114	114
Incomplete Total		*332*	*798*	*1.130*
Grand Total		**349**	**927**	**1276**

As the County moves forward with the development of recommendations, it is recommended that it focus on target intersections of Arterials, Expressways and crossing of State Highways in areas that are likely to serve pedestrian trips. Intersections will require field review to assess the need for marked crosswalk installation as well as any accompanying infrastructure such as Pedestrian Hybrid Beacons (PHBs) and signage that is required to create a safe roadway crossing. It is important to note that solar powered traffic control devices may be necessary in rural areas which may not have full access to connections to the electric grid.

Marked Crosswalk Distance Assessment, Major Roads

The location of marked crosswalks provides insight not only into existing travel patterns but also where crossing opportunities may not be sufficient. Frequent crossing opportunities along roadways support increased pedestrian access by reducing the need for out of direction travel. Out of direction travel can add significant distance and time to a trip or result in people crossing roadways at undesignated locations. While there is no set standard for marked crosswalk spacing in Santa Clara County, guidance from Pedestrian and Transit Oriented Design Manuals suggests that crossing spacing of 300 feet can best support direct routes of travel. While distances of greater than 300 feet can still support pedestrian travel, those exceeding 600 to 800 feet in length can negatively impact pedestrian-scale design. This analysis assesses the spacing of marked crossings on major roadways but does not consider the location of traffic signals or other enhancements that can create safer crossing conditions.

Based on a review of marked crosswalk spacing along major roadways, the distance between marked crosswalks tends to be more than ¼ mile or even more than ½ mile along most major corridors. For a typical pedestrian that walks about three miles an hour, this could mean five or even ten minutes of out of direction travel to reach the nearest marked crosswalk, effectively doubling the length of a short one-mile trip. It is likely that this extra travel time is prohibitive to many pedestrians and can result in jaywalking or means that a particular trip is not taken. Based on a review of the data, roads with a crosswalk spacing of more than ½ mile in **urban** areas include:

- Page Mill Road
- Foothill Expressway
- Central Expressway
- Lawrence Expressway
- San Tomas Expressway
- Montague Expressway
- Capitol Expressway
- Almaden Expressway

In **rural** areas this includes the Monterey Highway and Santa Teresa Boulevard.

Local Roadways

In both **rural** and **urban** areas there are many local roadways that do not have marked crosswalks and are therefore excluded from the analysis of marked crosswalk spacing. However, these roadways typically have lower posted speeds and motor vehicle volumes and do not meet the requirements for the installation of a marked crosswalk by the County and should be considered safe for use by the average adult.

Recommendations will focus on providing marked crossings in areas of high pedestrian demand and improving safety at major roadway crossings with safety concerns, like those with long distances between marked crossings. Intersections identified through the safety analysis should be prioritized. This includes the following intersections along the Almaden and Capitol Expressways:

- Almaden Expressway and Cherry Avenue
- Almaden Expressway and Blossom Hill Road
- Capitol Expressway and Story Road
- Capitol Expressway and Seven Trees Boulevard
- Capitol Expressway and Senter Road

These intersections were included in the HIN and are characterized by wide geometries, slip lanes where auto oriented commercial land uses are prioritized. See **Appendix E** for a detailed safety analysis of Santa Clara County.

Figure 18. Marked Crossings at Intersections Santa Clara County (Urban)

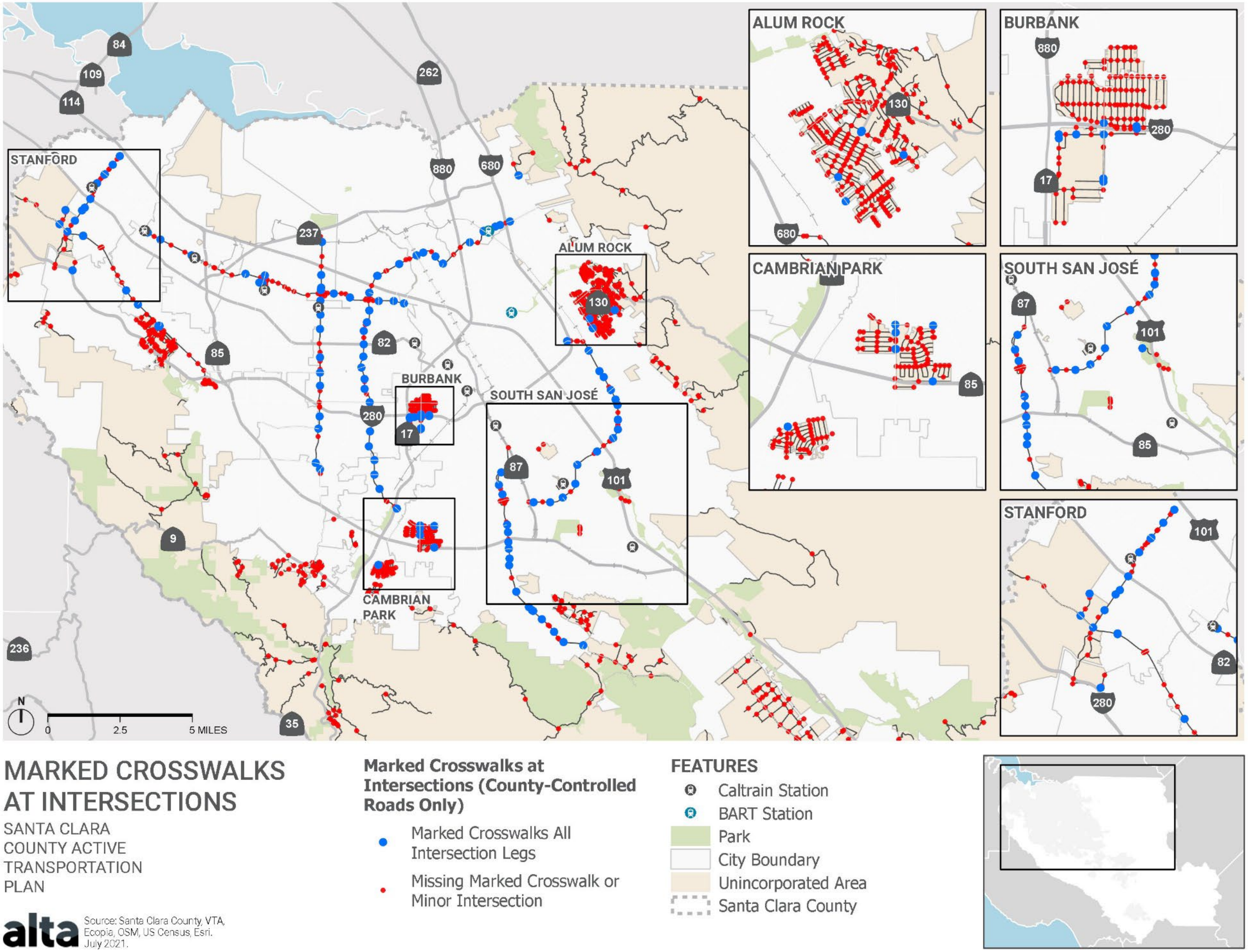


Figure 19. Marked Crossings at Intersections Santa Clara County (Rural)

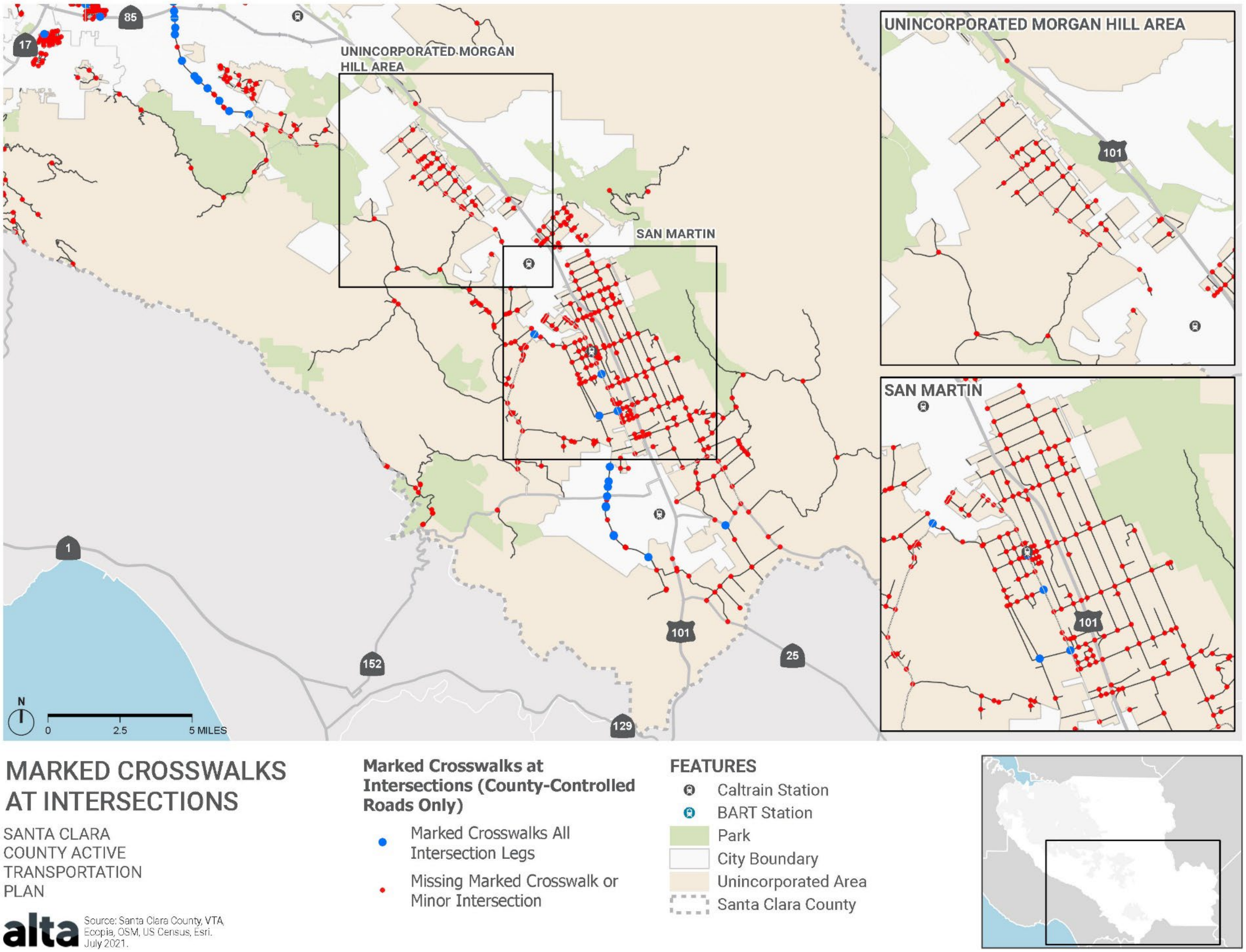


Figure 20. Marked Crossing Spacing Santa Clara County (Urban)

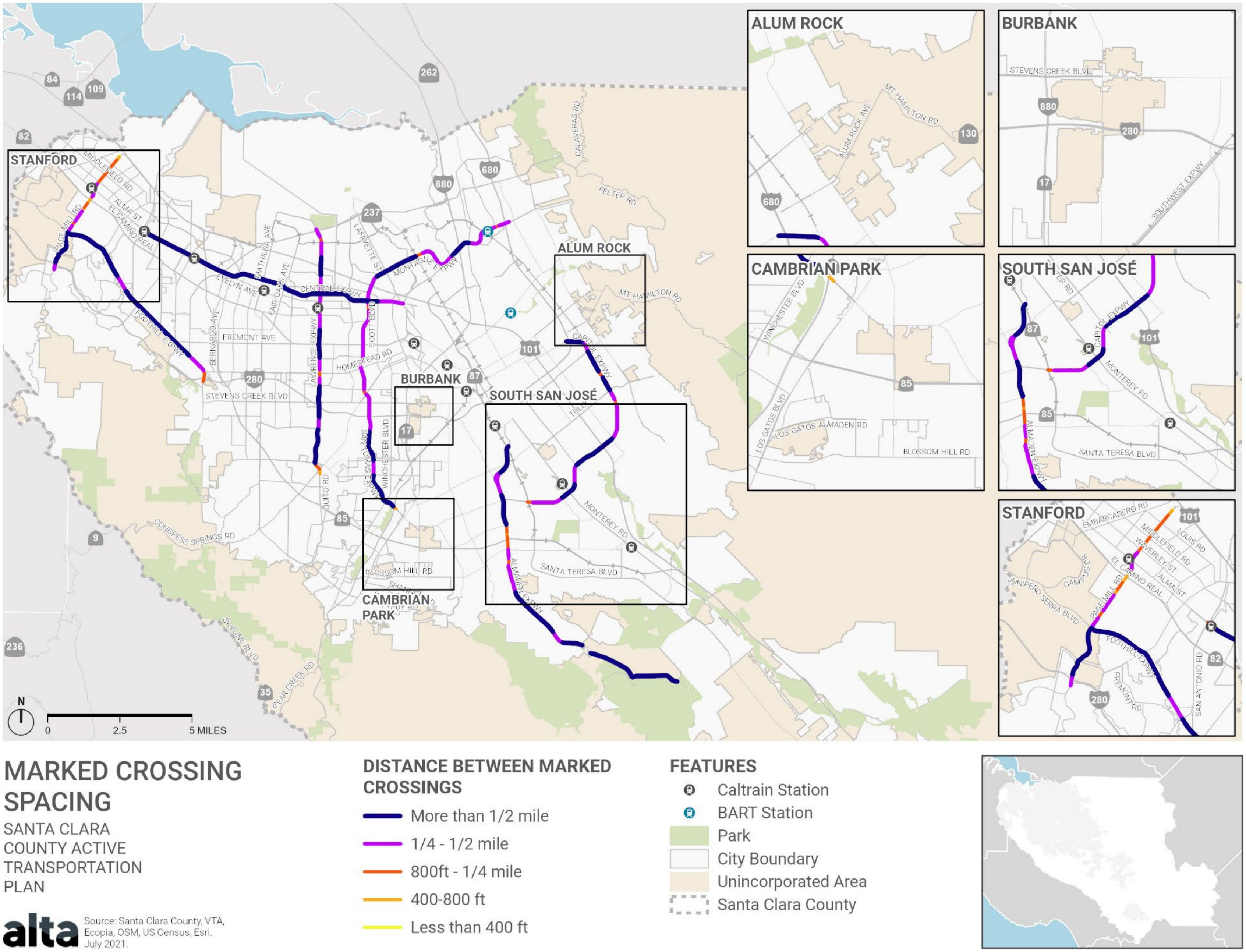
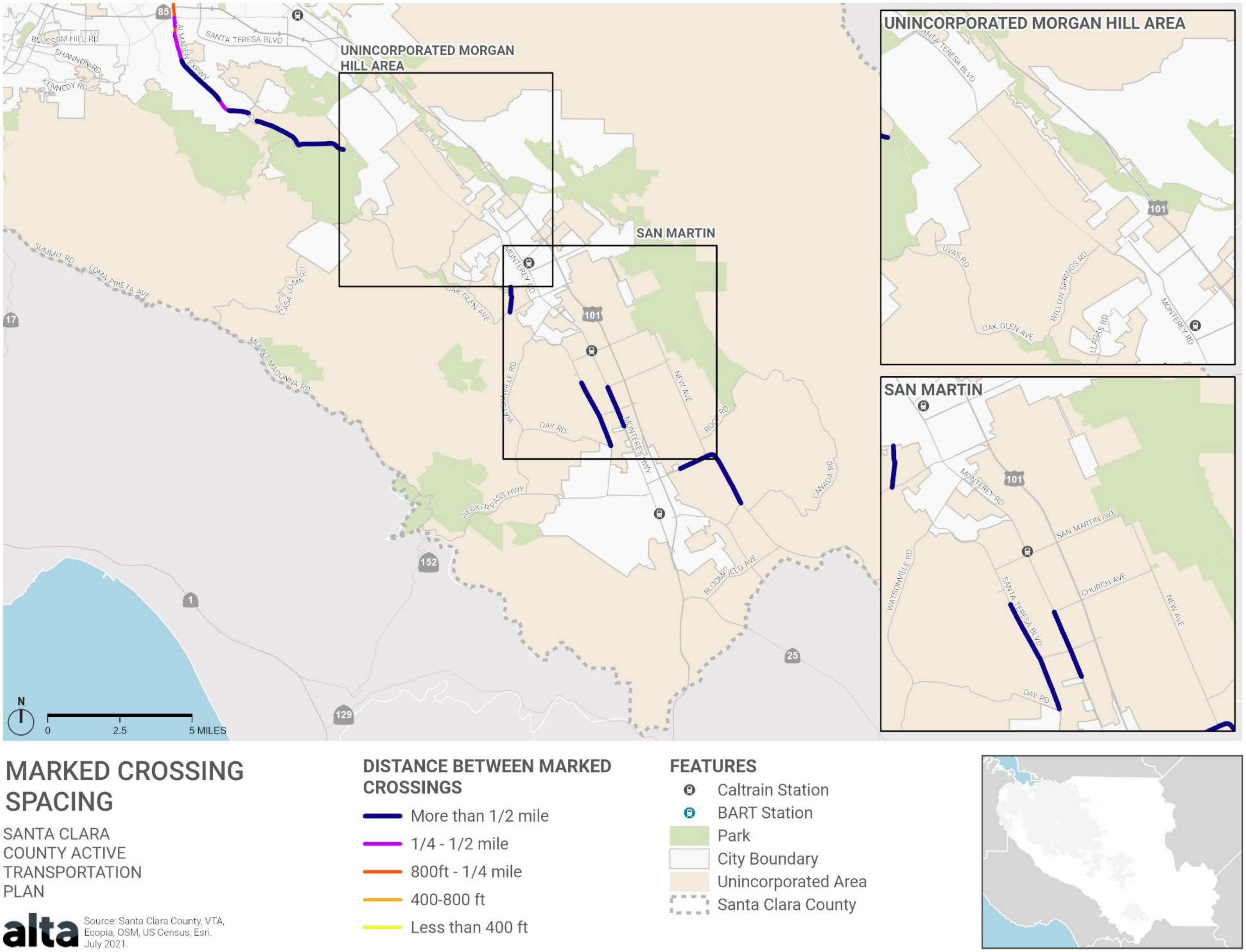


Figure 21. Marked Crossing Spacing Santa Clara County (Rural)



Pedestrian Level of Traffic Stress (PLTS) – County Roadways Only

The Pedestrian Level of Traffic Stress (PLTS) methodology used in this analysis has been adapted from the Oregon Department of Transportation (ODOT) ***Analysis Procedures Manual***[4] and is intended as a companion for BLTS. PLTS is determined by factors including sidewalk presence and width, sidewalk buffer width and type, posted speed limit, and number of travel lanes. PLTS scores classify road segments into one of four levels of traffic stress and, while similar to BLTS scoring, PLTS considers the level of attention required to safely walk in a specific environment in addition to the user experience:

- **PLTS 1** describes roadways where pedestrians of all ages and abilities would feel comfortable walking and require little attention to traffic.
- **PLTS 2** represents slightly less comfortable roadways that require more attention to traffic and are suitable for children over 10, teens and adults.
- **PLTS 3** represents moderately uncomfortable roadways, where most able-bodied adults would feel uncomfortable but safe.
- **PLTS 4** represents high traffic stress and would be used only by able-bodied adults with limited route choices.

Appendix C includes a more detailed description of the PLTS methodology. PLTS results are shown in **Figure 22** and **Figure 23** summarized in **Table 5.**

Table 5. PLTS by Miles of County Roadway

Rural				Urban				Grand Total
PLTS Level	Arterial[5]	Other[6]	Rural Total	Arterial	Other	Expressway	Urban Total	
1	0.0	96.7	96.7	0.0	132.8	1.7	134.5	231.2
2	0.0	24.0	24.0	0.0	16.8	0.0	16.8	40.8
3	0.0	95.1	95.1	0.4	104.5	0.0	104.9	200.0
4	20.5	32.9	53.4	6.1	41.1	59.3	108.2	159.9
Grand Total	**20.5**	**248.7**	**269.2**	**6.5**	**295.2**	**61.0**	**363.7**	**631.9**

Considerations:

- The PLTS calculated for **study roads** is based on local county data containing information roadways. Ecopia data was used for information on sidewalks. The PLTS calculated for other roads is based on OSM data.
- A PLTS score is calculated for roadway segments; the segment score is assumed to apply to the intersections for the purpose of analyzing stress islands.

[4] Oregon Department of Transportation, Transportation Development Division Planning Section: Transportation Planning Analysis Unit. 2020. Analysis Procedures Manual Version 2. https://www.oregon.gov/odot/Planning/Pages/APM.aspx

[5] Examples of Arterial Roadways include: McKean Road, Santa Teresa Boulevard, Hale Avenue, Watsonville Road.

[6] Other roadways are defined as any road under county control other than a State Highway, Expressway or Arterial. Identified 'Other' rural roads include Metcalf Road, Uvas Road, Monterey Road, Santa Teresa Boulevard, Hale Avenue, Center Avenue, Bolsa Road, East Main Avenue, East San Martin Avenue, Pole Line Road, Santa Teresa Boulevard, and other short roadway segments, mostly in the south county around US 101.

Figure 22. PLTS Santa Clara County (Urban)

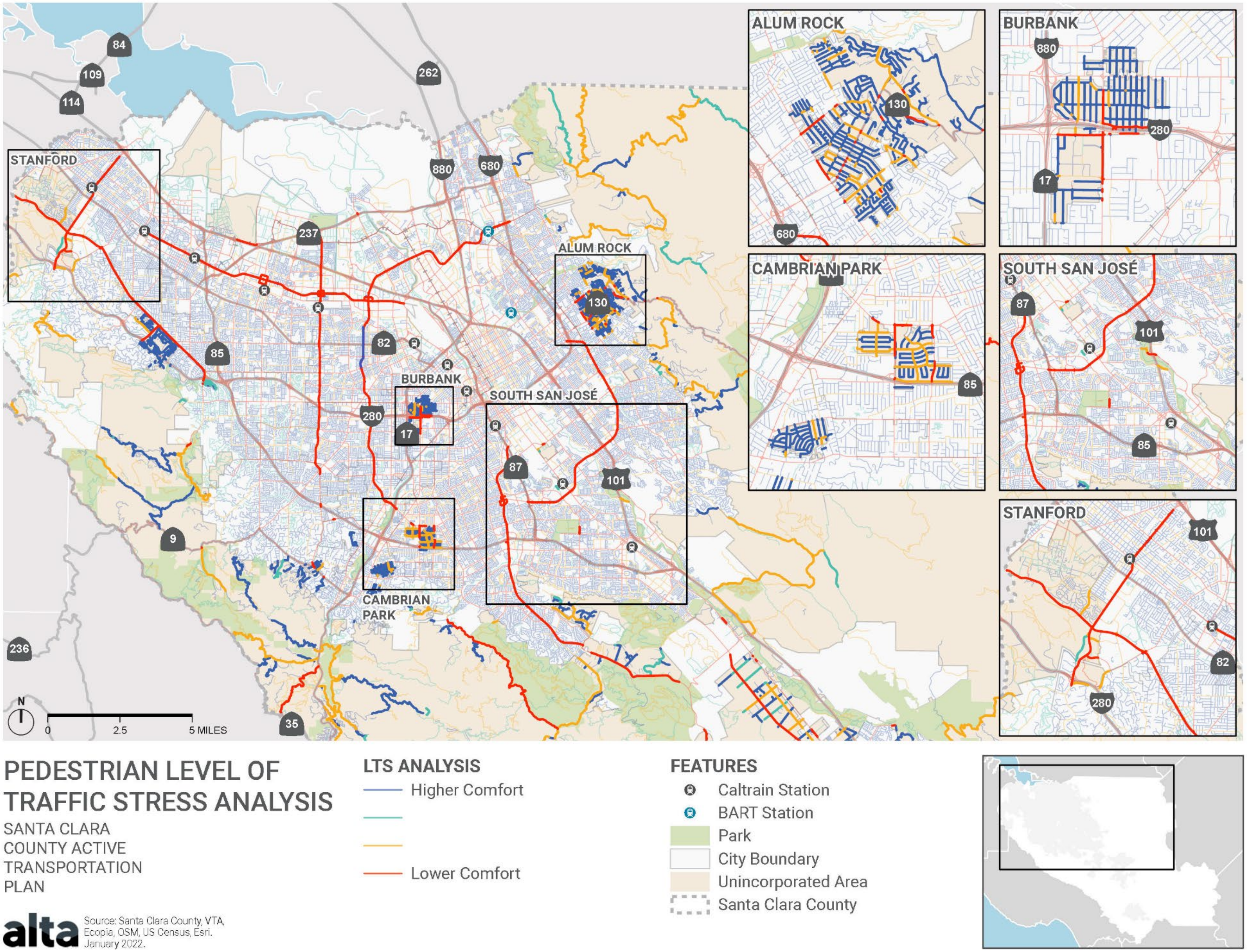
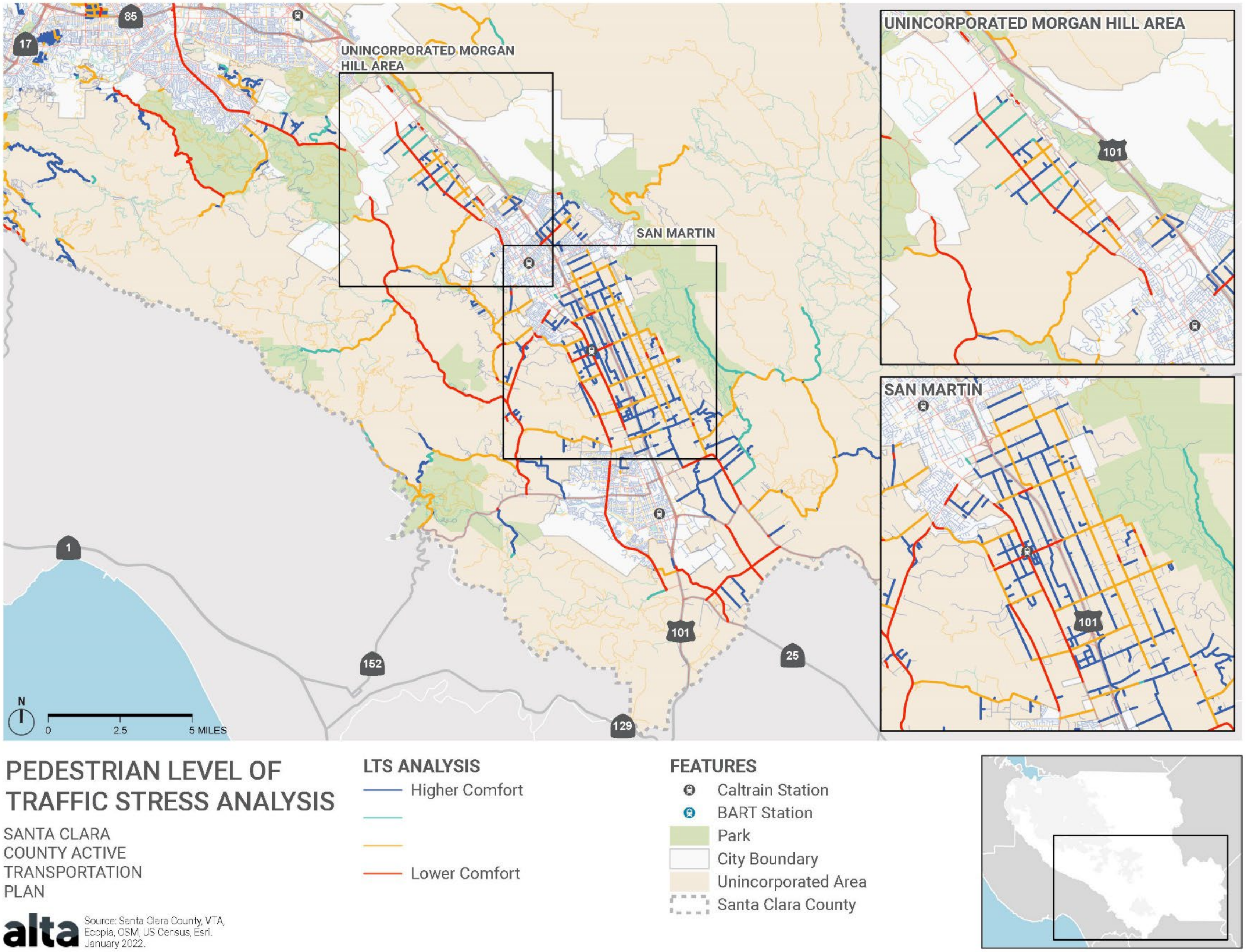


Figure 23. PLTS Santa Clara County (Rural)



PLTS Stress Island Analysis (All Roadways)

Figure 24 and Figure 25 highlight low-stress PLTS connectivity islands in Santa Clara County comprised of both study roadways and other municipal roadways. The analysis also emphasizes how high-stress roadways act as barriers for people walking along and across the corridors. Areas shown in the same color (i.e., blue and green) are locations that are connected by a continuous low-stress network. Further, as many destinations are located along major roadways, it may not be possible to access a destination while traveling along only low-stress routes.

Findings

Overall, the distribution of study roadways with a PLTS score of 1, 3, or 4 are fairly evenly distributed. Roadways that score PLTS 2 are underrepresented in both urban and rural areas. In urban areas roadways receiving a score of PLTS 1 tend to be concentrated in pockets like Burbank and Alum Rock. Major roadways and expressways like the San Tomas Expressway, Foothill Expressway among others are characterized by PLTS 3 and PLTS 4 scores due to missing sidewalk and higher speed motor vehicle traffic. The PLTS scoring of roadways in rural areas is typically higher (i.e., increased pedestrian traffic stress) along major roadways due to a greater prevalence of missing sidewalks.

High-stress routes also act as barriers to safe and comfortable travel along connecting routes. This means that while connecting routes may provide low-stress, comfortable travel opportunities, a high-stress crossing will effectively limit the reach of the route. This is illustrated in the PLTS stress island analysis (Figures 25 and 26), which shows that Santa Clara County is a checkerboard of low-stress islands in both urban and rural areas.

As the County moves forward on the development of recommendations, it should consider focusing on improving conditions for people walking by creating continuous low-stress travel facilities along major County-controlled roads and connecting existing low-stress islands. This could include sidewalk widening projects, widening buffers between motorists and pedestrians, creating low-stress crossing facilities on high-stress roadways as well as improving roadway geometry at intersections. Roadways and intersections highlighted the HIN with high numbers of pedestrian collisions should be prioritized including:

Roadways

- Capitol Expressway
- Lawrence Expressway
- Foothill Expressway

Intersections:

- Almaden Expressway and Cherry Avenue
- Almaden Expressway and Blossom Hill Road
- Capitol Expressway and Story Road
- Capitol Expressway and Seven Trees Boulevard
- Capitol Expressway and Senter Road

Figure 24. PLTS Stress Islands Santa Clara County (Urban)

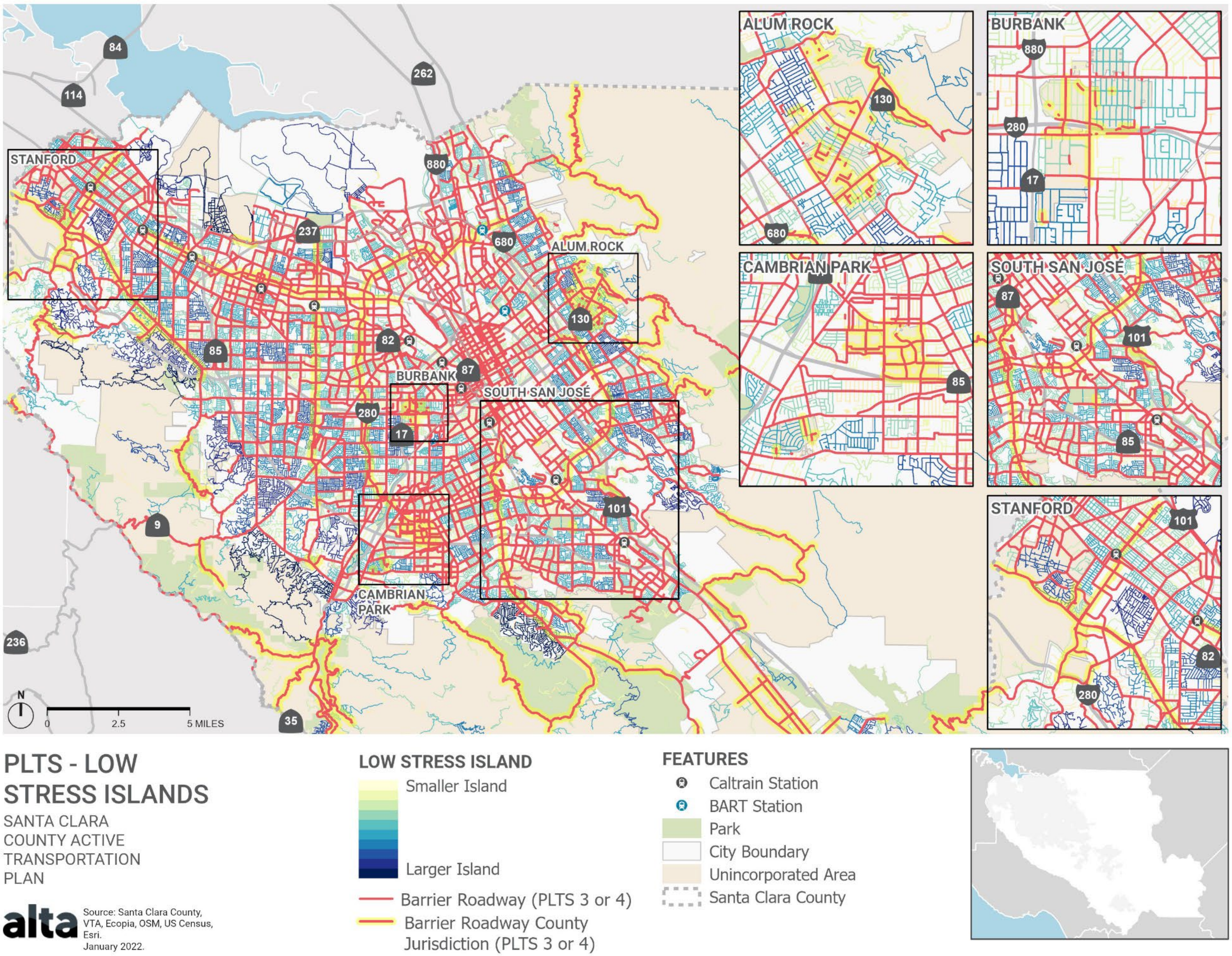
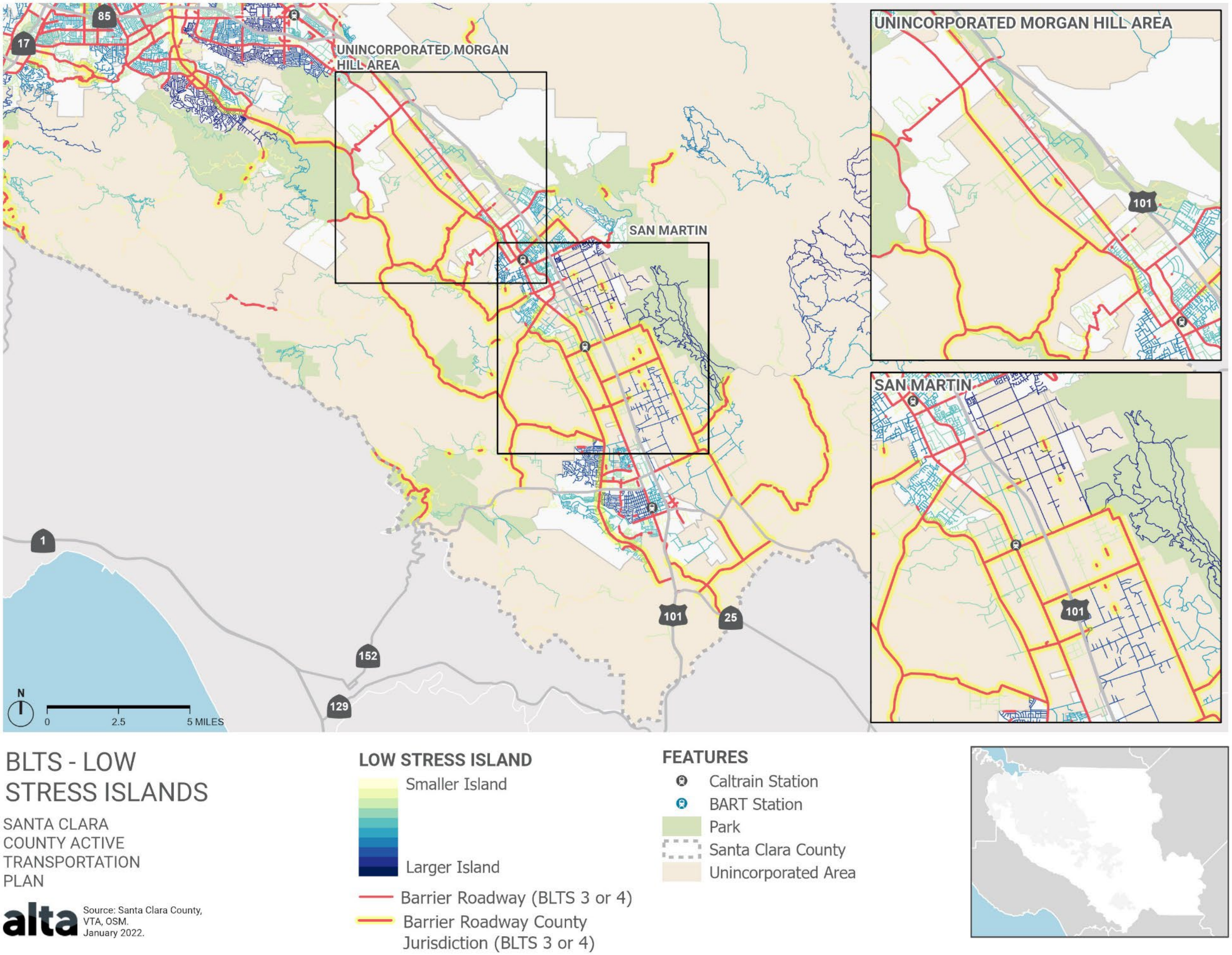


Figure 25. PLTS Stress Islands Santa Clara County (Rural)



Connectivity Analysis

Alta's connectivity indexes measure how far a user can go on real world conditions (represented by LTS scores) using the existing roadway network if embarking on a 10-minute walk or 15-minute bicycle ride, called a **comfort-adjusted bicycle or pedestrian connectivity index**. These indices also provide an understanding of the existing walksheds and bikesheds of a particular area. As freeways and other limited access roadways often act as barriers limiting connectivity for people walking and biking, they have not been included into the routable network for such users. This analysis is further illustrated in **Figure 26** and **Figure 27**. Maps on the following pages of this memo display the connectivity analysis using hexagons. A darker colored hexagon shows an area where the network is more connected and lighter colored hexagons are areas where the network is less connected.

Bicycle Connectivity

As shown in **Figure 28** and **29** the comfort-adjusted bicycle connectivity ratios in **urban** areas are highest in parts of the County that have a dense network of well-connected low-stress roadways like Burbank and Alum Rock. Conversely, the ratio is lower around areas of high travel stress, meaning that the network is less connected and travel takes longer. For example, areas around the intersection of the Lawrence Expressway and I-280, and the Capitol Expressway through South San José are shown in a lighter color on the connectivity maps. These areas experience high bicycle stress (as measured by BLTS Analysis) and the connectivity ratio in these areas is low.

In **rural** areas there are a number of pockets with high connectivity ratios. For example, areas near the Gilroy Transit Center tend to experience higher connectivity ratios. However, because of the sparse roadway network and higher stress roads, many of south County jurisdictions experience low connectivity ratios. Further, as noted in the BLTS analysis, many of the major study roadways experience BLTS 3 and BLTS 4 representing barriers to bicycling, which in turn decreases general network connectivity.

Pedestrian Connectivity

As with bicycle connectivity, pedestrian connectivity ratios tend to be lower (i.e., less connected) in areas bifurcated by high stress roadways (as measured by PLTS analysis) that lack sidewalks, and experience higher motorist speeds. These in turn represent major barriers for connectivity between low-stress areas at both **urban** and **rural** levels. This can be seen along expressways like Capitol Expressway Almaden Expressway and Montague Expressway in **Figures 30** and **31**.

Considerations:

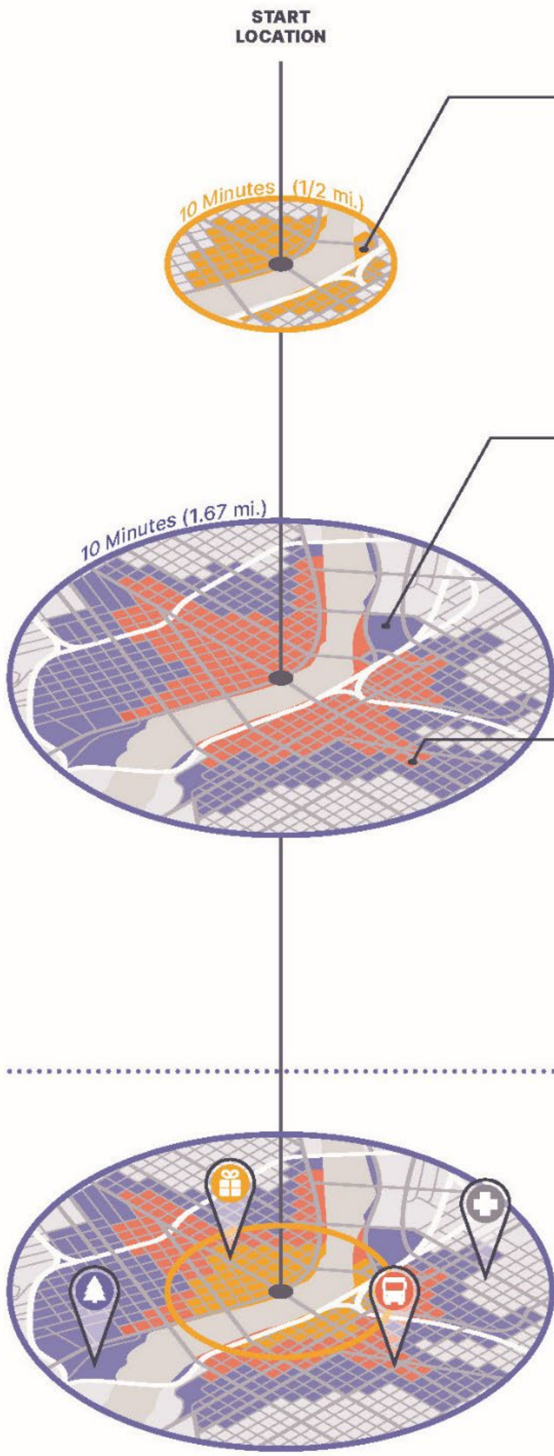
- Both the bicycle and pedestrian connectivity analysis utilize the BLTS and PLTS respectively to adjust assumed travel times and generate index scores.
- The OSM roadway network was used as the basis for analysis; limited access roadways were removed prior to analysis.

Recommendations will focus on creating connections between areas with high pedestrian and bicycle connectivity levels as well as targeting key connectivity gaps identified at the end of this memo.

Figure 26. Connectivity Analysis Methodology Explained

Connectivity Ratio

*Connectivity ratios help identify the degree of **connection** and **reach** in a network given a start location, mode, and travel time. This ratio is created by comparing reach using the network relative to a "perfect" scenario where the user could travel in a straight path in every direction.*



Pedestrian Connectivity Index

WALKSHED AREA / CROW-FLIES TRAVEL

This index compares where you could reach by walking from a starting point in a straight line (as the crow flies), to the smaller area you could actually reach in the real world, in the same amount of time, due to the many turns you would have to make and obstacles you would have to walk around, such as major highways or waterways (walkshed area)

Bicycle Connectivity Index

BIKESHED AREA / CROW-FLIES TRAVEL

This index compares the area of bikesheds that use all facilities normally to that of the area that would be covered if you could bike as the crow flies. It provides an understanding of wider bicycle network connectivity in terms of the number of connections provided on a cyclable network.

Comfort Adjusted Bicycle Connectivity Index

COMFORTABLE BIKESHED AREA / CROW-FLIES TRAVEL

This index compares the area of a bikeshed that has been adjusted based on the underlying network's comfort to that of the area that would be covered if you could bike as the crow flies. This adjustment includes slowing down travel on more stressful segments of road.

Considering Accessibility

Connectivity ratios measure the reach a network provides relative to a perfect goal, but how far one can go is not the contributor to human wellbeing. The distinction between connectivity and accessibility is that accessibility contextualizes this reach in terms of the opportunities available to a network user.

Figure 27. BLTS-adjusted Bike Network Connectivity Urban Santa Clara County

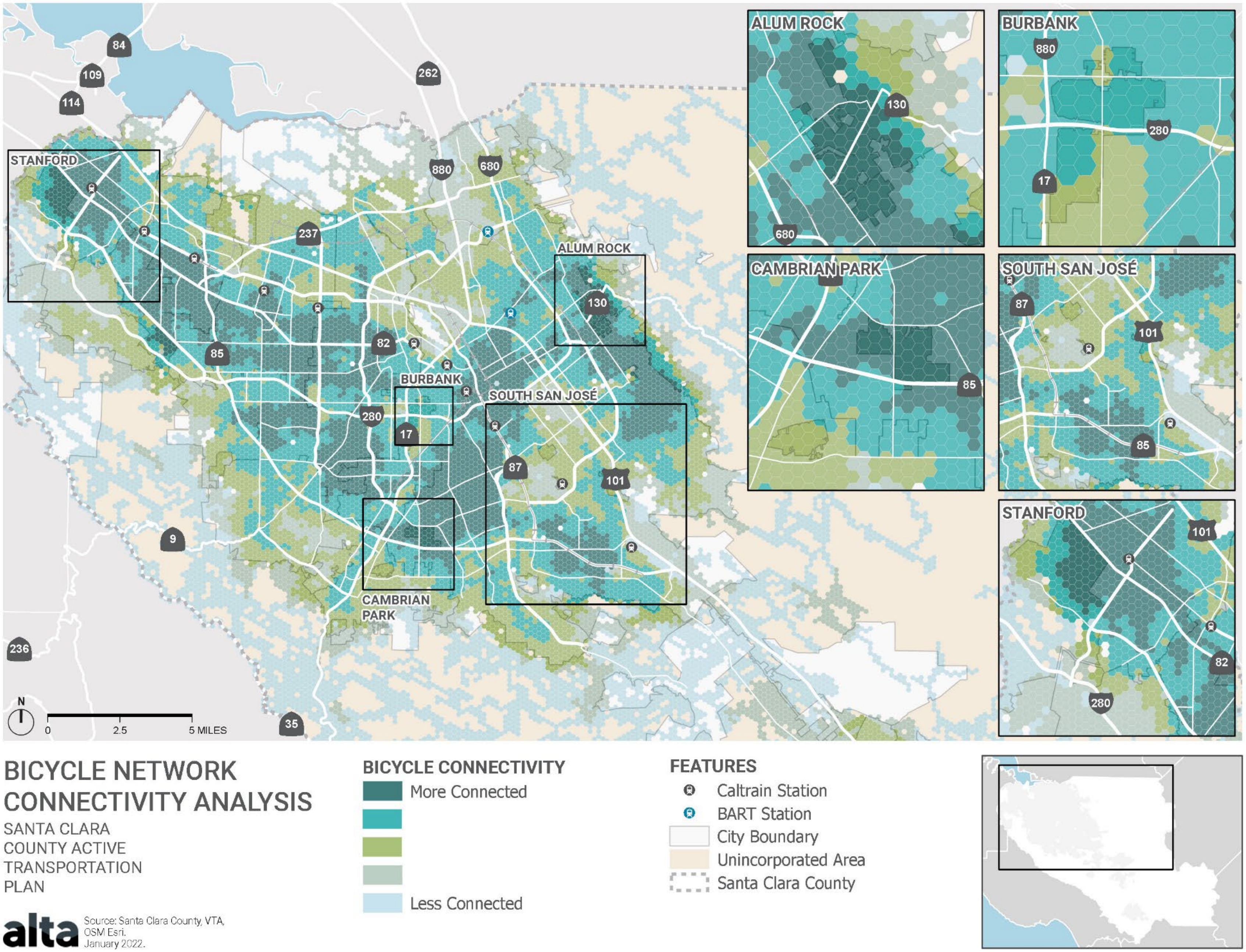


Figure 28. BLTS-adjusted Bike Network Connectivity Rural Santa Clara County

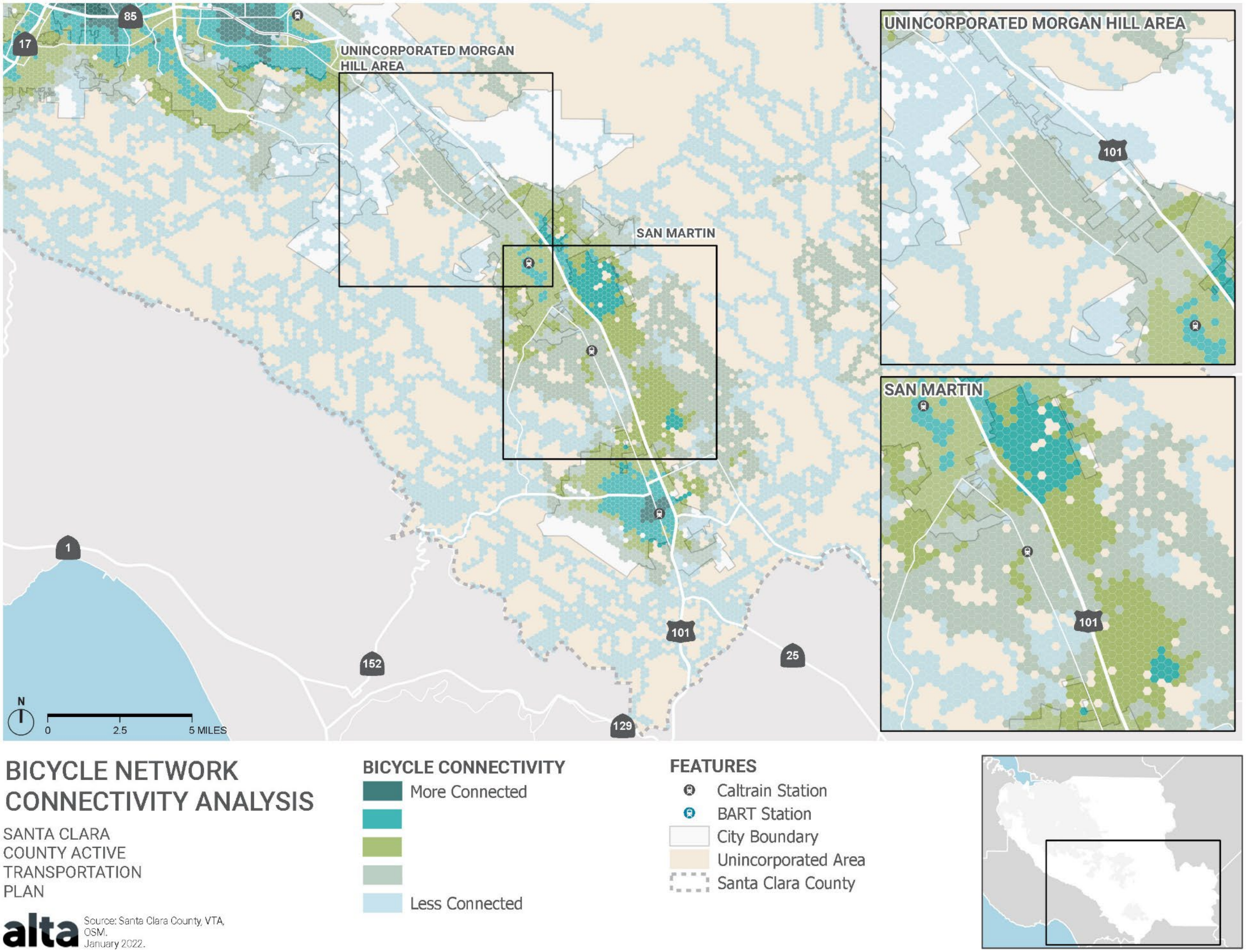


Figure 29. PLTS-adjusted Pedestrian Network Connectivity Urban Santa Clara County

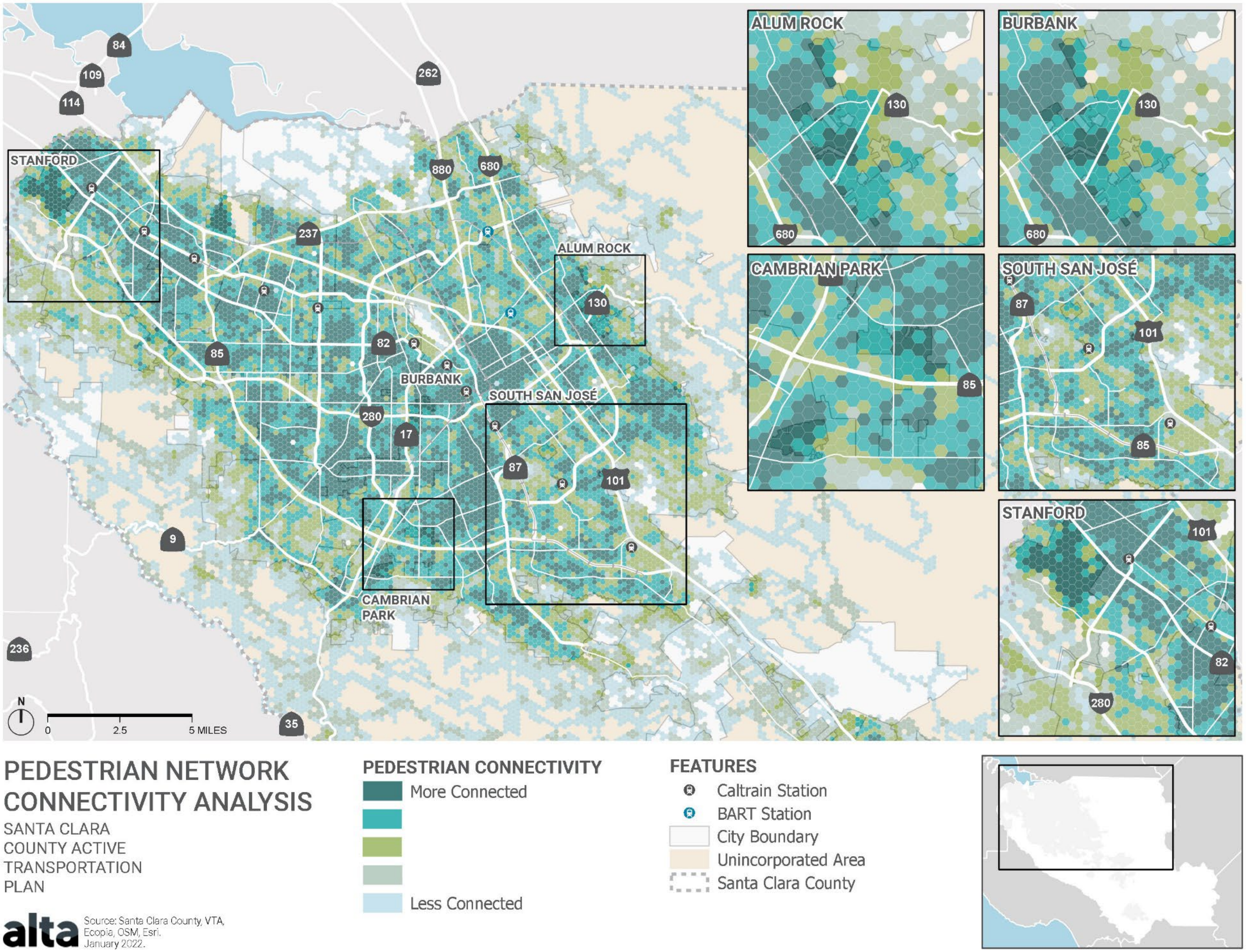
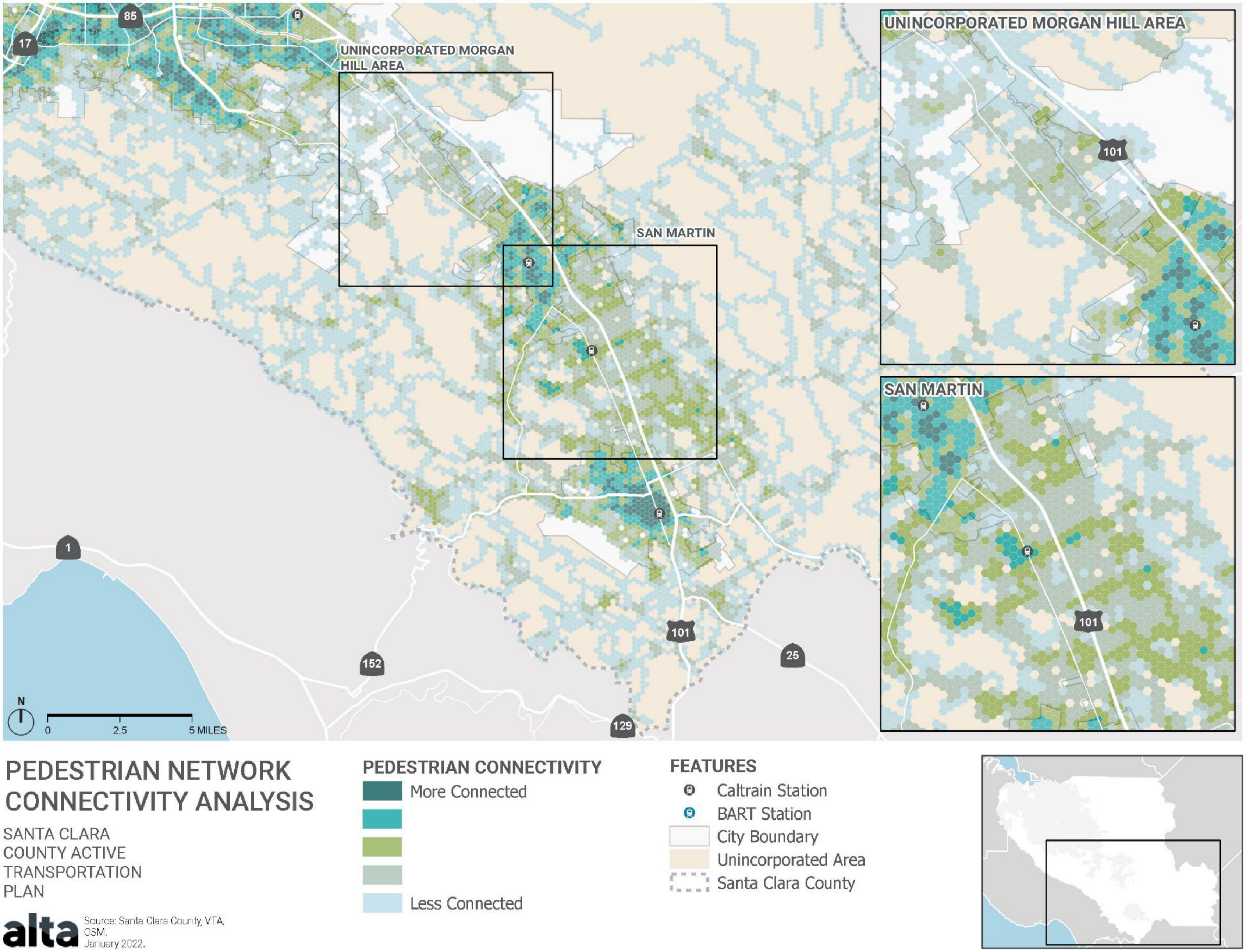


Figure 30. PLTS-adjusted Pedestrian Network Connectivity Rural Santa Clara County



Active Trip Potential Analysis

Understanding potential demand for active transportation will help Santa Clara County identify where facilities may be needed or improved to best support walking, bicycling, bike share/scooter share, and other first/last mile trips. Not all locations can support active transportation modes easily as a result of unsupportive infrastructure or long trip distances, making walking and bicycling infeasible. While emerging technologies, such as e-bikes and e-scooters, provide new options, ranges, and convenience, their ability to effect change is still contextual. The conceptual basis and approach for the active trip potential is illustrated in **Figure 31**, and a detailed methodology is provided in **Appendix D**.

To understand active travel demand, Alta conducted an active trip potential using the Metropolitan Transportation Commission (MTC) travel demand model to visualize short trips that could reasonably be accomplished by bicycling (i.e., less than three miles) or by walking (i.e., less than one mile)[7]. In this analysis, short trip activity was assessed in tandem with existing walking and bicycling activity and overlaid on major roadways in Santa Clara County to create a demand index. While short trips tend to be indicators of potential trips that could be met using active modes (i.e., walking, biking, rolling), the analysis assumes that it may be unrealistic to expect that all short trips be converted to active transportation modes. Further, even if supportive and more comfortable infrastructure is provided, there are a number of reasons why trips may still be made by non-active modes, including:

- **Heavy Loads.** In many cases, cargo bikes can support many types of grocery or shopping trips, but some heavy loads are often bulky or heavy enough to warrant the use of the vehicle.
- **Travel Trip Type.** Some trips are chained in a way that make it difficult to envision using active transportation for the entire tour/trip. For example, if one leg of a trip, that is part of a chain of trips is too long to consider using an active mode, the entire tour/trip may be better made using a vehicle. Specifically, if a pedestrian typically walks half a mile to work on most days but on occasion needs to travel to a doctor's appointment that is two miles away. On these days, they might drive rather than walk.
- **Personal Preference.** Some members of the community may elect to never bike or walk even if an all ages and ability network is provided in a community.
- **Physical Impairment.** Some members of the community may have an impairment that prevents them from comfortably using active transportation.
- **Seasonal Weather.** Active trips become more difficult to accomplish in some weather conditions. While walking and biking trips may still be viable in many instances, there may be some times where it is inadvisable, such as a heat wave or unhealthy air conditions.

Figure 32 through **Figure 35** show density of trip starts by Transportation Analysis Zones (TAZs) to allow a comparison of travel activity normalized by land area. The demand index for major county roadways including **study roads** is shown in **Figure 36.**

Findings

Urban areas of the County experience the highest active trip potential for bicycling trips - that is trips of three miles or less. In this urban setting, the areas with the highest active trip potential are Stanford University and South San José according to the analysis and data. Major **study roads** border areas with high active trip potential including the Central Expressway, Capitol Expressway and Montague Expressway. The pattern for short trips of one mile or less (those that could be accomplished on foot) are similar. **Urban** areas with high active trip potential for short trips also include Stanford and South San José as well as areas along **study roadways** such as the Central Expressway, Capitol Expressway and Montague Expressway.

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[7]The MTC Travel Demand Model can be accessed at https://github.com/BayAreaMetro/travel-model-one

Figure 31. Demand Analysis Process Explained

HOW DO WE DETERMINE DEMAND FOR ACTIVE TRAVEL?

CORRIDOR: *The road under study*
TRIP: *A journey using any transportation mode*

Read on to learn about the steps we take to identify the most suitable corridors for bicycle and pedestrian facilities.

A

Start & End

FEWER TRIPS — MORE TRIPS

When we go somewhere, we **start our trip at one location (such as our home) and end at another (such as the grocery store).** Using start and end locations for many people's trips, we can understand travel patterns throughout the region. We use these travel patterns to identify which roads may be most suitable for bicycle and pedestrian facilities.

B

Proximity

OUTSIDE OF ONE MILE — WITHIN ONE MILE

We want to know how many people are traveling **within one mile** of a corridor. Trips closer in can be given more influence on demand scores than those further away.

C

Parallelism

LESS PARALLEL — MORE PARALLEL

We want to know how many people are traveling **in the same direction** as a corridor. For example, if our corridor runs north-south, we want to include trips where people are also traveling north-south.

D

Trip Distance

LESS SUITABLE DISTANCE — MORE SUITABLE DISTANCE

We want to know if the distance people are traveling would be well-served by a bicycle or pedestrian facility. Typically, the distances considered will be less than 3 miles for bicycling and one mile for walking.

★ REPEAT A-D FOR EACH CORRIDOR IN THE NETWORK

The Result

LESS DEMAND — MORE DEMAND

Finally, we **add it all up!** We include trips that are near the corridor, going in the same direction, and are the appropriate distance to get a total demand score for our corridor. When we analyze all corridors in our network, we can see which corridors have more demand. These corridors are better options for a bicycle or pedestrian facility.

Figure 32. Active Trip Potential - Trips Less Than Three Miles - Santa Clara County (Urban)

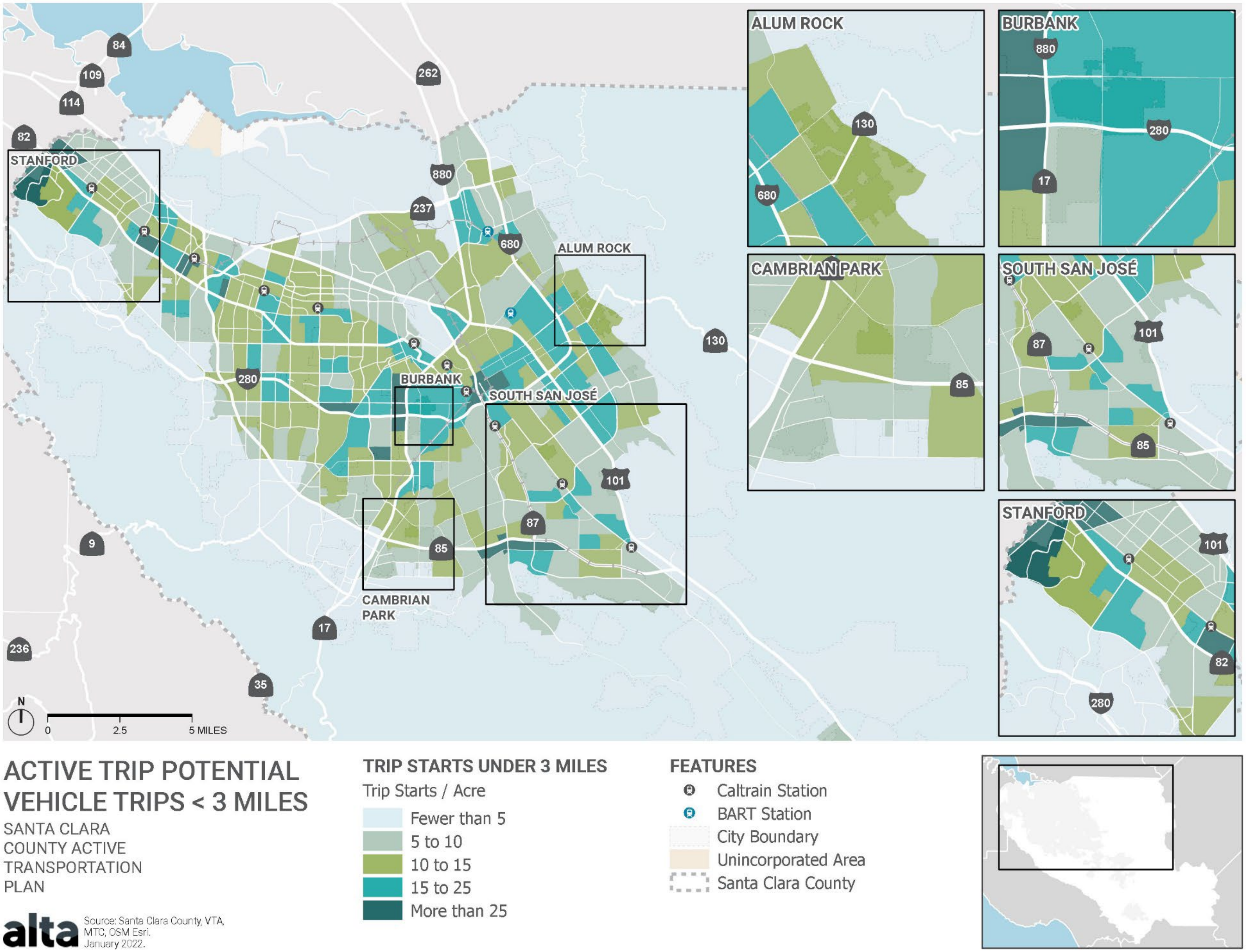


Figure 33. Active Trip Potential - Trips Less Than Three Miles - Santa Clara County (Rural)

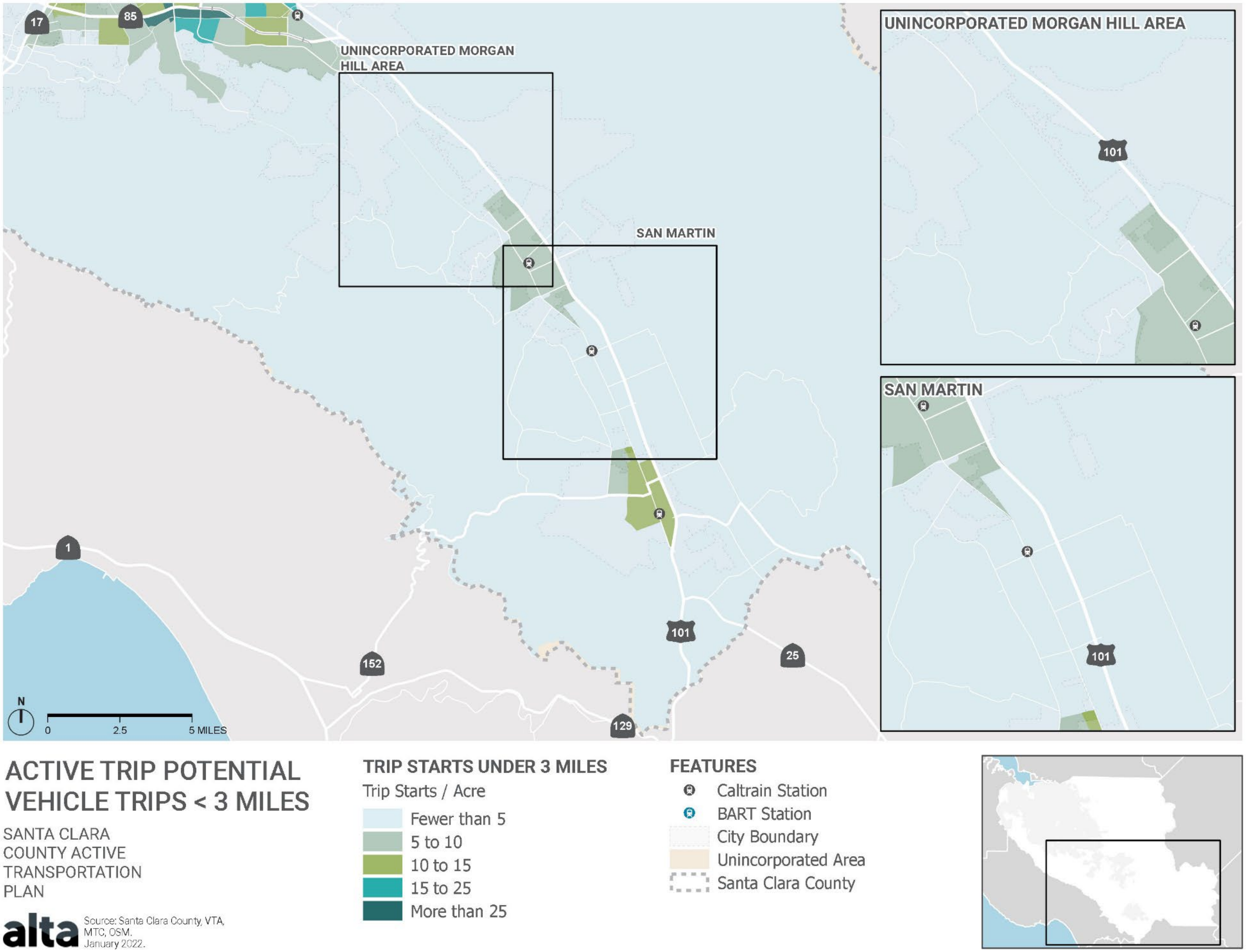


Figure 34. Active Trip Potential - Trips Less Than One Mile - Santa Clara County (Urban)

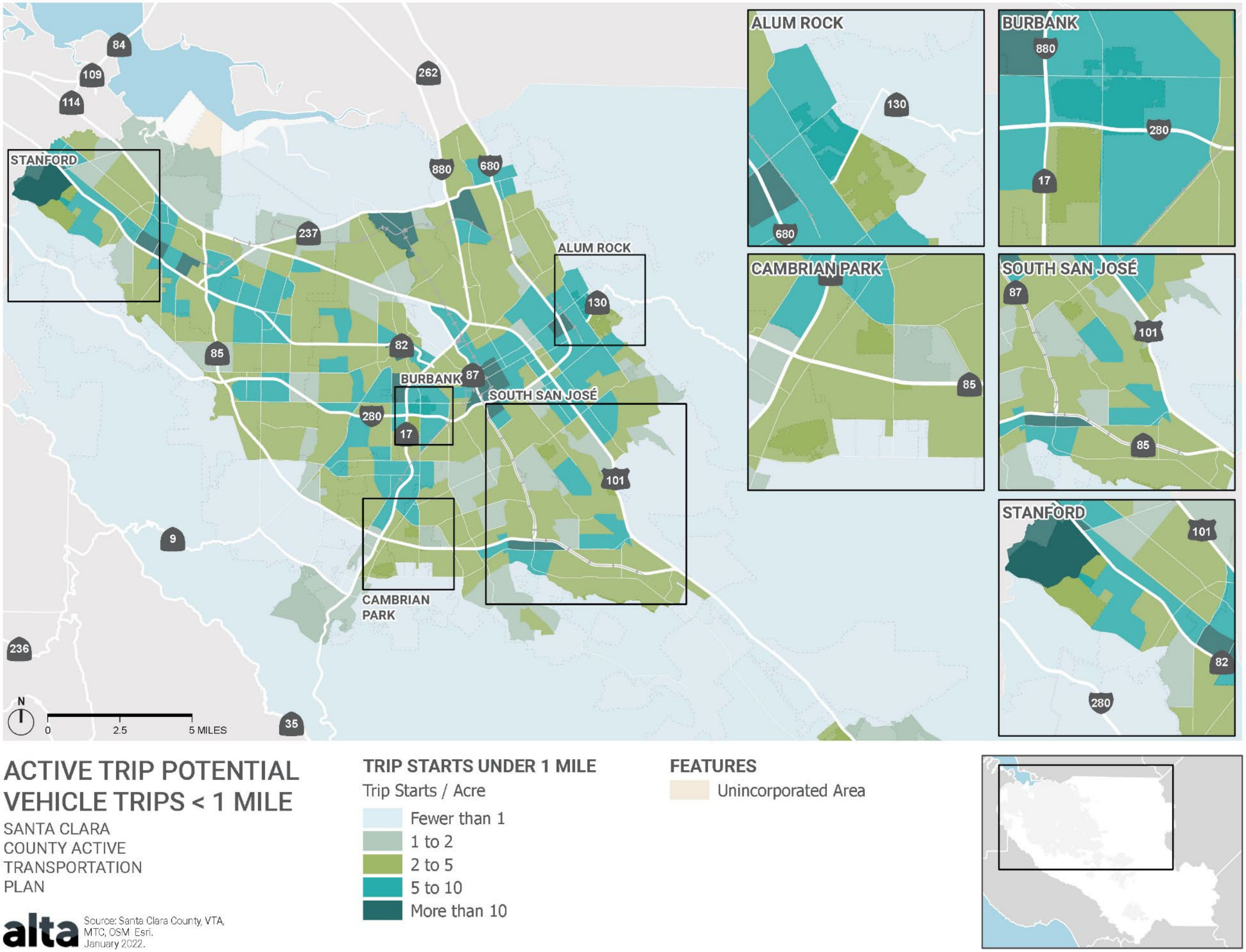


Figure 35. Active Trip Potential - Trips Less Than One Mile - Santa Clara County (Rural)

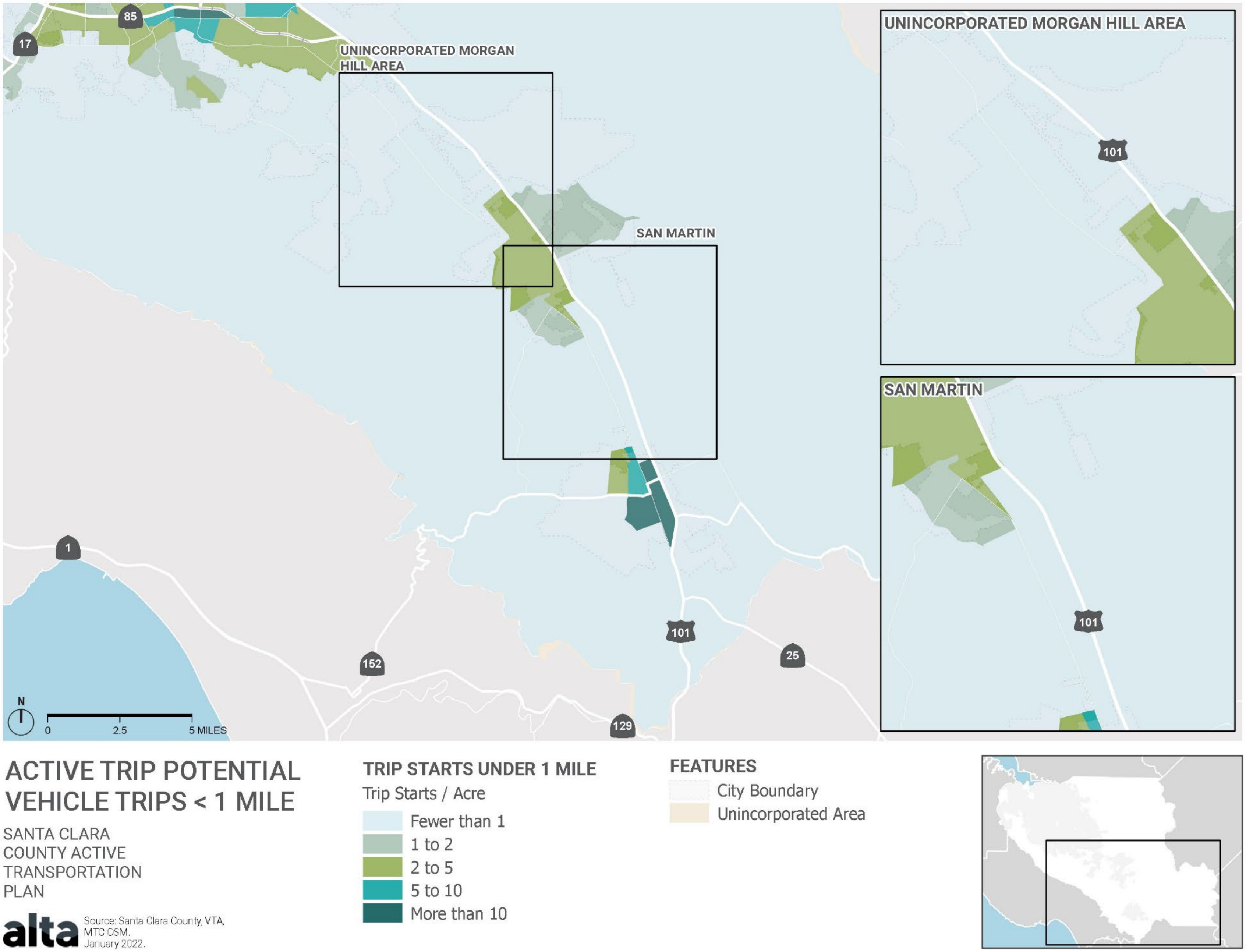


Figure 36. Active Trip Demand, Major Roadways Santa Clara County (Urban)

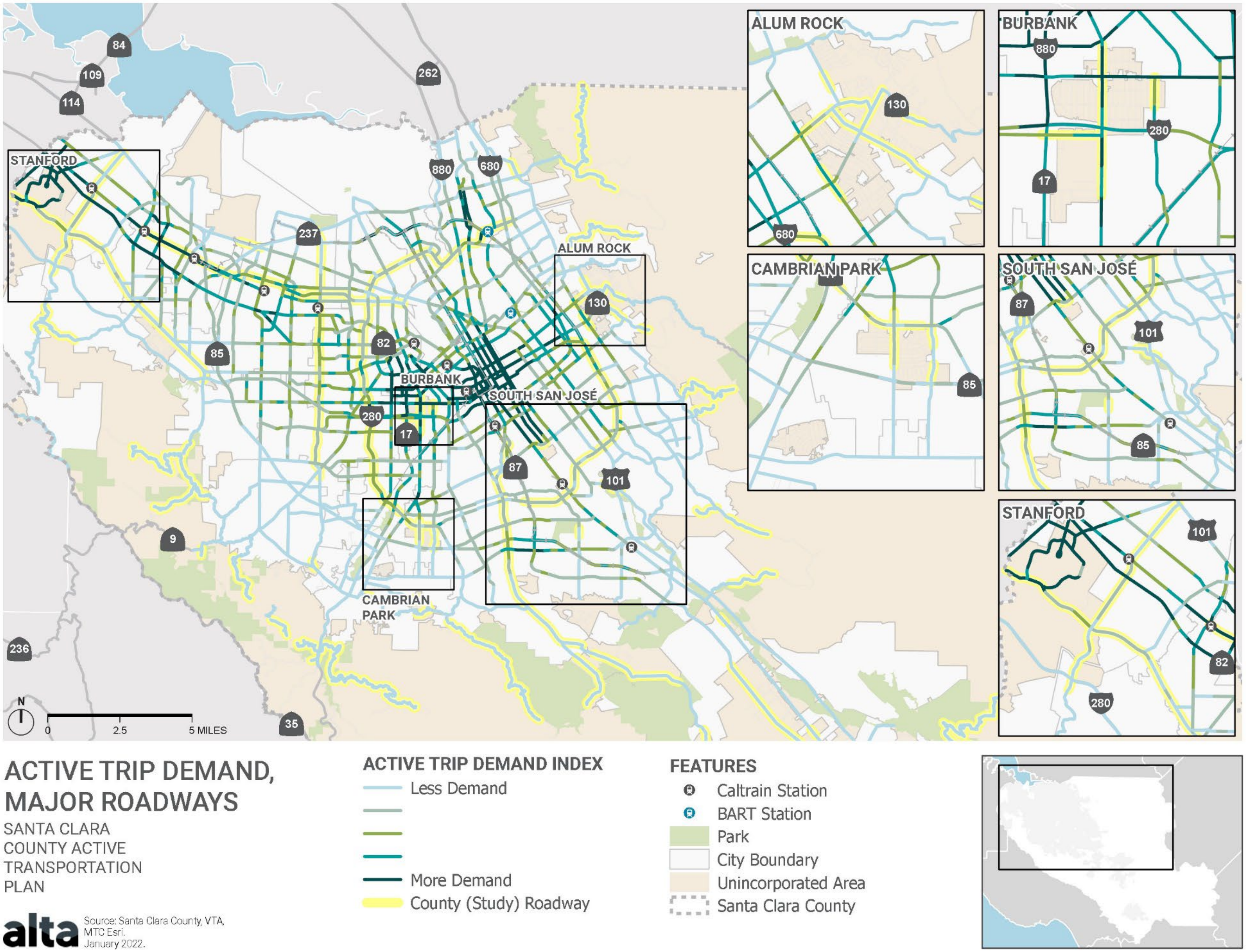
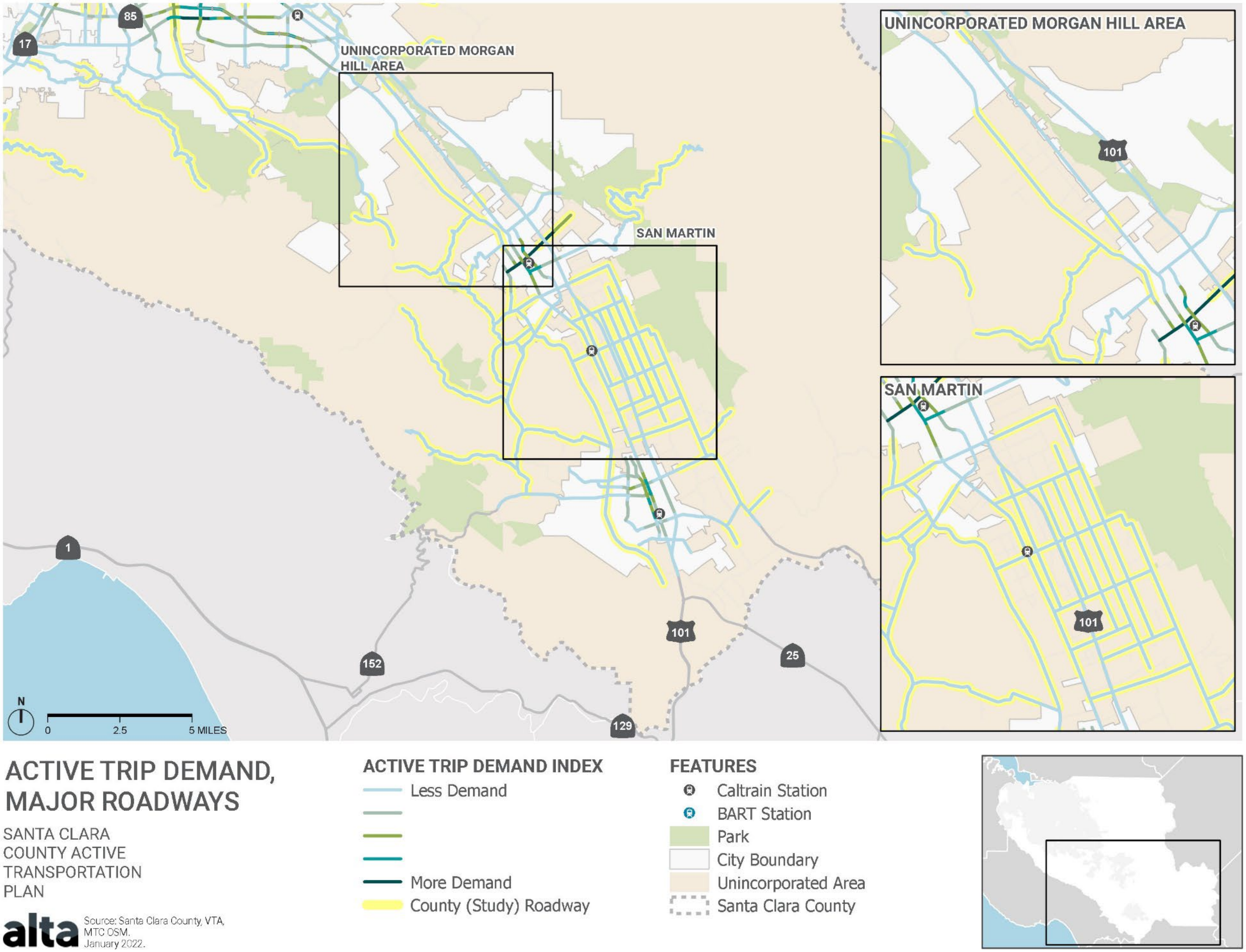


Figure 37. Active Trip Demand, Major Roadways Santa Clara County (Rural)



Primary Network Gap Identification

The primary network gap identification aggregates the results from the BLTS, PLTS, stress island, connectivity, and active trip potential analyses to identify roadways where providing upgrades to the bicycle and pedestrian infrastructure will likely provide a high return on investment in relation to increased network connectivity, number of trips that can be reasonably accomplished by walking and bicycling, and increased user comfort. The analysis identifies corridors and intersections based on the data shown the following criteria:

Corridors with high active trip potential and have:

- Existing bike infrastructure
- BLTS score of 3 or 4
- Incomplete sidewalks or missing sidewalks on both sides of the roadway
- PLTS score of 3 or 4
- More than ½ mile between marked crossings of arterial roadways
- Making a direct connection (within ¼ mile) of a rail station, regional trail (see **Figure 38**) or school
- Traverse an area with high need as identified through CalEnviroScreen

Major intersections that are:

- Within ¾ miles of a school
- Have high active trip potential
- Where marked crosswalks are missing
- Identified as part of the HIN
- Making a direct connection (within ¼ mile) of a rail station, regional trail (see **Figure 38**)

Primary Network Gaps are shown on **Figure 39** and **Figure 40** and listed in **Table 6** and **Table 7**. Identification numbers have been included in the tables as cross-reference for understanding the maps.

Findings

As noted in **Table 6** and **Table 7** and shown on **Figure 39** and **Figure 40,** most commonly network gaps are found along multilane roadways with high posted speeds that lack bicycle infrastructure or complete pedestrian infrastructure. These corridors also experience distances between marked crosswalks of more than ½ mile; and a school or transit station is nearby. Most of the roadways that fit this profile include expressways which provide cross-county connectivity. Roadways like Bascom Avenue in Burbank that provide more local circulation are also identified. However, there are several corridors that do not fall within this typical profile: roadways like De Witt Avenue in Morgan Hill are more rural two-lane roads that also exhibit high active trip potential and may benefit from infrastructure upgrades.

Intersection gaps are found primarily in **urban** areas and follow expressways and arterials. Many of the intersections are collocated with primary network gaps. But also represented are other County-controlled roadway intersections like the intersection of **McVay Avenue** and **Fleming Avenue**.

Figure 38. Regional trails used in identification of primary network gaps

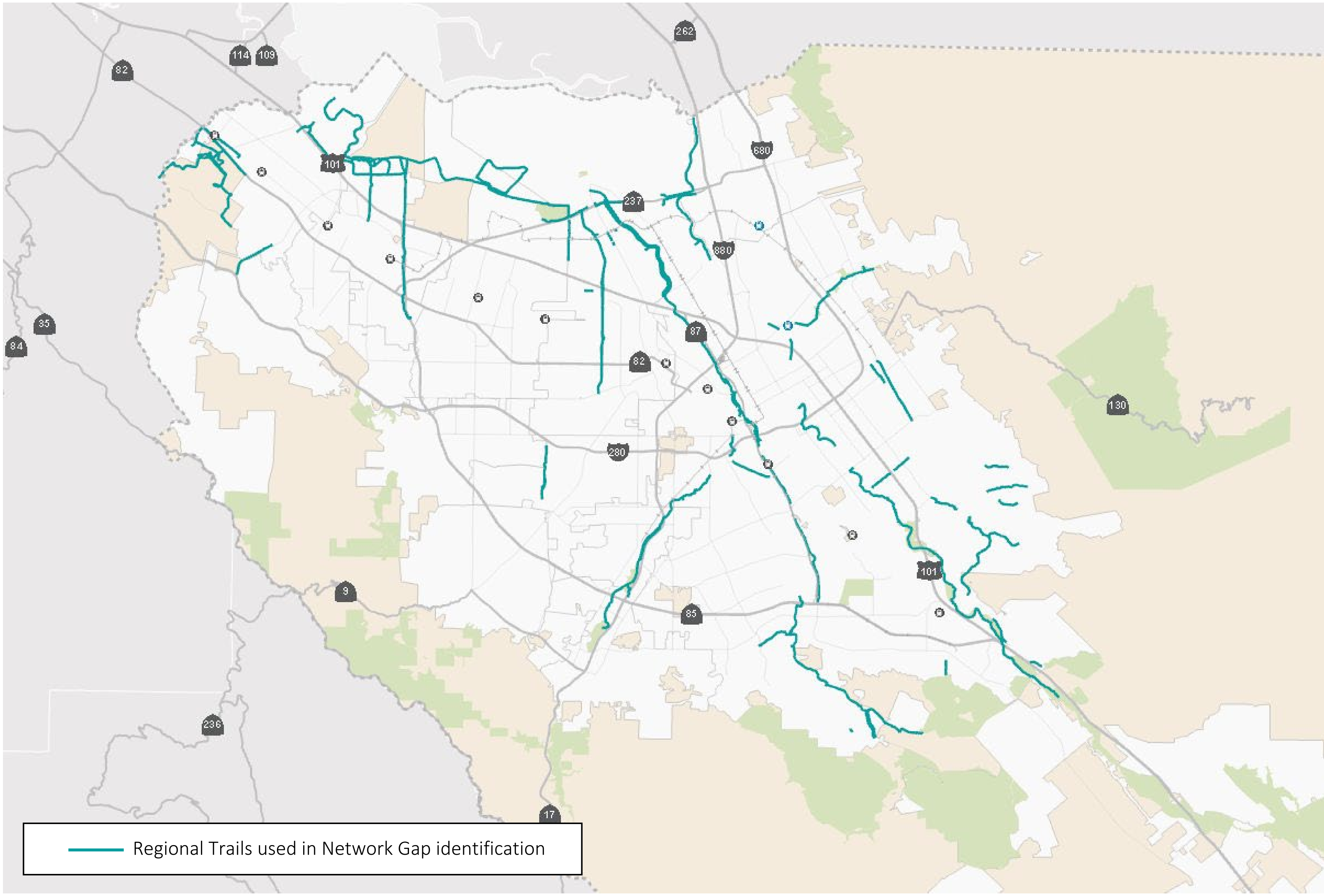


Table 6. Primary Network Gaps (Corridors)

ID	Name	Start	End	Road Class[8] (Non-County Owner)	Proximity To:				Cal Enviro Screen	High active trip potential	Low BLTS	Incomplete Sidewalk	Low PLTS	Crosswalk Spacing	Length (Mi)
					Bike	Rail	Trail	School							
12	Lawrence Expressway	US 101	Prospect Road	Expressway	○	●	●	●	●	●	●	●	●	●	6.85
16	Montague Expressway	Scott Boulevard	I-680	Expressway	○	●	●	●	●	●	●	●	●	●	6.01
2	Almaden Expressway	Almaden Road	McAbee Road	Expressway	○	●	●	●	○	●	●	●	●	●	3.77
7	Capitol Expressway	SR 87	South Jackson Avenue	Expressway	○	●	●	●	○	●	●	●	●	●	8.51
8	Central Expressway	San Antonio Road	Bowers Avenue	Expressway	○	●	●	○	○	●	●	●	●	●	7.93
10	Foothill Expressway	Arastradero Road	Old Oak Court	Expressway	○	○	●	●	○	●	●	●	●	●	2.49
21	San Tomas Expressway	US 101	SR 17	Expressway	●	○	●	●	○	●	●	●	●	○	8.23
11	Junipero Serra Boulevard	Santa Cruz Avenue	Page Mill Road	Arterial	●	○	●	○	○	●	●	●	●	○	2.37
19	Page Mill Road	Birch Street	Porter Drive	Expressway	●	○	●	○	○	●	●	○	●	●	0.26
20	Page Mill Road	Porter Drive	Birch Street	Expressway	●	○	●	○	○	●	●	●	●	○	1.28
22	Tully Road	Monterey Road	South 10th Street	Arterial (City of San José)	○	○	○	●	●	●	●	●	●	○	0.07
1	Almaden Expressway	Orto Street[9]	Canoas Garden Avenue	Expressway	○	○	●	○	○	●	●	○	●	●	0.45

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[8] Includes corridors not controlled by County.
[9] Ibid

ID	Name	Start	End	Road Class[8] (Non-County Owner)	Proximity To: Bike	Rail	Trail	School	Cal Enviro Screen	High active trip potential	Low BLTS	Incomplete Sidewalk	Low PLTS	Crosswalk Spacing	Length (Mi)
14	Main Avenue	Beletto Drive	Cochrane Road	Other (City of Morgan Hill)	○	○	○	●	○	●	●	●	●	○	1.46
23	Union Avenue	Cambrianna Drive	Logic Drive	Arterial (City of San José)	○	○	○	●	○	●	●	●	●	○	0.42
3	Bascom Avenue	Forest Avenue	Lindaire Avenue	Arterial	○	○	○	●	○	●	●	○	●	○	0.79
4	Camden Avenue	Calico Avenue	Union Avenue	Arterial (City of San José)	○	○	○	●	○	●	●	○	●	○	0.23
5	Camden Avenue	SR 17	Parsons Avenue	Arterial (City of San José)	○	○	○	○	○	●	●	●	●	○	0.1
6	Camden Avenue	Union Avenue	Leigh Avenue	Arterial (City of San José)	○	○	●	○	○	●	●	○	●	○	0.1
9	De Witt Avenue	Price Drive	Spring Avenue	Other	○	○	○	○	○	●	○	●	●	●	0.17
15	McKee Road	North White Road	La Pala Drive	Arterial (City of San José)	○	○	○	●	○	●	●	○	●	○	0.4
17	Moorpark Avenue	I-880	South Bascom Avenue	Other	○	○	○	●	○	●	●	○	●	○	0.39
18	Oregon Avenue	Alma Street	Birch Street	Expressway	○	●	○	○	○	●	●	○	●	○	0.26
24	South White Road	Madeline Drive	Florence Avenue	Arterial (City of San José)	○	○	○	●	○	●	●	○	●	○	0.28
13	Leigh Avenue	West San Carlos Street	Scott Street	Other	○	○	○	●	○	●	○	○	●	○	0.23

Primary Network Gaps by Classification	
Expressways	11
Arterials	9

Other	4

Table 7. Primary Network Gaps (Intersections)

ID	Roadway 1	Roadway 2	Functional Class[10] (Non-County Owner)	School Proximity	High active trip potential	On HIN	Missing Crosswalk	Rail Proximity	Trail Proximity
1	Capitol Expressway	South Capitol Avenue	Expressway	●	●	●	●	●	●
2	Capitol Expressway	Guadalupe Parkway	Expressway	●	●	○	●	●	●
3	Capitol Expressway	Massar Avenue	Expressway	●	●	○	●	●	●
4	Foothill Expressway	Arastradero Road	Expressway	●	●	●	●	○	●
5	Wren Avenue	Tatum Avenue	Other (City of Gilroy)	●	●	○	●	○	●
6	Snell Avenue	Obert Drive	Arterial (City of San José)	●	●	○	●	○	●
7	Snell Avenue	Kehoe Court	Arterial (City of San José)	●	●	○	●	○	●
8	San Tomas Expressway	White Oaks Road	Expressway	●	●	○	●	○	●
9	San Tomas Expressway	Los Gatos Creek Trail	Expressway	●	●	○	●	○	●
10	Capitol Expressway	Narvarez Avenue	Expressway	●	●	○	○	●	●
11	San Tomas Expressway	Dell Avenue	Expressway	●	●	○	●	○	●
12	San Tomas Expressway	South Winchester Boulevard	Expressway	●	●	○	●	○	●
13	Capitol Expressway	New Street	Expressway	●	●	○	●	○	●
14	Capitol Expressway	McLaughlin Avenue	Expressway	●	●	●	○	○	●
15	Lawrence Expressway	Doyle Road	Expressway	●	●	○	●	○	●
16	South Bascom Avenue	Renova Drive	Arterial	●	●	●	●	○	○
17	Moorpark Avenue	Empey Way	Other	●	●	●	●	○	○
18	Lawrence Expressway	Junipero Serra Freeway	Expressway	●	●	○	●	○	●
19	South Bascom Avenue	Elliott Street	Arterial	●	●	●	●	○	○
20	Capitol Expressway	Tully Road	Expressway	●	●	○	●	○	●

[10] Includes corridors not controlled by county

ID	Roadway 1	Roadway 2	Functional Class[10] (Non-County Owner)	School Proximity	High active trip potential	On HIN	Missing Crosswalk	Rail Proximity	Trail Proximity
21	Capitol Expressway	South Jackson Avenue	Expressway	●	●	●	○	○	●
22	Story Road	Meadow Lane	Other (City of San José)	●	●	●	●	○	○
23	Foothill Expressway	South Springer Road	Arterial	●	●	○	●	○	●
24	San Tomas Expressway	Monroe Street	Expressway	●	●	○	●	○	●
25	San Tomas Expressway	Central Expressway	Expressway	●	●	○	●	○	●
26	McKee Road	Ridge Vista Avenue	Arterial (City of San José)	●	●	●	●	○	○
27	Montague Expressway	Lick Mill Boulevard	Other	●	●	○	●	○	●
28	Junipero Serra Boulevard	Page Mill Road	Expressway	●	●	●	○	○	●
29	Montague Expressway	Falcon Drive	Expressway	●	●	○	●	●	○
30	Montague Expressway	Piper Drive	Expressway	●	●	○	●	●	○
31	Central Expressway	San Antonio Road	Expressway	●	●	○	●	●	○
32	Oregon Expressway	Park Boulevard	Expressway	●	●	○	●	●	○
33	Oregon Expressway	Alma Street	Expressway	●	●	○	●	●	○
34	Almaden Expressway	Blossom Hill Road	Expressway	●	●	●	○	○	○
35	Leigh Avenue	Wyrick Avenue	Other	●	○	●	●	○	○
36	Almaden Expressway	Cherry Avenue	Expressway	●	●	●	○	○	○
37	Capitol Expressway	Senter Road	Expressway	●	●	●	○	○	○
38	Capitol Expressway	Silver Creek Road	Expressway	●	●	●	○	○	○
39	Capitol Expressway	Aborn Road	Expressway	●	●	●	○	○	○
40	McVay Avenue	Fleming Avenue	Other	●	○	●	●	○	○
41	Capitol Expressway	Seven Trees Boulevard	Expressway	●	○	●	○	○	○

Primary Intersection Gaps by Classification *(Highest Functional Classification at intersection)*	
Expressways	29
Arterials	6
Other	6

Figure 39. Primary Network Gaps (Urban) Santa Clara County

04-13-22

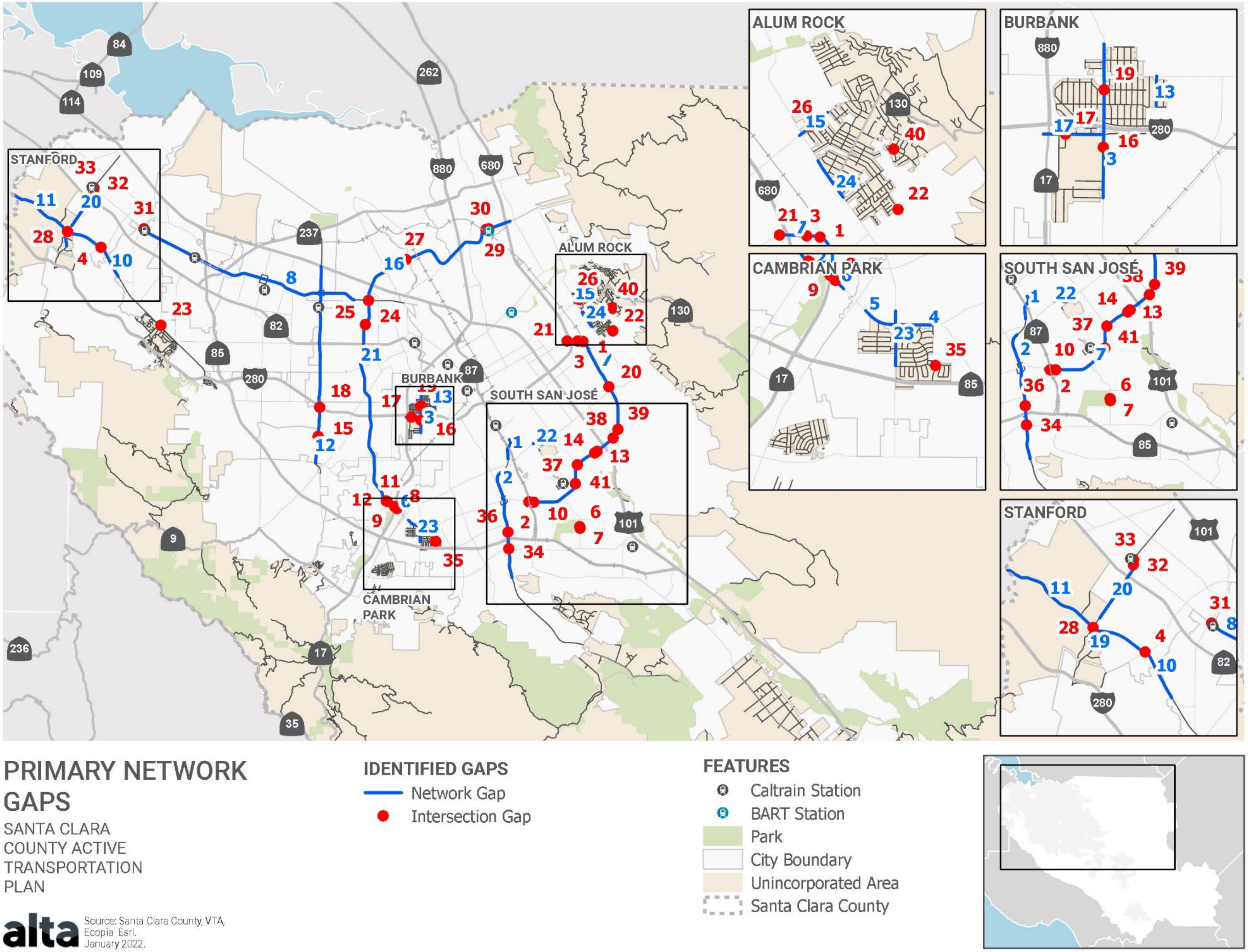
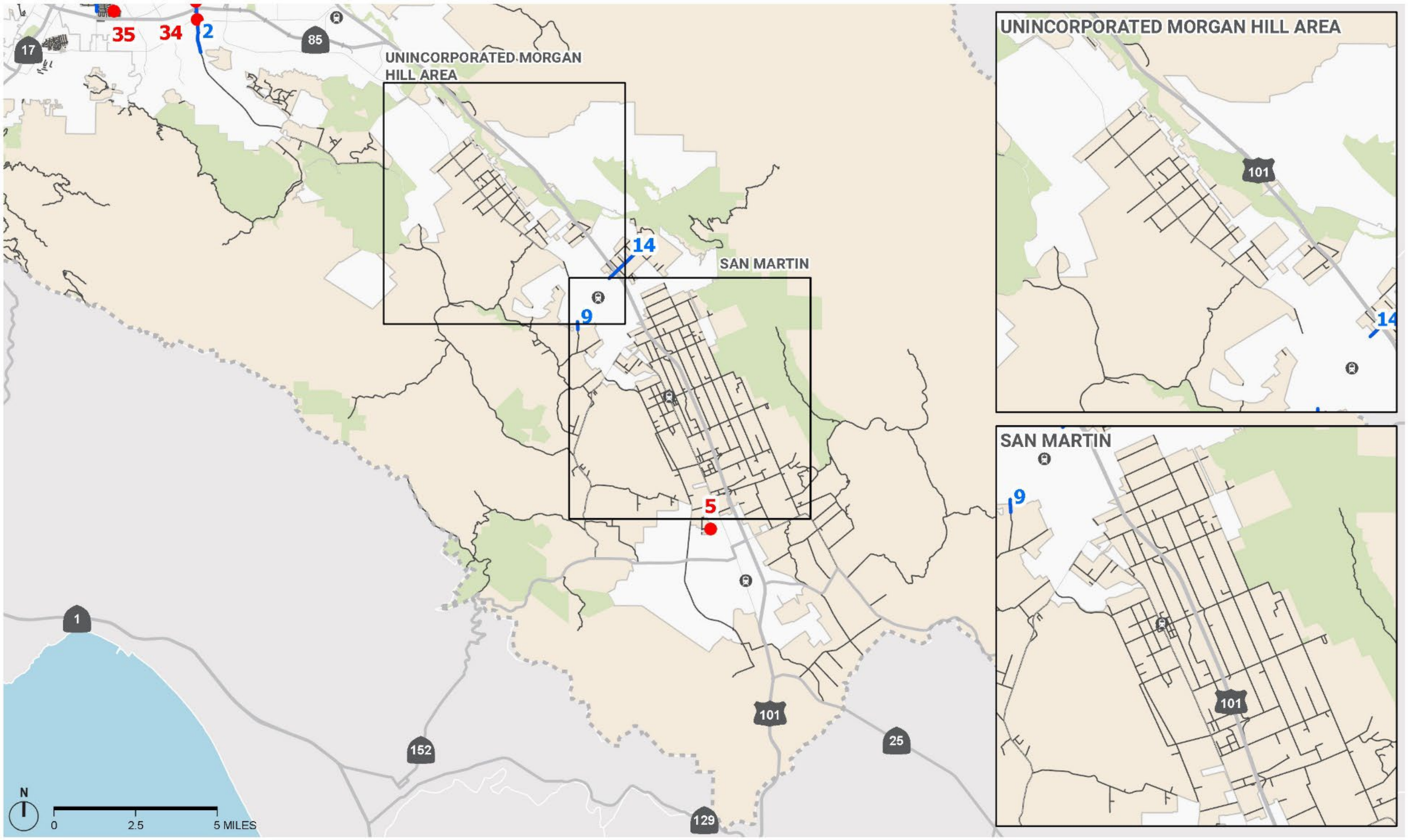


Figure 40. Primary Network Gaps (Rural) Santa Clara County



PRIMARY NETWORK GAPS

SANTA CLARA COUNTY ACTIVE TRANSPORTATION PLAN

alta

Source: Santa Clara County, VTA, MTC, Ecopia, OSM. January 2022.

IDENTIFIED GAPS

- Network Gap
- Intersection Gap

FEATURES

- Caltrain Station
- BART Station
- Park
- City Boundary
- Unincorporated Area
- Santa Clara County

Summary of Findings and Discussion

The results of the needs assessment demonstrate significant opportunities throughout Santa Clara County to improve active transportation infrastructure and address existing barriers. Based on the infrastructure and needs assessment, the County **should consider investing on infrastructure upgrades to improve crossing conditions at identified intersection gaps and to improve conditions along identified primary network gaps.** Primary network gaps include 46 miles of expressways, 4.8 miles of major arterials, and 2.3 miles of other major roads. There are 41 primary intersection gaps. The vast majority (31), are on expressways. There are also 6 arterial intersections and 4 other intersections. As noted, the primary network and intersection gaps identified through this assessment are generally high-capacity roads with significantly high levels of vehicle traffic, high posted speeds, minimal formal bicycle facilities, and no pedestrian infrastructure. While these roadways serve primarily **urban** areas of the County due to the higher level of active transportation potential and local connectivity, additional roadways particularly in **rural** areas of the County, merit further investments and attention to determine a comprehensive set of coordinated upgrades. To this end, the **County should consider developing a list of recommended sidewalk infill projects for rural areas that improve local pedestrian access.**

Expressways

The primary network gaps identified comprise 53 total miles of roadway: 87% of the total mileage (46 miles) is represented by expressways. Additionally, based on the primary network gap scoring, seven of the top ten highest scoring primary network gaps were expressways. These roadways represent the greatest opportunity for significant enhancements to pedestrian and bicycle connectivity. These roadways have some of the highest active transportation demand of any study roadway and provide connections between areas of higher active trip demand such as Stanford and Downtown San Jose. However, these roadways generally have the highest levels of traffic stress for pedestrians and bicyclists and may serve as barriers to travel for alternative modes.

Beyond the opportunity to address active trip potential, expressways present a significant opportunity to address safety concerns for all modes, especially for the most vulnerable roadway users: bicycles, pedestrians, and wheelchair users. The safety analysis identified expressways as a major portion of the HIN with six included in the HIN such as Capitol Expressway. This roadway had a high number of intersection collisions and includes six of the top ten high collision signalized intersections and two of the top ten unsignalized intersections.

There are numerous proven countermeasures identified by the Federal Highway Administration (FHWA) and allowed by Caltrans which the County may consider for implementation on Expressways including:

- **Appropriate Speed Limits for All Road Users** – "Speed control is one of the most important methods for reducing fatalities and serious injuries. Speed is an especially important factor on non-limited access roadways where vehicles and vulnerable road users mix."[11]
- **Longitudinal Rumble Strips and Stripes** – These are milled or raised elements on the pavement that alert drivers through vibration to the edge of the roadway (shown on **Figure 41**). This has been proven to reduce run-off road fatal and injury vehicle collisions by up to 51%.Where rumble strips cannot be placed due to noise concerns, the county may consider a design using an oscillating sine wave pattern (also known as "mumble strips") that reduces noise outside of the vehicle.[12]

Figure 41. Longitudinal Rumble Strips and Stripes example

[11] https://safety.fhwa.dot.gov/provencountermeasures/appropriate-speed-limits.cfm
[12] NCHRP Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, (2009).

- **Backplates with Reflective Borders** – This strategy adds a highly reflective 1–3-inch yellow border to traffic signal backplates to make them more visible in both daytime and nighttime (**Figure 42**). This countermeasure has been proven to reduce collisions at signalized intersections by 15%.[13]
- **Pedestrian Hybrid Beacons (PHBs)** – These pedestrian crossing enhancements are most appropriate on multi-lane roadways with speed limits in excess of 35 mph and is typically installed at a mid-block location to support safe pedestrian crossings (see **Figure 44**). This type of enhancement may reduce pedestrian collisions by up to 55%[14] and all collisions by 29%.[15] Please note that the county currently does not support uncontrolled mid-block crossings. Department standards would need to be established prior to implementation of said facilities.
- **Rectangular Rapid Flashing Beacons (RRFBs)** – These pedestrian crossing enhancements are typically installed on multi-lane roadways with speed limits of 40 mph or lower (**Figure 47**). This type of enhancement may reduce pedestrian collisions by up to 47%.[16]
- **Walkways (creating transit connections)** – The addition of sidewalks has been shown to reduce collisions with pedestrians walking along roadways by 65-89%.[17]

Figure 42. Retroreflective Backplate (Source: FHWA)

Finally, Caltrans Director's Policy on Complete Streets (DP-37) allows for the implementation of context sensitive solutions to improving comfort and safety of all roadway users.[18]

Figure 44. Context Sensitive Bicycle Facility on Multi-Lane Roadway

Figure 43. Pedestrian Hybrid Beacon at Morse Road / El Camino Real intersection.

[13] Sayed, T., Leur, P., and Pump, J., "Safety Impact of Increased Traffic Signal Backboards Conspicuity." 2005 TRB 84th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#05-16, Washington, D.C., (2005).
[14] Zegeer et al. NCHRP Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments. TRB, (2017).
[15] Fitzpatrick, K. and Park, E.S. Safety Effectiveness of the HAWK Pedestrian Crossing Treatment, FHWA-HRT-10-042, (2010).
[16] NCHRP Research Report 841 Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, (2017).
[17] Gan et al. Update of Florida Crash Reduction Factors and Countermeasures to Improve the Development of District Safety Improvement Projects. Florida DOT, (2005).
[18] Caltrans Director's Policy 37 – Complete Streets https://dot.ca.gov/-/media/dot-media/programs/sustainability/documents/dp-37-complete-streets-a11y.pdf

Signalized Intersections

Signalized intersections were identified as the leading location of collisions in the safety analysis. Major signalized intersections on **study roadways** prioritize the movement of vehicles and often include channelization islands or “slip lanes” (see **Figure 45**) which allow vehicles to turn while maintaining a high rate of speed through potential conflict points with vulnerable users including people walking and biking. Further, these design features prioritize vehicle capacity and throughput over active transportation safety. Higher rates of speed increase the probability that a collision will result in a fatality or serious injury, especially when involving a vulnerable road user.[19] Finally, all signalized intersections identified in the top ten high frequency collision locations included at least one slip lane. There are numerous proven countermeasures identified by FHWA and allowed by Caltrans under DP-37 which the County may consider for implementation at signalized intersections including:

Figure 45. Channelization island at Almaden Expressway / Cherry Avenue (Highest Collision Signalized Intersection)

- **Leading Pedestrian Interval** – This enhancement gives pedestrians a head-start and allows them to enter the street approximately 3-7 seconds prior to vehicles receiving a green-light. This allows pedestrians to better establish themselves in the crosswalk and improves pedestrian visibility while crossing and increases the likelihood of motorists yielding to pedestrians.[20] This treatment has been proven to reduce pedestrian-vehicle collisions at intersections by 13%.[21]
- **Crosswalk Visibility Enhancements** – Improving pedestrian visibility at crosswalks through the addition of high visibility crosswalk treatments[22] (**Figure 46**), enhanced lighting[23], and signing & pavement marking improvements.[24] These strategies have been proven to reduce pedestrian collisions by up to 42%.
- **Backplates with Reflective Borders** – This strategy adds a highly reflective 1 to 3-inch yellow border to traffic signal backplates to make them more visible in both daytime and nighttime. This countermeasure has been proven to reduce collisions at signalized intersections by 15%.[25]

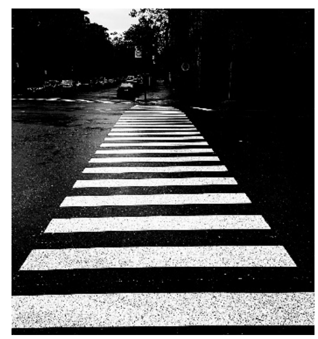


Figure 46. High Visibility Crosswalk Markings

Additionally, the removal or reconfiguration or channelization islands at major intersections is recommended in order to improve pedestrian and bicycle intersection safety.

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[19] Pilkinton, Paul. Reducing the speed limit to 20 mph in urban areas: Child deaths and injuries would be decreased. BMJ, Published April 29, 2000.
[20] https://safety.fhwa.dot.gov/provencountermeasures/lead_ped_int.cfm
[21] Goughnour, E., D. Carter, C. Lyon, B. Persaud, B. Lan, P. Chun, I. Hamilton, and K. Signor. "Safety Evaluation of Protected Left-Turn Phasing and Leading Pedestrian Intervals on Pedestrian Safety." Report No. FHWA-HRT-18-044. Federal Highway Administration. (October 2018)
[22] Chen, L., C. Chen, and R. Ewing. The Relative Effectiveness of Pedestrian Safety Countermeasures at Urban Intersections - Lessons from a New York City Experience. (2012).
[23] Elvik, R. and Vaa, T. Handbook of Road Safety Measures. Oxford, United Kingdom, Elsevier, (2004).
[24] Zeeger et al. Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments, FHWA, (2017).
[25] Sayed, T., Leur, P., and Pump, J., "Safety Impact of Increased Traffic Signal Backboards Conspicuity." 2005 TRB 84th Annual Meeting: Compendium of Papers CD-ROM, Vol. TRB#05-16, Washington, D.C., (2005).

Unsignalized Intersections

Unsignalized intersections present their own unique safety challenges for bicycles and pedestrians. While signalized intersections represent the largest portion of collisions, unsignalized intersections present an opportunity for the County to proactively and systemically address safety concerns for all modes while simultaneously improving connectivity for bicycles and pedestrians.

The County should consider implementation of context sensitive solutions to the pedestrian infrastructure allowed under Caltrans DP-37 and consider implementation of the following countermeasures at high collision unsignalized intersections including Bascom Avenue and Elliott Street (see **Figure 51**), which experienced the second highest total number of collisions across all study intersections. [26]

Figure 47: Pedestrian Hybrid Beacon on El Camino Real (photo: Sergio Ruiz)

- Crosswalk Visibility Enhancements
- Pedestrian Hybrid Beacons (PHBs) (see **Figure 47**)
- Rectangular Rapid Flashing Beacons (RRFBs) (see **Figure 48**)
- **Reduced Left-Turn Conflict Intersections** – Intersections may be modified to alter left-turn movement and reduce potential conflict points and crash types including head-on and angle collisions (see **Figure 49** and **50**). One of the most common forms of these intersections, Restricted Crossing U-Turn (RCUT) intersection, has been shown to reduce fatal and injury collisions by 63% when installed at an unsignalized intersection.[27] This strategy is appropriate for a wide variety of contexts including high-speed rural locations and high-volume suburban, multimodal corridors.
- **Systemic Application of Multiple Low-Cost Countermeasures** – This strategy combines multiple low-cost countermeasures like adding additional signage, striping, and pavement markings surrounding unsignalized intersections to create a significant safety improvement. When implemented together these strategies have been shown to reduce fatal and serious injuries by up to 27% at rural locations and 15% during nighttime conditions.[28]

Figure 48. Rectangular Rapid Flashing Beacon (RRFB)

These countermeasures have been shown by the FHWA to have a significant reduction in collisions at unsignalized intersections and may also be implemented proactively as intersections with similar characteristics as high collision unsignalized intersections.

[26] FHWA Proven countermeasures https://safety.fhwa.dot.gov/provencountermeasures/fhwasa18068/
[27] Hummer et al. Superstreet Benefits and Capacities. FHWA/NC/2009-06, NC State University, (2010).
[28] T. Le et al, "Safety Effects of Low-Cost Systemic Safety Improvements at Signalized and Stop-Controlled Intersections," 96th Annual Meeting of the Transportation Research Board, Paper Number 17-05379, January 2017.

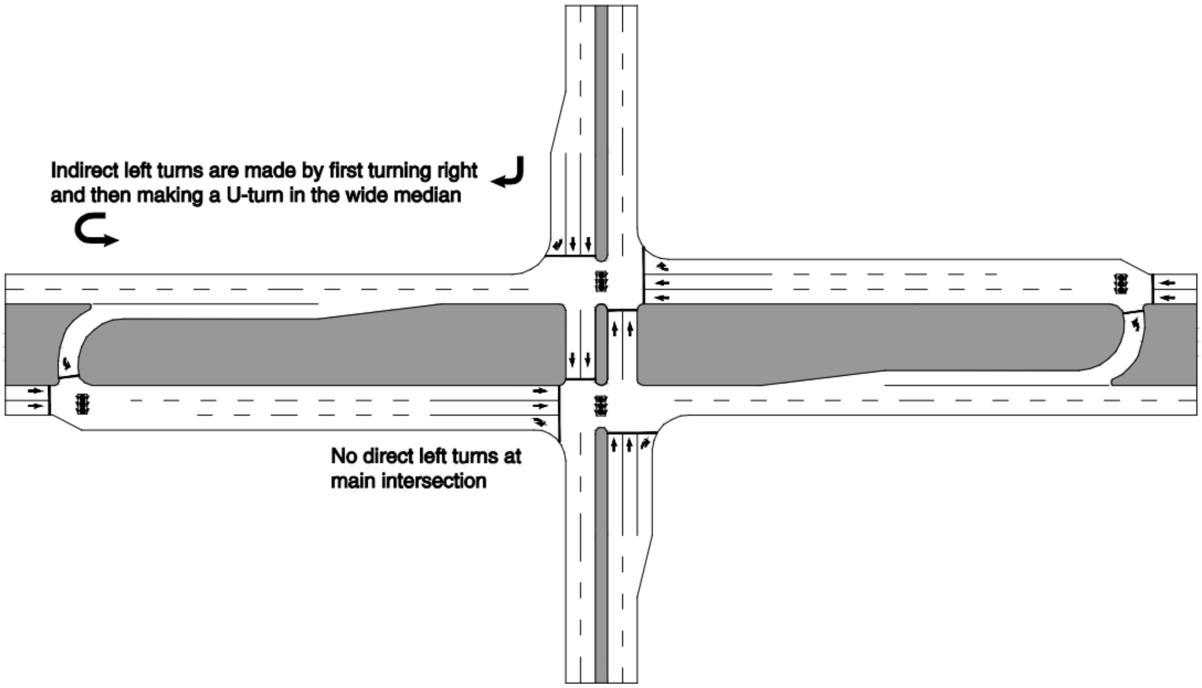

Figure 49. Example of Reduced Left Turn Conflict Intersection (MUT - Median U-Turn Intersection configuration)

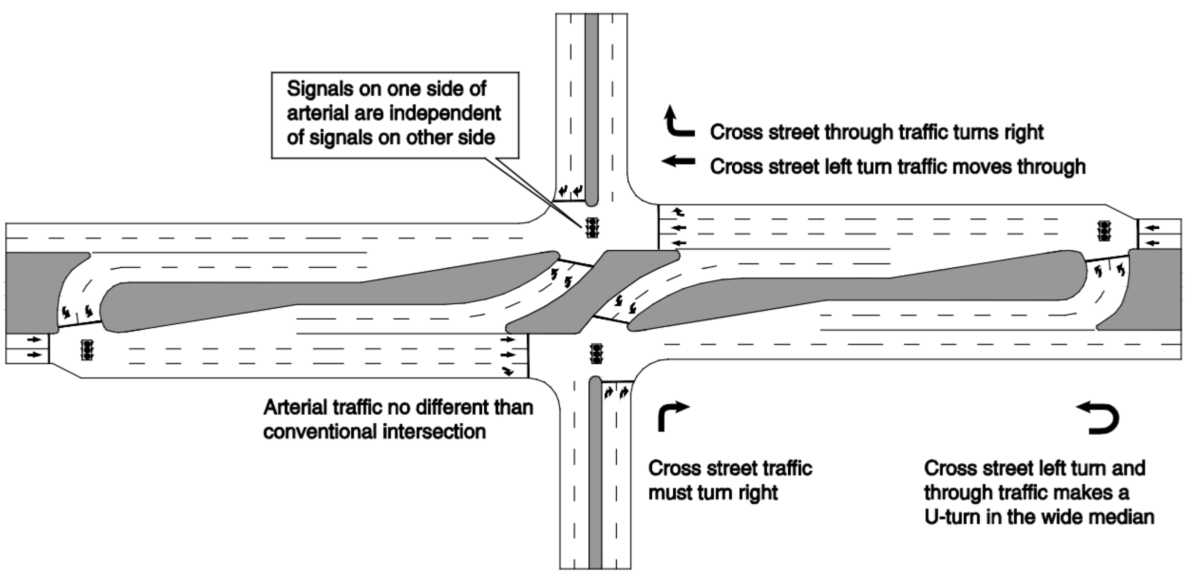

Figure 50. Example of Reduced Left Turn Conflict Intersection (RCUT - Reduced Crossings U-Turn Intersection configuration)

Figure 51. Bascom Ave and Elliott Street intersection (Second Highest Total Collisions of All Intersections)

Transit Connections

The recent implementation of multiple Transit Only lanes throughout Santa Clara County for the use of Santa Clara Valley Transportation Authority (VTA) buses presents a significant opportunity for the County to coordinate efforts with a partner agency in order to maximize the benefit to the public. Transit only lanes installed on existing County expressways may result in improved transit service and reduced delays for transit, which may consequentially help increase transit ridership. In order to best support the VTA's effort and encourage transit usage across the County, the County should consider making direct active transportation connections to transit stops along all County controlled roadways while prioritizing pedestrian connections along expressways and within close proximity to schools.

Next Steps

Next steps identified below are based on the findings from the needs assessment and safety analysis and indicate a path forward to addressing identified safety and connectivity issues. To this end, the County should consider:

- Providing **revisions or sunsetting the use** of the County Expressway Bicycle Accommodation Guidelines (2003). Consider incorporation of recent guidance such as *FHWA Bikeway Selection Guide* (February, 2019) and *Caltrans Contextual Guidance for the Selection of Bicycle Facilities* (March, 2020).
- Closing **bicycle and pedestrian network gaps** on County controlled roadways. Prioritize existing gaps in close proximity to schools and transit centers. Prioritize **completion of sidewalks on both sides of the road** in close proximity to transit.
- **Identifying intersections** in **urban** pockets and **rural** areas that might benefit from the installation of additional marked crosswalks.
- **Improving conditions at signalized and unsignalized intersections** with high level of collisions using FHWA proven countermeasures and other design features.
- Enhancing **existing connections to transit** while prioritizing connections on expressways and in close proximity to schools.

- Developing a list of **recommended sidewalk infill projects** for **urban** pockets and **rural** areas that improve local pedestrian access.
- Conducting **corridor studies** on Capitol Expressway and Almaden Expressway to identify location specific coordinated recommendations.
- **Enhancing existing pedestrian crossing** locations to increase visibility, reduce pedestrian crossing distances, and reduce vehicle speeds through intersections by eliminating channelization islands and reducing corner radii. High collision intersections should be prioritized for this treatment however, this treatment may be applied proactively across the transportation system to intersections with similar characteristics.
- Providing **increased opportunities to cross major roads** prioritizing roadways with sidewalks on both sides of the street, in close proximity to schools, and with transit service.

The project team anticipates using the results of this analysis coupled with feedback from public and stakeholder groups to help define the final recommendations and prioritization of infrastructure upgrades throughout County-controlled roadways. Particular attention will be noted at the interface of County-operated facilities with City and Caltrans facilities. The team also anticipates that the list of projects and recommendations contained in the final Active Transportation Plan will require further evaluation on a case-by-case basis to identify the most appropriate context-sensitive improvements based on the unique characteristics of that corridor such as land use context, available right-of-way, user comfort and vehicular capacity among others. Additionally, facility recommendations developed for the Plan may consider roadways that have other combinations of these attributes or that are important for other reasons (e.g., connect to a municipal bike network but has low active trip potential).

Appendices

A. LTS OSM Assumptions

Alta uses a tiered data collection framework for Level of Traffic Stress (LTS) analysis that derives initial analysis inputs from readily accessible data, in order to determine where additional data collection will be of the most value to meet project goals. In the case of LTS analysis, Alta derives initial base analysis inputs from OpenStreetMap (OSM) data.[29] This appendix documents how Alta develops the input variables for this analysis. Where OSM data includes values for lanes, posted speeds, bike lanes, sidewalks, parking lanes, and one-way tags, these tags are used to populate a database for LTS inputs. Once that database is populated, Alta uses the Mekura et al, 2012Level of Traffic Stress methodology to score roadway segments. This initial LTS is intended to be augmented by either automated or manual review of aerial imagery, local GIS data and/or street view data. Once the base input values have been validated, the LTS scores can be refreshed using Alta's LTS calculation scripts. This enables evaluation of new scenarios as needed in addition to standardized network analysis.

OSM Processing

When using OSM networks for LTS analysis, there are several considerations for creating a useful network for visualization and analysis. The sections below outline how Alta processes OSM data for LTS and related network analysis.

Network Connectivity

OSM networks contain segments that are not ready for network analysis in most instances. There are various software processing packages such as the Open-Source Routing Machine and OpenTripPlanner that come with routines to prepare OSM networks for network analysis. Alta uses scripts built on the OSMnx[30] Python package to derive its geospatial networks. This package is used to ensure that extracted networks are valid and have appropriate end-to-end connectivity provided by network segments. This process complies all OSM networks wherein the highway tag[31] is available and the corresponding geometry is a line. For cartographic presentation, it is often preferable to filter out features such as service roads (roads within parking lots) and footways (sidewalks drawn separately from the centerline). This is typically done to focus attention to facilities that jurisdictions and regions can reasonably improve.

Tag Processing

In many cases, OSM data includes tags for attributes such as lanes, posted speed, bicycle infrastructure, and other facility information recorded in the database. This data tends to more likely to be completed in urbanized areas globally, and on major facilities such as arterials and highways. There can be substantial variance in tag availability from location to location, but the presence of Bike Paths and a consistent indicator of functional classification is generally well recorded in OSM. In the case of bike lane blockage rates, Alta assumes these instances are rare unless manual review of commercial districts indicates otherwise. When tags are missing from OSM for the purposes of LTS analysis, the assumptions outlined in Table 1 are used as proxy values.

[29] OpenStreetMap (OSM) is a crowd-sourced database of geographic features including administrative boundaries, street centerlines, points of interest, building footprints, physical and natural features, and other types of geographic information. OSM is one of the most prominent examples of Volunteered Geographic Information (VGI), where community processes drive the contributions of geographic information to a shared database (2). These geographic features are tagged based on their attributes, and while community wiki-pages provide guidance on which tags apply to which features, there is no centralized authority that authenticates these contributions. For example, street networks in OSM may include tags where contributors denote functional classification, number of lanes, one-way classification, speed limits, presence of sidewalks, and the type of bicycle facility that might be present on the network. While OSM is not always accurate, it has been benchmarked against comparable map data sources such as Google and found to have comparable or better accuracy for Bike Paths depending on the type of error (3). Multiple non-profits, academics, and practitioners have found OSM to be an acceptable base for initial derivation of LTS analysis (4,5,6,7).

[30] Boeing, G. 2017. OSMnx: New Methods for Acquiring, Constructing, Analyzing, and Visualizing Complex Street Networks. Computers, Environment and Urban Systems 65, 126-139. doi:10.1016/j.compenvurbsys.2017.05.004

[31] Highway Tag. Key:highway - OpenStreetMap Wiki. (n.d.). https://wiki.openstreetmap.org/wiki/Key:highway.

Table 1. Alta's OSM Assumptions for Missing Inputs

Functional Class	Lanes [1,2,3]	Speed Limit [1,2,3]	Centerline Present [3]
Residential	2	25	No
Living Street	2	25	No
Unclassified	2	25	Yes
Track	2	30	Yes
Tertiary	3	30	Yes
Secondary	4	35	Yes
Primary	4	45	Yes
Trunk	6	65	Yes
Motorway	6	65	Yes
OTHER	2	25	Yes

1. Lane assumptions for one-way streets are halved to reflect an accurate per-segment assumption. In addition, all one-way streets are assumed to have medians for the purposes of LTS computations.
2. These assumptions only apply if there is no tag provided for speed limit or number of lanes.
3. These assumptions were developed based on Wasserman et al, 2019 and Harvey et al, 2019.

LTS analysis also requires an understanding of other geometric considerations, such as bicycle facility width and parking lane width (if present). Alta begins with a "benefit of the doubt" approach for these attributes, meaning that if they are present, they are assumed to be of sufficient width. Validation is recommended for detailed LTS assessments, but this is typically less important for less rigorous, or large scale (e.g., county-, region-, or state-wide) LTS-based analysis. Bicycle infrastructure-related tags are processed using assumptions outlined in Table 2.

Table 2. Alta's OSM Assumptions for Bicycle Facilities

Cycleway Tag[1]	Bicycle Facility Type	Assumed Bicycle Facility Width (Feet)	Is Protected
Shared	Bike Route / Class III	0	No
Shared_lane	Bike Route / Class III	0	No
Lane	Bike Lane / Class II	6	No
Shared_busway	Bike Lane / Class II	6	No
Opposite_lane	Bike Lane / Class II	6	No
Cycleway[2]	Bike Path / Class I	10	Yes
Path	Bike Path / Class I	10	Yes
Track	Separated Bikeway / Class IV	8	Yes
Opposite_track	Separated Bikeway / Class IV	8	Yes
Buffered_lane	Separated Bikeway / Class IV	8	Yes
OTHER	NA	0	No

1. Alta processes a non-directional cycleway tag and directional cycleway tags as part of its conversion. The final LTS score is the worst-case score based on the direction of facilities.
2. Highway tags including the tag "cycleway" are also considered to be Class I facilities.

When parking lane-related tags are processed, assumptions related to their width and rates of bike lane blockage are outlined in Table 3.

Table 3. Alta's OSM Assumptions for Parking Facilities

Parking Lane Tag	Assumed Parking Lane Width (Feet)
Parallel	8
Marked	8
Diagonal	16
Perpendicular	20
OTHER	NA

Citations

1. Mineta Institute. Mekuria M., Furth P., Nixon H. Low-Stress Bicycling and Network Connectivity. 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity
2. Mocnik, F.-B., A. Mobasheri, and A. Zipf. Open-Source Data Mining Infrastructure for Exploring and Analysing OpenStreetMap. Open Geospatial Data, Software and Standards, Vol. 3, No. 1, 2018, p. 7. https://doi.org/10.1186/s40965-018-0047-6.
3. Hochmair, H. H., D. Zielstra, and P. Neis. Assessing the Completeness of Bicycle Bike Path and Lane Features in OpenStreetMap for the United States. Transactions in GIS, Vol. 19, No. 1, 2014, pp. 63–81. https://doi.org/10.1111/tgis.12081.
4. PeopleForBikes. Bicycle Network Analysis. PeopleForBikes. https://peopleforbikes.org/placesforbikes/bicycle-network-analysis/.
5. Conveyal. Better measures of Bike Accessibility. https://blog.conveyal.com/better-measures-of-bike-accessibility-d875ae5ed831
6. Wasserman D, Rixey A, Zhou X (Elynor), Levitt D, Benjamin M. Evaluating OpenStreetMap's Performance Potential for Level of Traffic Stress Analysis. Transportation Research Record. 2019;2673(4):284-294. doi:10.1177/0361198119836772
7. Mineta Institute. Chester Harvey, Kevin Fang, Daniel A. Rodriguez. Evaluating Alternative Measures of Bicycling Level of Traffic Stress Using Crowdsourced Route Satisfaction Data. 2019. https://scholarworks.sjsu.edu/mti_publications/276/

B. BLTS Methodology

The Bicycle Level of Traffic Stress (BLTS) analysis estimates the level of comfort for people biking on a given roadway segment. BLTS helps to identify where "gaps" or deficiencies in a bike network exist, and provides a measure of how likely different types of riders, based on ability and comfort level, are to use the facility.
Alta's BLTS analysis methodology is adapted from the 2012 Mineta Transportation Institute Report 11-19: *Low-Stress Bicycling and Network Connectivity*.[32] LTS is determined by characteristics of a given roadway segment that affect a bicyclist's perception of safety and comfort, including posted speed limit, number of travel lanes, and the presence and character of bicycle lanes. The combination of this criteria classifies a road segment into one of four levels of traffic stress:

- BLTS 1 represents roadways where bicyclists of all ages and abilities would feel comfortable riding. These roadways are generally characterized by low volumes, low speeds, no more than two travel lanes, and traffic control measures at intersections. These roadways may have bicycle facilities; separated shared-use paths for bicycles also fall into this category.
- BLTS 2 represents slightly less comfortable roadways, where most adults would feel comfortable riding.
- BLTS 3 represents moderately uncomfortable roadways, where most experienced bicyclists would feel comfortable riding.
- BLTS 4 represents high-stress roadways where only strong and fearless bicyclists would feel comfortable riding. These roadways are generally characterized by high volumes, high speeds, several travel lanes, and complex transitions approaching and crossing intersections.

The results of the BLTS analysis helps identify existing areas that are low-stress for many bicyclists, and identifies the degree to which roadways must be improved in order to provide a comfortable experience for riders of all ages and abilities. Additionally, scenario testing can be used to determine how a roadway or route's level of stress may change with improvements.

Methodology

BLTS analysis is completed through an assessment of street segments using spatial data and aerial imagery. Each segment of the roadway is evaluated based on its characteristics; if multiple scores are present within a segment the highest (most stressful) score is used as the overall segment score.

Figure 1 illustrates the overall BLTS scoring process. Notes on data inputs and assumptions are found in Table 1. Segment scores are assigned as shown in Table 2 through Table 5.

[32] Mineta Institute. Mekuria M., Furth P., Nixon H. Low-Stress Bicycling and Network Connectivity. 2012. https://transweb.sjsu.edu/research/Low-Stress-Bicycling-and-Network-Connectivity

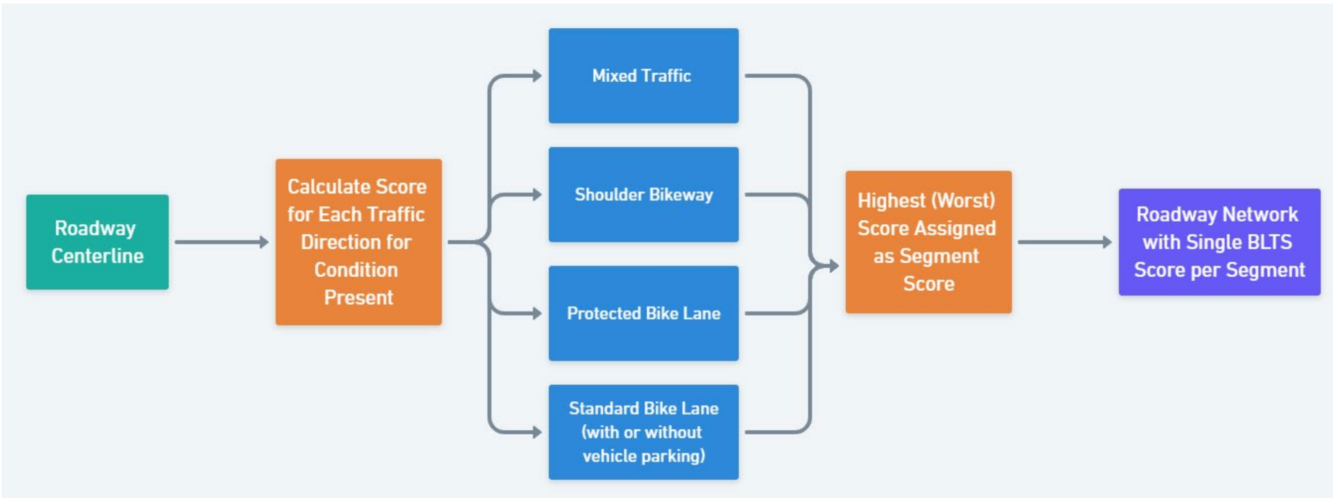

Figure 1. BLTS Generalized Segment Scoring Process

Table 4: Data Inputs and Assumptions

Inputs	Notes	Assumptions
Bicycle Facilities	Bicycle lanes have a positive impact on bicycle level of travel stress and are a primary input for developing a BLTS model. The width of facilities can have an impact on the associated comfort level. Wider facilities provide greater comfort, especially on higher speed roadways.	For analysis purposes, a standard width of 6 feet was assumed for all bike lanes within the city. Buffered bike lanes, which provide an additional degree of separation from motor vehicles and great operating space for bicyclists, were considered to be greater than 6 feet, meeting the requirements for a BLTS 1 score as outlined in Table 2 and Table 3 below.
Speed Limit	Higher speed roadways are considered to be less comfortable for bicyclists, particularly in mixed traffic or with minimal separation from motor vehicles. Low-speed roadways are considered more comfortable.	Speed limit data was available for county roads. As so, the BLTS evaluation takes indicated speed limit data on county roadways into account. For non-county roads the posted speed limit in OSM was used.
Presence and width of on-street parking adjacent to bicycle lanes	On-street parking is particularly important for corridors on which bicycle lanes are present. Bicycle levels of travel stress are greater on bicycle lanes adjacent to parking than on bicycle lanes not adjacent to parking, due to the potential for 'dooring' incidences.	A standard width of 7.5 feet was assumed for all parking lanes.
Number of Lanes	The number of travel lanes corresponds with an increase in the roadway width, which has an effect on bicyclists' level of stress. Roadways with fewer lanes are generally less stressful for bicyclists.	When data was not available or was inadequate, assumptions about number of lanes were made based on the roadway's functional classification according to OSM or other available data.
Presence of Trails	Class I facilities can be a vital component of a municipality's active transportation network. Increased separation from motor vehicles can improve comfort and safety.	Class I facilities are scored as a BLTS 1.

Tables 5 through 7 specify the scoring criteria based on roadway configuration, speed, and bike lane/parking lane presence and width. The criteria are adapted from the original 2012 Mineta Institute report. These tables are used in combination to assign an overall LTS score; if multiple scores are present within a segment the highest (most stressful) score is used as the overall segment score. These tables are used in combination to create the segment, approach, and intersection scores described above.

Table 5: Criteria for Bicycle Level of Traffic Stress in Mixed Traffic

Prevailing Speed or Speed Limit (mph)	Street Width		
	2-3 Lanes	4-5 Lanes	6+ Lanes
≤ 25	BLTS 1 or 21	BLTS 3	BLTS 4
30	BLTS 2 or 3[1]	BLTS 4	BLTS 4
≥ 35	BLTS 4	BLTS 4	BLTS 4

1. Lower value is assigned to streets without marked centerlines or classified as residential with fewer than 3 lanes. Residential roadways are identified based on the Open Street Map 'highway' tag.

Table 6: Criteria for Bike Lanes Not Alongside a Parking Lane

	BLTS 1	BLTS 2	BLTS 3	BLTS 4
Street Width (Through lanes per direction)	1	2	More than 2	(no effect)
Bike Lane Width	6 feet or more	5.5 feet or less	(no effect)	(no effect)
Speed Limit (mph)	30 mph or less	(no effect)	35 mph	40 mph or more
Bike lane blockage[1]	rare	(no effect)	frequent	(no effect)

1. Bike lane blockage is part of Alta's analysis methodology, but assumed to be rare by default.

Table 7: Criteria for Bike Lanes Alongside a Parking Lane

	BLTS 1	BLTS 2	BLTS 3	BLTS 4
Street Width (Through lanes per direction)	1	(no effect)	2 or more	(no effect)
Sum of Bike Lane Width + Parking Lane Width	15 feet or more	14 or 14.5 feet	13.5 feet or less	(no effect)
Speed Limit (mph)	25 mph or less	30 mph	35 mph	40 mph or more
Bike lane blockage[1]	rare	(no effect)	frequent	(no effect)

1. Bike lane blockage is part of Alta's analysis methodology, but assumed to be rare by default.

C. PLTS Methodology

Overview

The Pedestrian Level of Traffic Stress (PLTS) analysis estimates the level of comfort for people walking on a given roadway segment. PLTS helps identify where "gaps" or deficiencies in a pedestrian network exist, and provides a measure of how likely pedestrians are to use the facility, based on ability and comfort level.

Alta's PLTS analysis methodology is adapted from the Oregon Department of Transportation (ODOT) 's *Analysis Procedures Manual* [33] and is intended as a companion for Bicycle Level of Traffic Stress (BLTS). PLTS is determined by characteristics of a given roadway segment that affect a pedestrian's perception of safety and comfort including sidewalk presence and width, sidewalk buffer width and type, posted speed limit, and number of travel lanes. PLTS scores classify road segments into one of four levels of traffic stress and, while similar to bicycle LTS scores, PLTS considers the level of attention required in addition to the user experience:

- PLTS 1 represents roadways where pedestrians of all ages and abilities would feel comfortable walking and require little attention to traffic.
- PLTS 2 represents slightly less comfortable roadways that require more attention to traffic and are suitable for children over 10, teens and adults.
- PLTS 3 represents moderately uncomfortable roadways, where most able-bodied adults would feel uncomfortable but safe.
- PLTS 4 represents high traffic stress and would be used only by able-bodied adults with limited route choices.

The results of the PLTS analysis helps identify existing areas that are low-stress for pedestrians, and identifies the degree to which roadways must be improved in order to provide a comfortable experience for pedestrians of all ages and abilities. Additionally, scenario testing can be used to determine how a roadway or route's level of stress may change with improvements. The analysis is intended for use in urban areas specifically; while it can be used in rural conditions where pedestrian facilities exist, the methodology will yield a high PLTS score (greatest discomfort) where higher speed traffic is present.

[33] Oregon Department of Transportation, Transportation Development Division Planning Section: Transportation Planning Analysis Unit. 2020. Analysis Procedures Manual Version 2. https://www.oregon.gov/odot/Planning/Pages/APM.aspx

Methodology

PLTS analysis is completed through an assessment of street segments using spatial data and aerial imagery. Each segment of the roadway is evaluated based on its characteristics; if multiple scores are present within a segment the highest (most stressful) score is used as the overall segment score.

PLTS considers elements of the pedestrian environment both individually (e.g., buffer type), and in combinations that are known to influence each other (e.g., sidewalk width and pavement quality). The analysis uses the following overall guiding principles:

- The presence of a complete sidewalk serves as the foundation of the pedestrian network.
- As the sidewalk width increases and sidewalk condition improves, the level of stress of the pedestrian environment decreases.
- Buffering width is the total distance between the sidewalk and motor vehicle travel lanes. As width increases, the amount of separation between pedestrians and motor vehicles increases, and the pedestrian environment becomes less stressful.
- Buffer type describes the quality of the buffer that separates the sidewalk from the travel lanes. The presence of a buffer itself provides both actual and perceived safety benefits for the pedestrian, thus decreasing the stress of the pedestrian environment. A buffer with vertical elements is especially effective at increasing the safety of the pedestrian. Landscaping serves to enhance the pedestrian's travel experience.

Scores for each element of the pedestrian environment are assigned to each segment of the sidewalk centerline, and the worst (highest scoring) of the elements is used. If two sidewalks are present on a street, the worst (highest scoring) result is mapped to the centerline.

Figure 1 illustrates the overall PLTS scoring process. Notes on data inputs and assumptions are found in Table 1. Segment scores are assigned as shown in Table 2 through Table 5.

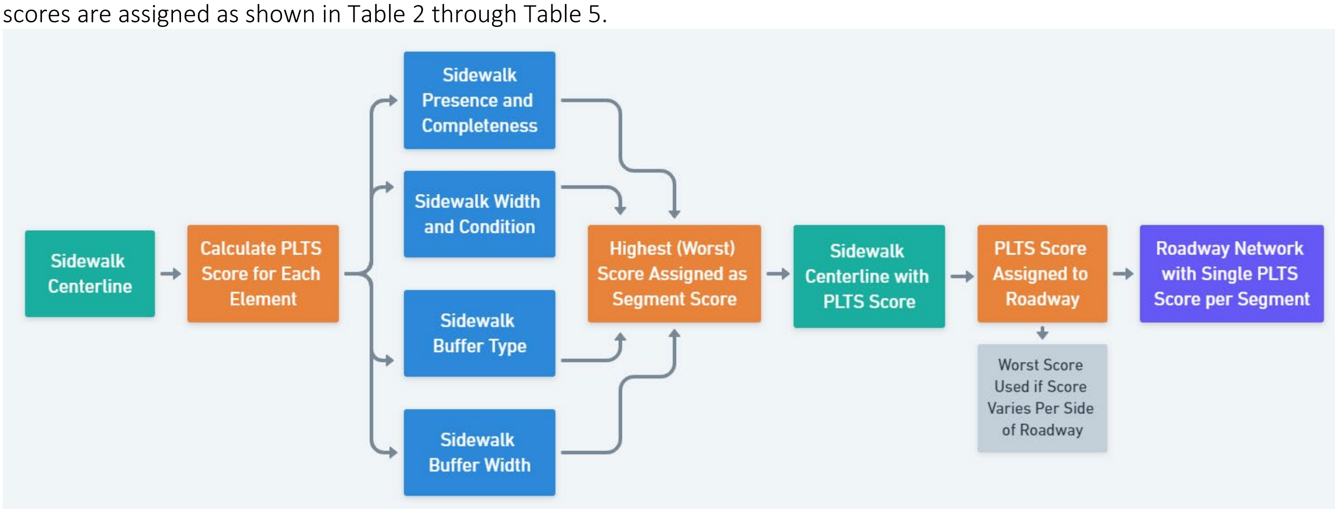

Figure 1. The PLTS scoring process

Table 8. Data Inputs and Assumptions

Pedestrian Element	Rationale	Data Inputs
Sidewalk Presence and Completeness (Table 2)	The presence and completeness of sidewalk facilities is the baseline for measurement. At a minimum, sidewalks should be present and complete on most roadways to facilitate pedestrian travel.	For municipal roads sidewalk presence was based on OSM data. For county roads, Ecopia sidewalk data was used, after going through an intensive manual review within the study area.
Sidewalk Width and Condition (Table 3)	The width of the sidewalk can have an impact on the associated comfort level. Wider sidewalks provide greater comfort, especially on higher speed roadways. The condition of the sidewalk is primarily based on concrete quality.	For municipal roads sidewalk presence was based on OSM data. For county roads, Ecopia sidewalk data was used, after going through an intensive manual review within the study area.
Sidewalk Buffer Type (Table 4)	The buffer type changes the pedestrian experience as it can offer a range of perceived and actual levels of protection. Higher speed roadways are considered to be less comfortable, and a more substantial buffer increases pedestrian comfort.	Based on OSM data and supplemented by manual review within the study area.
Sidewalk Buffer Width (Table 5)	Total buffering width is the summation of the width of buffer, width of parking, width of shoulder, width of curb & gutter, and width of the bike lane on the same side of the roadway as the pedestrian facility being evaluated.	Based on OSM data and supplemented by manual review within the study area.

Tables 9 through 12 specify the scoring criteria based on sidewalk presence, sidewalk width and condition, buffer type, and buffer width, in relation to the existing roadway condition (factors such as speed and number of lanes). The criteria are adapted from the ODOT Analysis Procedures Manual. These tables are used in combination to assign an overall PLTS score; if multiple scores are present within a segment the highest (most stressful) score is used as the overall segment score.

Table 9. PLTS Based on Sidewalk Presence and Completeness

Number of Travel Lanes	Posted or prevailing speed				
	<= 25 mph		*30 – 35 mph*		*>= 40 mph*
	2 lanes	*> 2 lanes*	*2 lanes*	*> 2 lanes*	*2 lanes*
Complete sidewalk on both sides[1]	LTS 1	LTS 2	LTS 2	LTS 3	LTS 3
Complete sidewalk on one side	LTS 2	LTS 3	LTS 3	LTS 4	LTS 4
No sidewalk	LTS 2[2]	LTS 4	LTS 4	LTS 4	LTS 4

1. Partial sidewalk coverage on a block is not considered complete.
2. Residential (OSM Highway class local) roadways without sidewalk default to LTS 2; roadways without sidewalk default to LTS 4.

Table 10. PLTS Based on Sidewalk Width and Condition

Actual / Effective Sidewalk Width (ft)[12]		Sidewalk Condition[3]			
		Good	*Fair*	*Poor*	*Very Poor*
Actual/Effective Width (ft)	<4	LTS 4	LTS 4	LTS 4	LTS 4
	≥4 to <5	LTS 3	LTS 3	LTS 3	LTS 4
	≥5	LTS 1	LTS 2	LTS 3	LTS 4
	≥6	LTS 1	LTS 1	LTS 2	LTS 3

1. Effective width is the available/useable area for the pedestrian clear of obstructions. Effective width does not include areas occupied by storefronts or curbside features.
2. For analysis purposes, a standard width of 5 feet was assumed for all sidewalks.
3. Sidewalk conditions is assumed to be 'Good' unless other information is available.

Table 11. PLTS based on Physical Buffer Type

Buffer Type[1]	Prevailing or Posted Speed			
	≤25 MPH	*30 MPH*	*35 MPH*	*≥40 MPH*
No Buffer (curb tight)	LTS 2[2]	LTS 3	LTS 3	LTS 4
Solid surface	LTS 2[2]	LTS 2	LTS 2	LTS 2
Landscaped	LTS 1	LTS 2	LTS 2	LTS 2
Landscaped with trees	LTS 1	LTS 1	LTS 1	LTS 2
Vertical	LTS 1	LTS 1	LTS 1	LTS 2

1. Combined buffer: If two or more of the buffer conditions apply, use the most appropriate (typically the lower stress type).
2. If no centerline is present (residential street) or the street is traffic calmed (including sporadic vertical separation such as street furniture, street trees, lighting, planters, surface change, etc.) then the PLTS can be lowered by 1 PLTS level.

Table 12. PLTS Based on Physical Buffer Width. Source: Based on ODOT Analysis Procedures Manual, Table 14-23.

Total Number of Travel Lanes (both directions)[2]	Total Buffering Width (ft)[1]				
	<5	*≥5 to <10*	*≥10 to <15*	*≥15 to <25*	*≥25*
<=2	LTS 2[3]	LTS 2	LTS 1	LTS 1	LTS 1
3	LTS 3[3]	LTS 2	LTS 2	LTS 1	LTS 1
4-5	LTS 4[4]	LTS 3	LTS 2	LTS 1	LTS 1
6>=	LTS 4[4]	LTS 4[4]	LTS 3	LTS 2	LTS 2

1. Total Buffering Width is the summation of the width of buffer, width of parking, width of shoulder, width of curb & gutter, and width of the bike lane on the side same side of the roadway as the pedestrian facility being evaluated.
2. One-way facilities are assumed to have their lanes multiplied by 2 to represent exposure to lane crossing.
3. If no centerline is present (residential street) or the street is traffic calmed (including sporadic vertical separation such as street furniture, street trees, lighting, planters, surface change, etc.) then the PLTS can be lowered by 1 PLTS level.
4. Sections with a substantial physical barrier/tall railing between the travel lanes and the walkway (like might be found on a bridge) can be lowered to PLTS 3.

D. Active Travel Analysis

In addition to evaluating active trips, Alta generated an analysis of modeled walking and bike trips from MTC's Travel Demand model. These trips were summarized to their origin TAZs (represents trip starts). These estimates of walking & biking trips make up a smaller subset of all trips represented in MTC's travel demand model, but provides a rough understanding of where we might expect more active travel to occur such as at compact, mixed-use areas that have good bicycle & pedestrian connectivity.

Segment Level Demand Index

Alta's demand analysis utilizes data inputs from the MTC travel demand model to summarize active trip potential and active trips that align with major roads and select county facilities across Santa Clara County. The analysis will assess the alignment and magnitudes of short trip flows and active travel flows between zones and then associate those flows to network facilities. The approach is visually communicated in the example presented in Figure 1 below.

The project team estimated the approximate volume of bicycle-length trips currently made by bicycle (*Existing Bicycle Demand*) and short trips made by single occupancy vehicles (SOV) or high occupancy vehicles (HOV) (*Active Trip Potential*) for each study segment based on Origin-Destination (OD) flows from the MTC travel demand model. Flows between OD pairs were attached to HPMS segments using the following procedure:

1. Draw straight lines, which we call OD lines, between the centroids of MTC traffic analysis zones (TAZs). The OD lines represent the trajectory of demand between each pair of zones, similar to "desire lines" that might be mapped in a site plan.
2. Attach counts of trips made by walking and biking and active-length trips made by SOV and HOV modes to the OD lines, providing an estimate of trip volumes along these trajectories.
3. Attach trip volumes from the OD lines to study segments based on two factors: their proximity and angular similarity.
4. Proximity – ODs line were associated to facilities if they were generally within one-mile of the facility. Association via proximity had a distance decay function developed that associated more trips to a segment if the flow was generally more proximal. The weights for proximity were assigned as follows:

0 to .5 miles away from facility	1.0
.5 to 1 miles away from the facility	0.5

5. Angular Similarity- OD lines had conditional weights assigned to them based on their angular similarity. This enabled the analysis to incorporate more OD flow lines into each segment evaluation than a purely binary metric with a strict angle threshold. The assigned weights were used to determine the number of trips to associate with any particular facility. The weights for angular similarity were assigned as follows:

0 – 10 Degrees Relative Angle Difference	1.0
10 – 20 Degrees Relative Angle Difference	0.9
20 – 25 Degrees Relative Angle Difference	0.6
25 – 30 Degrees Relative Angle Difference	0.2
30 – 45 Degrees Relative Angle Difference	0.1
More than 45 Degrees Relative Angle Difference	0

6. Active Trip Potential trips by all modes were evaluated so that the cyclable distances were weighted on a continuous basis. This weighting was informed by the project team's review of trip distances for biking trips seen in MTC's Travel Demand Model. The assigned weights were used to determine the number of trips to associate with any particular facility. These weights were used in combination with angular similarity weights, thus if an angularity similarity weight was 0.5 and a suitable distance weight was 0.5, the number of trips associated to the segment from that OD line was 25% of its total. The weights for bicycle-length trips were assigned as follows:

0 – 3 Mile Trips	1
3 – 6 Mile Trips	0.3
6 – 10 Mile Trips	0.1
More than 10 Mile Trips	0

7. Calculate percentile rankings for trips by all modes and by bicycle and converted those into ratings of 0 to 10 for Active Trip Potential and Existing Active Demand, respectively. Because tabulated trip volumes were uncalibrated approximations, it is best to interpret them through a ranked index rather than as precise volumes.
8. A Demand Index is created by blending the Active Trip Potential with the Existing Active Demand identified in MTCs travel demand model. They are combined with each getting equal (50%) weight in a weighted sum.