FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Final Report

December 2015

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1 INTRODUCTION

The Fairfax-San Anselmo-San Rafael corridor is one of the most important transportation corridors in Marin County, connecting San Rafael's Canal area and downtown San Rafael to the Miracle Mile, San Anselmo Hub, and downtown Fairfax. Its main streets are major arterials and pedestrian-friendly shopping districts; it includes a major bicycle route; and it includes both the County's busiest transit node, the San Rafael Transit Center (and future Sonoma Marin Area Rail Transit, or SMART, station), as well as the busy stop at the San Anselmo Hub. Tens of thousands of people per day travel within the corridor on a variety of different transportation modes. The corridor is also home to tens of thousands of people who live and work in a built environment shaped over time, first by urban rail service and then by the automobile.

Figure 1-1 Corridor Overview

Reflecting its continuing importance for transit, the corridor is one of the busiest bus corridors in the county. A mix of peak-only, local, and regional services combine to create a high level of service—peak combined frequencies between San Anselmo Hub and Butterfield Road are every four to five minutes average. Yet just two routes, Marin Transit Routes 23 and 68, connect the corridor from Downtown San Rafael to Manor; only one, Route 23, extends the entire length of the study corridor, from Target in east San Rafael to Manor, west of Fairfax.

The corridor features a diversity of land uses, as well as several different roadway, pedestrian, and bicycle network configurations from east to west. The Canal, at its eastern end, is a dense, diverse neighborhood with disperse commercial and community uses. The rest of the corridor is bookended by the historic town centers of Downtown San Rafael and Fairfax, the former featuring the largest transit node in the county, and in its center is the major crossroads of San Anselmo Hub. Between are segments posing unique challenges – and opportunities – for implementing effective transit service: the unique design of the Miracle Mile poses difficulties for a "complete corridor" with parallel streets prioritized for different modes, while side streets adjacent to Center Boulevard, with its history rooted in rail transit, offer an alternative for people who choose to bike. Between the Miracle Mile and Center Boulevard is the San Anselmo Hub crossroads, a major congestion point, and Downtown Fairfax at the west end of the corridor is another historic town center.

PROJECT PROCESS & DIRECTIVES

The Transportation Authority of Marin (TAM) initiated the Fairfax-San Rafael Corridor Transit Feasibility Study in order to better understand options for higher-quality transit service in this important corridor.

While this study may be a precursor to a more complex federally funded Small Starts process, it is a feasibility study rather than a full "Alternatives Analysis"[1]. The goal of this study is to provide clear and accurate technical information that can be used to inform and support a more detailed analysis if TAM or its member agencies decide to move forward with a transit project on the corridor. In short, this study and its deliverables are designed to give Marin policymakers a solid foundation on which to determine the most appropriate investment strategy for this critical corridor.

This report is the result of a group effort and careful consideration. Throughout the process, the project Technical Advisory Committee (formed of policymakers, planners, and transit agency representatives) provided critical input to the process, guiding the development of and coming to consensus on the two feasible alternatives.

GOALS OF THIS PROJECT

At its outset, the Fairfax-San Rafael Corridor Transit Feasibility Study was shaped by the goals outlined by the TAC in its original scope of services. They were:

- Identify connections to and from new SMART Rail service
- Identify connections to other regional transit services
- Improve mobility for all modes in the Corridor
- Reduce local congestion in the Corridor
- Achieve mode shift to transit in the Corridor/attract auto-dependent and choice riders
- Improve peak travel times for transit in the Corridor

[1] Furthermore, it should be noted that the feasible alternatives described in this report were not developed within the context of an FTA project development process or formal Alternatives Analysis.

Subsequently, at the project kick-off in late 2014, the TAC developed and confirmed the following project vision and goals, building on the original set of project goals to provide the foundation of this planning effort, offering a means of evaluating and refining the draft alternatives:

Vision Statement

Improve the quality of life for residents, employees and visitors throughout the corridor through the implementation of a transit investment that will incentivize transit mode shift, maximize mobility for all modes, provide seamless connectivity with SMART and other transit modes and support local communities in their goals for complete streets and sustainability.

Project Goals

1. Maximize transit ridership
2. Connect the Sonoma-Marin Area Rail Transit (SMART) station and San Rafael (Bettini) Transit Center with residential and employment opportunities throughout the corridor
3. Reduce greenhouse gas emissions
4. Reduce transit travel times in the corridor
5. Enhance transit reliability in the corridor
6. Maintain or improve conditions for all other modes and goods movement

What this Report Contains

The Final Report is built on the foundation of several detailed Technical Memoranda, developed with the assistance of the TAC and the Transportation Authority of Marin. In essence, it provides a step-by-step summary of the planning process, which included the following steps:

- **Existing Conditions Analysis.** This step included preparing detailed analyses of the historical context of the area, current land uses and development plans in corridor municipalities, density and demographics, multimodal (i.e., roadway, pedestrian, and bicycle) networks, and existing transit services. The resulting report, the Existing Conditions Briefing Book, also included a summary of opportunities and constraints gleaned from on-the-ground conditions that the project team used to inform preliminary development of transit service alternatives.
- **Peer Review.** The project team provided case studies of bus and streetcar systems throughout the United States, many of which from development and land use contexts similar to the study corridor. This review provided a context in which to understand how corridor transit projects may be implemented.
- **Travel Market Analysis.** As a precursor to the development of draft transit alternatives, the project team developed an analysis of where transit service would be most likely to succeed in the study corridor, in particular evaluating the origins and destinations of existing transit riders to determine where demand is the highest.
- **Initial Alternatives Summary.** The purpose of this memorandum was to summarize the range of viable alignment options within the study corridor. From this range of options, the TAC built two Feasible Alternatives – the “low investment” alternative, which

would most likely be bus technology, and the "high investment" alternative, which would most likely be streetcar technology.

- **Ridership Analysis.** With a better understanding of the two alternative alignments, along with assumptions of vehicle technology, service frequency, and other amenities, the project team developed a thorough analysis of expected ridership for each alternative.
- **Multimodal Analysis.** To understand how the feasible alternatives would impact other study corridor users (such as pedestrians, bicyclists, and motorists), the project team developed conceptual alignment drawings for potential bus route (low investment) and streetcar track (high investment) transitions (i.e., challenging locations along the alignments) as well as examples of standard operations.
- **Streetcar Technology Analysis.** Project team member AECOM, a known expert in streetcar implementation projects nationwide, contributed a white paper assessing the options and risks of streetcar vehicle and power generation technologies currently available on the market.

The Final Report is the culminating deliverable in this process, incorporating information from all of the previous project stages. It also contains a new section focused on **Implementation & Funding**, in an effort to give policy makers all of the relevant information needed to guide decision-making moving forward.

Appendices

All of the Technical Memoranda prepared for this project are included as appendices attached to this report. They include:

- Appendix A: Existing Conditions Briefing Book
- Appendix B: Summary of Case Studies
- Appendix C: Travel Market Assessment
- Appendix D: Initial Alternatives Summary
- Appendix E: Ridership Analysis
- Appendix F: Transitions and Multimodal Analysis
- Appendix G: Streetcar Technology White Paper

2 EXISTING CONDITIONS

This chapter includes summaries of the analysis of existing transportation, land use, demographic and other relevant conditions in the corridor conducted at the onset of this study, as well as case studies of peer systems.

The Fairfax-San Anselmo-San Rafael corridor is one of the most important transportation corridors in Marin County, connecting San Rafael's Canal area and downtown San Rafael to the Miracle Mile, San Anselmo Hub, and downtown Fairfax. Its main streets are major arterials and pedestrian-friendly shopping districts; it includes a major bicycle route; and it includes both the County's busiest transit node, the San Rafael Transit Center (and future Sonoma Marin Area Rail Transit station), as well as the busy stop at the San Anselmo Hub. Tens of thousands of people per day travel within the corridor on a variety of different transportation modes. It is also home to tens of thousands of people who live and work in a built environment shaped over time by rail service and then by the automobile.

From east to west, the corridor consists of five core segments:

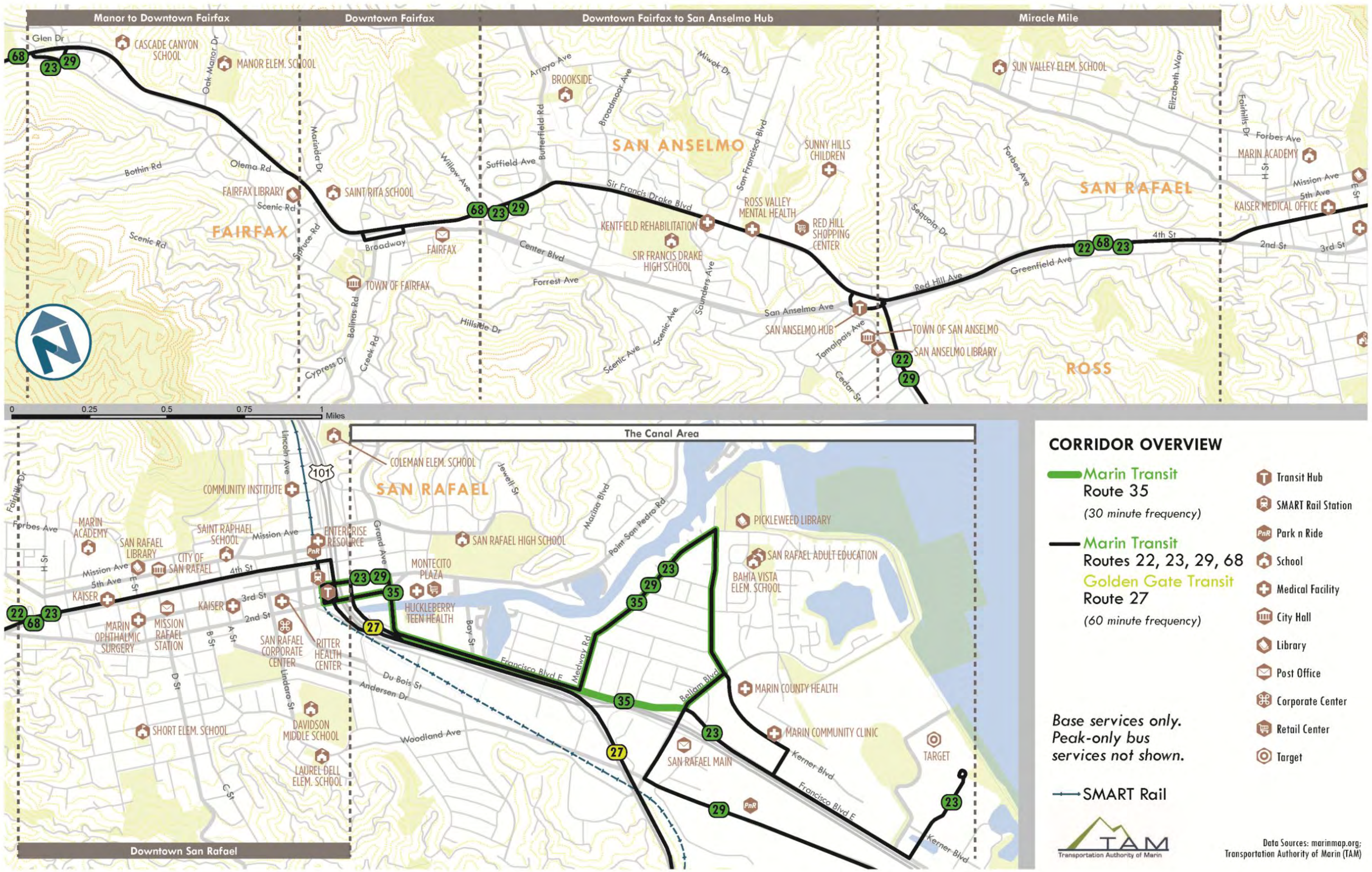
- *Downtown San Rafael*, where the pedestrian- and retail-oriented Fourth Street parallels Second and Third Streets.
- *The Miracle Mile*, where a landscaped boulevard, alternately known as Second Street, Fourth Street and Red Hill Avenue, has segments of parallel streets along its south side.
- *San Anselmo Hub to Downtown Fairfax*, where the arterial Sir Francis Drake is roughly paralleled by another neighborhood serving street, Center Boulevard.
- *Downtown Fairfax*, where Sir Francis Drake becomes a two-lane street and Center Boulevard becomes Broadway Boulevard and runs just south of Sir Francis Drake.
- *Downtown Fairfax to Manor*, where Sir Francis Drake features bike lanes and two-way left-turn lanes and begins its transition to a rural highway.

An associated corridor segment is *the Canal area of San Rafael*. This segment is a major generator of transit trip origins, as it contains a mix of land uses and densities, including a high concentration of multifamily housing units that are home to a diverse population.

See Figure 2-1 for a detailed overview of the study corridor, which identifies these segments and highlights key landmarks. It also illustrates the study area's natural topography, which profoundly affects mobility, land use, and development within the corridor.[2]

[2] Note: Given that a major component of this study is improving transit service within the corridor, unless otherwise noted, all maps in this chapter include an illustration of weekday base (i.e., off-peak, or midday) transit service and frequency.

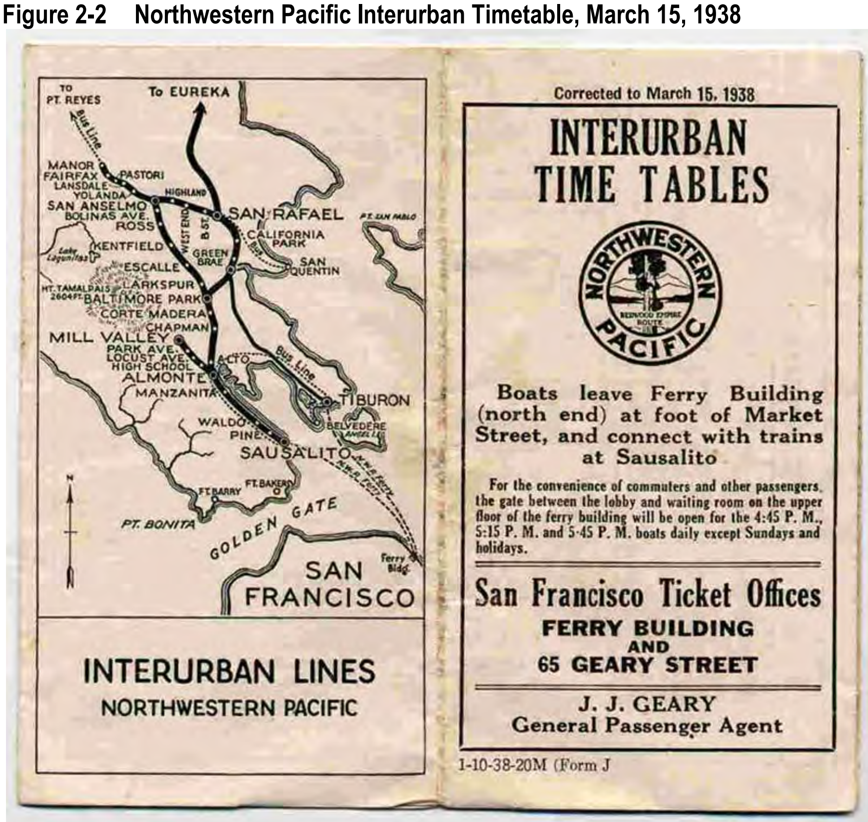
Figure 2-1 Fairfax-San Rafael Corridor: Key Segments and Landmarks



HISTORICAL TRANSPORTATION CONTEXT

The Fairfax-San Rafael corridor, from Manor to Downtown San Rafael, was built by railroads. Beginning in 1875, the North Pacific Coast, and later the electrified Northwestern Pacific Railroad, operated trains from Manor (then an unincorporated community, now part of Fairfax) to Downtown San Rafael and on to Sausalito, where connections could be made to ferries (Figure 2-2). Much like today's bus routes, train service was also available from Fairfax to Sausalito via Larkspur. Also much like today, full corridor service from Manor to San Rafael in 1938 was neither as frequent nor as consistent as services operating in the Manor to San Anselmo or the San Anselmo to San Rafael corridor segments.

Figure 2-2 Northwestern Pacific Interurban Timetable, March 15, 1938



Source: Medocino Coast Model Railroad & Historical Society

EXISTING LAND USES

Encompassing three pedestrian-oriented neighborhood/city centers, as well as automobile-oriented connecting areas in between these centers, the corridor features a wide range of land uses ranging from high- and medium-density, mixed-use (e.g., in Fairfax, San Anselmo, and San Rafael) to low-density commercial and light industrial (e.g., in the Canal area and along Francisco Boulevard East). Unique arrangements abound, largely the result of piecemeal, auto-oriented development after rail service ceased: the Miracle Mile is mostly lined by retail, but a long stretch fronts onto back yards; and while a mixture of shops and homes alternate along Sir Francis Drake Boulevard, adjacent neighborhoods consist of single-family homes on narrow streets.

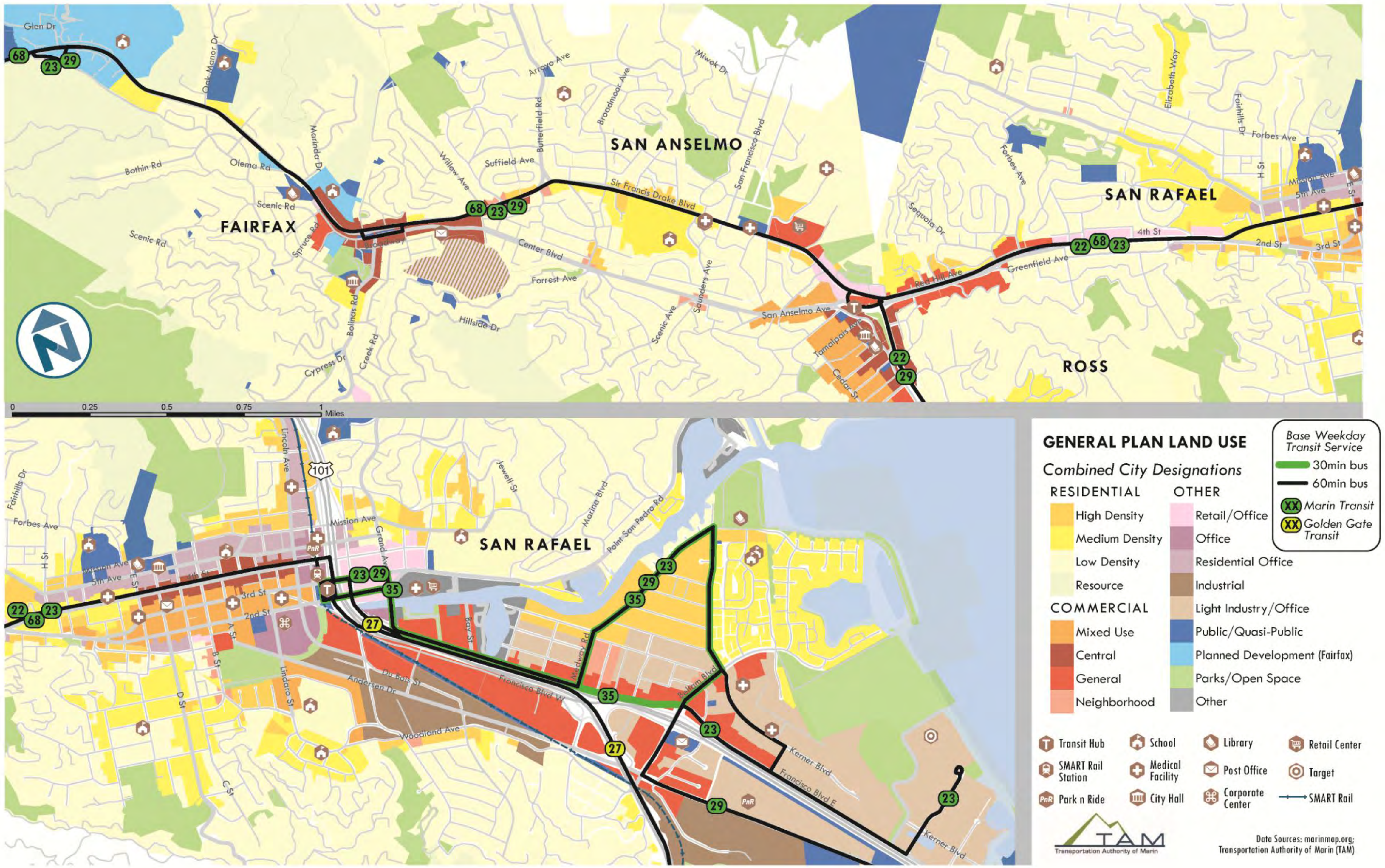
The area's natural topography is also a major influence on development patterns (and non-vehicular mobility) in the corridor, with steep hills rising up from the floor of Ross Valley often no more than a quarter-mile from major corridor streets. From Manor to San Rafael, and particularly along the Miracle Mile, a sizable amount of the area's residential development – composed primarily of single-family homes – is situated in these hilly areas. By contrast, the natural landscape in San Rafael and the Canal area is comprised of lowlands adjacent to current and former tidal flats, which allows for a greater diversity of land uses.

The current land use map (Figure 2-3) is sourced from each community's latest General Plan. It should be noted that while most of the land use designations are interchangeable, each community's definition of Residential density varies and these designations have been consolidated to facilitate the creation of a corridor-wide map.[3]

[3] Please refer to the table below for a concordance of residential density by community.

Residential Density Category	San Rafael	San Anselmo	Fairfax	Ross
High	15-32 units/acre	13-20	-	-
Medium	6.5-15	6-12	7-12	6-10
Low	2-6.5	1-6	1-6	1-3; 3-6
"Resource" (Very Low/Hillside)	0.5-2	1 or less	0.25	0.1-1

Figure 2-3 Existing General Plan Land Uses in the Corridor



POPULATION DENSITY, FUTURE DEVELOPMENT & DEMOGRAPHICS

Population & Employment Density

Population and employment density in the corridor follow expected patterns. There are higher levels of combined population and employment density in the historic neighborhood centers of Fairfax, San Anselmo, and particularly San Rafael. Transit serves these areas at a minimum of hourly headways during weekday midday periods, and also generally serves most areas with at least a medium level of population or employment density. More frequent service is available during peak commute times, including service to San Francisco.

Still, there are a few pockets of medium density housing or employment areas that are located beyond one-quarter mile of transit service. These include a pocket of medium population density on Woodland Avenue south of downtown San Rafael, and a small pocket of employment density located along Center Boulevard at the former interurban stop Yolanda Station (near the intersection of Center Boulevard and Saunders Avenue).

Figure 2-4 illustrates current population and employment density in the corridor, along with locations of proposed developments in the corridor (briefly described below).

Planned Development

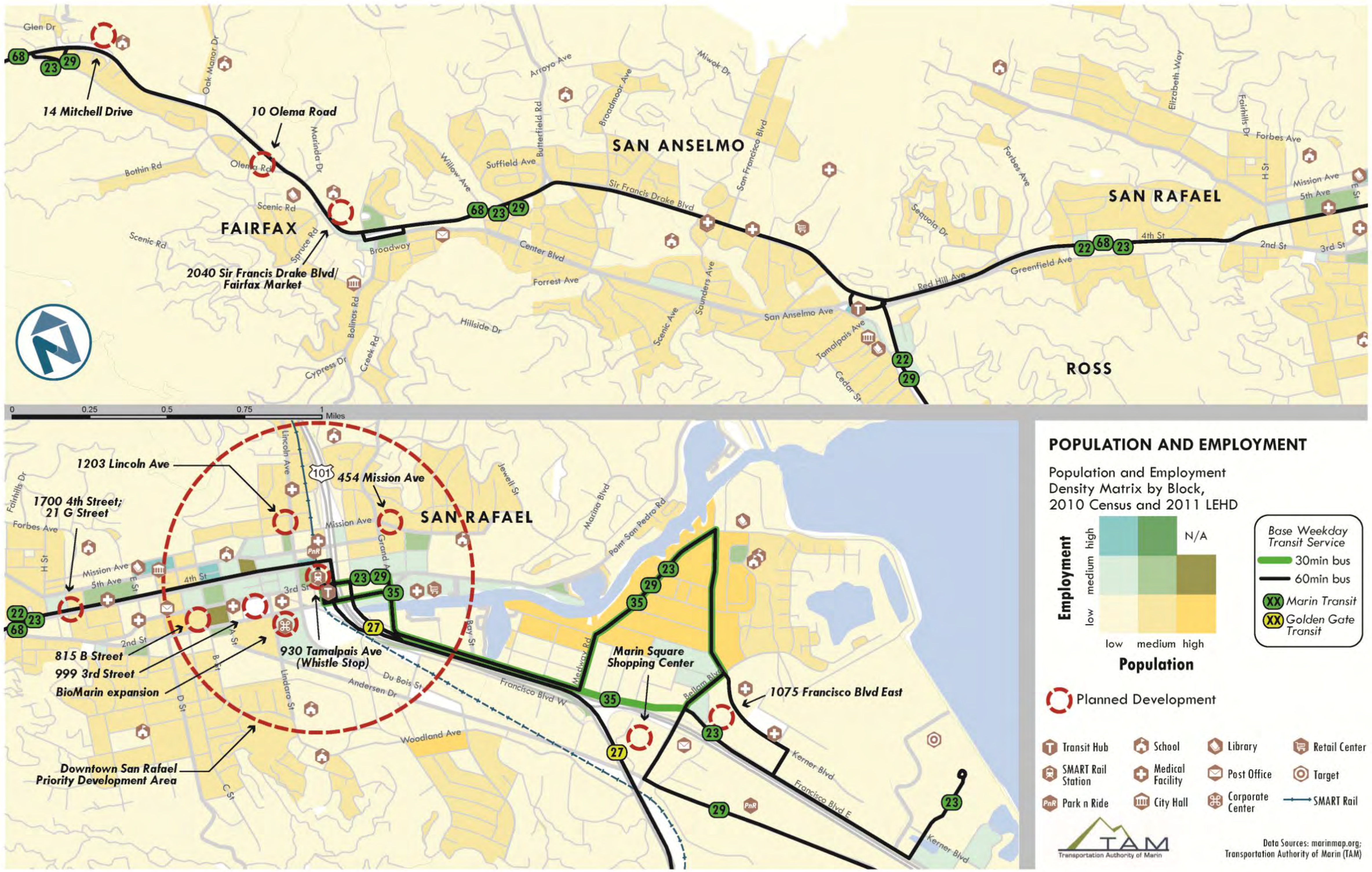
While future population and employment projections are not as geographically precise as current data, the Town of Fairfax and the City of San Rafael are each planning for several residential developments within the scope of the corridor that may increase demand for transit service in the short- to mid-term future. Future residential developments in the corridor include:

- Fairfax
  - 40 units of senior housing
  - 20 units of "work-force" housing (tentative)
  - 8 units of general public residential housing
  - 6,000 SF of commercial space
- San Rafael
  - 104 units of general public housing
  - 50 units of senior housing[4]
  - 80,000 SF of office space

In the longer-term future, there may be additional developments in San Rafael around the SMART station. The 2012 San Rafael Station Area Plan identified a total of five development opportunity sites around the vicinity of the future San Rafael station.

[4] These represent total amounts, and omit three pipeline projects in San Rafael that have an unknown number of units, uses, or square footage. For a full account of all planned developments along the corridor, please refer to Figure 2-6 in the Existing Conditions Briefing Book, provided as an appendix to this report.

Figure 2-4 Current Population and Employment Density in the Corridor, with Planned Developments



Demographics

The corridor is home to a variety of people, including people in all stages of life and people who earn a range of incomes. Generally, more low income residents (defined as monthly wages of approximately $1,250 a month or less, or at most $15,000 a year) live in the Downtown San Rafael segment, while the Miracle Mile houses more seniors age 65 and older than other segments of the corridor. The highest percentage of youth under the age of 18 lives in the Downtown Fairfax to San Anselmo Hub segment. The adjacent Canal area is also home to relatively high portions of youth and low-income residents as well.

MULTIMODAL TRANSPORTATION

The Fairfax to San Rafael corridor is a true multi-modal corridor, serving automobiles, trucks, buses, bicycles, and pedestrians. Historic rail right of way, linking the downtowns in the corridor now serve as the primary East-West route from San Rafael to Fairfax, including portions of Red Hill Avenue and 2nd Street (San Rafael), the Miracle Mile (San Anselmo), and Center Boulevard, and Sir Francis Drake Boulevard through Fairfax. Every day, thousands of people drive, walk, or cycle on these historic connections, legacies of the railroads that helped build corridor communities.

This section explores current and future automobile, bicycle, and pedestrian facilities in the corridor.

Overall Travel Patterns

The study corridor is the primary means of east-west travel across Marin County, connecting the communities of Fairfax, San Anselmo, and San Rafael with regional destinations via Highway 101 and Interstate 580. The corridor's commercial centers and schools generate traffic within the corridor and from surrounding communities. Not surprisingly, a great deal of traffic in the corridor is tied to work commutes, with traffic generally moving eastward toward employment centers in the morning and returning westward in the evening.

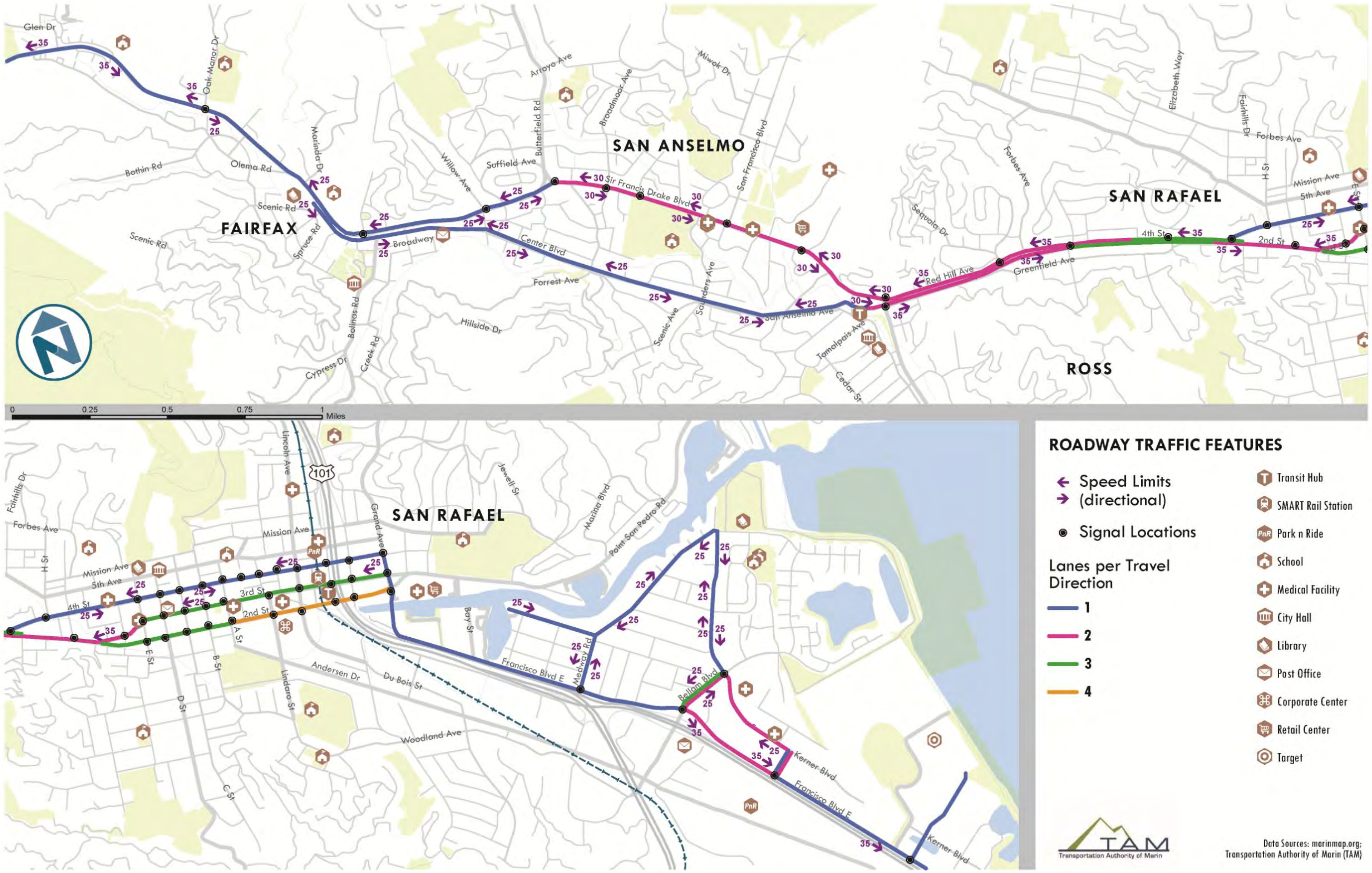
In addition to transit riders, the corridor accommodates people who walk, bike, and drive.

Demand is also strong within the corridor, with Sir Francis Drake High School, located on Sir Francis Drake Boulevard in San Anselmo, accounting for a significant portion of school morning and afternoon peak traffic along both Sir Francis Drake Boulevard and Center Boulevard. Roadways within the adjacent Canal area accommodate two different types of users: in this area, roadways are increasingly oriented toward highways with Francisco Boulevard West, the primary connector between San Rafael, the Canal area, and Shoreline Parkway, serving as a frontage road along Highway 101 and then I-580. In addition to serving as significant collector roads for people traveling to and from Highways 101 and 580, these roadways also have a very high bicycling and walking mode share, owing in part to the lower socio-economic demographic living in the Canal area. Finally, downtown Fairfax is both a starting and destination point for recreational bicyclists.

Roadways & Automobile Facilities

Figure 2-5 provides a graphical overview of automobile facilities on all primary corridor roadways, including number of travel lanes in each direction, speed limits, and traffic signal locations.

Figure 2-5 Automobile Facilities in the Study Corridor



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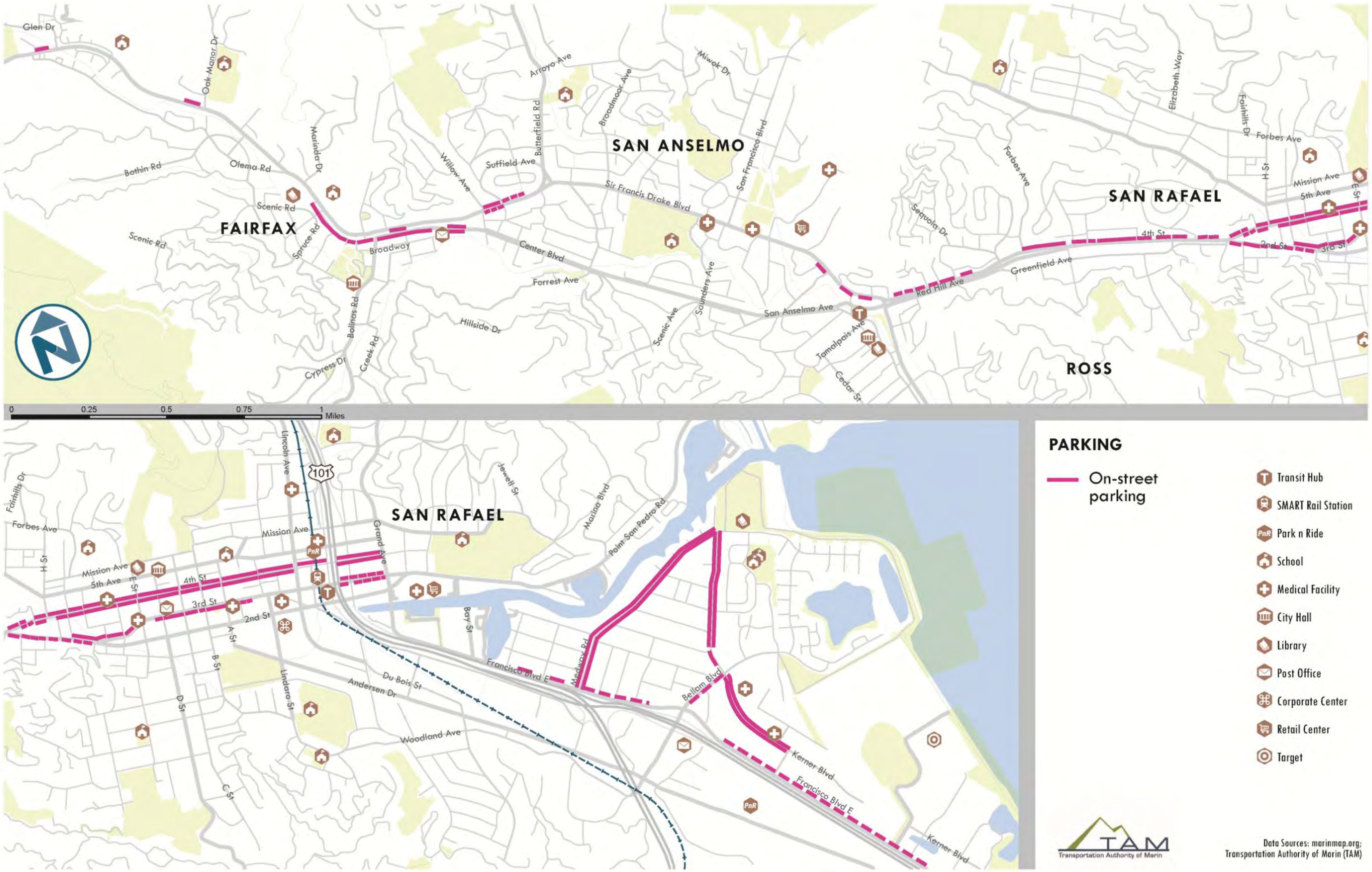
On-Street Parking

Generally, on-street parking is readily available in the traditional downtown areas of Fairfax and San Rafael. Elsewhere along the corridor between Manor and San Anselmo, on-street parking is relatively scarce. Moving into San Rafael, on-street parking is available on most portions of the north side of Miracle Mile, and in the Canal neighborhood, there is a significant amount of on-street parking on Kerner Boulevard, Canal Street, and Medway Road, as well as along Francisco Boulevard East.

See Figure 2-6 for a map showing the location of on-street parking facilities in the study corridor.

Figure 2-6 On-Street Parking in the Study Corridor



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Motor Vehicle Level of Service (LOS) and Average Daily Traffic (ADT)

Average daily traffic (ADT) measures the average number of vehicles using a designated portion of roadway in a 24-hour period. While ADT is a measure of demand, the level of service (LOS) is a common measure comparing demand to available capacity. LOS uses letters A through F, with A representing free flow traffic with no delays and F representing highly delayed, gridlocked conditions. Cities set their own goals for roadway performance. In general a level of service D or higher is considered acceptable in downtown areas and LOS C or higher is acceptable in higher density residential areas outside of downtowns.

LOS measurements show that most of the service area meets performance targets with the exception of the congested intersections, the most significant being at "the Hub" of Miracle Mile/Sir Francisco Drake Boulevard/Center Boulevard, which often experiences "E" and "F" levels during peak times.

Depending on whether it is a weekday (more cars) or weekend (relatively fewer cars), daily traffic levels along Sir Francis Drake Boulevard in San Anselmo range from approximately 25,000-28,000 cars per day. Along Center Boulevard, ADT ranges from approximately 9,000-11,000 cars. The Miracle Mile ranges from approximately 34,000-41,000 cars. Traffic within downtown San Rafael ranges quite a bit, generally increasing as it collects from 4th to 2nd Streets, and from F and G Streets (westernmost area of downtown San Rafael, connecting 4th, 3rd, and 2nd Streets) to Highway 101. See Figure 2-7.

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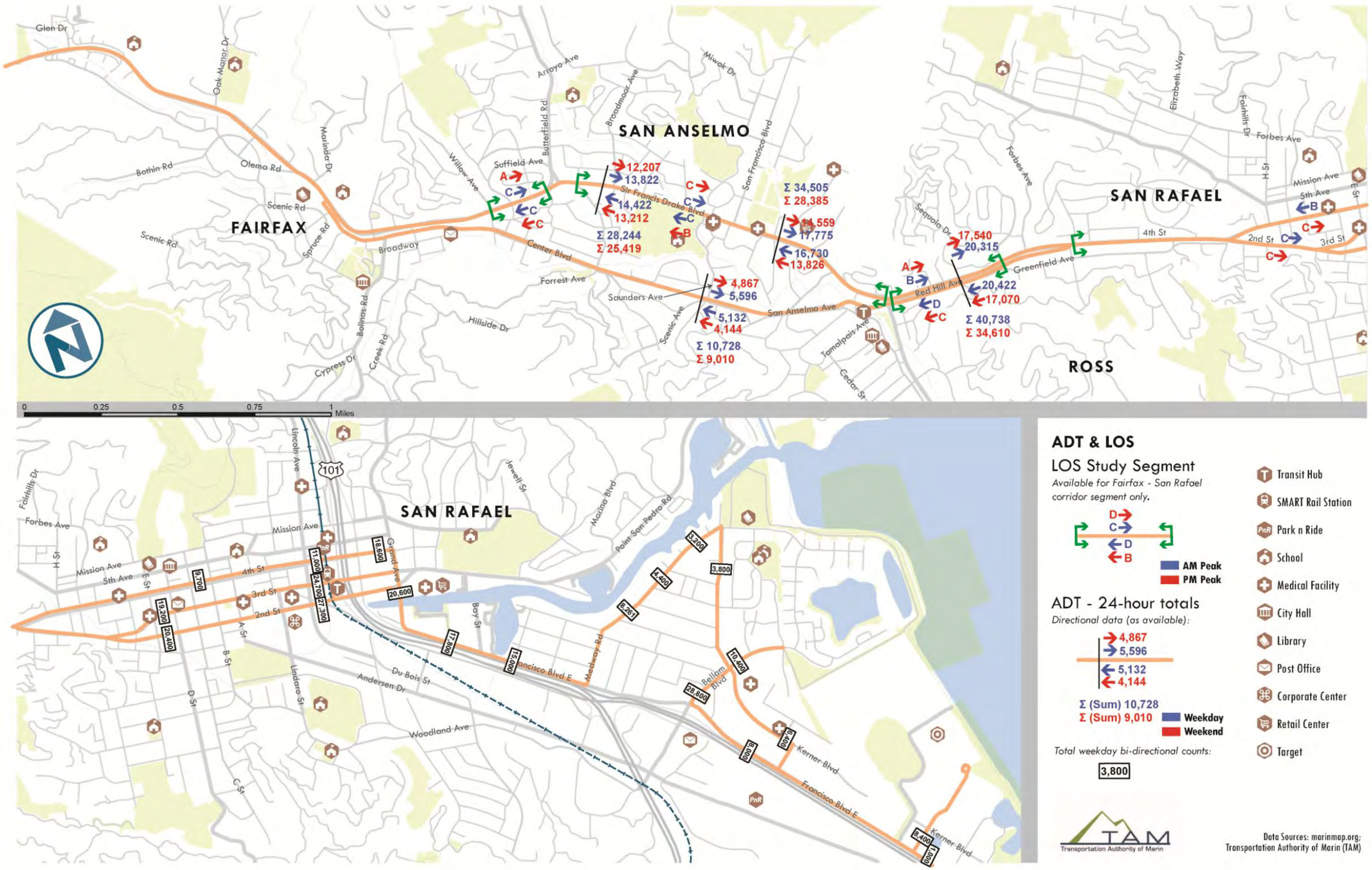
Figure 2-7 Motor Vehicle Average Daily Traffic Volumes and Level of Service (LOS) in the Corridor



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Existing Bicycle and Pedestrian Facilities

The Fairfax to San Rafael transportation corridor is frequently used by people who choose to bike and walk for work, shopping, and recreation purposes. A network of bicycle-specific facilities has been built to increase the safety and visibility of bicyclists.

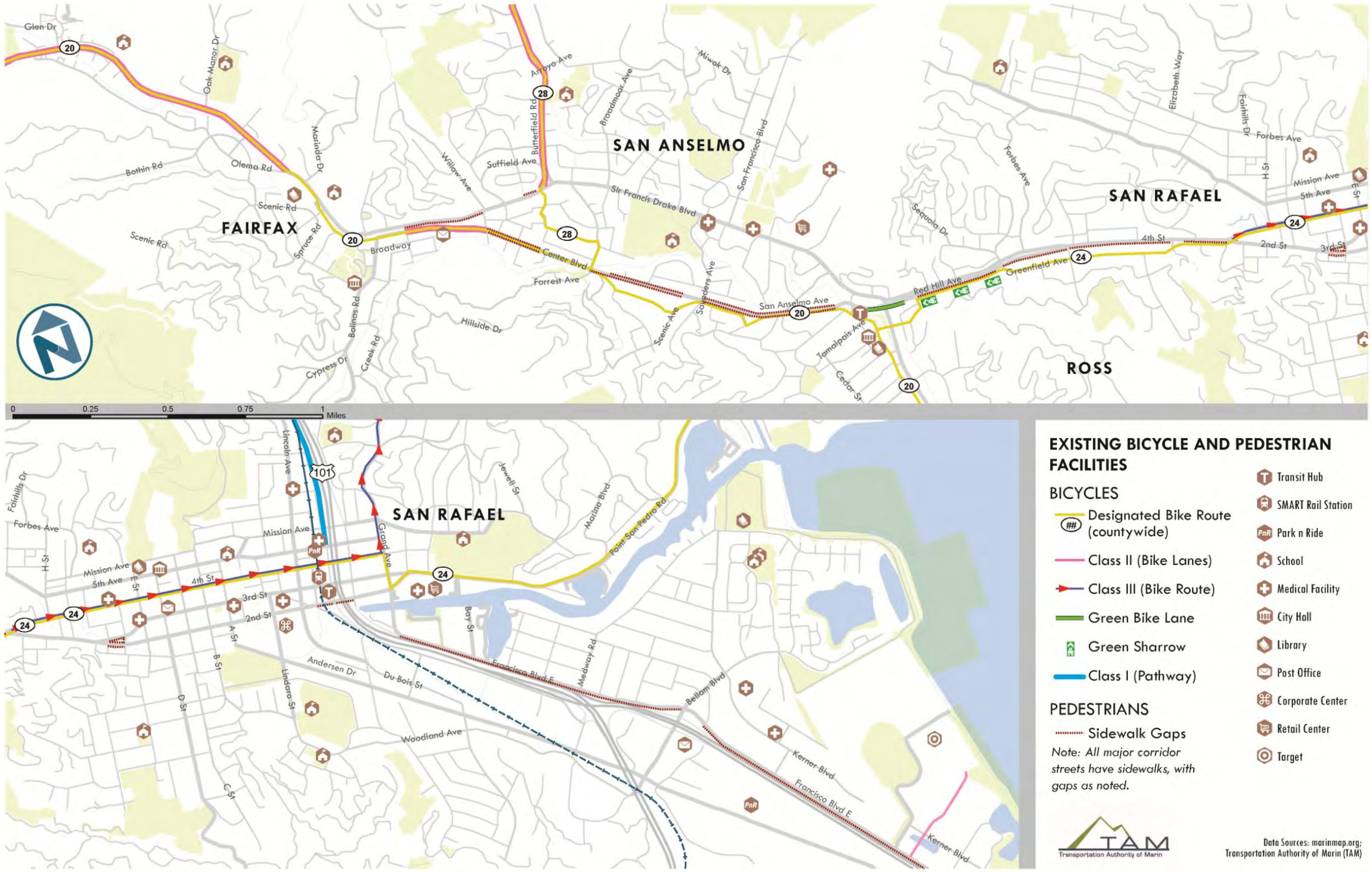
Marin County has a system of designated bicycle routes. These routes are denoted with a special sign and route number visible to both bicyclists and motorists. Four Marin County bicycle routes are situated along the study corridor, and are composed of a network of Class I (off-street or physically separated), Class II (bike lanes), and Class III (shared use) facilities can be found along the study corridor.

Bicycle facilities along Center Boulevard near Fairfax.

Likewise, a network of sidewalks generally permits pedestrians to walk the entire length of the study corridor, though there are a few locations that lack this infrastructure, most notably along Center Boulevard between Fairfax and San Anselmo and on the south side of E. Francisco Boulevard in the Canal area (adjacent to Highway 101).

Figure 2-8 illustrates both pedestrian and bicycle facilities as they currently exist in the study corridor.

Figure 2-8 Existing Bicycle and Pedestrian Facilities



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Proposed Bicycle and Pedestrian Facilities

The Bicycle and Pedestrian Master Plans for each of the three municipalities in this study corridor contain both an inventory of existing facilities as well as proposed improvements to the bicycle and pedestrian system. These master plans were consulted as a source for potential future improvements. The San Rafael Bicycle & Pedestrian Plan was updated and adopted relatively recently, in 2011; the San Anselmo and Fairfax 2008 Bicycle & Pedestrian Plans are slated to be updated in 2015-2016. See Figure 2-9 for an overview of all pedestrian and bicycle facility improvements in the study area.

The following proposed bicycle and pedestrian facilities are of significant relevance to the study corridor:

- A Class I bicycle facility along Center Avenue from Fairfax to San Anselmo, which has the potential in some sections to provide a separated pathway as a direct alternative to the local neighborhood roads used by bicyclists or Sir Francis Drake Boulevard.
- Numerous intersection improvements in San Anselmo and San Rafael, many of which are designed to improve safety for both school children and bicyclists, [5] and a proposed roundabout at San Anselmo's "Hub" (where Sir Francis Drake Boulevard meets both Red Hill Avenue and Center Boulevard) that would address some of the vehicular non-motorized concerns with this major intersection.
- Pedestrian crossings linking the Canal area with East San Rafael and bridging Highway 101 between Francisco Boulevard East and Francisco Boulevard West.
- Improvements to the Fairfax Parkade, including safer pedestrian crossings, widened sidewalks, rearranged parking layouts, and improved traffic circulation.[6]

The Fairfax Parkade, slated for improvements in the short-term future.

5 In San Anselmo: Sir Francis Drake Boulevard and San Anselmo Avenues and Sir Francis Drake Boulevard and San Francisco Avenue; in San Rafael, 5th Avenue and D Street; 2nd Street and Tamalpais Avenue; Mission Avenue and Tamalpais Avenue; and 2nd Street and Grand Avenue.

6 NTPP Project 501: Parkade Study, (July, 2010)
http://walkbikemarin.org/documents/Parkade_501/501%20Parkade.pdf

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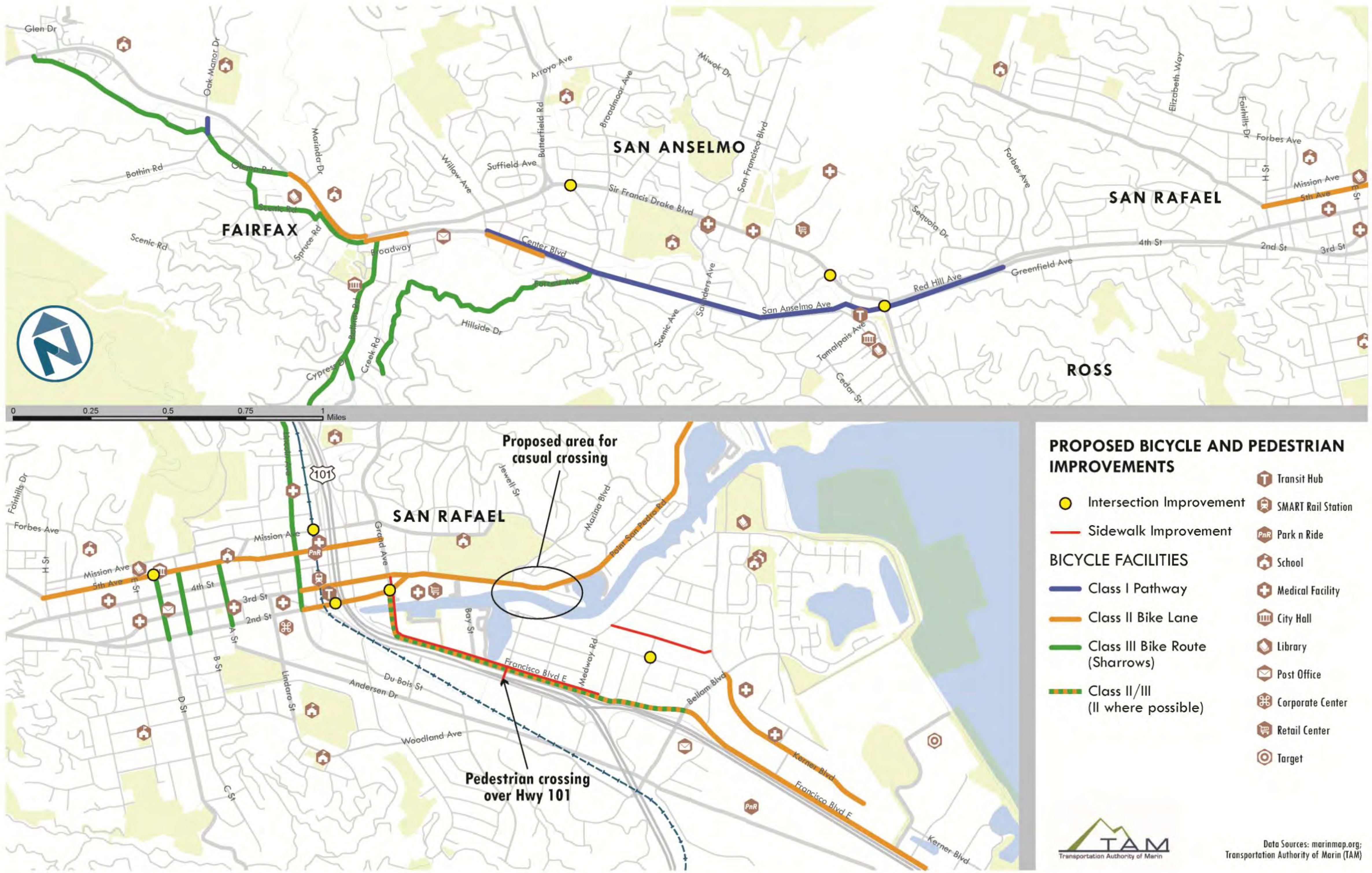
Figure 2-9 Proposed Bicycle and Pedestrian Network Improvements



EXISTING TRANSIT SERVICE

The study corridor is served by three types of transit service: local service, provided by Marin Transit on seven routes which travel at least part of the corridor; commuter service, provided by three Golden Gate Transit routes; and a shuttle operated by Golden Gate Transit exclusively to and from the Larkspur Ferry Terminal on weekdays.

This section of Chapter 2 summarizes data about the most important components of transit service in the corridor as pertains to existing and potential future transit demand:

- **Frequency**, which is a measure of how often buses serve transit stops. Increasing the frequency of transit service is a significant factor in increasing ridership and making transit a more convenient option to choice riders.
- **Current ridership**, which provides a snapshot of the current geography and magnitude of transit demand in the corridor.

Additional details about current transit service in the corridor, including detailed operational and demographic information about each route, is available in the Existing Conditions Briefing Book (Appendix A). This section also briefly describes the Bettini Transit Center in San Rafael, which is the most important transit facility in the corridor, and provides a summary of expectations for Sonoma-Marin Area Rail Transit (SMART) service, which is expected to begin operations in 2016.

Transit Services in the Corridor

Marin Transit provides local service in the study area via seven non-"tripper" (i.e., school service) routes serving various segments of the corridor. (Like the interurban rail service in the 1930s, most of the transit lines within the corridor do not serve the entire corridor, but rather, serve only one or two of three core transit segments.) Golden Gate Transit provides commuter bus service from Marin County and parts of Sonoma County to San Francisco. Sections of the study corridor are served by three Golden Gate routes: Route 24 and Route 25, connecting Manor and the San Anselmo Hub; and Route 27, which operates on the Miracle Mile between San Anselmo and the San Rafael Transit Center.

Figure 2-10 below provides a summary of key operating statistics for services along the corridor.

Figure 2-10 Summary of Transit Service in the Corridor

Route	Destinations	Corridor Segments Served	Frequency (minutes)	Notes
Golden Gate Transit				
24	Ross Valley – San Francisco	Manor – San Anselmo Hub	Peak: 10-20	Peak only; to/from San Francisco
25	Manor – Larkspur Ferry via San Anselmo	Manor – San Anselmo Hub	Peak: 20-30	Peak only; to/from Larkspur Ferry; branded The Wave
27	San Rafael – San Francisco; select trips to Sleepy Hollow	San Anselmo Hub – Downtown San Rafael	Peak: 15–45 (AM) 30-60 (PM)	Peak only beyond San Rafael; one AM/PM trip to Sleepy Hollow

Route	Destinations	Corridor Segments Served	Frequency (minutes)	Notes
Marin Transit				
22	Marin City – San Rafael via San Anselmo Hub	Miracle Mile (San Anselmo Hub – Downtown San Rafael)	Peak: 30 Base: 60	
23	Manor – Shoreline Parkway via Canal area	Entire study corridor (with exceptions – see Notes)	60	Weekends/ holidays operates downtown Fairfax to Shoreline Pkwy. only
29	Manor – San Rafael via Larkspur Ferry and Canal area	Manor – San Anselmo Hub & Canal area	Peak: 30 Base: 60	Weekend/holiday service provided by Route 228.
35	San Rafael – Canal area	San Rafael – Canal area	Peak: 10-30 Base: 30	
36	Canal area – Marin City via San Rafael	San Rafael – Canal area	30	Peak only
68	Inverness – San Rafael	Manor – Downtown San Rafael	60-120	West Marin Stagecoach route
228	Manor –San Rafael via Larkspur Ferry	Manor – San Anselmo Hub	60	Weekday service provided by Route 29.

Figure 2-11 illustrates the frequency of services in the corridor during weekday peak periods, with Figure 2-12 and Figure 2-13 depicting service frequency for all transit providers during weekday base (i.e., off-peak) times and on weekends, respectively. Because much of the transit service in the corridor operates only during commute hours, midday or base service is an indicator of the service available throughout the day.

As illustrated, frequency of service varies greatly among the three legs of the corridor, with the highest frequency from Fairfax to San Anselmo, and the lowest on the Miracle Mile between San Anselmo and San Rafael.

At some locations (like at the San Anselmo Hub), service along the corridor during weekday peak periods appears robust, with the combined frequency among all services under 10 minutes. While this gives the impression of quality transit service in the corridor, it is also misleading; only one of the ten transit routes providing service in the corridor, Marin Transit Route 23, travels the entire corridor every 60 minutes from Manor in Fairfax to Shoreline Parkway east of San Rafael. Half of the routes start in Fairfax and continue on Sir Francis Drake after the San Anselmo Hub, heading toward Highway 101 and the Larkspur Ferry. Likewise, service during off-peak times and on weekends is not as frequent or direct.

Generally, base (midday) service frequency between Manor, Fairfax, and the San Anselmo Hub, and along the Miracle Mile is 30 minutes, due to the combined effect of hourly Route 68 and 23 service (with the exception of two pulse periods). Likewise, midday Route 35 transit service operates every 30 minutes between San Rafael and the Canal area.

Figure 2-11 Weekday Peak Transit Frequency in the Fairfax–San Rafael Corridor

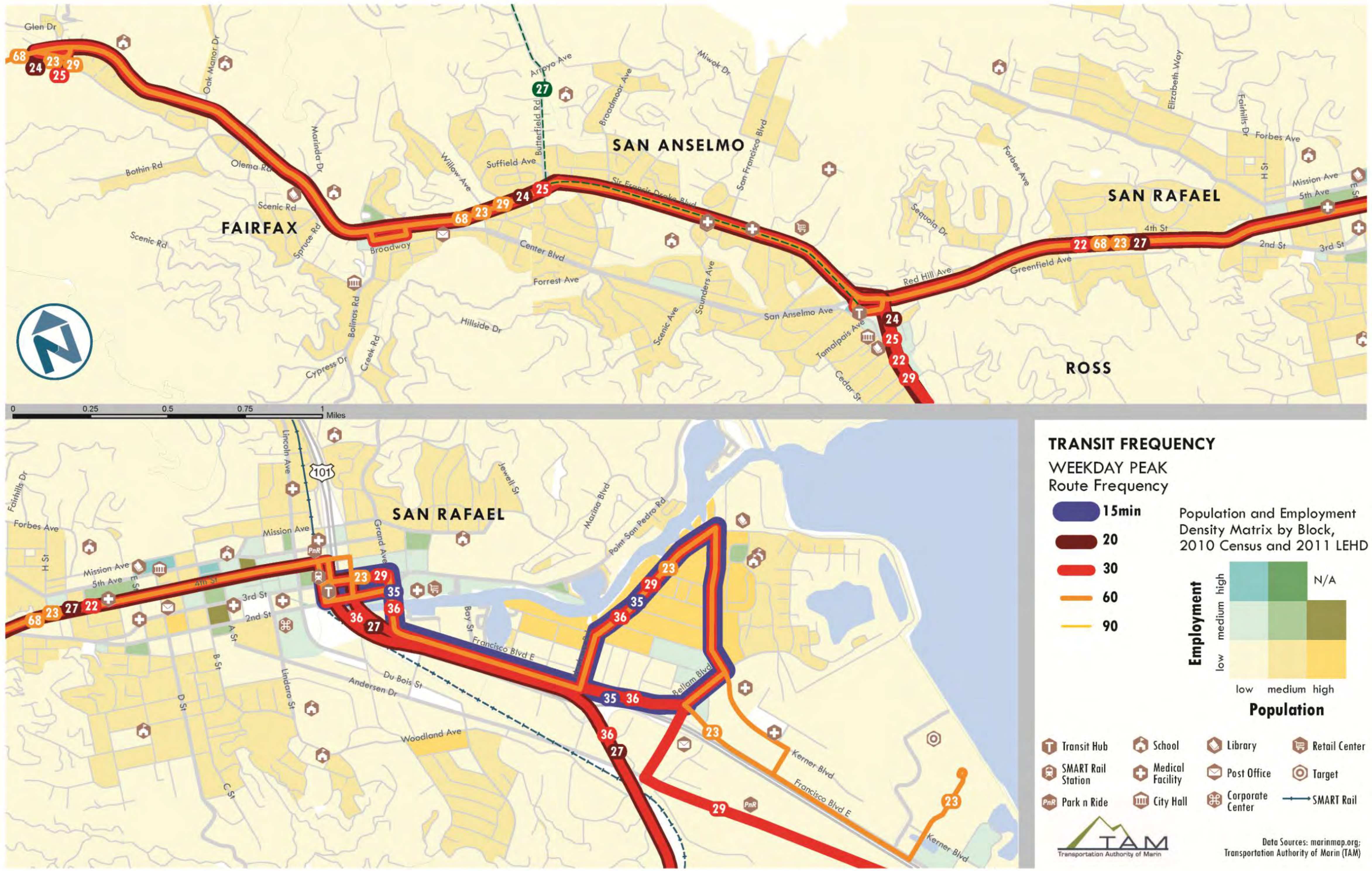


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Figure 2-12 Weekday Off-Peak (Base) Transit Frequency in the Fairfax–San Rafael Corridor

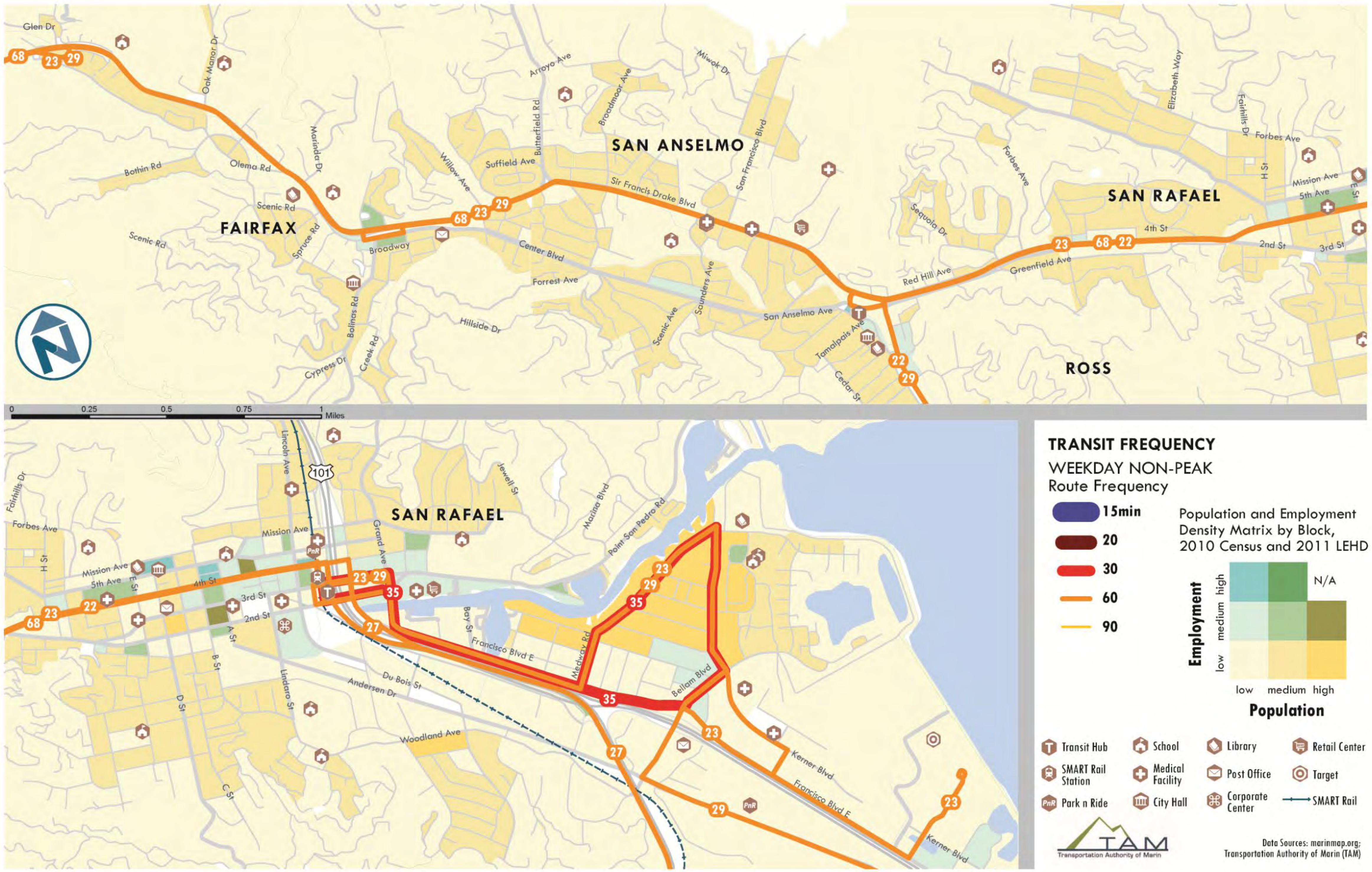

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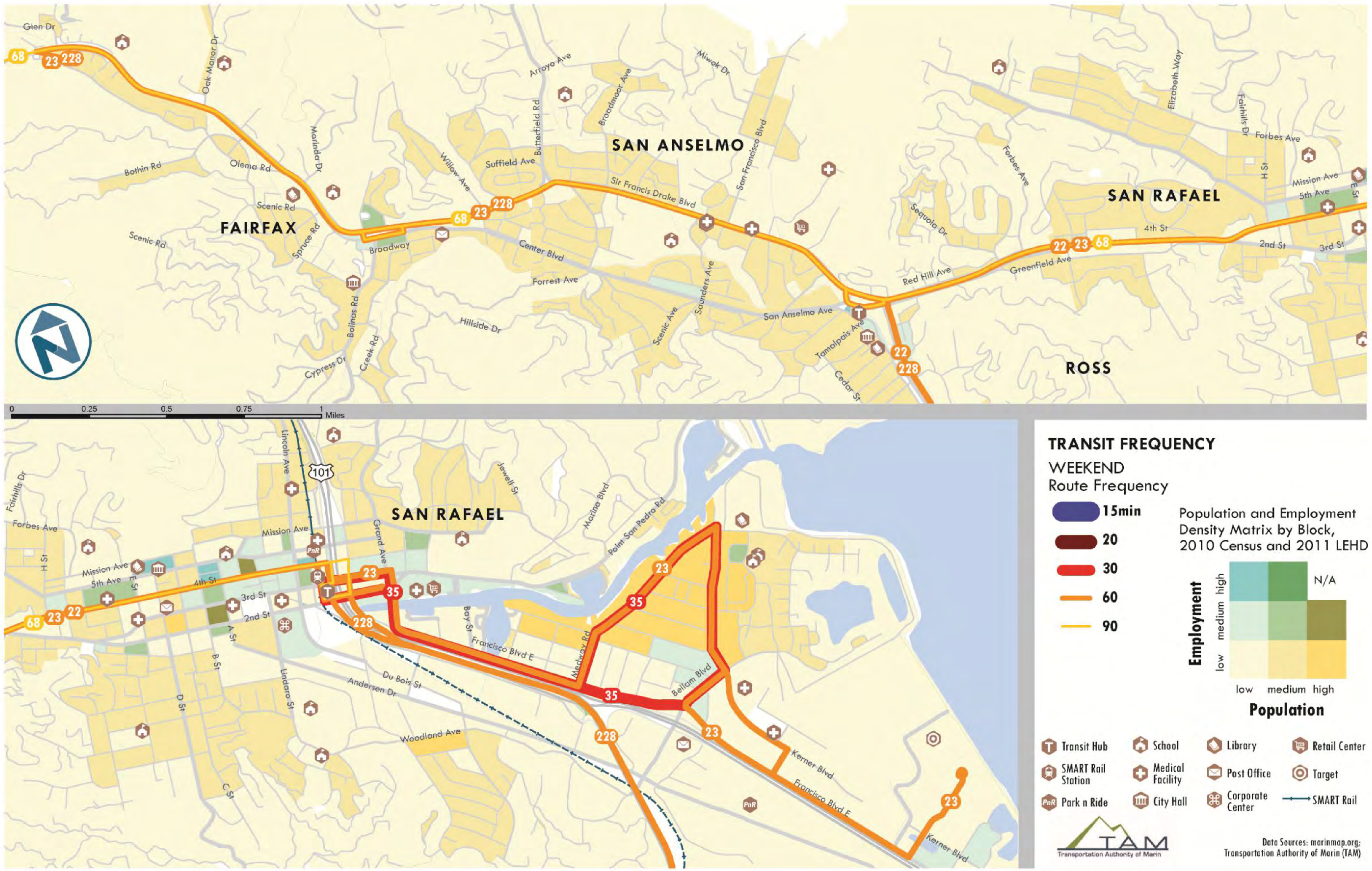
Figure 2-13 Weekend Transit Frequency in the Fairfax–San Rafael Corridor



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Existing Transit Ridership

Generally, ridership activity within the study area is clustered in the three major community and employment hubs along the corridor – San Rafael, San Anselmo, and Fairfax. Adjacent to the core study corridor, the Canal area also generates significant transit ridership.

Figure 2-14 depicts the weekday ridership by stop for transit routes with readily available ridership data. At this time, ridership data for Marin Transit Routes 22, 23, 29, 35, 36, and 68 are depicted. (Due to unavailability of total weekday data – i.e., for all daily runs – data for Route 23 in the Canal area are not illustrated.)[7]

These data show that the highest total boardings and alightings occur in the three major community and employment hubs along corridor – San Rafael, San Anselmo, and Fairfax. Consistent levels of daily activity occur along the connecting parts of the corridor such as the Miracle Mile and between Fairfax and San Anselmo.

Adjacent to the core study area, higher levels of transit activity are centered in the Canal area, particularly on Kerner Boulevard, Canal Street, and Medway Road, where there is higher residential density than farther inland along the corridor.[8]

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[7] Additionally, while total daily boardings data for Golden Gate Transit data were unavailable and therefore are not included on this map, limited <u>average</u> boardings by stop data were available for Routes 24, 25, and 27. Reviewing these data indicates that the system indeed largely serves the commuter market, with very few trips (i.e., less than one on average) occurring wholly within the boundaries of the study area.

[8] Based on a very limited sample of weekday and weekend Route 23 trips in 2013 and 2014, boarding and alighting data used to compute Passenger Miles Traveled indicate relatively little passenger activity at the Target on Shoreline Parkway, with an average of less than one weekday boarding and alighting at this location.

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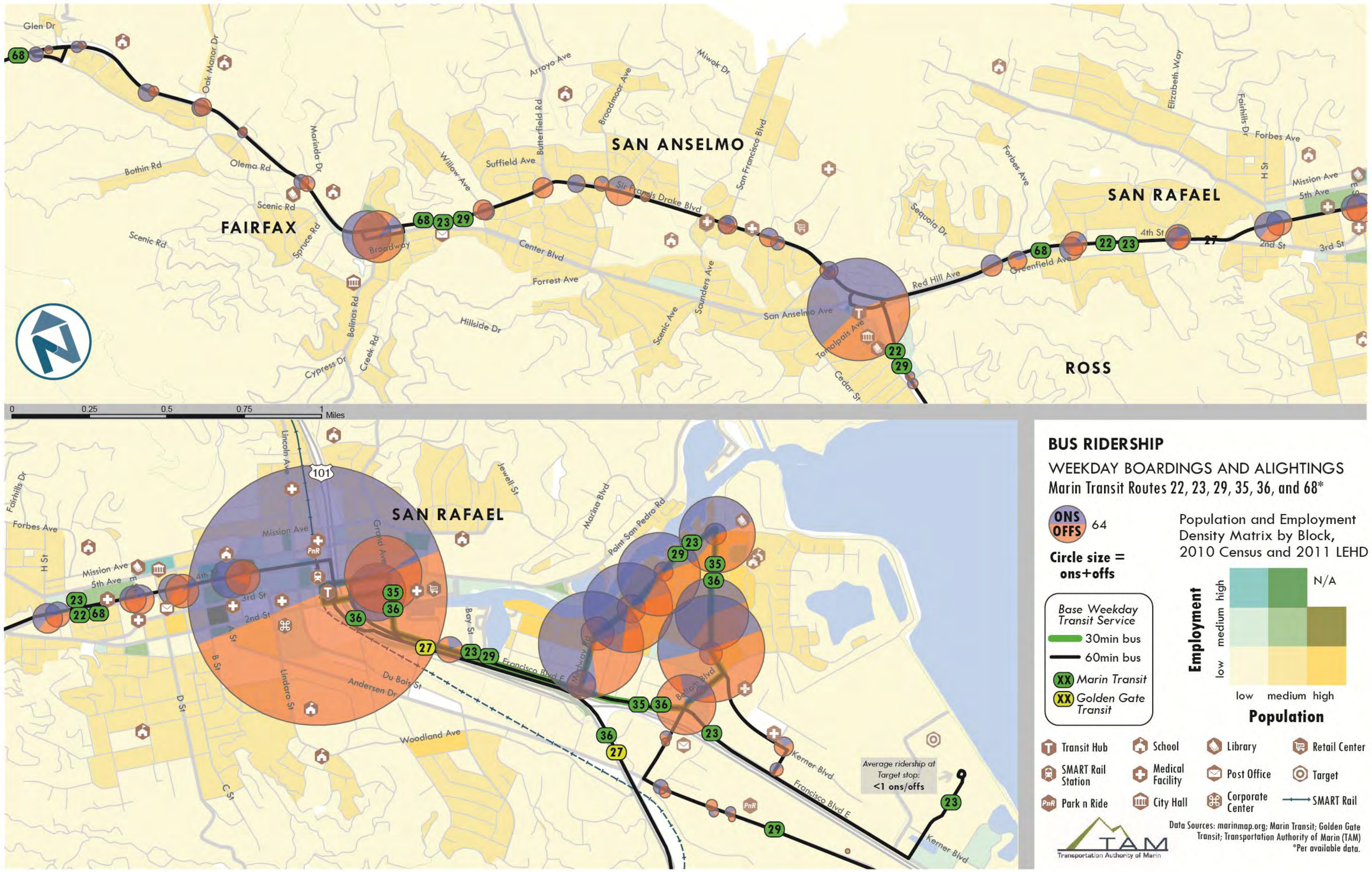
Figure 2-14 Weekday Ridership along the Fairfax–San Rafael Corridor



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Major Transit Facilities

The C. Paul Bettini Transit Center in San Rafael functions as the central hub of the Golden Gate Transit and Marin Transit systems and is a major transfer point to several intercity services. A total of 24 routes operated by three public transit providers and three private bus operators serve the Transit Center. Operationally, eastbound buses currently enter from 2nd Street on the south side of the transit center; westbound buses enter from 3rd Street on the north side of the facility.

Because it is located on the SMART right-of-way, there will be some basic operational changes at this location in the near future, though the precise nature of these changes is still under discussion.

Preparing for SMART Service

Within three years, Marin County will see some significant changes to local and regional transportation as a new commuter rail service, Sonoma-Marin Area Rail Transit (SMART), comes online, and local bus service is adjusted to reduce redundant service and to provide feeder service to the rail stations.

SMART is a commuter rail system currently being built in Sonoma and Marin Counties. Funded by a quarter-cent sales tax measure passed in 2008, the initial service, from the Sonoma County Airport north of Santa Rosa to Downtown San Rafael, is expected to be operational in 2016. This 43-mile Initial Operating Segment (IOS) is expected to carry 70% to 80% of the estimated ridership for the full system.[9] See Figure 2-15 for a map of SMART's two phases – the IOS (Phase I), and Phase II, which is currently being planned to include extensions to the north and south of the IOS.

As of summer 2015, SMART service operations are not fully planned. However, some basic service parameters are known:

- **Frequency:** SMART will run 30-minute peak period frequency. Schedules will be matched to bus pulses at the Bettini Transit Center in San Rafael.
- **Service span:**
  - Weekdays, during commute periods (6:30 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m.), plus one midday trip. A total of 30 trips will be made per day (15 southbound, 15 northbound).
  - Weekends, four northbound and four southbound trips per day.[10]

As part of the implementation plan, SMART will work with local transit agencies to design feeder bus services to the stations. The planned Downtown San Rafael SMART station is adjacent to the San Rafael Transit Center, at the center of the corridor study area.

[9] SMART website, www.sonomamarintrain.org, accessed November 5, 2014

[10] Evaluated in 2008 supplemental EIR.

Figure 2-15 Future SMART Service

Source: SMART website, sonomamarintrain.org, 12/02/14

Projected SMART Activity and Ridership

While its final operating schedules are still in development, it is expected that SMART will primarily function as a peak commuter service, with a majority of ridership commuting south to San Rafael and other job centers in the morning and returning northward in the evening.

As the SMART project was refined to adapt to changing economic conditions, a range of ridership estimates for the Downtown San Rafael station emerged from the planning process, each reflecting a different set of inputs and assumptions (such as the relocation of two stations and the adjustment of the IOS based on a downturn in tax revenue). Keeping these caveats in mind, projected boardings at the Downtown San Rafael station in 2035 range from just under 250 boardings per day to nearly 1,200 boardings per day.

INITIAL SUMMARY OF OPPORTUNITIES AND CONSTRAINTS

Figure 2-16 describes the project team's initial assessment of corridor opportunities and constraints based on a review of all available existing conditions data.

Figure 2-16 Summary of Initial Opportunities and Constraints

Briefing Book Chapter	Opportunities	Constraints
Land Use and Demographics ▪ Corridor's land use patterns were partly shaped by natural topography and partly by historical rail service. ▪ San Rafael has a larger mix of land uses, with a mix of higher density residential, commercial, and industrial uses in downtown and in the adjacent Canal area. ▪ Lower density residential uses are designated adjacent to the corridor in some locations. ▪ Largely following prescribed land uses, population and employment density is highest in the traditional centers of Fairfax, San Anselmo, and San Rafael, with the corridor-adjacent Canal area being the most densely populated residential area. ▪ Within one-half mile of the corridor (including the adjacent, transit-supportive Canal area), 21% of the population are under 18, 10% are aged 65 and over, and 21% are characterized as "low income."	▪ The corridor connects three historic, pedestrian-friendly downtown areas – Fairfax, San Anselmo, and San Rafael – as well as a busy regional transit node (Bettini Transit Center), with the densest housing in the area within walking distance of existing transit services. ▪ The corridor is home to several important nodes and travel destinations, including hospitals, schools, and major employers.	▪ A standard walkshed pedestrian access to high-capacity transit is one-half mile, however the existing topography constrains access to transit nodes, particularly for seniors and transit riders with disabilities.
Multimodal Transportation ▪ The corridor is used regularly by people who walk, bike, and drive in addition to those who take transit. ▪ Automobile facilities vary by location, though most roadways outside of San Rafael are only one lane each way, and speed limits top out at 35 mph. ▪ For areas where data are available, auto LOS exceeds C in only one location: westbound Red Hill Avenue in the AM peak period. ▪ There is already a robust network of bicycle facilities and amenities for pedestrians, though some sidewalk gaps remain in the corridor. ▪ Corridor communities have identified several projects to improve bicycle and pedestrian networks in the corridor.	▪ Roadways in several parts of the corridor have medians, providing an opportunity for exclusive transit rights-of-way without eliminating travel lanes. ▪ Bicycle infrastructure improvements are being built and planned along routes that parallel the main corridor, helping to eliminate this potential source of conflict.	▪ N/A

Briefing Book Chapter	Opportunities	Constraints
Existing Transit Service ▪ The corridor was built by transit and continues to benefit from frequent service, particularly during peak hours. While a total of 11 bus routes operate within the corridor, only one (Route 23) makes the full trip from Manor to Shoreline Parkway in the adjacent Canal area. ▪ Base (midday) service frequency between Manor and San Rafael is 30 minutes due to the combined effect of hourly Route 23 and 68; between San Rafael and the Canal area, service also operates at a 30 minute base frequency. During peak times, transit between San Rafael and the Canal area is available every 15 minutes. ▪ Ridership activity clusters in Fairfax, San Anselmo, and San Rafael, with consistent levels of daily activity observed along the Miracle Mile and between Fairfax and San Anselmo. Adjacent to the study area, higher levels of activity occur along routes operating in the Canal area. ▪ Origin-destination data reveals that over one-third of trips from Manor and Fairfax are going to San Rafael; few trips beginning in the Canal area have destinations beyond San Rafael; and there is demand for intra-corridor trips west of San Anselmo. ▪ Sonoma-Marin Area Rail Transit (SMART) is under construction, with completion expected in 2016. Expected ridership at Downtown San Rafael station is unknown but 2035 projections do not exceed 1,200 boardings per day.	▪ There is high existing demand for transit between the corridor-adjacent Canal area (and San Rafael High School) and downtown San Rafael. ▪ There are opportunities for serving short intra-corridor trips, particularly between Bettini Transit Center and the Canal area. ▪ As few trips beginning in the adjacent Canal area have destinations beyond San Rafael, job growth in the corridor west of San Rafael will largely determine whether demand will increase in the future. (Note: due to the unavailability of precise job growth data, this is also a constraint.) ▪ Sonoma Marin Area Rail Transit (SMART) service is under construction and on schedule, delivering high-quality and high-capacity transit between Santa Rosa and San Rafael beginning in 2016.	▪ With current transit services already designed to match existing demand, there appear to be few opportunities for additional corridor-length transit service. ▪ As few trips beginning in the adjacent Canal area have destinations beyond San Rafael, job growth in the corridor west of San Rafael will largely determine whether demand will increase in the future. (Note: due to the unavailability of precise job growth data, this is also an opportunity.) ▪ Future SMART service is important, but not expected to fundamentally change short-term demand in the corridor. It is unlikely that large numbers of San Rafael and Marin County residents will board SMART in the morning commute period. Most southbound SMART trips will likely end in San Rafael, with few continuing westward along the study corridor.

ANALYSIS OF PEER SYSTEMS

As part of the existing conditions analysis, a total of 20 peer case studies were conducted. Together, these case studies showed how similar cities have approached the opportunity to make a major transit investment along a key local and regional corridor (or multiple corridors). The peer case studies were chosen by the consultant team with input from the Technical Advisory Committee, and included examples of streetcar, Bus Rapid Transit (BRT), and traditional bus services. They generally fell into three categories:

- **Exclusive Right of Way** services are those that operate within their own exclusive trackway or roadway and largely do not share operating space with other vehicles. Peer examples in this category include the S-Line streetcar in Salt Lake City, Utah and the South Busway in the vicinity of Miami, Florida.
- **Enhanced Stations** services are those that operate in a mixed-flow lane but feature distinctive and enhanced stations. Peer examples in this category include the Portland

(Oregon) Streetcar "CL" (Central Loop) Line and the Quickline BRT service in Houston, Texas.

- **Circulator** services are usually shuttles that circulate among key destinations, operating in mixed-flow lanes. They may be shorter in length than the other types of services described in this summary. Examples in this category include the Tacoma, Washington Streetcar and Irvine, California's iShuttle service.

The complete case studies can be found in **Appendix B Summary of Case Studies**. Figure 2-17 summarizes "lessons learned" from the case studies, while Figure 2-18 summarizes key capital and operating statistics (where statistics were available).

Figure 2-17 Case Studies Lessons Learned

System	Mode	Lessons Learned
Exclusive Right of Way		
S-Line, Salt Lake City, UT	Streetcar	Ridership has been much lower than originally estimates of 3,000 users per day in 2014—during first week of operation the streetcar had only an average of 781 riders per day. No ridership rates have since been reported (perhaps because of bad publicity). But the corridor is benefiting from nearby real estate development (about 1,000 new apartments and condominiums will soon open in Sugar House) Despite the low ridership, the Sugar S Line extension is being studied: The S Line is "part of a future-looking network that would give mass transit riders many choices" (Hutcheson, Transportation Director)
UTA MAX, Salt Lake City, UT	BRT	Reliability improvements caused ridership increase
South Busway, Miami-Dade, FL – Initial Segment	BRT/Bus	▪ An at-grade "feeder" busway provides a cost-effective alternative to extending rail transit through low-density areas. However, the MDT found necessary to overlay the line-haul busway routes with services to residential areas, in order to minimize transfers ▪ The railroad right-of-way provided an opportunity for building a low-cost, low-impact busway. In addition, Obtaining inexpensive right-of-ways is a challenge and yet essential to avoid alignments and implementation problems in the future ▪ Wherever, the buses operate close to or crosses a major roadway, care must be exercised in coordinating traffic signals and ensuring safety of all users. Educational programs for transit riders and motorists are helpful ▪ A fixed-transit facility with frequent and reliable service will increase ridership and encourage people to shift mode, even with no travel time advantage. Improved identity and amenities of the Busway, along with the provision of new services, have contributed to the ridership growth ▪ Working in close relationship with planners, engineers and transit agencies allows more efficiency in the implementation process ▪ Effective support from the state, regional and local government agencies as well as the public is essential
Red Line, Minneapolis, MN	BRT	Ridership growth suppressed by slow trip off freeway to Cedar Station

System	Mode	Lessons Learned
Enhanced Stations		
Sun Link, Tucson, AZ	Sun Link, Tucson, AZ	Officials have received complaints regarding passes, and are utilizing customer service to educate the public about how to purchase re-loadable passes
Quickline, Houston, TX	Quickline, Houston, TX	Officials have received complaints regarding passes, and are utilizing customer service to educate the public about how to purchase re-loadable passes. Aesthetics are overrated. METRO could have spent less on capital (stations) and branding and received comparable ridership and fare revenue. METRO: a) eliminated most discounted fare media by March 2008; and b) increased local base fares from $1.00 to $1.25 in November 2008. These fare changes had a significant impact on expected ridership on the Quickline as well as existing ridership on Route 2 Bellaire whose passengers had a low average household income. Deferring until time savings can be achieved is more important than opening early. METRO implemented the service when construction was still ongoing on Bellaire with the thought that any time savings would be appreciated. However, the effect was to minimize the actual potential time savings by breaking the savings into two intervals. By the time real time savings were realized, many customers had already decided that the service didn't save time and reverted back to the Bellaire
Circulator		
TECO Line Streetcar, Tampa, FL	Streetcar	Real estate impact greater than expected
Tacoma Link, Tacoma, WA	Streetcar	Sound Transit is betting that passengers will be attracted not just by the convenient route, but by the fast, comfortable service provided by the 21st-century, state-of-the-art electric streetcars which will glide up and down the route.
River Rail, Little Rock, AR	Streetcar	In addition of the high ridership, within six months of opening the line, over $80M in new development was announced along the line and more recently a new $28M ballpark in North Little Rock was built within several blocks of the line as well as a large executive corporate residence complex. CATA organizes seasonal events and rents streetcars in order to increase revenue
Streetcar Circulator, Kenosha, WI	Streetcar	Lift on board saves station cost.
Emery Go-Round, Emeryville, CA	Bus	Approximately 80% of all Emery Go-Round trips begin or end at MacArthur BART Station, supporting a significant increase in patronage at the station and a shift in primary mode of access.
Wave Trolley, Monterey, CA	Bus	▪ Monterey-Salinas Transit (MST) is planning to reduce emissions by 30% and noise pollution thanks to a new electric trolley powered by the WAVE 50kW wireless charging system

System	Mode	Lessons Learned
		▪ The financing structure ensures that no local tax dollars or passenger fares will be used to fund this infrastructure improvement project ▪ The new 32-foot vehicles will last about two years and 50,000 miles longer than MST's old 17-passenger minibuses. They will also provide greater capacity and flexibility and can be used on busy routes that don't have quite enough riders to require larger standard coaches

Figure 2-18 Case Studies Data Summary

System	Mode	Miles	Ridership/mile (1,000s)	Operating Cost/mile ($, 1,000s)	Operating Cost/rider ($)	Capital Cost/mile ($, 1,000s)	Capital Cost/rider ($)
Exclusive Right of Way							
S-Line, Salt Lake City, UT	Streetcar	2.0	135	$800	$5.92	$28,700	$212.22
Canal Streetcars, New Orleans, LA	Streetcar	5.5	291	1,273	4.38	39,300	135.09
UTA MAX, Salt Lake City, UT	BRT	10.0	39	310	7.95	1,870	47.95
South Busway, Miami-Dade, FL – Initial Segment	BRT/Bus	8.3	108	N/A	N/A	6,670	61.63
Red Line, Minneapolis, MN	BRT	11.0	20	291	14.67	10,370	523.29
Enhanced Stations							
Sun Link, Tucson, AZ	Streetcar	3.9	468	744	1.59	51,970	111.06
CL Line, Portland, OR	Streetcar	3.3	1,706	1,667	0.98	46,430	27.21
Quickline, Houston, TX	BRT	9.0	19	223	11.74	473	24.94
Circulator							
TECO Line Streetcar, Tampa, FL	Streetcar	2.7	136	956	7.03	18,240	134.26
Tacoma Link, Tacoma, WA	Streetcar	1.6	304	938	3.09	64,520	212.49
River Rail, Little Rock, AR	Streetcar	3.4	30	282	9.56	8,990	304.44
M-Line Trolley, Dallas, TX	Streetcar	2.8	155	89	0.58	679	4.39

System	Mode	Miles	Ridership/mile (1,000s)	Operating Cost/mile ($, 1,000s)	Operating Cost/rider ($)	Capital Cost/mile ($, 1,000s)	Capital Cost/rider ($)
Streetcar Circulator, Kenosha, WI	Streetcar	1.9	36	173	4.85	3,160	88.82
iShuttle, Irvine, CA	Bus	19.7	8	147	17.50	128	15.21
Emery Go-Round, Emeryville, CA	Bus	7.6	211	434	2.06	N/A	N/A
Tri-Rail Shuttle Buses, South Florida	Bus	167	6	29	5.13	35	6.29
Downtown & Waterfront Shuttles, Santa Barbara, CA	Bus	3.0	141	583	4.13	975	6.90
Wave Trolley, Monterey, CA	Bus	2.0	50	N/A	N/A	1,050	21.16

3 FEASIBLE ALTERNATIVES

This chapter describes the process used to develop project alternatives, as well as summarizing the alternatives considered feasible for further study. The alternatives developed for this study were based on:

- Analysis of potential travel markets to be served in the study area, including an analysis of markets most likely to use improved transit service
- A field assessment of on-the-ground conditions analysis used to determine how different modes would fit on existing streets, including opportunities for developing exclusive transit right-of-way
- Development of a "kit of parts" which provided a variety of potential alignments for each segement of the study area along with high level drawings of each of these options Extensive input from TAC members representing various constituencies including the transit operators and local officials from cities in the corridor.

Through this carefully considered process, the project Technical Advisory Committee developed the "low investment" (enhanced bus) and "high investment" (streetcar) alternatives described in this chapter.

DEVELOPING THE FEASIBLE ALTERNATIVES

The Travel Market Assessment described below helped provide an understanding of the overall travel demand and travel markets within the study area. The Travel Market Assessment also provided an understanding of how these markets might be served by enhanced transit service.

The cross-section analysis of constrained locations that followed, meanwhile, was used to identify options in each segment, and to clearly articulate opportunities and constraints associated with each option.

Travel Market Assessment

The Travel Market Assessment evaluated the potential transit travel markets in the corridor based on the existing built environment, socio-economic factors, travel demand, and existing ridership.

This report (provided in full as **Appendix C Travel Market Analysis**) included the following:

- A transit likelihood index which evaluates whether existing built environment and socio-economics of the area provide a supportive base for transit use.
- Existing and forecast travel demand across the corridor and region in order to understand the potential market for transit trips between various origins and destinations.

- Evaluation of Marin Transit Route 23 riders as a basis for understanding the characteristics of current transit users in the study corridor.
- Assessment of transit demand to future SMART station areas.

A summary of key findings is included below.

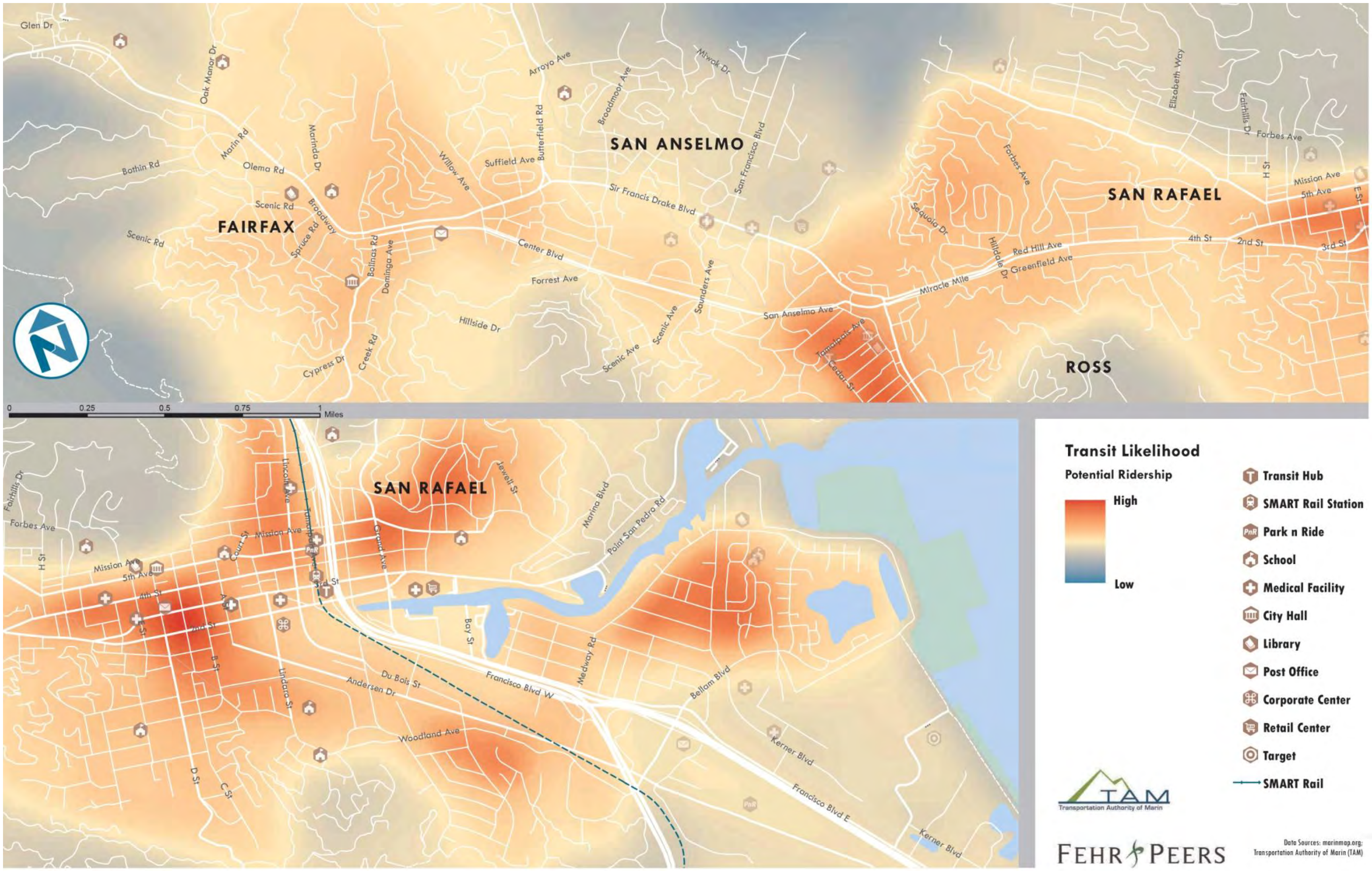
Built Environment and Socioeconomics

The built environment and socio-economic factors of the existing population can be used as a base for determining locations at which transit is most likely to be effective. Research has examined how various principle dimensions, often referred to as "D" variables, effect trip rates and mode choice. Higher levels of D variables such as density, diversity of land uses, pedestrian-oriented designs and certain socio-economic factors have been shown to encourage transit use. Several D variables were evaluated and combined into a transit likelihood index, which measures the propensity for transit use in an area based on the built environment and socio-economics. A market assessment of existing Marin Transit riders in 2013 found that zero-car households and low income households in particular have a propensity to ride transit.[11]

As the transit likelihood index (Figure 3-1) shows, transit propensity based on built environment and socio-economic factors is highest in Downtown San Anselmo, Downtown San Rafael and the Canal area. Propensity in the downtown areas is primarily driven by high concentrations of households and employment while propensity in the Canal is due to the higher density of low income residents and zero vehicle households in the area, although the employment density and pedestrian scale design are lower in this area. Transit likelihood is slightly lower in Fairfax and the propensity in downtown Fairfax is not as concentrated as in other downtown areas.

[11] Nelson\Nygaard, "Countywide Transit Market Assessment: Final Market Assessment" Memorandum presented to Marin Transit in June, 2013

Figure 3-1 Transit Likelihood Index



Other Key Findings

A summary of the general findings of the travel market assessment is provided in Figure 5-1. Based on this analysis, the OD pair with the highest potential for increased transit ridership is between Downtown San Rafael and the Canal. The potential for increased ridership between Downtown San Rafael and Downtown San Anselmo is also high. Potential also exists, although at a lower volume, for increased transit ridership between Downtown San Anselmo and Downtown Fairfax. The demand for transit travel from one end of the corridor to the other is expected to be low.

Figure 3-2 Summary of Key Findings, Opportunities, and Constraints

Travel Market Aspect	Opportunities	Constraints
Transit Likelihood Index	The following areas have the strongest base of built environment and socio-economic characteristics to support higher levels of transit ridership: ▪ Downtown San Anselmo ▪ Downtown San Rafael ▪ The Canal	Built environment and socio-economic characteristics supportive of transit use are less concentrated in Fairfax, suggesting more limited potential demand for transit except for around specific activity generators, such as schools and medical facilities.
Transit Market Share	Many short trips are being made within the corridor and only a small share of these are made on transit, suggesting an opportunity to shift some trips from auto to transit, particularly between the following OD pairs: ▪ Downtown San Rafael / Canal ▪ Downtown San Rafael / Downtown San Anselmo ▪ Downtown San Anselmo / Downtown Fairfax	The potential to shift trips from auto to transit depends on the competitiveness of transit with autos. This will depend on many factors including congestion levels along the corridor, transit versus auto speeds, transit service levels, quality of transit service amenities and transit priority treatments.
Rider Analysis	Current riders along the corridor are transit dependent. There is potential to increase the number of “choice” riders by providing improved transit services able to be more competitive with auto travel.	Current transit provision along the corridor has not been able to attract “choice” riders. Considering current levels of congestion along the corridor, it may be difficult to implement measures to make transit service more competitive in terms of travel time, which is a the key factor in attracting choice riders.
Travel to Future SMART Station Catchment Areas	Preliminary analysis shows potential for introduction of SMART to shift some trips between the study corridor and areas along the SMART corridor from auto to transit. This would increase transit demand along the corridor to and from the Downtown San Rafael SMART Station, meaning local transit could be used as a feeder system for SMART travel.	Demand for transit may be impacted by the level of park-and-ride and feeder bus service provided at SMART stations at either end of the trip.

Corridor Alignment Options

Using the results of the travel market assessment and the existing conditions briefing book, the project team developed a series of alignment options suitable for implementation in the corridor.

Appendix D Initial Alternatives Summary provides additional detail on the process of evaluating each service option in the corridor, including existing and potential future cross-sections at the most spatially constrained location(s) and a summary of opportunities and constraints for each segment option.

In addition to serving a wide range of populations, the Fairfax-San Rafael corridor constitutes a complex transit operating environment, with individual parts of the corridor posing unique challenges and opportunities for the implementation of high-capacity transit service. Figure 3-3 on the following page identifies each of the segments used to develop alignment options. The key segments, from east to west, are:

- Manor (Segment A)
- Downtown Fairfax (Segment B)
- Fairfax-San Anselmo Hub (Segment C)
- Miracle Mile (Segment D)
- Downtown San Rafael (Segment E)
- Montecito Plaza/Canal Area (Segment F)

For each corridor segment, a variety of different alignment options were developed, considering the needs of both bus and potential streetcar options. These options are examined in more detail below, along with specific opportunities and constraints associated with each option. Generally speaking, the greatest challenges common to both modes within the corridor include:

- Right-of-way constraints, particularly on Sir Francis Drake Boulevard between Fairfax and San Anselmo.
- Potential need for replacement parking.
- Reintroduction of service along historical rail corridor (i.e., Center Boulevard) and impacts on residents.

A unique major constraint for rail (streetcar) service is the high cost and feasibility of crossing the SMART tracks. Due to the restrictions that would result from crossing freight rail tracks with a streetcar, potential rail alignments are assumed to end at the San Rafael (Bettini) Transit Center, and a suitable turnaround option must be identified as part of finalizing an alignment in downtown San Rafael (Segment E).

Figure 3-4 presents an overview of the various alignment options for both bus and streetcar services in each major corridor segment. Any of these segment alignments could be combined in a variety of ways to develop a corridor wide alternative. These segment alignments are also summarized in tabular form in Figure 3-3.

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Figure 3-3 Fairfax-San Rafael Corridor: Map of Alignment Options by Corridor Segment

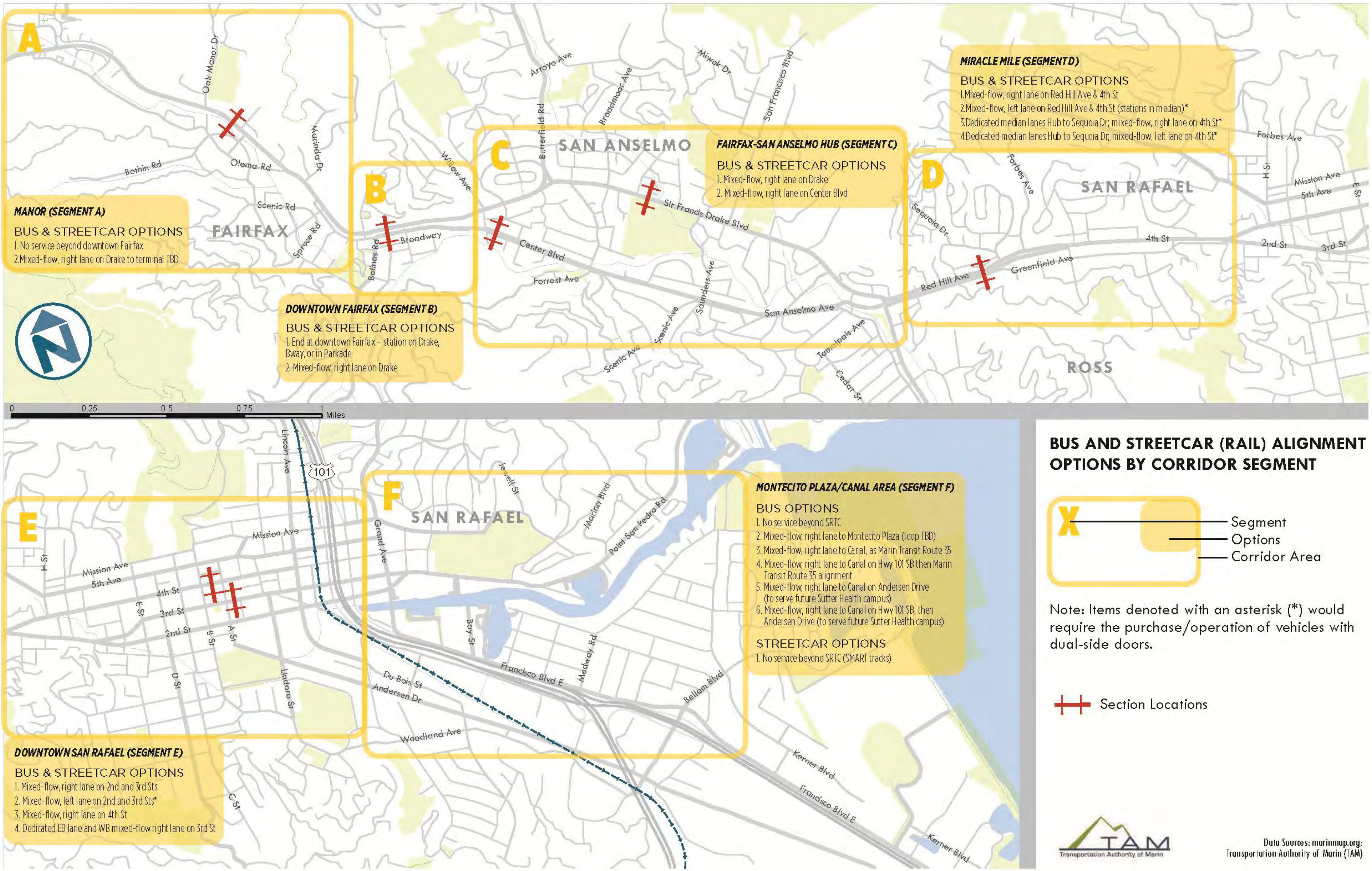

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Figure 3-4 Fairfax-San Rafael Corridor: Viable Alignment Options by Corridor Segment

Corridor Segment	Bus Options	Streetcar (Rail) Options
Manor (Segment A) *Cross-section: Drake at Oak Tree Lane*	1. No service beyond downtown Fairfax. 2. Mixed-flow, right lane on Drake to terminal TBD.	1. No service beyond downtown Fairfax. 2. Mixed-flow, right lane on Drake to terminal TBD.
Downtown Fairfax (Segment B) *Cross-section: Drake and Broadway at the Parkade/Fairfax Theater*	1. End at downtown Fairfax – station on Drake, Bway, or in Parkade. 2. Mixed-flow, right lane on Drake.	1. End at downtown Fairfax – station on Drake, Bway, or in Parkade. 2. Mixed-flow, right lane on Drake.
Fairfax-San Anselmo Hub (Segment C) *Cross-sections: Drake at SFD HS; Center at Pastori Avenue*	1. Mixed-flow, right lane on Drake. 2. Mixed-flow, right lane on Center Blvd.	1. Mixed-flow, right lane on Drake. 2. Mixed-flow, right lane on Center Blvd.
Miracle Mile (Segment D) *Cross-section: 50 feet west of Red Hill Ave/Sequoia Dr intersection*	1. Mixed-flow, right lane on Red Hill Ave and 4th St. 2. Mixed-flow, left lane on Red Hill Ave and 4th St (stations in median). 3. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, right lane on 4th St.* 4. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, left lane on 4th St.*	1. Mixed-flow, right lane on Red Hill Ave and 4th St. 2. Mixed-flow, left lane on Red Hill Ave and 4th St (stations in median). 3. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, right lane on 4th St.* 4. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, left lane on 4th St.*
Downtown San Rafael (Segment E) *Cross-section: 3rd Street 50 feet east of A Street; 4th Street 200 feet west of A Street*	1. Mixed-flow, right lane on 2nd and 3rd Sts. 2. Mixed-flow, left lane on 2nd and 3rd Sts. 3. Mixed-flow, right lane on 4th St. 4. Dedicated EB lane and WB mixed-flow right lane on 3rd St.	1. Mixed-flow, right lane on 2nd and 3rd Sts. 2. Mixed-flow, left lane on 2nd and 3rd Sts. 3. Mixed-flow, right lane on 4th St. 4. Dedicated EB lane and WB mixed-flow right lane on 3rd St.
Montecito Plaza/Canal Area (Segment F) *Cross-section: N/A*	1. No service beyond SRTC. 2. Mixed-flow, right lane to Montecito Plaza (loop TBD). 3. Mixed-flow, right lane to Canal, as Marin Transit Route 35. 4. Mixed-flow, right lane to Canal on Hwy 101 SB then Marin Transit Route 35 alignment. 5. Mixed-flow, right lane to Canal on Andersen Drive. (To serve future Sutter Health campus.) 6. Mixed-flow, right lane to Canal on Hwy 101 SB, then Andersen Drive. (To serve future Sutter Health campus.)	1. No service beyond SRTC (SMART tracks).

THE FINAL ALTERNATIVES IN DETAIL

Building on the detailed analysis of each service option contained in the segment alteratives two potential future service options were proposed:

- A low investment alternative, which would most likely utilize bus technology to provide a direct, express service between Fairfax and the Canal area.
- A high investment alternative, which would most likely utilize streetcar technology to serve as a local "circulator" service between Fairfax and San Rafael.

Either alternative could be operated with either mode, although if streetcars operated in the low investment alternative, service could not be extended east from Downtown San Rafael past the SMART tracks to the Canal District. Enhanced bus has been assumed in the low investment alternative, and streetcars in the high investment alternative for purposes of analysis.

Within these general parameters, the TAC provided input on the physical details of each alternative such as where the alternatives could operate within San Rafael and between San Rafael and the Canal area.

Achieving Consensus on Feasible Alternatives

At the April 2015 TAC meeting, TAC members confirmed the general geographic alignment of each alternative, and directed the project team to finalize alternatives following a few basic principals:

- **Both alternatives will run in mixed-flow lanes on Center Boulevard between San Anselmo and Fairfax.** TAC members agreed that in many places in this segment, Sir Francis Drake is simply too narrow to accommodate a new transit service without significant reconstruction costs. Even expanding bus service on Sir Francis Drake would not be feasible due to existing congestion and difficult in placing stops.
- **The low investment (enhanced bus) alternative will operate in right-side, mixed-flow lanes on 2nd and 3rd Streets in San Rafael, and reach the Canal area via Highway 101 in the eastbound direction.** This routing maximizes speed and reliability in the busiest segments of the corridor.
- **The high investment (streetcar) alternative will operate on 4th Street in San Rafael**, and may, to the extent feasible, operate in dedicated median and/or left-side mixed-flow lanes in the Miracle Mile.
- **Both alternatives may be paired with significant multimodal infrastructure improvement projects in the short- to mid-term.** In particular, TAC members supported analyzing the effects of a streetcar or bus alignment on a new roundabout at the Hub and including dedicated median lanes in the Miracle Mile as an option for the high investment alternative.

Physical & Operational Characteristics

Below, Figure 3-5 provides an overview of more detailed assumptions about the physical (i.e., in terms of infrastructure and route alignment) and operational characteristics of the two feasible alternatives.

Figure 3-5 Alignment & Operational Details for the Feasible Alternatives

Category	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
Alignment		
Goal	*Express service within corridor, particularly downtown San Rafael*	*Circulator service within corridor, particularly downtown San Rafael*
Route	Fairfax – Canal area via Center Blvd. and 2nd / 3rd Streets in San Rafael.	Fairfax – San Rafael via Center Blvd. and 4th Street in San Rafael
Route Length (round trip)	11.7 miles	8 miles
Stop Spacing	Between 0.5 – 1 mile	~ 0.25 – 0.5 miles (closer together in downtown San Rafael
Potential Stop Locations	▪ Downtown Fairfax ▪ Saunders Ave & Center Blvd (Yolanda Station) – for SFD HS ▪ San Anselmo Hub ▪ Ross Valley Dr/Crescent Dr & 4th St ▪ C St & 2nd/3rd Sts ▪ SRTC ▪ Bellam & Francisco (bus only) ▪ Kerner & Fairfax " " ▪ Canal & Sonoma " " ▪ Medway & Francisco " " ▪ SRTC & return	▪ Downtown Fairfax ▪ Center Blvd & Pastori Ave ▪ Center Blvd & San Anselmo Ave (Lansdale Station) ▪ Center Blvd & Saunders Ave (Yolanda Station) ▪ San Anselmo Hub ▪ Red Hill Ave & Sequoia Dr ▪ 4th St & Ross Valley Dr/Crescent Dr ▪ 4th St & Greenfield Ave ▪ 4th St & H St ▪ 4th St & E St ▪ 4th St & C St ▪ 4th St & A St ▪ SRTC
Dedicated Lane Locations	None	Red Hill Avenue between Hub intersection and Sequoia Drive
Queue Jump Lane Locations (tentative)	Hub intersection	Hub intersection
Transit Signal Priority Locations (tentative)	Hub intersection	All major signalized intersections along alignment: Claus & SFD, Hub intersection, Red Hill Ave & Sequoia Dr, 4th & Ross Valley Drive, 4th & Greenfield Ave, 4th & 2nd , 4th & H Sts, 4th & E Sts, 4th & D Sts, 4th & C Sts, 4th & B Sts, 4th & A Sts, 4th & City Plaza, 4th & Lootens, 4th & Cijos, 4th & Lincoln
Operational Assumptions		
Technology	Bus	Streetcar/Bus (assumed streetcar for analysis)
Service Span	6 a.m. – 11 p.m., seven days a week	

Category	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
Frequency	4 transit vehicles per hour (15 minute headways)	

The alignments of the feasible alternatives are depicted graphically in Figure 3-6 and Figure 3-7 below.

Figure 3-6 Feasible Low Investment (Enhanced Bus) Alternative Alignment

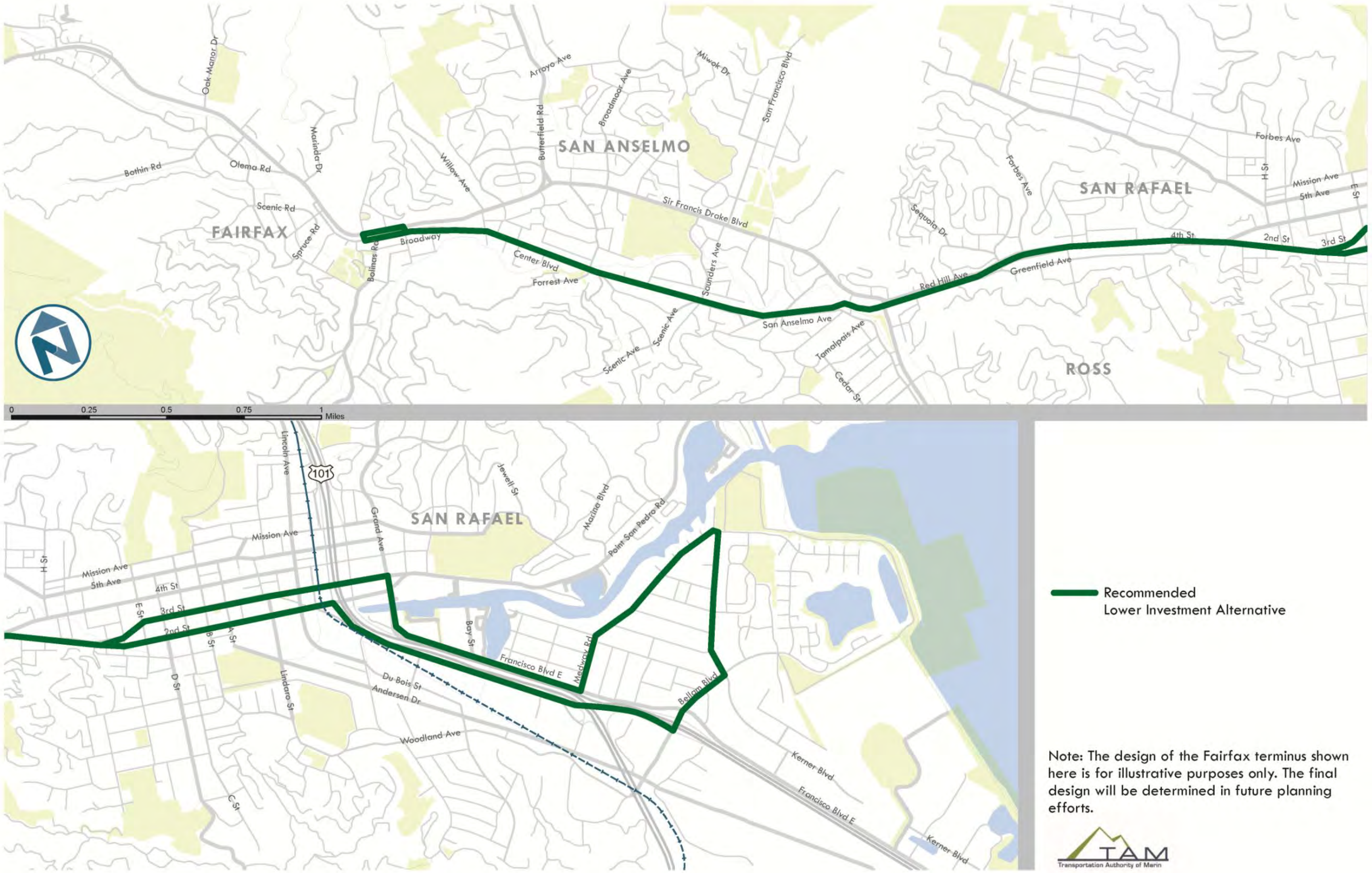
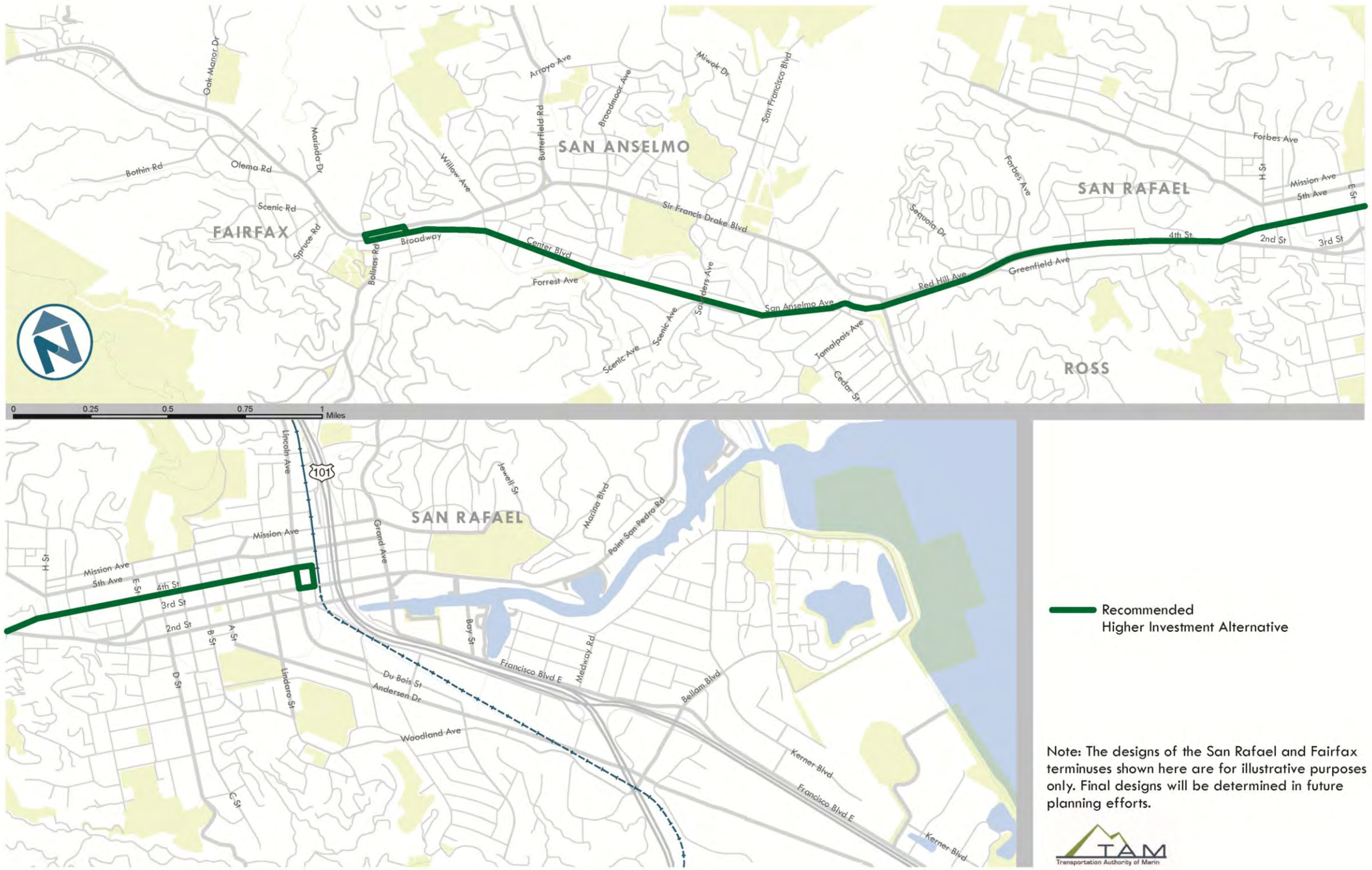


Figure 3-7 Feasible High Investment (Streetcar) Alternative Alignment



General Characteristics of the Feasible Alternatives

This section discusses characteristics that are shared between the low and high investment alternatives throughout the corridor.

Commonalities between the Two Alternatives

- **Shared transit enhancements.** To the extent possible, the alternatives seek to extend service reliability and user experience enhancements to other transit services within the corridor. For example, any queue jump lanes, right-side bus/rail station bulbs/shelters, or transit signal priority investments developed for this project would also be able to be used by local Marin Transit or Golden Gate Transit services, further increasing the attractiveness of transit within the corridor.
- **Station styles.** At a minimum, each alternative will feature distinctive station styles, helping differentiate the enhanced service from typical transit services. Depending on location and/or width constraints, stations would feature shelters, enhanced signage with wayfinding elements and/or system branding. As shown in Figure 3-8, typical station styles can be both modern and stylish, accommodating a host of rider amenities in a small overall profile. (Note: this quality of streetcar station design does come at a higher cost in resources, which is why streetcar technology is being considered for the Higher Investment Alternative.) Terminal and/or other key wayside stations may have enhanced treatments that may be determined if and when additional planning is conducted.

Figure 3-8 Potential Station Styles – Cincinnati & Portland Streetcars

Source: City of Cincinnati; Steve Morgan/Wikipedia

- **Commitment to community vitality, multimodal access, and sustainability.** Each alternative is designed to maximize the benefits of transit within corridor communities, creating a more socially equitable transportation system that can be used by all, including choice riders-- as well as riders who depend on transit. To the extent possible, and with the collaboration of relevant municipalities and agencies along the corridor, each alternative will feature bike parking, an improved pedestrian and bicycle orientation around stations, and/or other amenities.

4 CONCEPTUAL DRAWINGS & MULTIMODAL IMPACT ASSESSMENT

The next step in the process was to visualize how the proposed alternatives could be designed and built in the corridor. This analysis helps policymakers evaluate the spatial opportunities and constraints of the two alternatives, and better understand the effects of each alternative on other transportation users in the corridor.

Transition-Area Drawings

The project team developed conceptual alignment drawings for potential bus route and streetcar track transitions at select locations along the Technical Advisory Committee's (TAC's) preferred corridor alignments.

Please note: these are conceptual drawings, developed to better understand the potential physical nature of each recommended alternative. They are NOT design drawings and are subject to changes and/or refinements at later stages of corridor transit planning processes.

Based on input received at TAC meetings, the following transition and alignment areas were selected for depicting potential routing for the low investment (enhanced bus) alternative and the high investment (streetcar) alternative:

- Transit turnaround options in downtown Fairfax (low and high investment)
- Transit queue jumper lane opportunities on Center Boulevard (low and high investment)
- Routing options through Center Boulevard bridge area, including a potential roundabout alternative (low and high investment)
- Routing options through San Anselmo's Hub, including a potential roundabout alternative (low and high investment)
- Routing transitions into and out of Miracle Mile's center median (high investment)
- Routing transitions between Miracle Mile and Fourth Street (low and high investment)
- Routing options through downtown San Rafael (low and high investment)
- Transit turnaround concepts in downtown San Rafael (high investment)

The concepts were developed to scale using AutoCAD, and are based conceptual alignment cross-sections presented to the TAC as well as on design standards for busways and streetcar lines, e.g., APTA's modern streetcar guidelines.

Below are a few representative diagrams of a bus or streetcar (i.e., low or high investment) alternative at selected corridor locations. The full set of drawings is provided in Appendix E.

Fairfax

Figure 4-1 Potential Streetcar Turn-Around at Bank Street (High Investment Alternative Only)

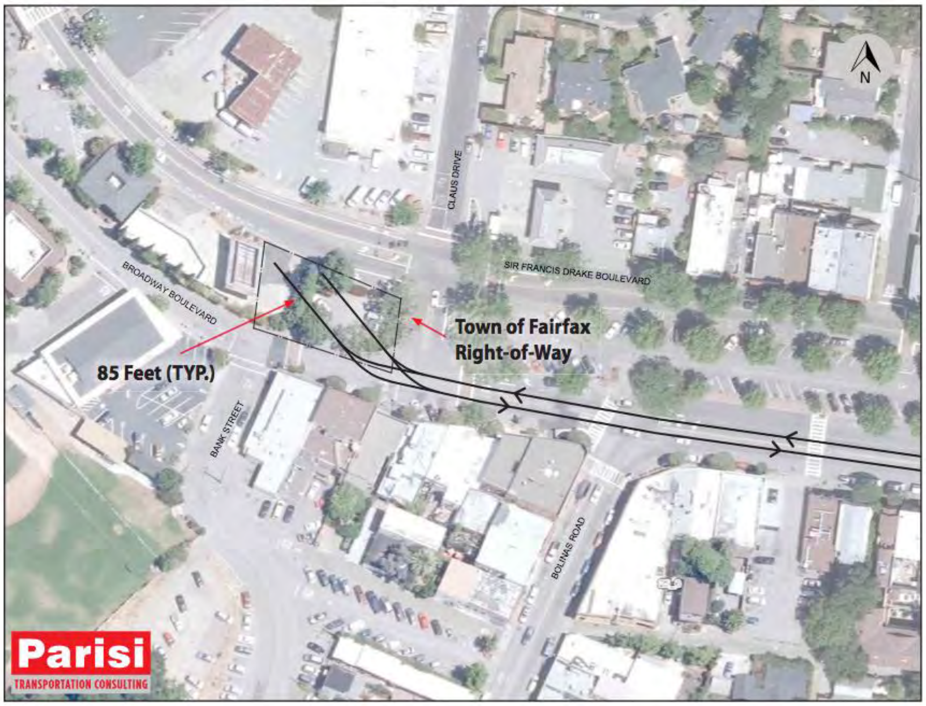
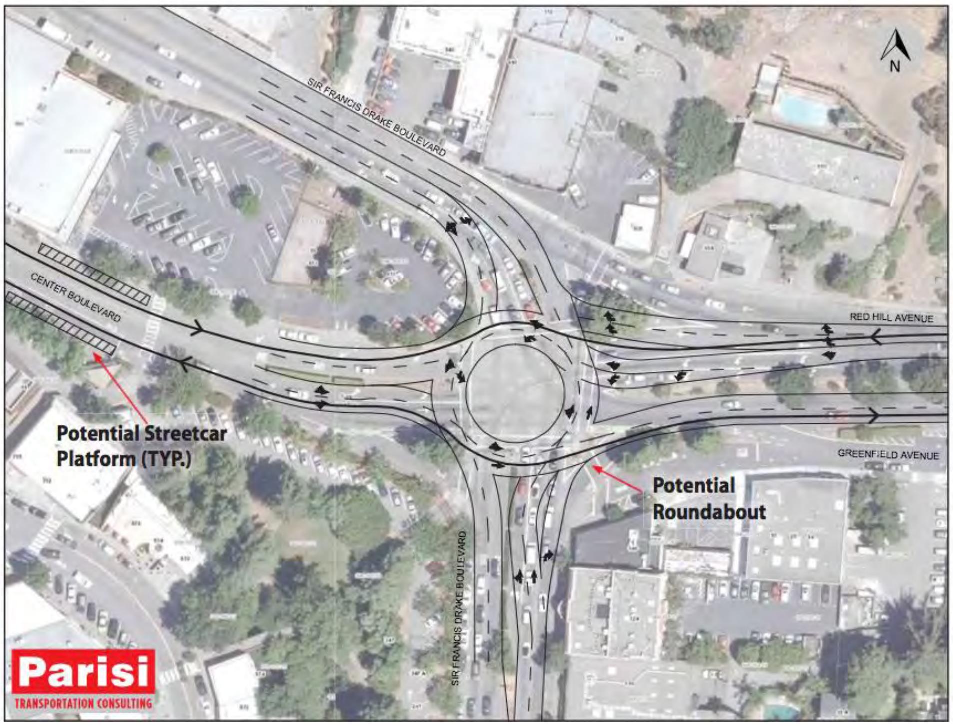


Figure 4-2 Potential Bus Turn-Around via Pacheco Avenue and Sir Francis Drake Boulevard (Low Investment Alternative Only)

San Anselmo

Figure 4-3 Potential Bus or Streetcar Queue Jumper Lane on Center Boulevard (example)

Figure 4-4 Potential Bus or Streetcar Routing Through Roundabout at the Hub



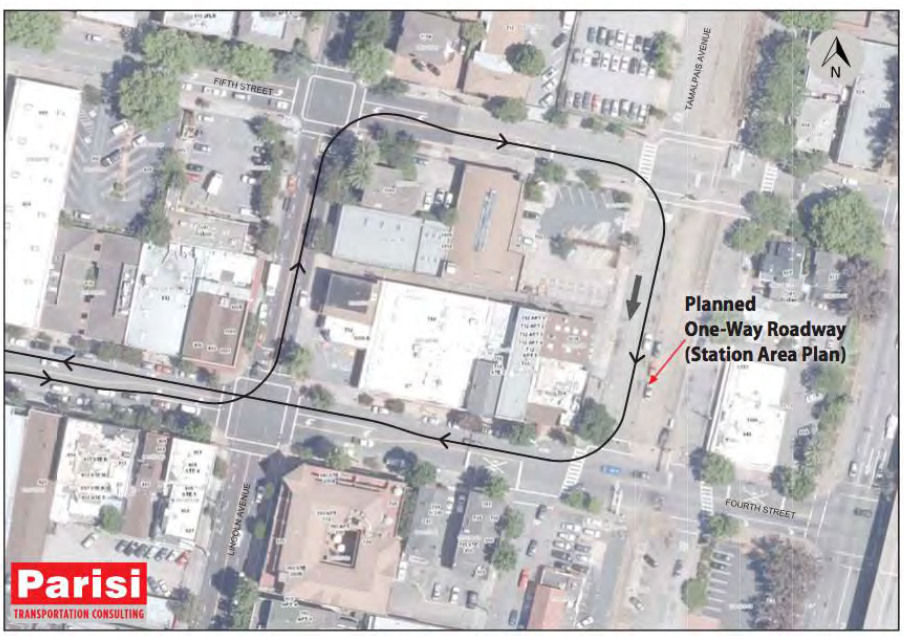
Miracle Mile

Figure 4-5 Potential Bus or Streetcar Routing in Outside Lane on Fourth Street/Miracle Mile in San Rafael

San Rafael

Figure 4-6 Potential Bus Routing on Second and Third Streets (Low Investment Only)

Figure 4-7 Potential Streetcar Turn-Around at Tamalpais Avenue and Fifth Street (High Investment Only)



Multimodal Impact Assessment

In part using the alignment drawings, the project team completed a high-level assessment of the impact of each feasible alternative on other modes, including pedestrians, bicyclists, and motorists, as well as on other activities taking place in the corridor such as existing transit service, parking, and truck loading. Figure 4-8 shows potential impacts that could result from the low investment (enhanced bus) and high investment (streetcar) alternatives at the most challenging corridor locations, rated on a scale of Low, Medium, or High potential impact.

An example of an alignment with a medium impact is the Bank Street Turnaround high investment alternative, which would affect the parking supply in downtown Fairfax. Likewise, a turnaround at Third Street in San Rafael would have a high impact on motorists because the track alignment would be located in the left lane and thereby affect traffic operations. A full set of detailed multimodal impacts is provided in Appendix F.

Figure 4-8 Summary of Multimodal Impacts of Two Feasible Alternatives

		Considerations / Impacts for High Investment						Considerations / Impacts for Low Investment					
Jurisdiction	Location/ Alternative	Pedestrians	Bicyclists	Transit Interface	Motorists	Parking	Truck Loading	Pedestrians	Bicyclists	Transit Interface	Motorists	Parking	Truck Loading
Fairfax	Bank Street Turnaround	Low	Low	Low	Low	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A
	SFD Turnaround	N/A	N/A	N/A	N/A	N/A	N/A	Low	Low	Low	Low	Low	Low
	Bolinas Road Turnaround	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Merwin Ave Turnaround	Low	Low	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	East of Lumberyard Turnaround	Low	Low	Low	Low	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A
San Anselmo	Center Blvd. Queue Jump	Medium	Low	Low	Low	Low	Low	Medium	Low	Low	Low	Low	Low
	Center and San Anselmo	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Center/San Anselmo Roundabout	Low	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Hub	Low	Low	Low	Medium	Medium	Low	Low	Low	Low	Medium	Medium	Low
	Hub Roundabout	Low	Medium	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low
	Median Lane	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
San Rafael	Fourth/Miracle Mile Outside	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
	Fourth/Miracle Mile Inside	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
	Fourth Street	Low	Low	Medium	Low	Medium	Medium	Low	Low	Low	Low	Medium	Medium
	Second and Third Street	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
	Fifth Street Turnaround	Low	Low	Low	Medium	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	Third Street Turnaround	Low	Low	Low	High	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	Tamalpais Ave Turnaround	Low	Low	Low	Medium	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A

5 RIDERSHIP ESTIMATES

This chapter summarizes the ridership forecasts developed for the Fairfax-San Rafael Corridor Transit Feasibility Study. Forecasts were developed for both the low investment (enhanced bus) alternative and the high investment (streetcar) alternatives. The low investment (enhanced bus) alternative is assumed to use enhanced bus technology, and would be 5.85 miles from end to end, running between Fairfax and the Canal. The high investment (streetcar) alternative is assumed to use streetcar technology and would be 4 miles from end to end, running between Fairfax and the San Rafael Transit Center.

Many factors influence transit ridership, including population and employment densities along the transit corridor, connecting transit, competing transit, vehicle technology, vehicle comfort, travel time, frequency of service, service span, reliability, ease of boarding, and other on-board or station area amenities. These factors were evaluated when developing the ridership forecasts for the two alternatives.

A key difference between the low and high investment (streetcar) alternatives evaluated in the ridership analysis are low investment (enhanced bus) alternative high investment (streetcar) alternative tied to the assumption of streetcar operation in the high investment (streetcar) alternative. Because streetcar tracks would not be able to cross the SMART tracks at the San Rafael Transit Center (SRTC the high investment (streetcar) alternative has a shorter alignment with a round trip length of 8 miles and does not serve the Canal area. The low investment, enhanced bus alternative does serve the Canal area and therefore has a longer alignment of 11.7 miles round trip, and correspondingly higher ridership.

METHODOLOGY

The ridership forecasting analysis builds off of the travel market analysis conducted for the travel market assessment and existing ridership data from Marin Transit and Golden Gate Transit. The analysis used outputs from the MTC Model to evaluate both overall travel and transit travel along the study corridor. Transit travel estimates were then compared to existing transit demand in order to make adjustments to the initial model results. Transit trips were then assigned to each alternative, taking into consideration connecting and competing transit. Ridership forecasts were then adjusted to account for the increased frequency of the new alternatives and other enhancements or amenities such as added comfort, more attractive vehicle technology, ease of boarding, and off-board fare payment.

Factors Influencing Ridership

Many factors influence transit ridership including population and employment densities along the transit corridor, connecting transit, competing transit, vehicle technology, vehicle comfort, travel time, frequency of service, service span, reliability, ease of boarding, and other on-board or station area amenities. A comparison of these factors between the two alternatives is provided in Figure 5-1.

Figure 5-1 Factors that Influence Ridership for Proposed Transit Alternatives

	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
Population and Employment Density	Higher – longer route, includes Canal (higher ridership potential)	Lower – shorter route, does not include Canal
Connecting Transit	SMART, Marin Transit, Golden Gate Transit	SMART, Marin Transit, Golden Gate Transit
Competing Transit	More competing transit between SRTC and the Canal, which is already well-served by transit	Some competing transit but at very low frequencies
Vehicle Comfort	Good comfort level	High comfort level (higher ridership potential)
Vehicle Technology	Enhanced bus	Streetcar (higher ridership potential)
Stations	Lower investment in station design, wayfinding and amenities	Higher quality station design, wayfinding and amenities (higher ridership potential)
Fare Payment	On-board fare payment only	Both on-board and off-board fare payment options (higher ridership potential)
Ease of Boarding	Near-level boarding	Level boarding (higher ridership potential)
Travel Time	No major differences between alternatives	
Frequency	No major differences between alternatives – 4 transit vehicles/hour (15 minute headways)	
Service Span	No major differences between alternatives	

Both alternatives have a similar level of connecting transit and will both serve as a connection point to SMART at the SRTC, which will increase ridership potential. Competing transit is discussed in more detail in the following section. Some competing transit currently serves the corridor between Fairfax and the SRTC, particularly Marin Transit Route 23, however current service frequencies along this portion of the corridor are much lower (60 min headways) compared to the proposed transit alternatives which would provide 15 minute headways. The increase in service frequency would increase ridership potential for both alternatives. However, the segment of the corridor between the SRTC and the Canal, which would only be served by the low investment (enhanced bus) alternative, is currently well-served by transit, so the added service would have a smaller proportional impact on increasing ridership.

The high investment (streetcar) alternative would have several attributes making it more attractive than the low investment (enhanced bus) alternative, including: higher level of vehicle comfort; more attractive vehicle technology (streetcar); higher quality station design, wayfinding and amenities; off-board fare payment; and easier boarding.

While the high investment (streetcar) alternative provides several measures to reduce travel time, including transit only lanes, queue jump lanes, and transit signal priority, it also has more stops between Fairfax and the SRTC than the low investment (enhanced bus) alternative. Adding stops would increase travel time across the corridor. Therefore the travel time enhancement measures applied along the high investment (streetcar) alternative would balance the increased travel time due to more frequent stops of the high investment (streetcar) alternative. The net effect is that the travel time between the two alternatives would be comparable. Therefore no ridership increases due to travel time savings were applied to either alternative.

Similarly, while increases in service span (hours per day the transit service is in operation) would increase ridership potential, since both alternatives would provide the same service span, no increases in ridership due to service span were applied to either alternative.

RESULTS

Since the alignment of the low investment (enhanced bus) alternative is longer than that of the high investment (streetcar) alternative, the section of the low investment (enhanced bus) alternative running between Fairfax and the San Rafael Transit Center was evaluated separately in order to make an apples to apples comparison with the high investment (streetcar) alternative ridership forecasts. A summary of the daily ridership forecasts is provided in Figure 5-2.

Figure 5-2 Daily Ridership Forecasts

Alternative	Study Segment	Daily Boardings	Daily Boardings per Route Mile	Route Miles
Low Investment (Enhanced Bus) Alternative (partial route)	Fairfax – San Rafael Transit Center	1,400 – 1,800	180-230	8.0
High Investment (Streetcar) Alternative (full route)	Fairfax – San Rafael Transit Center	1,690 – 2,200	210-270	8.0
Low Investment (Enhanced Bus) Alternative (full route)	Fairfax – The Canal	3,300 – 3,900	280 - 330	11.7

The high investment (streetcar) alternative is forecast to have between 1,690 – 2,200 daily boardings. This is approximately 22 percent higher than the ridership that would be expected if the same portion of the alignment were served by the low investment (enhanced bus) alternative. Rail service is viewed as being more attractive than bus service, adding a certain rail attractiveness factor which can provide a bump in ridership. Research on ways to quantitatively measure this "bump" is limited. The ridership forecasts in this report incorporate a streetcar attractiveness factor based on an equivalent in-vehicle travel time reduction value (described in more detail in the following section). This represents the additional amount of travel time travelers would be willing to spend on a streetcar rather than on a bus or in a car. When forecasting ridership, this value was applied to the streetcar alternative, reducing the (perceived) travel time of travelers, and making the streetcar alternative more competitive with auto, thus shifting travelers in the corridor from car to streetcar and therefore "bumping" streetcar ridership. This factor was only applied for the streetcar mode, which explains why the high investment (streetcar) alternative has higher ridership forecasts than the low investment (enhanced bus) alternative for this segment.

For the full alignment, the low investment (enhanced bus) alternative is forecast to have 3,300 – 3,900 daily boardings. Ridership on this alignment is expected to be much higher because the route would serve the Canal area, which was identified in the travel market analysis as an area with high transit likelihood due to its density of households, low income residents and lower car ownership rates. Existing ridership data also confirms tht transit ridership in this area is high, so it is expected that providing enhanced, more frequent service will attract many riders in this area, although many may be existing riders who would shift from using other services. Therefore, extension of service into the Canal area is seen as extremely beneficial from a ridership perspective.

These forecasts are in line with daily boardings per mile of similar existing systems. Streetcar systems in Little Rock, Memphis and Tampa have average daily boardings per route mile of 40-290. This is in the same range as the forecast daily boardings per route mile for the high investment (streetcar) alternative of 210-270. These boarding rates per route mile are lower than ridership levels seen on streetcars in Seattle, Portland and Tacoma. Streetcars in these three cities serve areas with much higher employment and residential densities as well as numerous activities centers or special generators.

Rapid bus routes operated by AC Transit (in Alameda and Contra Costa counties) and in Seattle have average daily boardings per route mile of 260-350. This is a similar range as the forecast daily boardings per route mile for the full alignment of the low investment (enhanced bus) alternative of 280-330.

Market Segments

Ridership forecasts were broken down by various market segments in order to get a better idea of ridership differences by time of day and by location.

Peak vs. Off-Peak

Transit ridership is generally highest during peak periods, primarily because these are the times when most people are commuting to or from work. Most Golden Gate Transit service is actually only in operation during peak periods, with a heavy focus on serving the commuter market between the North Bay and San Francisco. Marin Transit service has historically been less commuter-focused, and rider surveys have found that a higher share of Marin Transit riders have a trip purpose other than work, than for Golden Gate Transit riders.[12]

However, the enhanced transit features of the proposed alternatives and higher service frequencies, paired with the opening of SMART are expected to increase the commuter market and peak period ridership along the corridor. As transit service along the corridor is improved, more commuters are expected to shift from driving to taking transit. Furthermore, the opening of SMART will provide a more attractive transit alternative to driving for commute trips between the SMART corridor and the study corridor. The proposed alternatives would provide a first or last mile connection with SMART at the SRTC.

Figure 5-3 summarizes the peak and off-peak period ridership on the two alternatives. The peak period includes both the AM peak period (6-10AM) and the PM peak period (4-8PM). For both the low and high investment (streetcar) alternative on the study segment between Fairfax and the SRTC, approximately 76 percent of daily boardings are expected to occur during these peak periods, which include eight hours of the day. For the full alignment of the low investment

[12] Marin Transit 2012 Systemwide Onboard Survey, Golden Gate Transit 2013 Passenger Study Final Survey Findings Report

(enhanced bus) alternative, approximately 72 percent of daily boardings are expected to occur during the peak period.

Figure 5-3 Peak vs. Off-Peak Ridership

Alternative	Study Segment	Peak Period Boardings (6-10AM and 4-8PM)	Off-Peak Boardings (10AM-4PM and after 8PM)
Low Investment Alternative	Fairfax – San Rafael Transit Center	1,100 – 1,400	320 - 430
High Investment Alternative	Fairfax – San Rafael Transit Center	1,300 – 1,650	390 – 520
Low Investment Alternative	Fairfax – The Canal	2,400 – 2,800	940 – 1,100

Geographic Markets

Geographic markets were evaluated in order to evaluate where people would travel to and from and to get a sense of the overall transit market share and the transit market share of the proposed alternatives. The geographic markets evaluated were: 1) within the study corridor meaning riders have both an origin and destination within the study corridor, 2) between the SMART corridor and the study area, 3) between San Francisco and the study area, and 4) between the East Bay and the study area.

For each geographic market, all trips being made by transit on any provider (including Marin Transit, Golden Gate Transit and SMART) were reviewed and compared to all travel between those geographic market areas in order to estimate the share of travel that would be made on transit. The share of overall transit which would be made on the proposed alternatives was also reviewed and compared to all travel in order to estimate the alternative's share of overall travel for each geographic market. These results are summarized in Figure 5-4 and Figure 5-5.

Figure 5-4 summarizes the results for the entire alignment of the low investment (enhanced bus) alternative from Fairfax to the Canal. For trips with both an origin and destination within the study corridor, approximately 3,500 are forecast to be made on transit, which about 2 percent of all trips. About half of these transit trips would be on the low investment (enhanced bus) alternative. The other half of transit trips would be made on one of the other transit routes serving the area, most of which would likely be on Marin Transit Route 35, which would serve the high demand corridor between the SRTC and the Canal and at the same frequency as the low investment (enhanced bus) alternative. Therefore riders traveling between these two locations would likely take which ever vehicle comes first once they arrive at the stop.

Between SMART station areas and the study corridor, approximately 3,600 daily trips are forecast to be made on transit, which is about 18 percent of all trips. This high transit share indicates the high level of competitiveness SMART has with auto. Approximately 35 percent of these transit trips are forecast to be made on the low investment (enhanced bus) alternative, nearly all of which would be expected to use the low investment (enhanced bus) alternative as a first or last mile connection, transferring to or from SMART at the SRTC.

Between San Francisco and the study corridor, approximately 5,500 daily trips are forecast to be made on transit, which is about 24 percent of all trips. This high transit share indicates the high level of competitiveness between Golden Gate Transit and auto. Approximately 9 percent of these transit trips are forecast to be made on the low investment (enhanced bus) alternative, nearly all of which would be expected to use the low investment (enhanced bus) alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor could likely board a Golden Gate Transit route directly without needing to transfer.

Between the East Bay and the study corridor, approximately 1,150 daily trips are forecast to be made on transit, which is about 4 percent of all trips. This low transit share indicates the low level of competitiveness between Golden Gate Transit and auto between these locations. Approximately 6 percent of these transit trips are forecast to be made on the low investment (enhanced bus) alternative, nearly all of which would be expected to use the low investment (enhanced bus) alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor would likely either board a Golden Gate Transit route directly without needing to transfer or would not take transit if a transfer were needed.

Figure 5-4 Geographic Market Share: Low Investment Alternative

Geographic Market	Description	All Transit Providers	low investment (enhanced bus) alternative
Within Study Corridor	Daily transit trips with both an origin and destination within the study corridor	3,500	1,700 – 1,900
	Share of all trips with both an origin and destination within the study corridor	2%	1%
SMART Station Areas	Daily transit trips between study corridor and SMART Station areas	3,600	1,200 – 1,300
	Share of all trips between study corridor and SMART Station areas	18%	6%
San Francisco	Daily transit trips between study corridor and San Francisco	5,500	300 – 700
	Share of all trips between study corridor and San Francisco	24%	2%
East Bay	Daily transit trips between study corridor and East Bay	1,150	50-90
	Share of all trips between study corridor and East Bay	4%	0.3%

* Study corridor includes the Canal

Figure 5-5 summarizes the results for the alignment of the high investment (streetcar) alternative from Fairfax to the SRTC. For trips with both an origin and destination within the study corridor, approximately 800 are forecast to be made on transit, which about 1 percent of all trips. The majority, about 80 percent of these transit trips, would be on the high investment (streetcar) alternative.

Between SMART station areas and the study corridor, approximately 2,200 daily trips are forecast to be made on transit, which is about 18 percent of all trips. This high transit share indicates the high level of competitiveness SMART has with auto. Approximately 34 percent of these transit trips are forecast to be made on the high investment (streetcar) alternative, nearly all of which would be expected to use the high investment (streetcar) alternative as a first or last mile connection, transferring to or from SMART at the SRTC.

Between San Francisco and the study corridor, approximately 4,200 daily trips are forecast to be made on transit, which is about 25 percent of all trips. This high transit share indicates the high level of competitiveness between Golden Gate Transit and auto. Approximately 10 percent of these transit trips are forecast to be made on the high investment (streetcar) alternative, nearly all of which would be expected to use the high investment (streetcar) alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor could likely board a Golden Gate Transit route directly without needing to transfer.

Between the East Bay and the study corridor, approximately 550 daily trips are forecast to be made on transit, which is about 4 percent of all trips. This low transit share indicates the low level of competitiveness between Golden Gate Transit and auto between these locations. Approximately 17 percent of these transit trips are forecast to be made on the high investment (streetcar) alternative, nearly all of which would be expected to use the high investment (streetcar) alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point.

Figure 5-5 Geographic Market Share: High Investment Alternative

Geographic Market	Description	All Transit Providers	High Investment (Streetcar) Alternative
Within Study Corridor	Daily transit trips with both an origin and destination within the study corridor	800	600 – 700
	Share of all trips with both an origin and destination within the study corridor	1%	1%
SMART Station Areas	Daily transit trips between study corridor and SMART Station areas	2,200	720 – 760
	Share of all trips between study corridor and SMART Station areas	18%	6%
San Francisco	Daily transit trips between study corridor and San Francisco	4,200	300 – 590
	Share of all trips between study corridor and San Francisco	25%	3%
East Bay	Daily transit trips between study corridor and East Bay	550	70 – 120
	Share of all trips between study corridor and East Bay	4%	0.7%

* Study corridor does not include the Canal

Transit Dependent vs. Choice Riders

What are commonly referred to as choice riders are those riders who have an alternative to taking transit (typically auto) but choose to take transit. Transit dependent riders, on the other hand, are those who are largely dependent on transit. Transit dependency of Marin Transit was evaluated in the Travel Market Assessment based on responses of riders to an on-board survey. According to the survey, approximately 47 percent of Marin Transit Route 23 riders do not have an alternative to transit for trips made on transit, and 37 percent do not have access to a car. Furthermore, 75 percent of Route 23 riders are low income, earning less than $50,000 per household. These results show that a large share of current transit riders in the study corridor are transit dependent. It is likely that most transit dependent riders are already using the services available and that enhancements to this service may not be able to attract a large number of new transit dependent riders. However, service enhancements would have the potential to attract more choice riders to shift from driving to taking transit.

In order to estimate the number of choice versus transit dependent riders on the new alternatives, we assumed that 70 of riders, before enhancements, are transit dependent. Remaining riders and riders gained through frequency and premium service enhancements would be choice riders.

Table 4-6 summarizes the number of transit dependent and choice riders on each alternative. While currently, at baseline, we estimate that about 30 percent of daily riders are transit dependent (either have no alternative to transit, not access to a car, or are low income), under the high investment (streetcar) alternative it is expected that the percent of daily riders who are choice riders would increase to approximately 52 percent. Across the full length of the low investment (enhanced bus) alternative, it is expected that the percent of riders who are choice riders would increase to 38 percent of daily riders.

Figure 5-6 Transit Dependent vs. Choice Ridership

Alternative	Study Segment	Choice Rider Daily Boardings	Transit Dependent Rider Daily Boardings
Low Investment Alternative	Fairfax – San Rafael Transit Center	600 - 800	800 – 1,050
High Investment Alternative	Fairfax – San Rafael Transit Center	850 – 1,200	800 – 1,050
Low Investment Alternative	Fairfax – The Canal	1,250 – 1,500	2,050 – 2,400

Corridor Ridership Benefits

Provision of enhanced transit service would have benefits for the entire transit corridor. The new service would not only provide benefits to existing riders, but would also attract new riders and increase ridership on other transit services by providing better connections. This section describes the net new riders expected on the corridor, and the ridership benefits to Golden Gate Transit service.

Total New Transit Trips

Many of the riders served on the two alternatives would be existing riders who would shift from taking the current Marin Transit 23 (which is assumed to be discontinued with implementation of either proposed alternative) or from other existing routes. However, the enhanced service would also attract new riders who would shift from driving to taking transit. Figure 5-7 summarizes the net new transit riders forecast to be generated by the new service. The low investment (enhanced bus) alternative is expected to generate 380-460 new transit trips per day. The high investment (streetcar) alternative is expected to generate 520 – 680 new transit trips per day.

Figure 5-7 New Transit Trips Generated

Alternative	Net New Transit Trips
Low Investment Alternative	380 – 460
High Investment Alternative	520 - 680

Benefits to GGT Routes

Many riders would use the proposed alternatives to connect to Golden Gate Transit. Figure 5-4 and Figure 5-5 show the number of trips on each alternative that would be traveling between the study corridor and San Francisco and between the study corridor and the East Bay. Nearly of of these trips would be expected to include a transfer to Golden Gate Transit in order to reach San Francisco or the East Bay. Many of these would be existing riders who are currently making this trip. Figure 5-8 shows the new riders expected to be riding Golden Gate Transit as a result of the enhanced transit service on the proposed alternatives. Golden Gate Transit could expect 50-100 additional daily boardings on San Francisco routes with the low investment (enhanced bus) alternative and 10-20 additional daily boardings on East Bay routes. With the high investment (streetcar) alternative, Golden Gate Transit could expect 90-190 additional daily boardings on San Francisco routes and 30 – 50 additional daily boardings on East Bay routes.

Figure 5-8 New Transit Trips Generated on GGT Routes

Alternative	Net New Transit Trips on San Francisco Routes	Net New Transit Trips on East Bay Routes
Low Investment Alternative	50-100	10-20
High Investment Alternative	90-190	30-50

6 TECHNOLOGY ASSESSMENT

This chapter provides a high-level review of streetcar technology options, potential costs, risks, and other considerations to take into account when evaluating the high investment alternative, or any future proposal for streetcar service in Marin County. This alternative would be an investment in longer term infrastructure that would have higher up-front capital costs than a bus service, but would be more permanent, with a 30-plus year life expectancy.

The implementation of a streetcar system would include vehicles, rails, and power-delivery systems. A maintenance facility would be located in close proximity to the alignment, preferably within three or four blocks to minimize the amount of rail and electrical infrastructure that is not part of the route.

This chapter summarizes the types of streetcar vehicles and power delivery technologies that are currently available, the trade-offs involved with different power systems, the requirements for maintenance facilities, and other specific issues that should be considered for the Fairfax-San Rafael corridor.

Additional details are available in **Appendix G: Streetcar Technology White Paper**.

STREETCAR VEHICLE TECHOLOGY

Streetcars in the US are typically operated in mixed traffic environments and used for local circulation and short trips in downtown areas. US streetcars are generally not used for longer-distance regional travel, like light rail or commuter rail systems are, and are often used as feeder routes to larger regional routes. Generally, there are two types of streetcar vehicles: vintage and modern.

- **Vintage Streetcars.** Several systems in the US utilize vintage streetcar vehicles, either restored heritage vehicles or newly manufactured replica vehicles. Most of these tend to be on tourist-oriented systems, such as the San Francisco F Line, the Little Rock River Rail Streetcar, the Memphis Trolley, or the TECO Line in Tampa. The San Francisco F Line utilizes a diverse range of restored historic streetcar vehicles from around the world, while the Tampa streetcar utilizes modern replica vehicles.
- **Modern Streetcars.** Modern streetcar vehicles are similar to light rail vehicles (LRVs), but are generally shorter, lighter, and narrower. This gives them greater flexibility to maneuver in more constrained urban environments with mixed traffic. Streetcar vehicles are typically 8 feet wide and in the range of 65 to 75 feet long. This makes them better suited to operation in narrow traffic lanes and navigation of tighter radius turns. They are typically not coupled together like LRVs.

Typically, power-delivery systems for streetcars consist of overhead wires and substations along the full length of the alignment. However, there are a number of developing alternatives to overhead wires, and some of the newest US streetcar systems under-construction or in planning are moving towards technologies that include on-board energy storage to enable off-wire operation. Other new technologies, including underground charging and hydrogen fuel cell on-board generators, are in various stages of development.

Figure 6-1 summarizes vehicles available, US experiences of major vehicle manufacturers, the off-wire technologies available, costs, and potential risks. Please see Appendix G: Streetcar Technology White Paper, for additional details on specific streetcar vendors.

Figure 6-1 Summary of Available Streetcar Vehicles

Manufacturer	Current US Experience	Off-Wire Technology	Vehicle Cost	Risk Factors	Applicability to Fairfax-San Rafael Corridor
Modern Streetcars					
Inekon	Provided several vehicles for Portland and Seattle. Off-wire capable vehicles for Seattle currently in testing	Partial off-wire using batteries.	Recently purchased off-wire capable vehicles for Seattle approximately $4.5 million each.	Low to moderate risk. Foreign made. May be issues meeting Buy America standards. Potential for supply chain issues.	High
Brookville (Modern & Vintage Replica)	Provided 2 off-wire capable vehicles for Dallas streetcar. Currently in operation	Partial off-wire using batteries.	$4.5 million each for Dallas. $5 million each for Detroit M-1. streetcar $6 million each for Oklahoma City.	Low risk. US company with experience providing off-wire vehicles.	High
CAF USA	Providing vehicles for Cincinnati and Kansas City streetcars.	Partial off-wire using batteries.	$4.2 million each for Cincinnati. $4.5 million each for Kansas City.		Low. May be too wide.
Siemens	Provided streetcar vehicles for Atlanta and Salt Lake City streetcars. Extensive light rail experience.	Partial off-wire using batteries.	$3.6 to $4.2 million each for Salt Lake City.	Low risk. Well established company with extensive US experience.	Low. May be too wide.

Manufacturer	Current US Experience	Off-Wire Technology	Vehicle Cost	Risk Factors	Applicability to Fairfax-San Rafael Corridor
Bombardier	Extensive light rail experience. No current streetcar experience.	Partial off-wire using batteries. PriMove inductive charging system.	(no existing vehicles)	Low risk. Well established company with extensive US experience.	Low.
Alstom	No US streetcar experience. Providing LRVs for Ottawa.	In-ground power delivery via central power rail.	(no U.S. purchases)	High risk for in-ground power delivery system. May be issues meeting Buy America standards.	Low.
Ansaldo-Breda	Light rail and heavy rail. No US streetcar experience.	In-ground power delivery via central power rail.	(no US purchases)	High risk for in-ground power delivery system. May be issues meeting Buy America standards.	Low.
Vintage Replica Streetcars					
TIG/m (Modern vehicle in development.)	Limited. Current examples at malls on private property.	Full off-wire, self-propelled vehicles using batteries and on-board CNG, LNG, or hydrogen fuel cell generator.	Quoted price of $3.4 million for modern streetcar vehicle that has not yet been produced. Approximately $1 million per four vehicles for hydrogen refueling station.	High risk. Newest technology, not yet proven in long term use. Modern streetcar vehicle not yet produced.	Low to moderate if there is a community desire to be a pioneer in a new technology.

Due to the existence of relatively narrow lanes in the corridor, the narrower Inekon and Brookville vehicles would likely be the most appropriate. Wider vehicles could be used, but would likely require elimination of the bike lanes on Center Boulevard. Vintage streetcar vehicles could also be used if there is a desire for a vintage style system. However, if the primary purpose of the project is to provide improved mobility for multiple trip types, including commuter travel, then the modern, low-floor vehicles would offer the greatest capacity and comfort as well as efficient operation.

The self-propelled hydrogen powered vehicles made by TIG/m (a California-based company) are an intriguing option. This option offers a high degree of flexibility in terms of both planning and operation, as the vehicles generate their own power through on-board batteries. Negating the need for overhead wires, which cost $2 million to $3.6 million per mile, could also generate substantial cost savings. Emerging battery technology thus offers a great deal of promise.

Because the technology is so new and the company still has a limited track record, the actual costs are as yet unclear. At this point, the technology would represent a high risk for the Fairfax-San Rafael corridor. This may, however, change prior to projet implementation, if TIG/m technology is successfully implemented in a similar (U.S., on-street) environment.

STREETCAR POWER SOURCES

Streetcar systems have traditionally been powered by overhead wires, known as an Overhead Contact System (OCS), made up of overhead wires supported by poles located on the side of the roadway, and Traction Power Sub-Stations (TPSS) located approximately every mile. The streetcar vehicle connects to the OCS wires via a pantograph located on top of the vehicle and draws power.

Propulsion system technologies have improved in recent years, including improvements to energy storage technology enabling smaller lithium-ion battery packs to hold larger charges for longer periods as well as rapid charging systems. This section describes some of the available off-wire technology options and discusses the associated trade-offs.

Traditional OCS Systems

Traditional traction electrification systems utilizing OCS have been in use over the past 120 years. These systems are designed to maintain a consistent line voltage within a specified range over the length of a streetcar route. OCS has become the standard means of providing traction electrification for streetcar and light rail systems worldwide.

Capital costs for streetcar systems vary widely and every project is unique. OCS systems typically make up a significant portion of the total capital costs. In general, the largest cost items for a streetcar project are the construction of the embedded rail in the roadway, the OCS system, vehicles, utility relocation, and the maintenance facility.

Recent streetcar projects in the US have been constructed with costs for OCS power systems (including wires, poles, and substations) of between approximately $400 and $700 per track foot. This translates to rough typical OCS costs in the range of approximately $2 million to $3.6 million per mile of one-way track. The OCS poles, wires, and substations all require ongoing maintenance as well.

OCS with Partial Off-Wire Capability

Traditionally, one of the most significant ongoing operating expenses for streetcar and light rail systems is energy use. Modern vehicles with modern climate control systems utilize significantly more energy than older systems. The passenger rail industry has made significant advances in weight reduction and energy saving technologies in recent decades.

The most mature energy saving technology for rail vehicles is energy recovery through regenerative braking. This technology enables the wheels to act as electricity generators while the vehicle is braking. This electricity can be redistributed back through the OCS wires to be utilized by other streetcar vehicles on the system. This energy recovery system is particularly well suited for urban public transportation systems because they are continuously accelerating and decelerating as they serve stations and navigate urban traffic.

On-Board Energy Storage Systems (OESS), utilizing either batteries or capacitors, offer the ability for recovered energy to be stored on board the vehicle. They also offer the ability to travel off-wire for short segments of the route. As battery storage technology has improved, the ability to travel longer distances off-wire has increased.

The primary reasons for utilizing off-wire capable vehicles to date have been concerns about aesthetics of overhead wires and physical constraints due to low vertical clearance. Off-wire capable systems offer potential for capital and maintenance cost savings. However, because these systems are new and there is relatively limited experience using them, their potential to provide cost savings over the life of a streetcar project are not yet well understood. Currently, the potential savings in infrastructure costs are largely offset by ongoing vehicle maintenance costs related to regular battery replacement.

Figure 6-2 summarizes the trade-offs of the various streetcar technologies.

Figure 6-2 Summary of Streetcar Power Sources: Costs, Risks, and Trade-Offs

Technology	Costs	Availability/ Flexibility	Risks	Applicability to Fairfax-San Rafael Corridor
Traditional OCS	Rough estimate: $2 million to $3.6 million per mile of one-way track for poles, wires, and substations. Actual cost varies significantly depending on local conditions.	Widely available from multiple suppliers.	Very low risk. Well known technology.	Very applicable.
Partial Off-Wire with On-Board Energy Storage	Somewhat higher costs for vehicles and ongoing costs for battery replacement. Cost savings due to less OCS infrastructure probably outweighed by ongoing battery replacement costs.	Somewhat limited availability, but increasing as technology becomes more standard. Potentially reduces operational flexibility.	Modest. Increasingly becoming a standardized technology.	Moderately applicable. Could be utilized if there is a community desire to reduce aesthetic impacts.
Ground-Level Power Systems	New technology. Likely not less expensive than OCS.	New and proprietary technology. Only available from certain suppliers. Good operational flexibility because vehicles would always be connected to a power source.	High risk because it is a new and proprietary technology. Controversial due to perceived potential for safety hazards.	Not applicable.
Self-Propelled Operation	New technology with potential for cost savings due to reduced power supply infrastructure. Actual costs not clear.	New and proprietary technology. Only available from one supplier. Good operational flexibility because vehicle does not need to be connected to a power source. California company.	High risk because it is a new and proprietary technology.	Potentially applicable if there is a community desire to be a pioneer in a new technology.

The lowest risk power delivery technology is a traditional OCS-powered system with overhead wires, poles, and substation equipment that are widely available from multiple suppliers. Partial off-wire with on-board energy storage is increasingly feasible with nearly every major streetcar manufacturer offering this equipment. This could be a good option for the Fairfax-San Rafael corridor if there is a community desire to minimize aesthetic impacts along sections of the route, such as in downtown Fairfax, downtown San Rafael, or along the tree lined residential streets between Fairfax and San Anselmo.

In-ground power delivery would likely not make sense for the Fairfax-San Rafael corridor. The technology is so new and not yet tested, that it would pose substantial risks of delays and cost overruns.

MAINTENANCE FACILITY CONSIDERATIONS

A streetcar maintenance facility is similar to a light rail maintenance facility. The most pertinent differences are related to the dimensions of the vehicles and the size of the vehicle fleet. A streetcar maintenance facility is generally smaller than a light rail maintenance facility. This is largely because light rail systems typically include a much larger fleet of vehicles than streetcar systems and require much larger yards for storage. Current US streetcar systems have maintenance facilities that generally are of a scale that they fit on a typical city block and can be designed to fit in with the surrounding neighborhood.

A fleet of six to eight vehicles has been estimated for the four mile Fairfax-San Rafael corridor. A maintenance facility to accommodate this size of a fleet would need a building of approximately 15,000 to 20,000 square feet and a site of approximately one to two acres. It is also important to locate a facility that is close enough to the route to minimize the amount of non-revenue track that would need to be constructed to move streetcar vehicles between the route and the maintenance facility.

Staffing at a maintenance facility of this size would likely be approximately 20 to 25 employees, including drivers, mechanics, dispatchers, and supervisors.

Site selection for a maintenance facility needs to consider the size of the facility, the topography of the site, the distance from the route, and the zoning. Generally streetcar maintenance facilities need to be located in industrial or commercial zones and away from residential areas. Streetcar maintenance facilities are generally active through the night, as many daily vehicle maintenance activities occur after revenue service ends. Streetcar maintenance facilities are generally best suited to relatively flat sites, but can be designed with multiple levels to fit on steeply sloped sites.

It may be challenging to locate a streetcar maintenance facility in the Fairfax-San Rafael corridor. Much of the corridor is residential and the historic downtown centers of Fairfax, San Anselmo, and San Rafael would not likely be appropriate fits for a maintenance facility. However, a streetcar maintenance facility to support the Fairfax-San Rafael corridor would be relatively small and could be designed in a manner that fits in with the surrounding neighborhood. If carefully designed, a streetcar maintenance facility can blend in with the surrounding neighborhood in such a way that it is not a noticeable presence from the street or the surrounding neighborhood. It can be incorporated into the designs of other developments, placed behind other buildings, or otherwise screened off or tucked away.

It is also important to consider potential future phases when determining the size and location needs of a maintenance facility. Typically the building needs to accommodate two vehicles at a time while they're being serviced. The site needs to be large enough to accommodate storage and marshalling of the entire vehicle fleet. If there is a foreseeable extension of the streetcar system, it may make sense to select a site with room to expand.

RELEVANT REGULATIONS

In addition to California and local traffic codes and regulations that would apply to either a bus or a streetcar alternative, the streetcar would be subject to regulation by the California Public Utilities Commission (CPUC). The CPUC regulates safety issues related to railroads and has jurisdiction over railroad crossings. As an in-street railroad operating in mixed traffic, the CPUC would have an interest in several aspects of a streetcar project, including vehicle speeds, vehicle safety equipment, overhead or in-ground electrical supply equipment, etc.

CPUC General Order 143-B, Safety Rules and Regulations Governing Light-Rail Transit,[13] would apply to a streetcar project. General Order (GO) 143-B was originally adopted in 1991. The most recent amendment was in 2000. The GO was written to accommodate light rail vehicles traveling primarily in exclusive right-of-way. It defines streetcar as light rail transit operating in mixed traffic.

There are several light rail and heavy rail (commuter rail or metro system) systems in operation in California. All of these are regulated by GO 143-B. Several communities in California have plans to introduce new modern streetcar systems, but none have yet been implemented. These include Sacramento, Los Angeles, Santa Ana, and Irvine. It will be important for any new in-street streetcar systems to coordinate with CPUC on compliance with GO 143-B and coordination should begin early in the project design process. Because the GO was intended for light rail systems operating in primarily exclusive right-of-way, there may be issues with compliance with GO 143-B for a streetcar project. Coordination should also be started early on with other California streetcar project sponsors in order to have consistent conversations with CPUC. It may also make sense to coordinate with other California streetcar project sponsors on their vehicle procurement in case there are any specialized vehicle requirements for complying with GO 143-B.

[13] http://docs.cpuc.ca.gov/PUBLISHED/Graphics/598.PDF

7 IMPLEMENTATION & FUNDING

This chapter outlines a funding and implementation strategy for a significant transit capital investment in the study corridor, identifying options for both the low and high investment alternatives.

IMPLEMENTATION STRATEGY

Costs

Capital Costs

Capital costs for the project could vary widely depending on the technology selected and right-of-way treatments, among other factors. The peer review conducted for this project found capital costs in 2014 dollars ranging from $35,000 to $1.05 million per mile for circulator bus projects, $473,000 to $10.37 million per mile for bus rapid transit projects, and $679,000 to $64.52 million per mile for streetcar projects. Moreover, the projects included in the peer review do not represent the full range of costs for such projects in North America: the Van Ness BRT project in San Francisco, for example, is currently estimated to cost $81 million per mile.

While some streetcar projects have been less expensive to implement than certain BRT projects, all else being equal, streetcars are costlier: at a minimum, tracks must be laid, streets must be dug up and rebuilt, more expensive vehicles must be purchased, and in most cases a new storage and maintenance facility must be constructed, requiring additional, non-revenue track for access. Most built streetcar projects also required overhead electrical infrastructure. While streetcar projects constructed some time ago generally cost $25 million per mile or less, more recent applications (including those using modern vehicles as well as New Orleans's Canal line, with its replica vehicles) have cost more, up to as much as $65 million per mile.

At a cost of $4 million to $7.2 million per mile (assuming two tracks), overhead electrical infrastructure is a major cost driver. New battery-powered technology offers the promise of partial or complete "off-wire" operation, but these technologies remain largely untested. Battery technology may reduce initial infrastructure costs substantially, but replacement batteries are themselves somewhat expensive at $125,000 to $400,000 per set (these may require replacement every two to eight years).

Vehicles are another major component of cost. Modern streetcar vehicles may cost $3.4 to $6 million each. Replica vehicles are less expensive (the TIG/m model, for example, is $1.4 million), but are less efficient to operate and are increasingly uncommon, as most recent projects have selected modern vehicles. Large, custom BRT vehicles, meanwhile, may cost $1 million to $1.5 million each, but most buses continue to cost less than $1 million apiece.

Given all of these uncertainties, it is difficult at this point to estimate a capital cost for the project. However, broad ranges may be provided.

Costs for vehicles can be estimated based on the operating cost estimates in the following section, which project a peak vehicle requirement for six vehicles for the low investment (enhanced bus) alternative and four vehicles for the high investment alternative. Assuming one spare vehicle for each, the number of vehicles that would need to be purchased would be seven for the low investment (enhanced bus) alternative and five for the high investment alternative. At a cost of $500,000 to $1 million per bus, the vehicle cost for the low investment (enhanced bus) alternative would be $3.5 million to $7 million. At a cost of $1.5 million to $6 million per streetcar, the vehicle cost for the high investment (streetcar) alternative would be $7.5 million to $30 million.

Overall project costs, meanwhile, can be estimated on a per-mile basis. The low investment (enhanced bus) alternative would be bus-based and depending on the ultimate alignment, would be approximately 5.85 miles in length. At a cost per mile of $1 million to $5 million per mile, the **low investment (enhanced bus) alternative would cost $5.85 million to $29.25 millon.** The high investment alternative, meanwhile, would be approximately 4 miles in length. At a cost of $25 million to $50 million per mile, the **high investment (streetcar) alternative would cost $100 million to $200 million.**

Operating Costs

Operating and maintenance (O&M) costs could vary widely depending on factors including the ultimate level of service (headway and span), cost per unit (e.g., per hour of revenue service), and operating speed. For purposes of estimation, the following were assumed:

- For both the low and high investment alternatives, service every 15 minutes between 7 a.m. and 7 p.m. and every 20 minutes between 6 and 7 a.m. and between 7 and 11 p.m., seven days a week.
- A fully allocated (i.e., including all costs, both fixed and variable) cost per revenue service hour of $175 for the low investment (enhanced bus) alternative and $195 for the high investment (streetcar) alternative (these figures are further explained below).
- For both the low and high investment alternatives, average speeds 15 percent faster than existing Route 23 service. While the low investment (enhanced bus) alternative would make fewer stops, the high investment (streetcar) alternative would feature dedicated lanes and more intersections with transit signal priority.

Based on these assumptions, annual O&M costs were estimated (in current-year dollars) of approximately **$5.9 million for the low investment alternative**, which would serve the Canal area, and approximately **$4.5 million for the high investment alternative**, which would terminate at the Bettini Transit Center. Again, these estimates should be viewed as conceptual and subject to further analysis. (For example, if speeds were improved by 25 percent, estimated cost for the low investment (enhanced bus) alternative could be reduced to $5.1 million.)

A key factor in ultimate operating cost would be the potential to offset cost increases by replacing existing service. In Fiscal Year 2013-14, Marin Transit Route 23 cost approximately $1.9 million to operate. The low investment (enhanced bus) alternative could essentially duplicate the Route 23 alignment if some service were extended to the Target store at Shoreline Parkway. Analysis of travel times suggests that every third or fourth trip might be able to serve Target without an increase in operating costs.

Another key factor would be the actual unit cost, which is difficult to accurately predict, particularly for streetcar service (which includes additional infrastructure requiring regular maintenance and replacement). This is because there are relatively few existing streetcar operations in North America, and very few modern streetcar operations upon which to base estimates. Analysis of unit (hourly) costs for bus and streetcar service between 2010 and 2012 in cities including San Francisco, Seattle, Portland, New Orleans and Philadelphia finds cost differentials ranging from less than 10 percent to more than 60 percent. In 2012, the difference was 23.9 percent in New Orleans, and 23.3 percent in Philadelphia. For this exercise, costs to operate streetcar service (in the high investment alternative) were assumed to be approximately 25 percent higher than the cost to operate regular bus service (which was $145.83 per revenue hour for Route 23 in 2013-14). Costs for the low investment alternative, meanwhile, were assumed to be 12.5 percent higher, a figure that takes into account increased costs for fare enforcement, station maintenance and TSP upkeep, but not tracks or electrical infrastructure (overhead wires or batteries).

FUNDING OPTIONS

Capital Funding Options

Federal Sources

Small Starts. Any significant capital investment would likely require a Federal Transit Administration (FTA) grant. Of FTA's three major funding programs (New Starts, Small Starts, and Very Small Starts), Small Starts would be the likeliest source of funding for this project, given its scale and estimated cost. Small Starts provides grants of up to $75 million to projects with a capital cost of less than $250 million.

As described in FTA's final policy guidance for New and Small Starts Evaluation & Rating Process (August 2013), FTA's decision to recommend a project for funding is driven by a number of factors, including the "readiness" of a project for capital funding, geographic equity, the amount of funds versus the number and size of the projects in the Section 5309 funding pipeline, and the project's overall Small Starts rating.

FTA prescribes a process for development of New and Small Starts projects. Major steps in this process include:

- adoption of a Locally Preferred Alternative (LPA)
- advancement into formal FTA project development, including project evaluation of costs and benefits
- environmental (National Environmental Policy Act/California Environmental Quality Act) review/clearance
- preliminary engineering and final design
- development and approval of project management and finance plans prior to award of a Project Construction Grant Agreement

Once the FTA approves a project sponsor's request to advance into project development, the sponsor has two years to complete the NEPA process and submit adequate information on the project's cost, financial commitments, and rating (for evaluation criteria, see detailed description later in this chapter). It may then qualify for a PCGA.

Small Starts typically funds streetcar or BRT projects. To qualify for Small Starts, at least 50 percent of the project alignment must be fixed-guideway (rail and/or exclusive right-of-way), at least during peak periods. Alternately, a "corridor-based bus project" with the following characteristics may qualify:

- substantial transit stations
- traffic signal priority/pre-emption (to the extent that there are traffic signals on the corridor)
- low-floor vehicles or level boarding
- branding of the service
- 10-minute peak/15-minute off-peak headways and a weekday service span of at least 14 hours

All Smart Starts projects must be evaluated and assigned a project rating. Fifty percent of that rating is based on evaluation against criteria updated as part of the Moving Ahead for Progress in the 21st Century Act (MAP-21) adopted in 2012, and described below (the criteria are weighted equally):

- **Land Use.** Criterion includes existing density and zoned development capacity.
- **Economic Development.** Criterion includes the potential for economic development to occur as part of the transit development. Project sponsors are allowed to submit economic development scenarios that project specific development for a mode investment such as streetcar.
- **Cost Effectiveness.** The criterion for cost effectiveness for Small Starts program projects is the cost per ride for the federal share of the project. To achieve a high rating, the cost per ride must be below $1.00.
- **Mobility Benefits.** Mobility benefits are determined by the number of people served or benefitted by the investment.
- **Environmental Benefits**. Environmental benefits are determined by the use of the mode and the effectiveness in reducing environmental impacts. The benefits of the development are not included in this criterion which is limited to evaluating the mode being utilized.
- **Congestion Relief**. No rules or guidelines have been established as this criterion was added to MAP-21 late in the process, and was not included in preliminary notice of the rule making. FTA intends to issue special guidance on this criterion.

Projects are rated on a scale from "low" to "high," and must receive an overall rating of "medium" in order to qualify for funding.

The other 50 percent of the FTA project rating is based on capacity to finance the project, including the level of commitment for non-federal sources of funding. The project sponsor's financial commitment to the project includes both capital and operations. Formal financial commitments are not necessary to advance into project development; however, during project development the project sponsor must produce formal commitments to fund 20 years of operation. Small Starts requires a minimum 20 percent local match, although due to its limited pool of funding and resulting competitive nature, in practice, local matches are typically range 50 percent and higher.

TIGER Grants. Transportation Investment Generating Economic Recovery (TIGER) is a discretionary USDOT grant program that allows the agency to invest in road, rail, transit and port projects. Funding varies from year to year based on Congressional allocations, and grants are awarded on a competitive basis. A key criterion is project readiness ("shovel ready"). A number of modern streetcar projects have been awarded significant TIGER grants to fund capital investments, including Tucson, Portland, Atlanta, Salt Lake City and Dallas.

TIFIA Loan Program. The Transportation Infrastructure Finance and Innovation Act (TIFIA) program provides federal credit assistance to national and regionally-significant surface transportation projects, including bus and rail transit. The program is designed to fill market gaps and leverage substantial private match (or co-development) by providing supplemental debt financing. The amount of a TIFIA loan cannot exceed 33 percent of the total capital cost of a project. The loans are backed by Federal revenues. It should be noted that the portion of capital funding from a TIFIA loan would not count toward the maximum Federal share under the Federal Small Starts program. It could instead count as part of the "local" match.

FTA Urbanized Area Formula Grant Program. MTC administers the FTA Urbanized Area Formula Grant program, combined with several other federal transit capital programs. For FY 2014-15 and 2015-16 MTC will allocate $793 million in regional apportionments of Federal Transit Administration (FTA) Section 5307 Urbanized Area, 5337 State of Good Repair, and 5339 Bus & Bus Facilities funds (together referred to as Transit Capital Priorities or TCP) and matching funds. Funds are awarded to transit agencies, and are available for a broad range of transit maintenance and improvement projects.

Regional Sources

Cap and Trade Funds/One Bay Area Grants. In order to begin the process of defining investment priorities for some $3.2 billion in state "cap and trade" carbon emissions trading revenues that the Bay Area anticipates receiving over the next few decades, MTC adopted a Cap and Trade Funding Framework at the end of 2013. Separately, state legislation supporting the formation of the cap and trade network (Assembly Bill 574) included transit operations, maintenance and capital costs among potential recipients for cap and trade funding.

The Cap and Trade Funding Framework adopted by MTC includes $1.05 billion for One Bay Area Grants, which support transit-oriented development and other local transportation improvements. The One Bay Area Grant program combines both regional and federal funding sources available to MTC into a comprehensive grant program that addresses federal transit guidelines, the state's climate laws and the region's sustainable community strategy. Project identification and selection is coordinated through CMAs in each county.

Notably, 50 percent of OBAG Grants must be spent in ways that benefit Priority Development Areas (PDAs) such as Downtown San Rafael.

Bridge Toll Funding. On March 2, 2004, voters passed Regional Measure 2 (RM2), raising the toll on the seven State-owned toll bridges in the San Francisco Bay Area by $1.00. This extra dollar was raised to fund various transportation projects within the region that have been determined to reduce congestion or to make improvements to travel in the toll bridge corridors, as identified in SB 916 (Chapter 715, Statutes of 2004). Specifically, RM2 establishes the Regional Traffic Relief Plan and identifies specific transit operating assistance and capital projects and programs eligible to receive RM2 funding.

The Bay Area Toll Authority (BATA) is responsible for the collection of the bridge tolls and MTC is responsible for administering the Regional Measure 2 program. Recently, BATA's Long Range Plan (PDF) was updated to incorporate the Regional Measure 2 projects.

While RM2 projects have been identified and the funding source is currently fully subscribed, future toll increases and longer term funding could be available for alternative transportation projects.

Local Sources

Community Facilities District. A Mello Roos Community Facilities District (CFD) is a tool available for assessing a property tax levy on properties that benefit from a local facility. Funds raised through a community facilities district may be used for capital, for loan repayment or for operating funds to support a local project. It is unlikely that both a CFD and Community Benefit District would be implemented in the same area, since they are both tools for generating a property tax levy in a confined area.

Developer Fees and Agreements. The City of San Francisco levies impact fees on new development as a condition of approval, and the City of Oakland is currently completing a nexus study as a precursor to establishing fees of its own.

Parcel Taxes. Parcel taxes are common tools used by California cities to raise money for specific projects in an era when general property tax rates cannot be raised because of Proposition 13. Parcel taxes can be bonded to accelerate projects and could be used for both capital and operating funding. The distinction between a parcel tax and a property levy within a district is that it is City wide and requires a two-thirds vote of residents. The majority of successful parcel taxes in California are for schools, libraries and other projects of citywide importance.

Real Estate Transfer Fees. A Real Estate Transfer fee is paid by property buyers at the time of transaction. Local fees can be increased only with a two-thirds supermajority of voters. Given increasing real estate costs, the amounts generated by such fees are increasing and are likely to continue to increase.

Commercial Parking Taxes (CPT). A commercial parking tax could be levied on all off-street parking spaces within the corridor. Parking tax would be collected by the parking operator and paid to the Cities. San Francisco and Seattle both have commercial parking taxes of 25 percent and 12.5 percent respectively. In those examples, portions of the revenue stream are allocated for major capital projects, with an emphasis on multimodal projects that reduce the demand for parking expansion. There is no statutory limit to the tax and it can be used for a wide variety of transportation uses. This revenue stream can be bonded to pay for capital projects.

Commercial parking tax funds are subject to competing priorities including general fund uses, construction and maintenance of parking facilities and other needs. However, depending on the rate they have the potential to provide needed capital and operating funds.

Parking Benefit Districts. In a PBD, cities spend a portion of meter revenue collected in the district on local priorities. Parking revenues can also be bonded to accelerate a capital project.

General Obligation Voter-Approved Bonds. Cities in the corridor could issue such bonds upon voter approval to levy an assessment on real property, payable by property owners. These "Unlimited Tax GO bonds" (UTGO) must be approved by a majority of voters, and can be used for capital projects. Bonds are generally raised against a specific asset or revenue source. Voters are generally more supportive of bonding than taxing, because taxes do not increase to pay for a GO Bond.

City General Funds. City general funds are generally composed of a number of funding sources including property tax revenues, sales tax revenues, fees and fines. Cities may elect to fund a portion of this project's capital or operating needs from their General Funds. Because any allocation from the General Fund would compete directly with other Citywide needs, this should be considered "last in" funding.

Private Sources

Community Benefit District/Business Improvement District (CBD). CBD formation requires the support of property owners who, in essence, agree to a special assessment on their property tax in exchange for special benefits that would not otherwise be provided by the City. A CBD currently lasts up to 10 years and ultimately requires a simple majority to implement. Funding for the project, either capital or operating, could come from an expansion, extension or reallocation of these funds, subject to a vote of the membership.

Funds from a CBD could be used for both capital and operating funds, and can be bonded to accelerate project delivery. Expenditures are guided by a "Management Plan" which spells out how collected funds can be used.

Note that while CBD/BID funding of streetcar projects is relatively common, CBDs are generally not formed in support of bus projects.

Value Capture. The concept of value capture is based on the anticipated development and commercial activity that is projected to be spurred by the transit investment over a reasonable period of time. Economic and land development will result in added value along the project segment, generating incremental property taxes and other fees.

Naming Rights. This concept is further discussed under "Stop and Vehicle Sponsorship" in the following section, addressing operation revenue sources.

Public-Private Sources

Public-Private Partnerships (P3s). So-called P3s are an increasingly common way to finance, construct and operate transportation infrastructure. In a P3, the sponsoring agency partners with a private firm or firms in an effort to a) reduce the risk of cost and schedule overruns (as the private partner agrees to deliver the project on a fixed schedule, for a fixed price), b) reduce initial cost (as the private partner typically contributes part of the capital cost), and c) reduce lifecycle costs by taking advantage of private-sector efficiencies (e.g., they may be unencumbered by regulations that apply to public agencies, such as "Buy America" requirements, or political pressure to add unnecessary elements to projects). Depending on how the P3 is structured, the private partner may take on (with public oversight) various roles that would typically be the responsibility of the sponsoring agency; for example, in a so-called "DBFOM" arrangement, the private partner would design, build, finance, operate and maintain the project. Such arrangements are common internationally, including in Canada, are commonly used for toll roads in the United States, and are increasingly common among transit projects, including the $2.2 billion "Eagle P3" commuter rail project in Denver, Colorado, a light rail project in Maryland, and streetcar projects in Washington, D.C., Los Angeles and Detroit. Congress has encouraged more widespread application of P3s to transit projects. While often criticized for perceived "privatization" of public assets, P3s are typically structured so that the public maintains ownership and control over assets and key aspects of operations, such as service levels and fares. Private partners are also typically subject to performance standards. However, P3s may ultimately cost taxpayers more over the long term. Moreover, sponsoring agencies accustomed to traditional contracting processes may be unprepared for the special requirements associated with a P3, from both a legal and administrative perspective. (Note: Federal Highway Administration guidance on P3s can be found here: http://www.fhwa.dot.gov/ipd/p3/default.aspx). Finally, private partners will only invest on the expectation of a return. If a future project were to pursue a P3 arrangement, much more detailed financial and revenue forecasting analysis would be required.

Operating and Maintenance Funding Options

In addition to capital funding, funding must be secured for operations. Given similar levels of service, operating costs for the low and high investment alternatives should be relatively similar. Existing transit service in the corridor is operated by Marin Transit and Golden Gate Transit, and is funded by those agencies' various sources of operating revenue, including fare revenues as well as federal formula grants (Section 5307) and other subsidies of various types.

Most transit investments are sponsored by transit agencies who reallocate current operating funds to operate the new service, often paid for in part by increasing operating speeds or by reducing parallel and overlapping service. If the sponsor were not a transit agency, one alternative would be to form a Joint Powers arrangement, either formally or informally with Marin Transit or Golden Gate Transit, who could then operate the service within the context of their other routes. Savings on existing routes, if any, could be allocated to service on this corridor. In addition, transit operators have access to some funds that the City would not be able to pursue on its own.

The following sources have been identified as potential contributors to the operating and maintenance costs of the project outside of the usual context of a transit operator.

Farebox Revenue. Fares are generally an important part of funding operating costs of a transit system; in 2013, revenues from fares accounted for 29 percent of Golden Gate Transit operating costs.

Stop and Vehicle Sponsorship. Various options are available for sponsorship of stops and vehicles, once stops are upgraded. Stop sponsorships, which provide branding of the glass panels at shelters, have been sold in many cities implementing streetcar or shuttle projects. Some systems such as Tampa's TECO Trolley also sold naming rights for the system. This practice builds on the more standard practice of selling advertising at stations and on vehicles and allows stations to remain uncluttered by ads while still generating revenue. The amount generated by sponsorships and naming rights varies but generally provides less than 15 percent of the operating cost of a system.

Other Private Funding. Additional efforts to raise revenue through streetcar promotions, sponsorships, annual pass sales, business promotions, and potentially private contributions may be possible. Portland Streetcar, for example, has been successful in raising private funds on the order of $300,000 annually through a non-profit corporation. Amazon.com, Inc., recently provided $5.5 million in funding including a fourth streetcar vehicle for the South Lake Union line and a 10-year commitment to provide operating funding for a 12-hour service span and increased frequency. Adding service to Kaiser and other "pill hill" locations may allow those institutions to eliminate or reduce their own shuttles, supporting the circulator as an alternative.

Flexible Funding from Local Sources. A number of sources described under the capital plan might be able to provide on-going operating funds. Funding could be drawn from a Community Benefit District or Community Facilities District, as well as contributions from a parcel tax, parking tax or parking benefit district. The size of contributions from these sources varies, but several sources combined could provide a significant share of funding towards the operation of the circulator.

Federal Regional Flexible Fund Allocations. Each region is granted flexible funds in a four-year cycle, traditionally for highway road capital projects or operations. It is possible to request a portion of these funds to go toward a first two-years operating commitment of rail transportation projects. A number of modern streetcar projects have received federal flex funds for operations, including the Washington D.C. streetcar.

Measure A Renewal. Marin County is a "self-help" county under California law with a share of its local sales tax dedicated to transportation capital funding and operations. The most recent renewal, Measure A, was passed in 2004 and will remain in effect through 2024, although renewal could occur sooner. Sales tax measures require two-thirds approval from voters. Note that sales tax revenues could be used to both help build and operate the project.

8 CONCLUSIONS & NEXT STEPS

This chapter provides a brief overview of the most salient findings of the Fairfax-San Rafael Corridor Transit Feasibility Study, particularly regarding the two recommended alternatives developed through this process. A set of next steps, outlining how this study may inform future planning processes, is also provided below.

This project is not intended to be a comprehensive alternatives analysis. For that reason, it does not recommend a single alternative. Rather, it serves as a first step in determining the right kind of transit investment for the Fairfax-San Rafael corridor, offering a set of clear and accurate technical information that can be used to inform and support a more detailed analysis.

KEY FINDINGS

Summary

- The Fairfax-San Rafael Corridor is one of the most important transit and travel markets in Marin County. The corridor is defined by its topography and a wide variety of land uses along arterials linking the historic downtowns of Fairfax, San Anselmo, and San Rafael, which were originally built by rail service. Beyond San Rafael, the Canal area contains some of the densest housing in the area. In 2016, the corridor's transportation landscape will change when the Sonoma-Marin Area Rail Transit (SMART) rail line will open, providing commute period service to Santa Rosa. Expected ridership at Downtown San Rafael station is unknown but 2035 projections do not exceed 1,200 boardings per day.
- A total of 11 transit routes operate in the corridor, with 30-minute base (midday) frequencies throughout the corridor. Consistent with population and employment densities, existing transit ridership activity clusters in Fairfax, San Anselmo, and San Rafael, with consistent levels of daily activity observed along the Miracle Mile and between Fairfax and San Anselmo. Adjacent to the study area, higher levels of activity occur along routes operating in the Canal area.
- The project team's Transit Likelihood Index determined the following areas to have the strongest base of built environment and socio-economic characteristics to support higher levels of transit ridership:
  - Downtown San Anselmo
  - Downtown San Rafael
  - The Canal
- Additionally, the Travel Market Assessment also determined that there may be opportunities to shift trips from auto to transit between the following O-D pairs.
  - Downtown San Rafael / Canal

  - Downtown San Rafael / Downtown San Anselmo
  - Downtown San Anselmo / Downtown Fairfax
- With this contextual information in mind, the project team carefully considered current on-the-ground conditions in the study corridor, and with input from the project TAC, developed two recommended alternatives for future analysis that offer opportunities to garner the highest ridership:
  - A low investment (enhanced bus) alternative, which would utilize bus technology to provide a direct, express service between Fairfax and the Canal area.
  - A high investmet alternative, which would most likely utilize streetcar technology to serve as a local "circulator" service between Fairfax and San Rafael.
- These alternatives offer contrasting benefits and impacts, as summarized in Figure 8-1 in the following pages. Figure 8-1 includes findings from a multimodal assessessment of terminus and transition options as well as projected ridership estimates developed for the study.
- Various streetcar vehicle technologies are available, including emerging "off-wire" technologies that rely only partly or not at all on overhead contact sysems (OCS) for electrical power. Narrower models would allow streetcars to operate alongside bike lanes on Center Boulevard.
- It may be challenging to site a maintenance facility, although a facility large enough to serve this corridor would have a relatively small footprint.

Existing Conditions

Land Use and Demographics

- The Fairfax-San Rafael Corridor's land use patterns were partly shaped by natural topography and partly by historical rail service.
- San Rafael has a larger mix of land uses, with a mix of higher density residential, commercial, and industrial uses in downtown and in the adjacent Canal area.
- Lower density residential uses are designated adjacent to the corridor in some locations.
- Largely following prescribed land uses, population and employment density is highest in the traditional centers of Fairfax, San Anselmo, and San Rafael, with the corridor-adjacent Canal area being the most densely populated residential area.
- Within one-half mile of the corridor (including the adjacent, transit-supportive Canal area), 21% of the population are under 18, 10% are aged 65 and over, and 21% are characterized as "low income."

Multimodal Transportation

- The corridor is used regularly by people who walk, bike, and drive in addition to those who take transit.
- Automobile facilities vary by location, though most roadways outside of San Rafael are only one lane each way, and speed limits top out at 35 mph.
- For areas where data are available, auto LOS exceeds C in only one location: westbound Red Hill Avenue in the AM peak period.

- There is already a robust network of bicycle facilities and amenities for pedestrians, though some sidewalk gaps remain in the corridor.
- Corridor communities have identified several projects to improve bicycle and pedestrian networks in the corridor.

Existing Transit Service

- The corridor was built by transit and continues to benefit from frequent service, particularly during peak hours. While a total of 11 bus routes operate within the corridor, only one (Route 23) makes the full trip from Manor to Shoreline Parkway in the adjacent Canal area.
- Base (midday) service frequency between Manor and San Rafael, and San Rafael and the Canal area is 30 minutes. During peak times, transit between San Rafael and the Canal area is available every 15 minutes.
- Ridership activity clusters in Fairfax, San Anselmo, and San Rafael, with consistent levels of daily activity observed along the Miracle Mile and between Fairfax and San Anselmo. Adjacent to the study area, higher levels of activity occur along routes operating in the Canal area.
- Origin-destination data reveals that over one-third of trips from Manor and Fairfax are going to San Rafael; few trips beginning in the Canal area have destinations beyond San Rafael; and there is demand for intra-corridor trips west of San Anselmo.
- Sonoma-Marin Area Rail Transit (SMART) is under construction, with completion expected in 2016. Expected ridership at Downtown San Rafael station is unknown but 2035 projections do not exceed 1,200 boardings per day.

Developing the Alternatives

Travel Market Assessment

- As determined through the development of a Transit Likelihood Index, the following areas have the strongest base of built environment and socio-economic characteristics to support higher levels of transit ridership:
  - Downtown San Anselmo
  - Downtown San Rafael
  - The Canal

  However, built environment and socio-economic characteristics supportive of transit use are less concentrated in Fairfax, suggesting more limited potential demand for transit except for around specific activity generators, such as schools and medical facilities.
- A review of origin-destination data confirm the importance of these destinations in corridor travel. In fact, many short trips are being made within the corridor and only a small share of these are made on transit, suggesting an opportunity to shift some trips from auto to transit, particularly between the following OD pairs:
  - Downtown San Rafael / Canal
  - Downtown San Rafael / Downtown San Anselmo
  - Downtown San Anselmo / Downtown Fairfax

However, the potential to shift trips from auto to transit depends on the competitiveness of transit with autos. This will depend on many factors including congestion levels along the corridor, transit versus auto speeds, transit service levels, quality of transit service amenities and transit priority treatments.

- Current riders along the corridor are transit dependent. There is potential to increase the number of "choice" riders by providing improved transit services able to be more competitive with auto travel, but it may be difficult to implement measures to make transit service more competitive in terms of travel time, which is a the key factor in attracting choice riders.
- Preliminary analysis shows potential for introduction of SMART to shift some trips between the study corridor and areas along the SMART corridor from auto to transit. This would increase transit demand along the corridor to and from the Downtown San Rafael SMART Station, meaning local transit could be used as a feeder system for SMART travel. However, demand for transit may be impacted by the level of park-and-ride and feeder bus service provided at SMART stations at either end of the trip.

Corridor Alignment Options Analysis

- In addition to serving a wide range of populations, the Fairfax-San Rafael corridor constitutes a complex transit operating environment, with individual parts of the corridor posing unique challenges and opportunities for the implementation of high-capacity transit service.
- Generally speaking, the greatest challenges common to both modes within the corridor include:
  - Right-of-way constraints, particularly on Sir Francis Drake Boulevard between Fairfax and San Anselmo.
  - Potential need for replacement parking.
  - Reintroduction of service along historical rail corridor (i.e., Center Boulevard) and impacts on residents.
- A major constraint for rail (streetcar) service only is the high cost and feasibility of crossing the SMART tracks. Due to freight restrictions, rail services are assumed to end at the San Rafael (Bettini) Transit Center, and a suitable turnaround option must be identified as part of finalizing an alignment in downtown San Rafael

The Feasible Project Alternatives

- With input and direction from the TAC, the project team created two alternatives:
  - A low investment (enhanced bus) alternative, which would utilize bus technology to provide a direct, express service between Fairfax and the Canal area.
  - A high investment (streetcar) alternative, which would most likely utilize streetcar technology to serve as a local "circulator" service between Fairfax and San Rafael.

Evaluating the Alternatives

The table below provides additional detail about the potential operational and physical details of the recommended alternatives, as well as potential issues and opportunities for implementing them.

Figure 8-1 Summary Evaluation of Alternatives

Category	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
Alignment		
Goal	Express service within corridor, particularly downtown San Rafael	Circulator service within corridor, particularly downtown San Rafael
Route	Fairfax – Canal area via Center Blvd. and 2nd / 3rd Streets in San Rafael.	Fairfax – San Rafael via Center Blvd. and 4th Street in San Rafael
Route Length (round trip)	11.7 miles	8 miles
Operational Assumptions		
Technology	Bus	Streetcar/Bus (assumed streetcar for analysis)
Service Span	6 a.m. – 11 p.m., seven days a week	
Frequency	4 transit vehicles per hour (15 minute headways)	
Multimodal Assessment (at Key Transition/Terminus Options in Corridor)		
Fairfax	Low impact on all other transportation modes for all terminus options.	Low impact on all transportation modes for most terminus options. A Bank Street streetcar turnaround would incur a medium impact on parking.
San Anselmo	Primarily low impact on all transportation modes, though this is highly dependent on treatment at Hub intersection. A queue jump on Center Boulevard would be expected to have a medium impact on pedestrians.	Mostly low impact on all transportation modes, though this is highly dependent on treatment at Hub intersection, which would impact bicyclists, motorists, and parking the most. A dedicated lane in the Red Hill Avenue median would have a medium impact on motorists, and a queue jump on Center Boulevard would be expected to have a medium impact on pedestrians.
San Rafael	Operating in the outside lanes in the Miracle Mile and on 2nd and 3rd Streets in San Rafael, the low investment (enhanced bus) alternative would have a low impact on all modes except motorists, who would be impacted moderately.	Operating in the inside lanes in the Miracle Mile and on 4th Street in San Rafael, the high investment (streetcar) alternative would have moderate impacts on motorists and parking, but low impacts for all other modes. Each potential turnaround in San Rafael would have higher impacts on motorists than other modes, with the 3rd Street turnaround incurring a "high" inpact.
Overall	Both alternatives would generally have low impacts on pedestrians and truck loading at key transition/terminus locations, with the low investment (enhanced bus)	Both alternatives would generally have low impacts on pedestrians and truck loading at key transition/terminus locations. Most of the medium or high impacts would affect motorists and parking. The high investment (streetcar) alternative would pose slightly more challenges than the "Low" with a

Category	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
	alternative offering fewer conflict points due to its mixed-flow lane operation in all locations.	dedicated median lane along Red Hill Ave, inside lane operation in the Miracle Mile, mixed-flow operation on busy 4th Street in San Rafael, and potential conflicts at turnaround locations near the San Rafael Transit Center.
Ridership, Costs, and Implementation Considerations		
Ridership Potential (Fairfax-San Rafael Transit Center)	1,400-1,800 Daily Boardings 180-230 Daily Boardings/Route Mile	1,690 – 2,200 Daily Boardings 210-270 Daily Boardings/Route Mile
Ridership Potential (Fairfax-Canal area)	3,300 – 3,900 Daily Boardings 280-330 Daily Boardings/Route Mile	*N/A – does not serve Canal area*
Estimated Capital Costs (2015$)	$5.85-$29.25 million	$100-$200 million
Estimated Annual O&M Costs (2015$)	$5.9 million	$4.5 million
Implementation Considerations	▪ Implementation of new service along Center Boulevard will require extensive outreach with neighbors. ▪ Substantially lower capital cost	▪ Implementation of new service along Center Boulevard will require extensive outreach with surrounding neighbors. ▪ Requires special investments at higher costs than low investment (enhanced bus) alternative, including vehicles, rails, and power-delivery systems. ▪ Requires maintenance facility at an as-yet undetermined location ▪ Subject to regulation by California Public Utilities Commission (CPUC) ▪ Substantially higher capital cost, but use of streetcar technology may make available additional funding sources such as a CBD/BID or P3
Core Issues & Opportunities		
Issues	▪ Implementation of new service along Center Boulevard will require extensive outreach with neighbors.	▪ Implementation of new service along Center Boulevard will require extensive outreach with neighbors. ▪ Depending on the terminus design chosen, may require land takings and/or parking loss. ▪ Represents the highest cost alternative, with potential features such as dedicated lanes and median stations as well as streetcar-related technology such as power delivery systems, new

Category	Low Investment (Enhanced Bus) Alternative	High Investment (Streetcar) Alternative
		vehicles, rails, and the need for a maintenance facility all incurring higher costs than an express bus/BRT project.
Opportunities	▪ Full Fairfax-San Rafael-Canal area route projects to have the highest ridership of the alternatives. ▪ Offers lower cost approach to faster, more direct service between Fairfax and San Anselmo along Center Boulevard.	▪ Within the core Fairfax-San Rafael, corridor, this alternative has the highest projected ridership. ▪ Streetcars often have an "it" factor that, in addition to attracting choice riders, may also attract additional economic investment in the corridor.

NEXT STEPS

This study is just step one of many required to design and fund a major transit investment. It does not provide a final recommendation; rather, it provides information for future decision-making.

If TAM should decide to pursue this project further, the project development process to be followed is described in detail in the previous chapter. Notably, however, the next formal step in the process would be a complete Alternative Analysis.

In general, funding considerations suggest a phased approach to implementation:

- Low investment (enhanced bus) alternative
  - Begin as an "Enhanced No Build" alternative by developing transit reliability improvements for existing transit routes between Fairfax and the San Anselmo Hub along Sir Francis Drake Boulevard.
  - Upgrading service between the Canal area and downtown San Rafael with improved station stops, reliability, and/or frequency.
  - Improving the connection between the Canal area and the San Anselmo Hub with more frequent and high-quality service.
- High investment (streetcar) alternative
  - If desired, this alternative could be completed in phases, with a first phase extending from downtown San Rafael to the San Anselmo Hub.

Appendix A

Existing Conditions Briefing Book

Transportation Authority of Marin

FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Existing Conditions Briefing Book

February 2015

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1 INTRODUCTION

The Fairfax-San Anselmo-San Rafael corridor is one of the most important transportation corridors in Marin County, connecting San Rafael's Canal area and downtown San Rafael to the Miracle Mile, San Anselmo Hub, and downtown Fairfax. Its main streets are major arterials and pedestrian-friendly shopping districts; it includes a major bicycle route; and it includes both the County's busiest transit node, the San Rafael Transit Center (and future Sonoma Marin Area Rail Transit station), as well as the busy stop at the San Anselmo Hub. Tens of thousands of people per day travel within the corridor on a variety of different transportation modes. It is also home to tens of thousands of people who live and work in a built environment shaped over time by rail service and then by the automobile.

Figure 1-1 Corridor Overview

This corridor was initially defined by transit. For decades, interurban trains ran from Fairfax to downtown San Rafael and on to Sausalito, where connections could be made to ferries. The legacy of the railroad can still be seen today, not just in the remnants of the old right-of-way—including the broad landscaped median of the Miracle Mile, and Center Boulevard with station platforms still intact—but in the pedestrian and transit-oriented downtowns built around their stations.

Reflecting its continuing importance for transit, the corridor is one of the busiest in the county for buses. A mix of peak-only, local, and regional services creates a high level of service—peak combined frequencies between San Anselmo Hub and Butterfield Road are every four to five minutes average. Yet just two routes, Marin Transit Routes 23 and 68, connect the corridor from Downtown San Rafael to Manor; only one, Route 23, extends the entire length of the study corridor, from Target in east San Rafael to Manor, west of Fairfax. Given these nuances, the corridor might be described as both well served and underserved by transit.

The corridor features a diversity of land uses, as well as several different roadway, pedestrian, and bicycle network configurations from east to west. The corridor's varied nature and often complicated arrangement presents both challenges and opportunities. The Canal area is a mixture of dense, diverse neighborhoods and dispersed commercial and community uses, offering a strong market for transit but presenting challenges to regional connectivity. Likewise, to the west of downtown San Rafael, the unique setup of the Miracle Mile poses difficulties for a "complete corridor" with parallel streets prioritized for different modes – but side streets adjacent to Center Boulevard, its history rooted in rail transit, offer an alternative for people who choose to bike. Elsewhere, though, street facilities and land uses vary widely, particularly between the historic downtowns and the arterials that connect them. In this way, the corridor poses unique challenges – and opportunities – for implementing effective transit service.

PURPOSE OF THIS REPORT

This "briefing book" is designed to compile existing information about the corridor in one concise document. It provides a basic overview of the corridor as it exists today – and as it is expected to look in the near future – and presents the context for more detailed planning and design work to be completed as part of the Fairfax-San Rafael Corridor Transit Feasibility Study. The outcome of this study will be recommendations for the most effective and functional rubber-tired and rail transit alternatives for the corridor.

Specifically, this report addresses the following contextual topics:

- Key demographics and existing and future land use, including information on the historical legacy of the corridor's railroad services
- Multimodal transportation, including existing and planned automobile, pedestrian, and bicycle facilities and use
- Existing and future transit services and facilities, including ridership
- A brief summary of issues and opportunities for the corridor

This report reflects currently available data and does not include any new data specifically collected for this report. As new information is developed, the Briefing Book may be expanded to include these data.

2 THE CORRIDOR: PAST AND PRESENT

This chapter describes the land use and demographics of the Fairfax-San Rafael corridor, focusing first on the historical factors that created the development patterns that exist today, and then exploring potential developments that may affect demand for transit services in the short- to mid-term future.

Broadly speaking, there is a diverse set of land uses along the corridor, which connects three historic downtowns (Fairfax, San Anselmo, and San Rafael) with a mixture of pedestrian- and automobile-oriented retail. The patterns of development are reflective of the transportation changes that occurred in the corridor during the past 100 years, with the three pedestrian-oriented downtowns built by local and regional rail, and the infill residential and commercial developments a result of an increasing reliance on car travel (particularly after the interurban railway closed).

HISTORICAL CONTEXT

The Fairfax-San Rafael corridor, from Manor to Downtown San Rafael, was built by railroads. Beginning in 1875, the North Pacific Coast, and later the electrified Northwestern Pacific Railroad, operated trains from Manor (then an unincorporated community, now part of Fairfax) to Downtown San Rafael and on to Sausalito, where connections could be made to ferries (Figure 2-2). Much like today's bus routes, train service was also available from Fairfax to Sausalito via Larkspur, with trains turning south at the San Anselmo "wye" or crossover – the location shown in Figure 2-3. Figure 2-1 below presents basic operating characteristics circa 1938; like today, full corridor service from Manor to San Rafael was neither as frequent nor as consistent as services operating in the Manor to San Anselmo or the San Anselmo to San Rafael corridor segments.

Figure 2-1 Weekday Interurban Service Characteristics, 1939

<table>
<tr><th colspan="2">Interurban Segment</th><th>Frequency</th><th>Span</th></tr>
<tr><td colspan="2">Manor – San Anselmo
(and San Francisco/Sausalito)</td><td>Peak – 30 minutes
Off-peak – 60 minutes</td><td>5:25 AM – 1:48 AM
(at Manor)</td></tr>
<tr><td colspan="2">(San Francisco/Sausalito to)
San Anselmo – San Rafael</td><td>Peak – 30 minutes
Off-peak – 60 minutes</td><td>5:33 AM – 1:42 AM
(at San Anselmo)</td></tr>
<tr><td rowspan="2">Manor – San Rafael
(Full Corridor)</td><td>Eastbound</td><td>3 trains/day</td><td>Leaving Manor: 10 AM, 10:45 PM; 1:48 AM</td></tr>
<tr><td>Westbound</td><td>6 trains/day (8 trains/day from B Street, San Rafael)</td><td>Leaving B Street, San Rafael: 5:10 AM – 4:56 PM</td></tr>
</table>

Source: Northwestern Pacific Interurban Time Tables, Corrected to October 1, 1939

Figure 2-2 Northwestern Pacific Interurban Timetable, March 15, 1938


Corrected to March 15, 1938

INTERURBAN TIME TABLES

NORTHWESTERN PACIFIC

Boats leave Ferry Building (north end) at foot of Market Street, and connect with trains at Sausalito

For the convenience of commuters and other passengers, the gate between the lobby and waiting room on the upper floor of the ferry building will be open for the 4:45 P. M., 5:15 P. M. and 5:45 P. M. boats daily except Sundays and holidays.

San Francisco Ticket Offices
FERRY BUILDING
AND
65 GEARY STREET

J. J. GEARY
General Passenger Agent

1-10-38-20M (Form J

INTERURBAN LINES
NORTHWESTERN PACIFIC

Source: Medocino Coast Model Railroad & Historical Society

Figure 2-3 Northwestern Pacific Interurban at San Anselmo, ca. 1930s

Source: Warren K Miller collection

Service ended in 1941 as auto travel became more prevalent, especially after the Golden Gate Bridge opened in 1937 providing a convenient way to drive between Marin and San Francisco. While subsequent auto-oriented development began to take hold in the corridor, remnants of the Northwestern Pacific rail line are still visible today. For example, the broad landscaped median of the Miracle Mile, and Center Boulevard itself, were reclaimed from the old rail right-of-way. The Parkade in Fairfax is located on the site of the old Fairfax railroad station. The concentrated, walkable, and transit-oriented downtowns of Fairfax, San Anselmo, and San Rafael are perhaps the most visible reminders of the corridor's rail legacy.

SEGMENTS & LANDMARKS

Over its approximately six miles in length, the study corridor features a wide variety of land uses and development styles. There are a total of six distinct segments within the corridor, each with a unique development context and roadway configuration (which is explored in more detail in the next chapter). A number of key landmarks and destinations are also located along the study corridor, including several schools, shopping centers, and civic and community centers.

From east to west, the corridor might be said to consist of five core segments:

- *Downtown San Rafael*, where the pedestrian- and retail-oriented Fourth Street parallels Second and Third Streets.
- *The Miracle Mile*, where a landscaped boulevard, alternately known as Second Street, Fourth Street and Red Hill Avenue, has segments of parallel streets along its south side.
- *San Anselmo Hub to Downtown Fairfax*, where the arterial Sir Francis Drake is roughly paralleled by another neighborhood serving street, Center Boulevard.
- *Downtown Fairfax*, where Sir Francis Drake becomes a two-lane street and Center Boulevard becomes Broadway Boulevard and runs just south of Sir Francis Drake.
- *Downtown Fairfax to Manor*, where Sir Francis Drake features bike lanes and two-way left-turn lanes and begins its transition to a rural highway.

An associated corridor segment, though not within the official study corridor, is *the Canal area of San Rafael*. This segment is a major generator of transit trip origins, as it contains a mix of land uses and densities, including a high concentration of multifamily housing units that are home to a diverse population. (Other transit trip generators east of San Rafael include the San Rafael High School and Montecito Plaza.) To provide a more complete context for the Fairfax-Downtown San Rafael corridor, existing data for the Canal area are also included in this report.

See Figure 2-4 for a detailed overview of the study corridor, which identifies these segments and highlights key landmarks. It also illustrates the study area's natural topography, which profoundly affects mobility, land use, and development within the corridor. Note: this map is the first of this report's landscape illustrations. Given that a major component of this study is improving transit service within the corridor, unless otherwise noted, all maps include an illustration of weekday base (i.e., off-peak, or midday) transit service and frequency.

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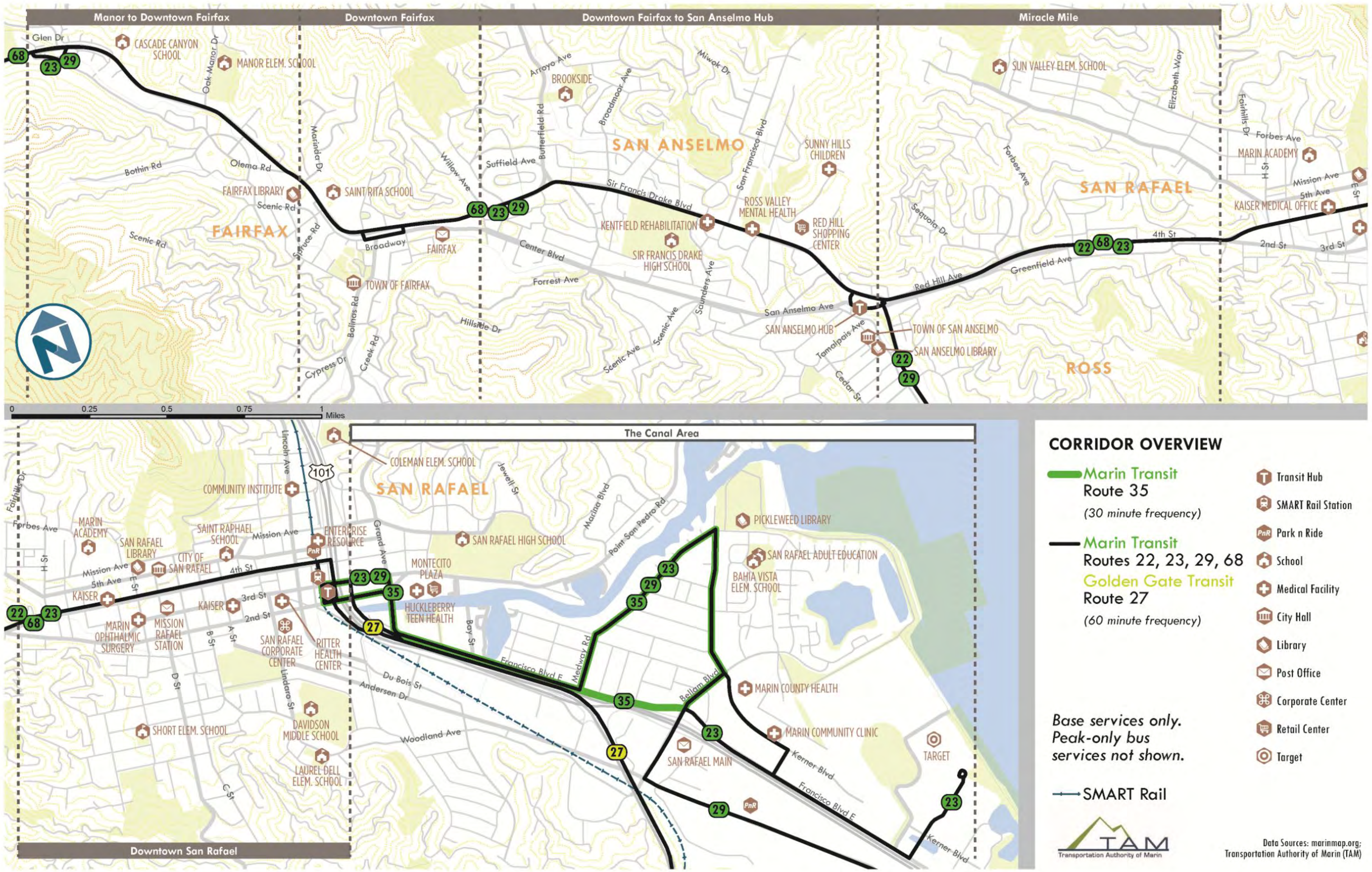
Figure 2-4 Fairfax-San Rafael Corridor: Key Segments and Landmarks



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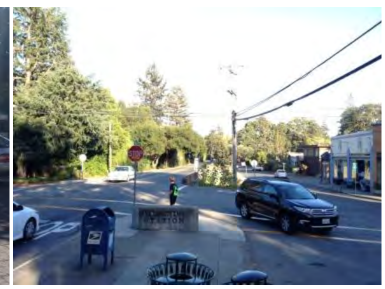
LAND USE & DEVELOPMENT

Encompassing three pedestrian-oriented neighborhood/city centers, as well as automobile-oriented connecting areas in between these centers, the corridor features a wide range of land uses ranging from high- and medium-density, mixed-use (e.g., in Fairfax, San Anselmo, and San Rafael) to low-density commercial and light industrial (e.g., in the Canal area and along Francisco Boulevard East). Unique arrangements abound, largely the result of piecemeal, auto-oriented development after rail service ceased: the Miracle Mile is mostly lined by retail, but a long stretch fronts onto back yards; and while a mixture of shops and homes alternate along Sir Francis Drake Boulevard, adjacent neighborhoods consist of single-family homes on narrow streets. See below for a sample of scenes within each segment of the corridor.

Manor-Fairfax

Downtown Fairfax


Fairfax-San Anselmo (Center Blvd.)


Miracle Mile


Downtown San Rafael


Canal area

The area's natural topography is also a major influence on development patterns (and non-vehicular mobility) in the corridor, with steep hills rising up from the floor of Ross Valley often no more than a quarter-mile from major corridor streets. From Manor to San Rafael, and particularly along the Miracle Mile, a sizable amount of the area's residential development – composed primarily of single-family homes – is situated in these hilly areas. By contrast, the natural landscape in San Rafael and the Canal area is comprised of lowlands adjacent to current and former tidal flats, which allows for a greater diversity of land uses.

Land Uses

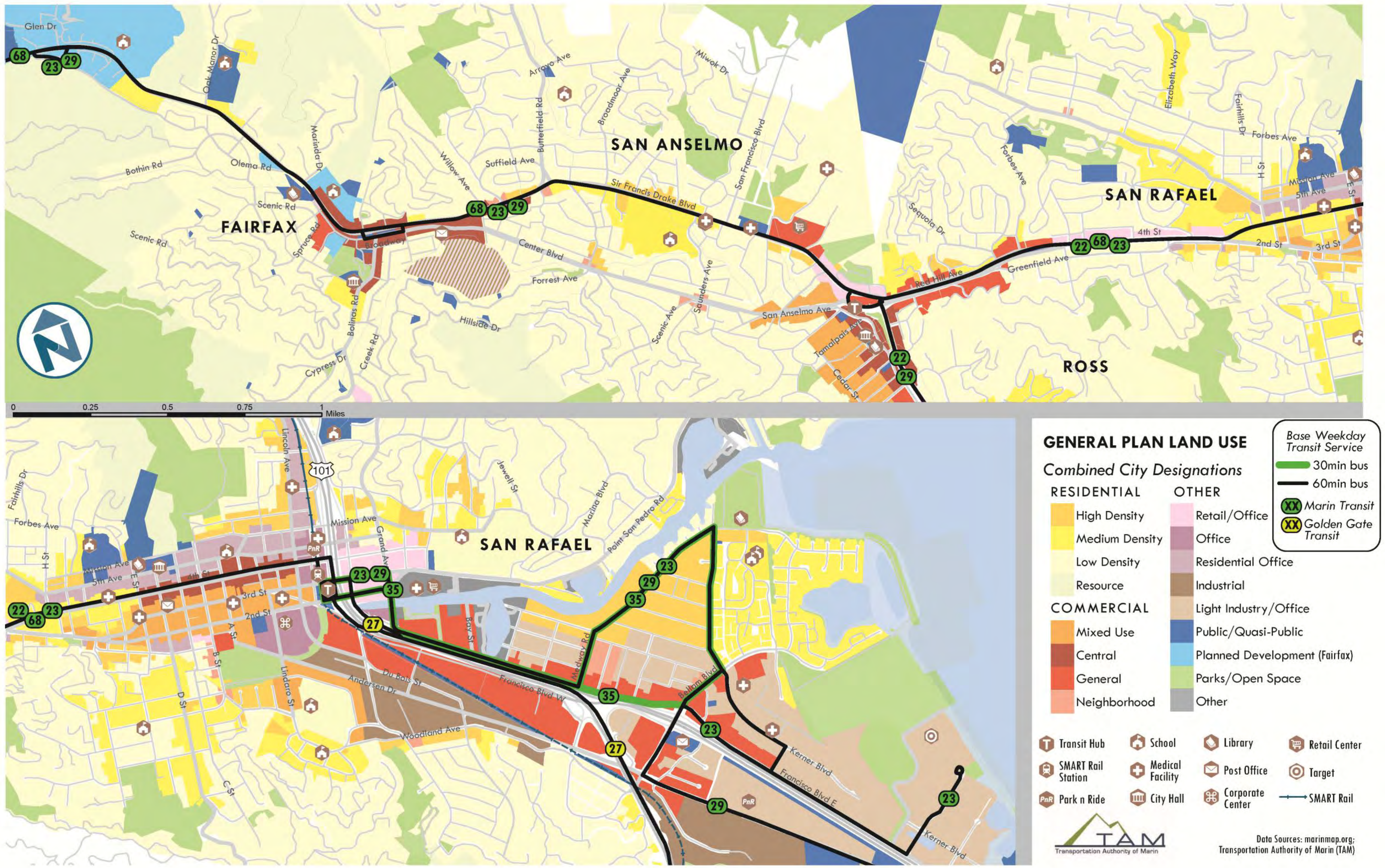
Land use planning within the corridor is the responsibility of the four communities that are served by the corridor – Fairfax, San Anselmo, Ross, and San Rafael – each of which has its own definition of land uses. The current land use map (Figure 2-5) is sourced from each community's latest General Plan. It should be noted that while most of the land use designations are interchangeable, each community's definition of Residential density varies and these designations have been consolidated to facilitate the creation of a corridor-wide map.[1]

Generally, the aggregated land use map helps explain the current state of the corridor, with high- and medium-density residential and mixed uses clustered in and around the historic centers of Fairfax, San Anselmo (whose downtown is just off the main corridor), and San Rafael. Understandably, as a larger city San Rafael has a larger mix of uses, with high and medium residential density, light industry/office, and commercial zones in the Canal area as well as industrial and general commercial uses adjacent to Highway 101 and Interstate 580. Another defining characteristic of the study area is the abundance of low density residential zoning, which in some places – including the south side of 4th Street along the Miracle Mile, parts of the south side of Sir Francis Drake between Fairfax and San Anselmo, and along much of Center Boulevard – directly abuts the corridor.

[1] Please refer to the table below for a concordance of residential density by community.

Residential Density Category	San Rafael	San Anselmo	Fairfax	Ross
High	15-32 units/acre	13-20	-	-
Medium	6.5-15	6-12	7-12	6-10
Low	2-6.5	1-6	1-6	1-3; 3-6
"Resource" (Very Low/Hillside)	0.5-2	1 or less	0.25	0.1-1

Figure 2-5 Existing General Plan Land Uses in the Corridor



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POPULATION DENSITY & DEMOGRAPHICS

The Fairfax-San Rafael corridor houses a range of residents and employers. Figure 2-8 depicts current population and employment density in the corridor, as well as proposed developments in the Town of Fairfax and the City of San Rafael that may affect the demand for transit in the short- to mid-term future. A more detailed overview of these projects follows the map.

Population and employment density in the corridor follow expected patterns. There are higher levels of combined population and employment density in the historic neighborhood centers of Fairfax, San Anselmo, and particularly San Rafael. Transit serves these areas at a minimum of hourly headways during weekday midday periods, and also generally serves most areas with at least a medium level of population or employment density. More frequent service is available during peak commute times, including service to San Francisco.

Still, there are a few pockets of medium density housing or employment areas that are located beyond one-quarter mile of transit service. These include a pocket of medium population density on Woodland Avenue south of downtown San Rafael, and a small pocket of employment density located along Center Boulevard at the former interurban stop Yolanda Station (near the intersection of Center Boulevard and Saunders Avenue).

Beyond downtown San Rafael, the Canal area is densely populated, with Marin Transit Routes 23, 29, 35, and 36 providing high levels of service to these residents.

Major Development Projects in the Study Corridor

A primary goal of this study is to explore opportunities to increase transit ridership in the corridor. Future population and employment projections are not as geographically precise as current data (and therefore not useful for predicting future additional demand for transit). However, the Town of Fairfax and the City of San Rafael are each planning for several developments within the scope of the corridor that may increase demand for transit service in the short- to mid-term future. Figure 2-6 provides details on these developments (which are illustrated in Figure 2-8 below).

Figure 2-6 Current and Future Corridor Developments

Project Name/Address	Use	Number of Units	Status
Fairfax			
14 Mitchell Street	Senior Housing	40	In process
10 Olema Street	“Work-force” Housing	20 (proposed)	Pipeline
“Fairfax Market” 2040 Sir Francis Drake Boulevard	Mixed-use	8 (Residential); 6,000 SF (Commercial)	Pipeline
San Rafael			
1700 4th Street	Residential	10	In process
815 B Street	Residential	41	In process
21 G Street	Residential	9	Approved

Project Name/Address	Use	Number of Units	Status
1203 Lincoln	Residential	32	Approved
454 Mission	Residential	12	Approved
BioMarin Office/Lab	Office	80,000 SF	Pipeline
930 Tamalpais Ave (Whistle Stop)	Senior Housing	50	Pipeline
999 3rd Street	Residential	Unknown (but large site)	Pipeline
1075 Francisco Blvd East	Residential	Unknown	Pipeline
Marin Square Shopping Center (Bellam Blvd between US 101 and I-580)	Institutional – potential Sutter Health center	Unknown	Pipeline

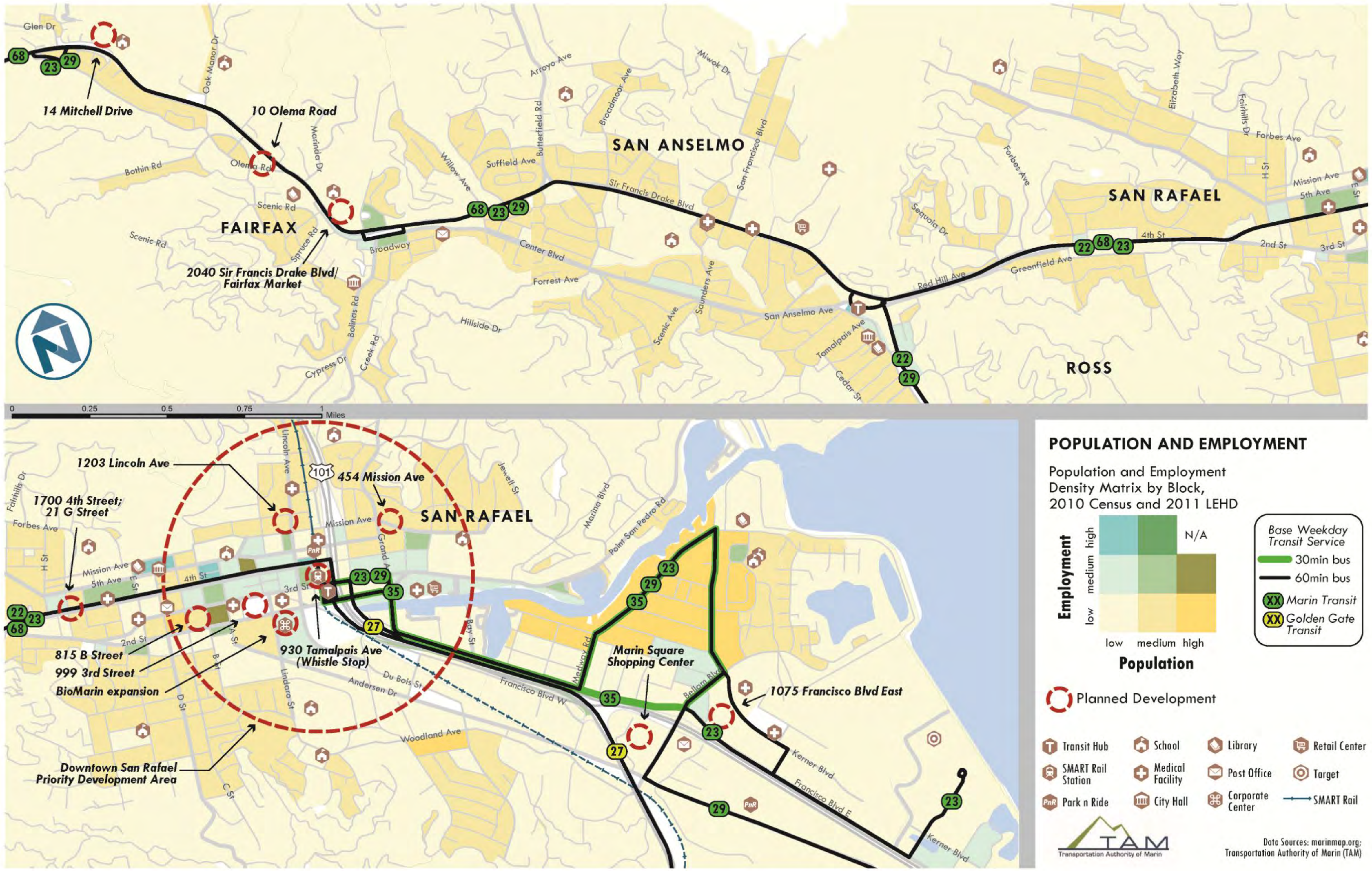
Sources: Town of Fairfax Housing Element and Jim Moore; Paul Jensen, City of San Rafael

In the longer-term future, there may be additional developments in San Rafael around the SMART station. The 2012 San Rafael Station Area Plan identified a total of five opportunity sites, including the Whistle Stop redevelopment listed above. See Figure 2-7 below.

Figure 2-7 Potential San Rafael Station Opportunity Sites

Source: 2012 Downtown San Rafael Station Area Plan

Figure 2-8 Current Population and Employment Density in the Corridor, with Planned Developments



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Selected Population Demographics in the Corridor

The corridor is home to a variety of people, including people in all stages of life and people who earn a range of incomes. Generally, more low income residents (defined as monthly wages of approximately $1,250 a month or less, or at most $15,000 a year) live in the Downtown San Rafael segment, while the Miracle Mile houses more seniors age 65 and older than other segments of the corridor. The highest percentage of youth under the age of 18 lives in the Downtown Fairfax to San Anselmo Hub segment. The adjacent Canal area is also home to relatively high portions of youth and low-income residents as well.

(Note: Segment-based population characteristics are provided for basic illustrative purposes only; due to analytical constraints, the figures for each segment also include people living in areas ½ mile on either end of the segment.)

Figure 2-9 Key Demographics for People Living within ½ Mile of Study Corridor

Segment	Total Population	Youth Under 18 (% of Total)	Age 65+ (% of Total)	% Low Income*
Full Corridor + Canal Area	**42,227**	**21%**	**10%**	**21.0%**
Manor – Downtown Fairfax	4,861	20%	13%	20.3%
Downtown Fairfax	7,157	21%	12%	21.2%
Downtown Fairfax to San Anselmo Hub	12,375	23%	13%	19.3%
Miracle Mile	10,020	20%	16%	19.1%
Downtown San Rafael	12,750	16%	12%	21.5%
The Canal (East of Highway 101)	16,048	23%	7%	23.2%

* Number of jobs earning less than $1,250 per month (approximately $15,000 annually), from LEHD data

Note: Sources: 2010 Census; 2011 Longitudinal Employer-Household Dynamics (LEHD) data

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3 MULTIMODAL TRANSPORTATION

The Fairfax to San Rafael corridor is a true multi-modal corridor, serving automobiles, trucks, buses, bicycles, and pedestrians. Historic rail right of way, linking the downtowns in the corridor now serve as the primary East-West route from San Rafael to Fairfax, including portions of Red Hill Avenue and 2nd Street (San Rafael), the Miracle Mile (San Anselmo), and Center Boulevard, and Sir Francis Drake Boulevard through Fairfax. Every day, thousands of people drive, walk, or cycle on these historic connections, legacies of the railroads that helped build corridor communities.

This section explores current and future automobile, bicycle, and pedestrian facilities in the corridor.

OVERALL TRAVEL PATTERNS

The study corridor is the primary means of east-west travel across Marin County, connecting the communities of Fairfax, San Anselmo, and San Rafael with regional destinations via Highway 101 and Interstate 580. The corridor's commercial centers and schools generate traffic within the corridor and from surrounding communities. Not surprisingly, a great deal of traffic in the corridor is tied to work commutes, with traffic generally moving eastward toward employment centers in the morning and returning westward in the evening.

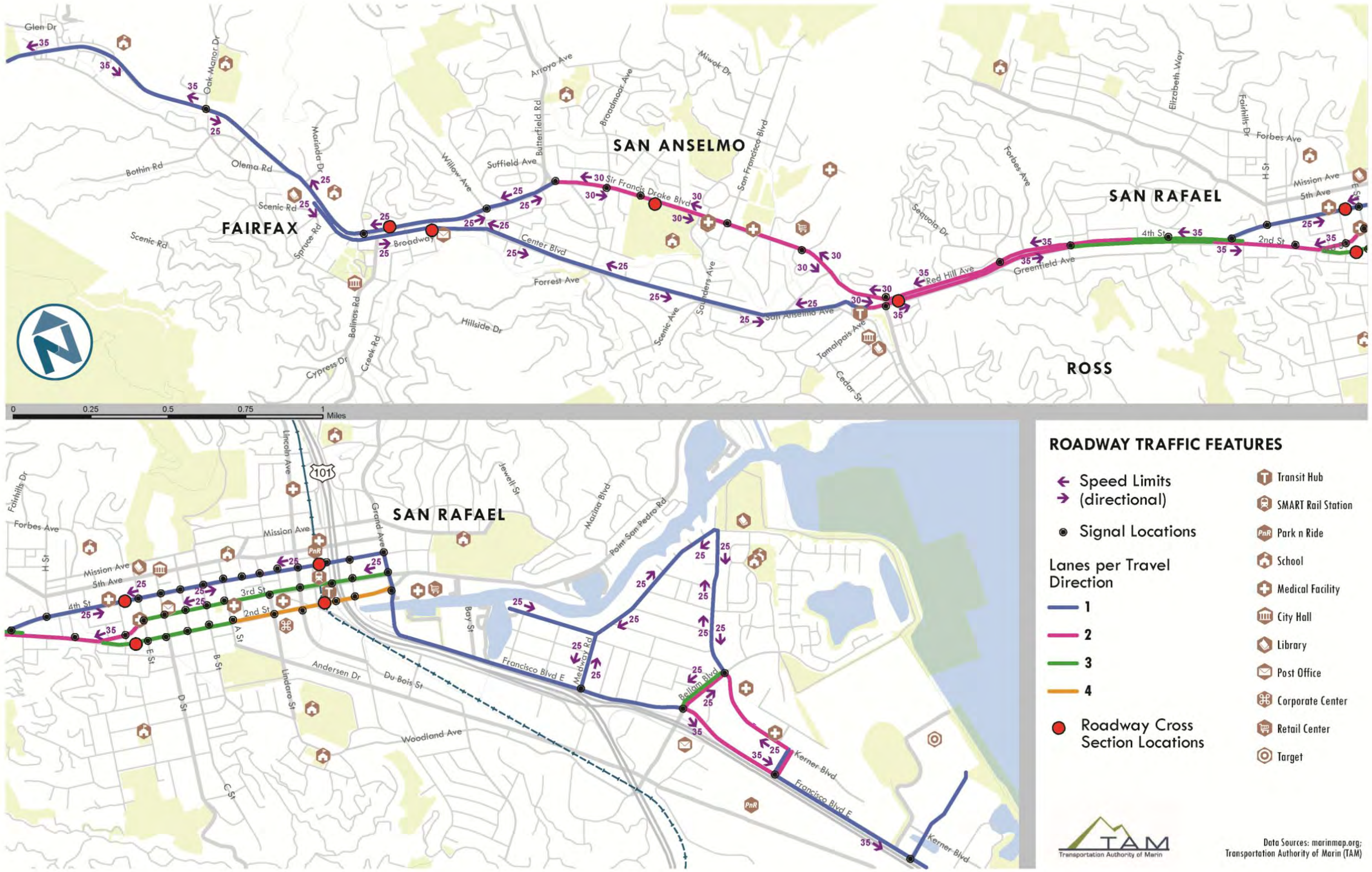
In addition to transit riders, the corridor accommodates people who walk, bike, and drive.

Demand is also strong within the corridor, with Sir Francis Drake High School, located on Sir Francis Drake Boulevard in San Anselmo, accounting for a significant portion of school morning and afternoon peak traffic along both Sir Francis Drake Boulevard and Center Boulevard. Roadways within the adjacent Canal area accommodate two different types of users: in this area, roadways are increasingly oriented toward highways with Francisco Boulevard West, the primary connector between San Rafael, the Canal area, and Shoreline Parkway, serving as a frontage road along Highway 101 and then I-580. In addition to serving as significant collector roads for people traveling to and from Highways 101 and 580, these roadways also have a very high bicycling and walking mode share, owing in part to the lower socio-economic demographic living in the Canal area. Finally, downtown Fairfax is both a starting and destination point for recreational bicyclists.

ROADWAYS & AUTOMOBILE FACILITIES

Figure 3-1 provides a graphical overview of automobile facilities on all primary corridor roadways, including number of travel lanes in each direction, speed limits, and traffic signal locations. As in previous sections, data for the adjacent Canal area are included for context. Additionally, eight roadway segments within the study corridor were selected to depict their existing cross sections. Cross section locations are also identified in Figure 3-1. The selected locations are representative of the varying conditions along the study corridor, and include existing pedestrian, bicycle, and automotive facilities. These diagrams, grouped by corridor segment and provided as Figures 3-2 through 3-9, illustrate how roadway space in the corridor is currently allocated among different modes.

Figure 3-1 Automobile Facilities in the Study Corridor, including Cross Section Locations



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Corridor Roadway Cross Sections

Fairfax to San Anselmo Hub

Study roadways in Fairfax (Sir Francis Drake Boulevard, Center Boulevard, and Broadway Boulevard) are one lane each direction, with speeds set at 25 mph. Speed limits within San Anselmo range from 25 mph along Center Boulevard to 30 mph along Sir Francis Drake Boulevard. Three traffic signals are within the study area in Fairfax, all along Sir Francis Drake Boulevard; all intersections along Broadway and Center Boulevards are controlled with stop signs. Nine traffic signals are located along Sir Francis Drake Boulevard in San Anselmo.

Figure 3-2 Sir Francis Drake Boulevard East of Taylor Drive – Cross Section

Figure 3-3 Center Boulevard East of the Fairfax Post Office – Cross Section

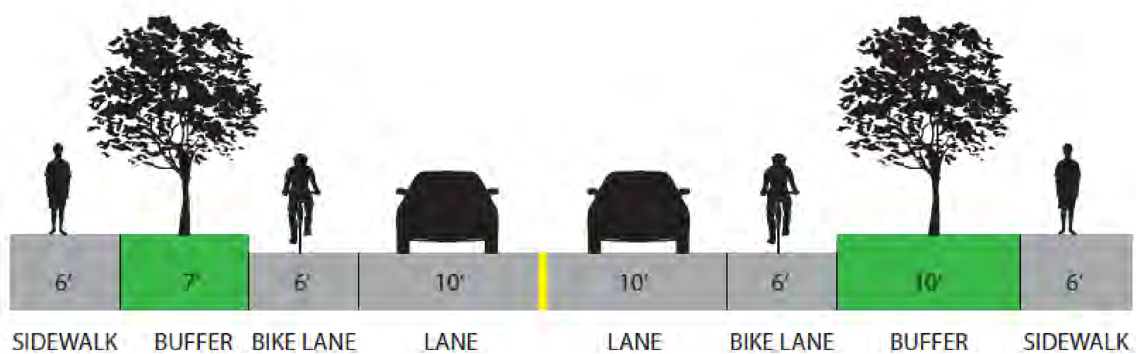


Figure 3-4 Sir Francis Drake Boulevard at Sir Francis Drake HS – Cross Section

The Miracle Mile

Along the Miracle Mile, travel lanes increase to two lanes per direction; beginning at the San Anselmo Hub, speed limits increase to 35 mph until downtown San Rafael.

Figure 3-5 The Miracle Mile East of the San Anselmo Hub – Cross Section

Downtown San Rafael

Within San Rafael, the 2nd/3rd Street one-way couplet widens to at least three lanes in each direction, with 4th Street remaining one lane in each direction. Within downtown San Rafael, all streets are marked for 25 mph. Signals are also located at nearly every intersection once entering downtown San Rafael from E Street through to Grand Avenue, accounting for a total of 37 traffic lights within this portion of the study corridor.

Figure 3-6 2nd Street East of Shaver Street – Cross Section

Figure 3-7 4th Street East of Shaver Street – Cross Section

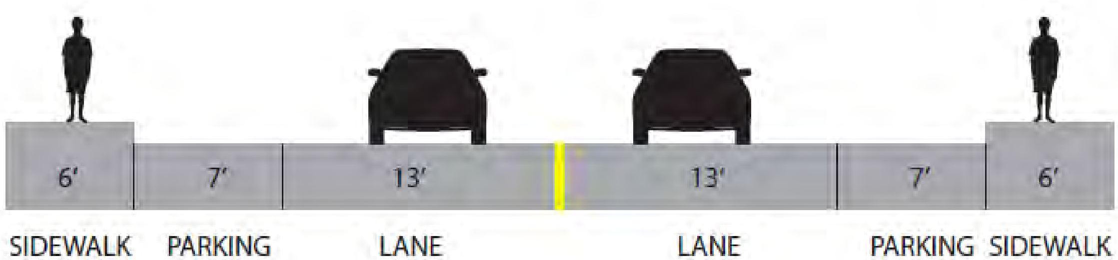


Figure 3-8 2nd Street West of Hetherton Street – Cross Section

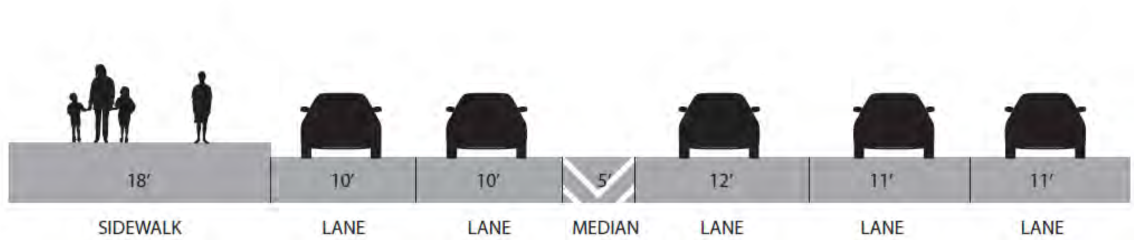
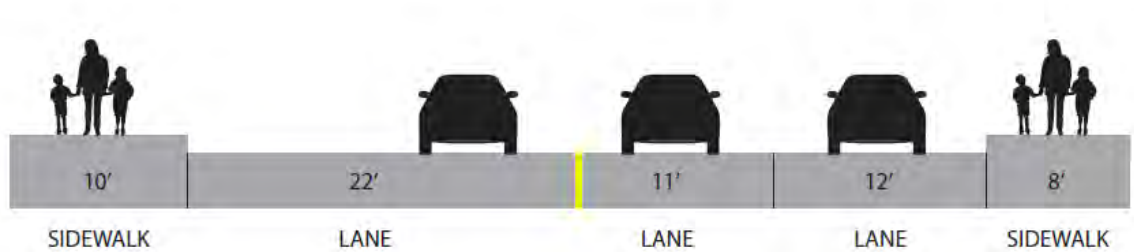


Figure 3-9 4th Street West of Hetherton Street – Cross Section



Beyond Downtown San Rafael

Southeast of downtown San Rafael, adjacent to the study corridor in the Canal area, travel lanes are typically one lane each direction, with lanes increasing to two or three per direction proximal to freeway on and off-ramps on Bellam Boulevard. Kerner Boulevard in the Canal area between Irene Street and Bellam Boulevard is one way. South of downtown San Rafael five additional traffic lights are located on the Francisco Boulevard West/Bellam Boulevard network and speed limits in this area range from 25 mph to 35 mph.

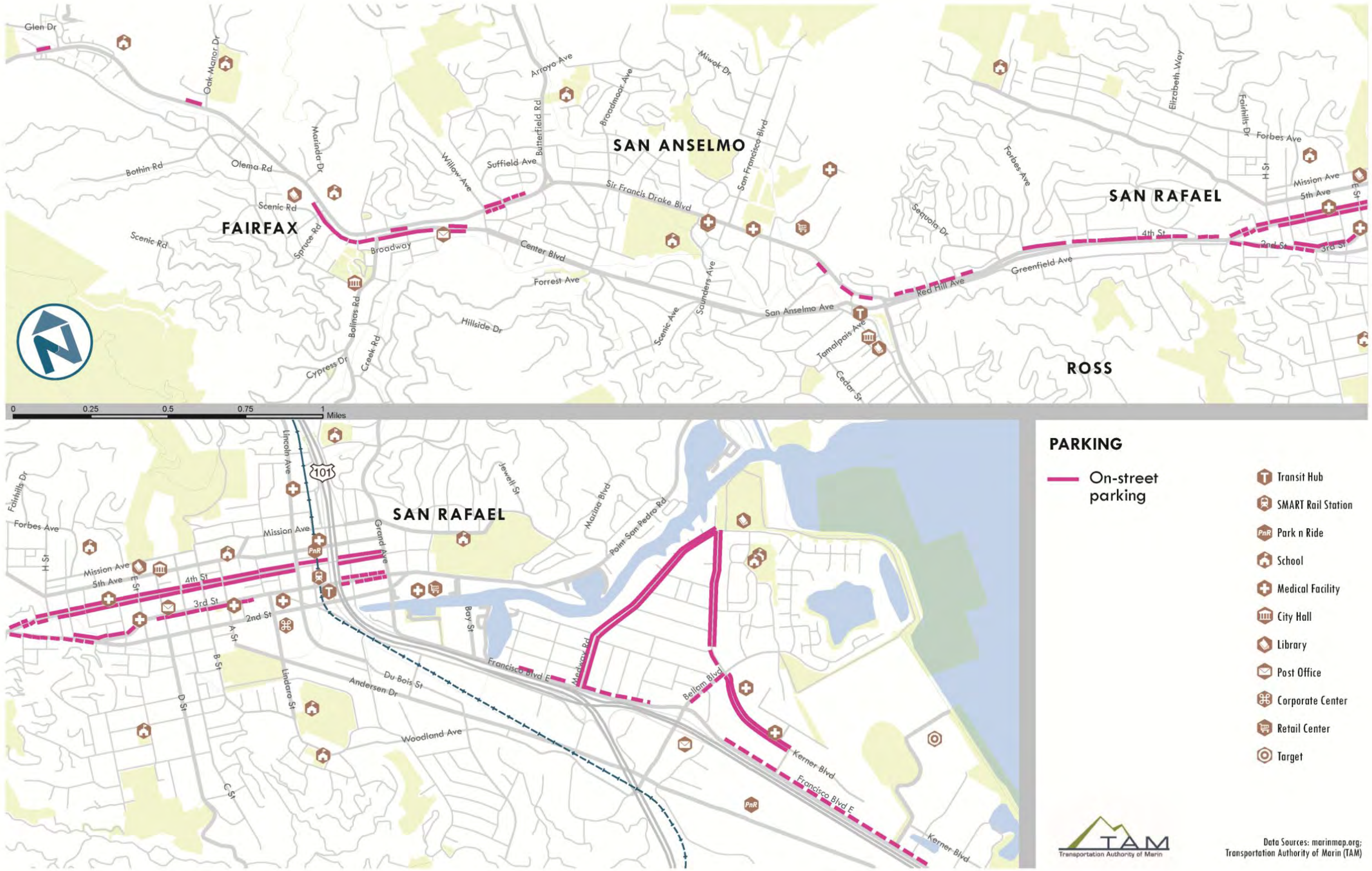
Varied street types in the Canal area. Bellam Boulevard (left) and Canal Street (right).
Source: Google maps

On-Street Parking

Generally, on-street parking is readily available in the traditional downtown areas of Fairfax and San Rafael. Elsewhere along the corridor between Manor and San Anselmo, on-street parking is relatively scarce. Moving into San Rafael, on-street parking is available on most portions of the north side of Miracle Mile, and in the Canal neighborhood, there is a significant amount of on-street parking on Kerner Boulevard, Canal Street, and Medway Road, as well as along Francisco Boulevard East.

See Figure 3-10 for a map showing the location of on-street parking facilities in the study corridor.

Figure 3-10 On-Street Parking in the Study Corridor



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Motor Vehicle Level of Service (LOS) and Average Daily Traffic (ADT)

Average daily traffic (ADT) measures the average number of vehicles using a designated portion of roadway in a 24-hour period. While ADT is a measure of demand, the level of service (LOS) is a common measure comparing demand to available capacity. LOS uses letters A through F, with A representing free flow traffic with no delays and F representing highly delayed, gridlocked conditions. Cities set their own goals for roadway performance. In general a level of service D or higher is considered acceptable in downtown areas and LOS C or higher is acceptable in higher density residential areas outside of downtowns.

LOS measurements show that most of the service area meets performance targets with the exception of the congested intersections, the most significant being at “the Hub” of Miracle Mile/Sir Francisco Drake Boulevard/Center Boulevard, which often experiences “E” and “F” levels during peak times.

Depending on whether it is a weekday (more cars) or weekend (relatively fewer cars), daily traffic levels along Sir Francis Drake Boulevard in San Anselmo range from approximately 25,000-28,000 cars per day. Along Center Boulevard, ADT ranges from approximately 9,000-11,000 cars. The Miracle Mile ranges from approximately 34,000-41,000 cars. Traffic within downtown San Rafael ranges quite a bit, generally increasing as it collects from 4th to 2nd Streets, and from F and G Streets (westernmost area of downtown San Rafael, connecting 4th, 3rd, and 2nd Streets) to Highway 101.

Adjacent to the study corridor in the Canal area, the same pattern of traffic collection near the Highway 101 and 580 on and off ramps can be seen with approximately 29,000 cars near the freeway exits and approaches on Bellam Boulevard, and 15,000-18,000 cars daily along Francisco Boulevard East. Shoreline Parkway at the eastern limits of the study area has several high-volume automotive dealerships as well as two major retail destinations, The Home Depot, and Target. This location has an ADT of 8,400 vehicles. See Figure 3-11.

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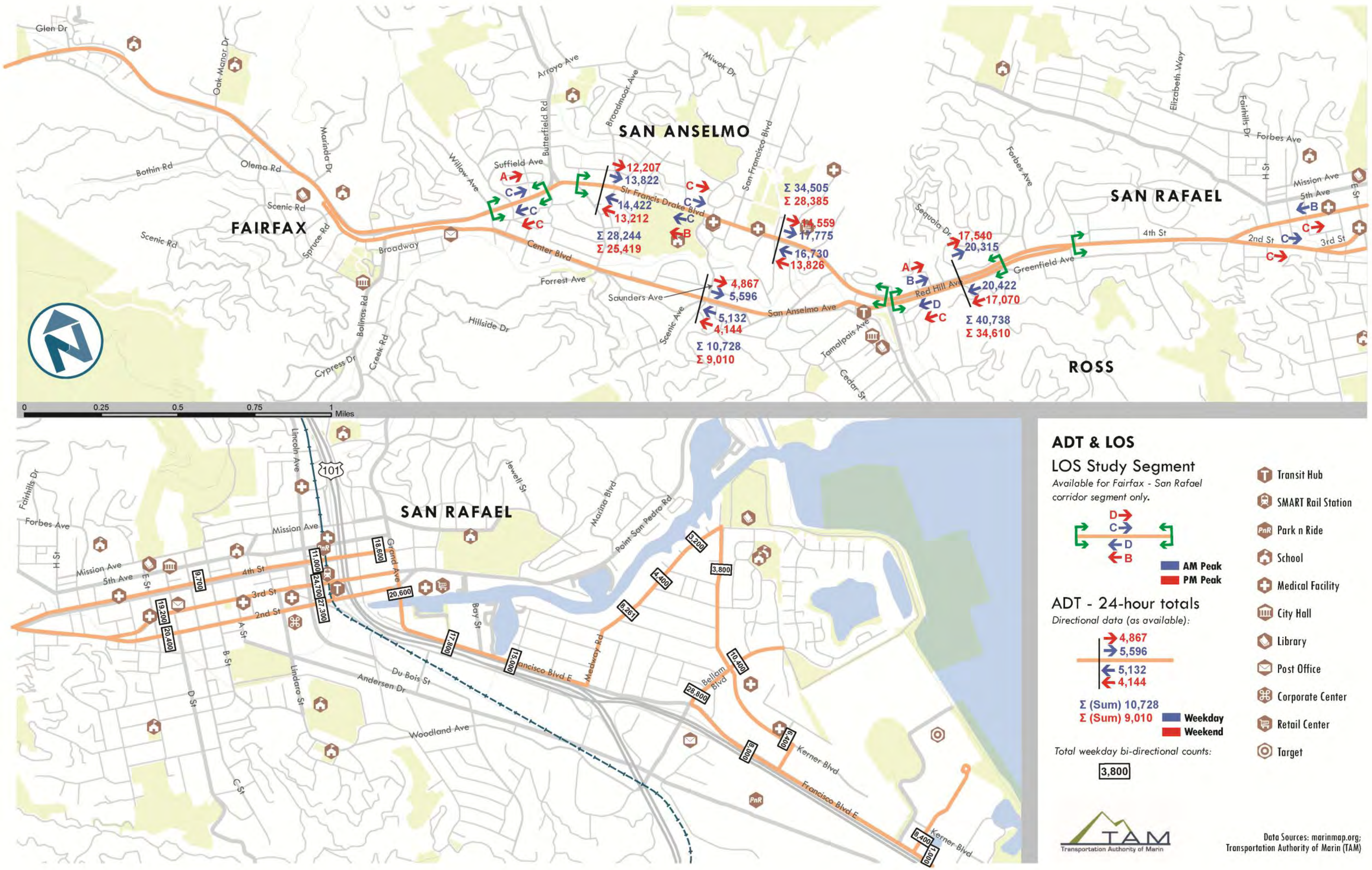
Figure 3-11 Motor Vehicle Average Daily Traffic Volumes and Level of Service (LOS) in the Corridor



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EXISTING BICYCLE AND PEDESTRIAN FACILITIES

The Fairfax to San Rafael transportation corridor is frequently used by people who choose to bike and walk for work, shopping, and recreation purposes. A network of bicycle-specific facilities has been built to increase the safety and visibility of bicyclists. Figure 3-12 illustrates both pedestrian and bicycle facilities as they currently exist in the study corridor.

Marin County has a system of designated bicycle routes. These routes are denoted with a special sign and route number visible to both bicyclists and motorists. Four Marin County bicycle routes are situated along the study corridor: Route 20 in an east-west alignment through Fairfax and San Anselmo along Sir Francis Drake Boulevard and Center Boulevard; Route 28 in a north-south alignment, along Butterfield Road in San Anselmo, crossing Sir Francis Drake Boulevard, and intersecting with Center Boulevard; Route 24 in an east-west alignment through San Anselmo and San Rafael, primarily along Greenfield Avenue (adjacent to Red Hill Avenue), and continuing along 4th Street in San Rafael; and Route 22 in San Rafael in an east-west alignment along Andersen Drive, meeting 2nd Street near the Bettini Transportation Center.

A network of Class I (off-street or physically separated), Class II (bike lanes), and Class III (shared use) facilities can be found along the study corridor. Of note is the Class I facility on Bicycle Route 22 running between Larkspur and San Rafael (the Cal Park Hill Tunnel just off of the map), and a Class I facility parallel to Highway 101 between the freeway and Lincoln Avenue, connecting Terra Linda with downtown San Rafael. Class II facilities are found in Fairfax along portions of Sir Francis Drake Boulevard and Center Boulevard and also in San Rafael along Anderson Drive (Bicycle Route 22). Finally, a network of Class III facilities, some with shared lane markings or "sharrows", tie the local neighborhoods in to the greater transportation system. Greenfield Avenue in San Anselmo and San Rafael and 4th Avenue in downtown San Rafael feature sharrows, and are important low-speed routes for bicyclists traveling in an east-west direction.

Bicycle facilities along Center Boulevard near Fairfax.

Likewise, a network of sidewalks permits pedestrians to walk the entire length of the study corridor. Sidewalks are available for nearly every street in downtown San Rafael with the exception of along the south side of 2nd Street as it approaches Highway 101 from the west (heading east). Sidewalks are absent of a small portion of the road where 2nd and s3rd Streets meet at the westernmost portion of downtown San Rafael. Sir Francis Drake Boulevard in Fairfax is notable for a lack of sidewalk on the south side of the road between Pacheco Avenue and Pastori Avenue, and a short distance in San Anselmo just west of Butterfield Road. Sidewalks are nearly absent along most of Center Boulevard between Fairfax and San Anselmo.

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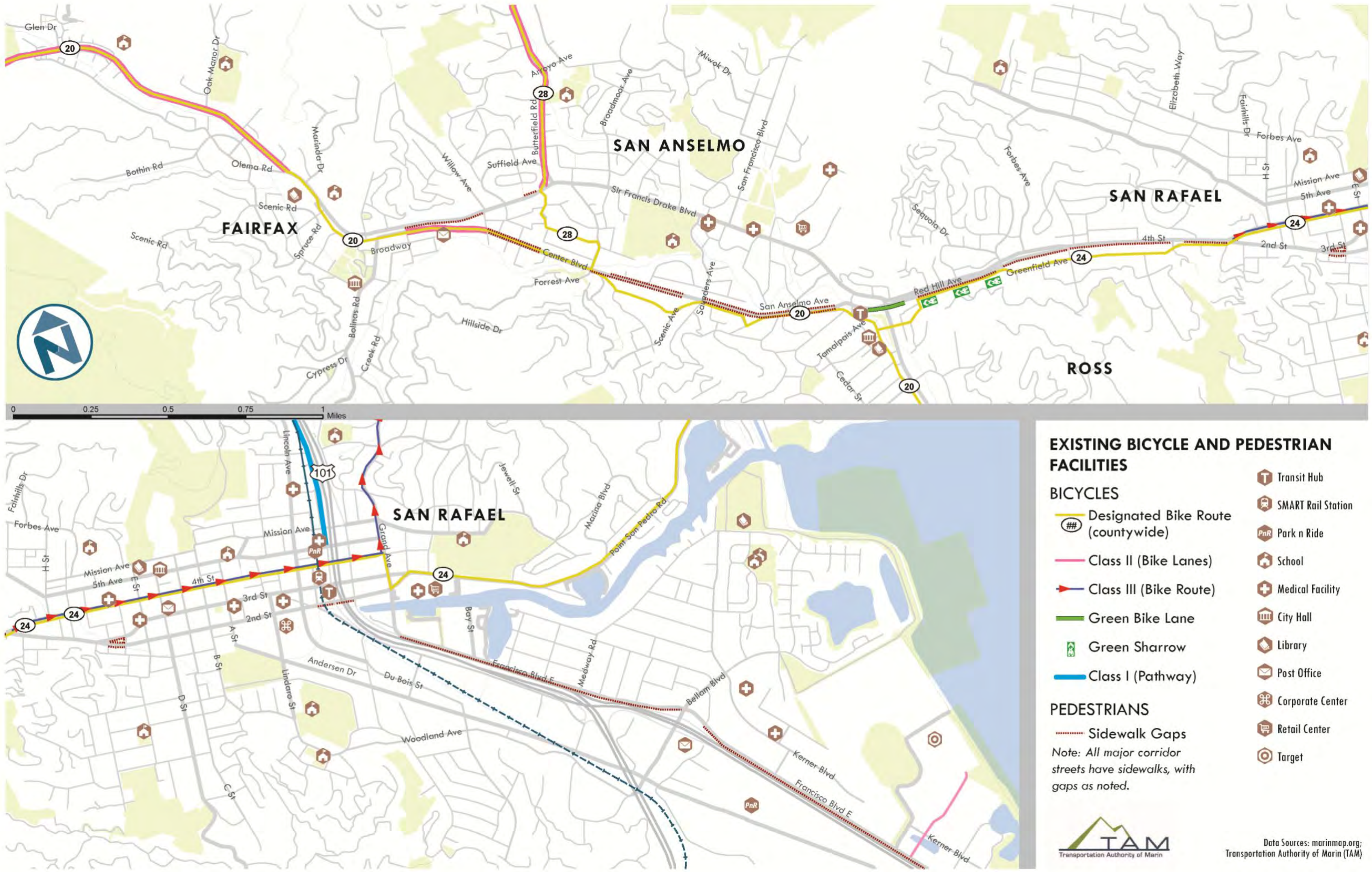
Figure 3-12 Existing Bicycle and Pedestrian Facilities



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PROPOSED BICYCLE AND PEDESTRIAN FACILITIES

The Bicycle and Pedestrian Master Plans for each of the three municipalities in this study corridor contain both an inventory of existing facilities as well as proposed improvements to the bicycle and pedestrian system. These master plans were consulted as a source for potential future improvements. The San Rafael Bicycle & Pedestrian Plan was updated and adopted relatively recently, in 2011; the San Anselmo and Fairfax 2008 Bicycle & Pedestrian Plans are slated to be updated in 2015-2016. See Figure 3-13 for an overview of all pedestrian and bicycle facility improvements in the study area.

Bicycle Facility Improvements

A Class I facility has been proposed for Center Avenue from Fairfax to San Anselmo. This former railroad right-of-way has the potential in some sections to provide a separated pathway as a direct alternative to the local neighborhood roads used by bicyclists or Sir Francis Drake Boulevard.

Class II bike lanes have been proposed along additional portions of Sir Francis Drake Boulevard in Fairfax as it approaches San Anselmo. Bike lanes have also been proposed for portions of 5th Avenue in downtown San Rafael as well as portions of 2nd and 3rd Streets in San Rafael, extending beyond 3rd Avenue and the study area and along Point San Pedro Road. Class II bike lanes have been proposed for Francisco Boulevard East as well as Kerner Boulevard in San Rafael's Canal neighborhood.

A roundabout has been proposed for San Anselmo's "Hub." The "Hub" is where Sir Francis Drake Boulevard meets both Red Hill Avenue and Center Boulevard. It has traditionally been a difficult intersection for bicyclists and pedestrians, as well as a point of significant congestion within the study corridor. A roundabout has the potential to address some of the vehicular and non-motorized concerns with this major intersection.

A network of Class III facilities has been proposed for most neighborhood streets in Fairfax as well as connectors to move bicyclists between 2nd, 3rd, and 4th Streets in downtown San Rafael.

Pedestrian Facility Improvements

Proposed pedestrian improvements were sourced from the local Bicycle and Pedestrian Master Plans for all three municipalities in the transit corridor study.

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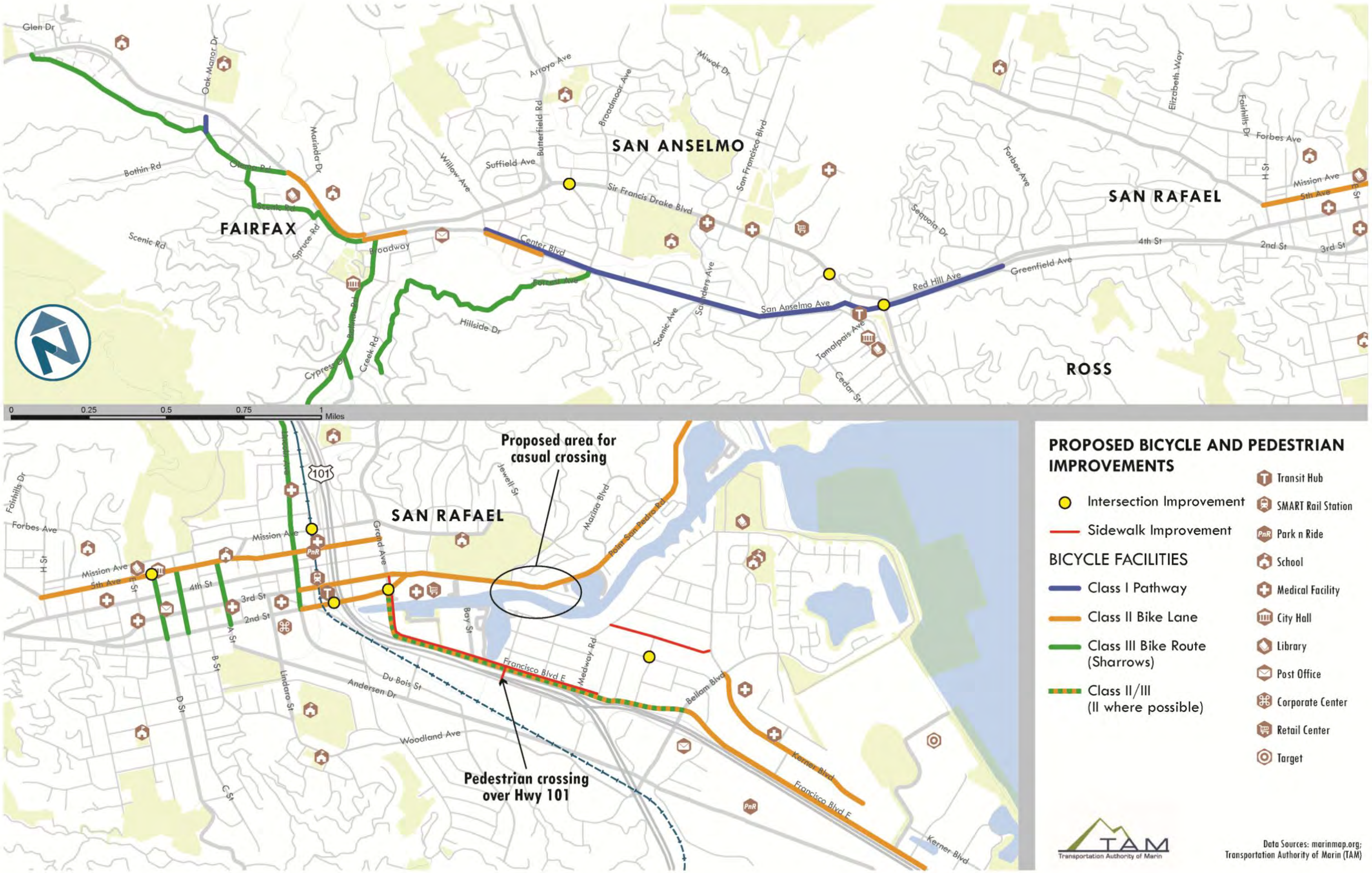
Figure 3-13 Proposed Bicycle and Pedestrian Network Improvements



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Intersection improvements account for the majority of proposed pedestrian improvements. While many were noted in all three master plans, several are worth noting in this study:

- Sir Francis Drake Boulevard and San Anselmo Avenues in San Anselmo (a major crossing for both school children and bicyclists)
- Sir Francis Drake Boulevard and San Francisco Avenue in San Anselmo (also a major crossing for school children)
- The Hub in San Anselmo, noted for wide crossing lengths, fast traffic, and as a major collection point for both bicyclists and pedestrians
- 5th Avenue and D Street in San Rafael (close to both the library and Marin Academy)
- 2nd Street and Tamalpais Avenue in San Rafael (close to both the freeway and the Bettini Transit Center)
- Mission Avenue and Tamalpais Avenue in San Rafael
- 2nd Street and Grand Avenue in San Rafael

Of special note are two proposed pedestrian crossings in San Rafael: one over a portion of the canal in the Canal area just beyond the study limits, and the other over Highway 101 connecting Francisco Boulevard East and Francisco Boulevard West. The sidewalks along Francisco Boulevard East have also been studied and are included for potential widening in the "San Rafael Bicycle and Pedestrian Master Plan (2011 Update)."

The Fairfax Parkade, slated for improvements in the short-term future.

Another significant project of note is the Fairfax Parkade Study. The Parkade is the primary downtown parking facility in Fairfax. It separates and acts as a barrier between two study area roads: Broadway and Sir Francis Drake Boulevard. Access between the two streets for pedestrians is limited especially for those with disabilities. A grade difference between the Parkade and Broadway further complicates enhancing pedestrian connections. Proposed changes include adding two high-visibility crosswalks through the parking area, adding stairways and pedestrian ramps to connect the businesses on either side of the facility, widened sidewalks, rearranged parking layouts, and improved traffic circulation.[1]

[1] NTPP Project 501: Parkade Study, (July, 2010) http://walkbikemarin.org/documents/Parkade_501/501%20Parkade.pdf

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4 EXISTING TRANSIT SERVICE

The Fairfax-San Rafael corridor is served by both local and regional transit service. This chapter provides a detailed overview of current transit services within the corridor, including:

- A high-level description of how transit service operates along the corridor;
- A summary of key operating statistics for current Marin Transit and Golden Gate Transit services, highlighting frequency at weekday peak, weekday off-peak, and weekend times;
- Available ridership data, including weekday boardings and alightings at bus stops within the corridor and rider demographics for local Marin Transit routes;
- Information about Bettini Transit Center, the most significant transit facility in the corridor; and
- A description of future transit service in the corridor, specifically related to the implementation of Sonoma-Marin Area Rail Transit (SMART) service in 2016.

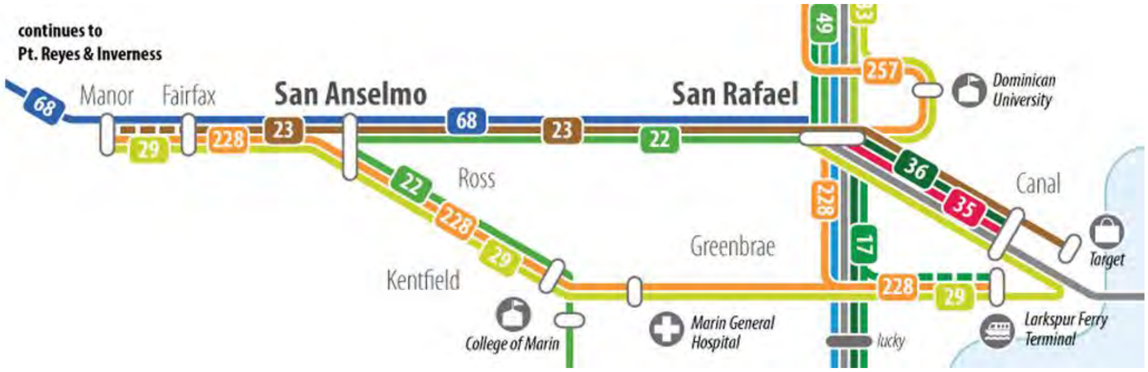
OVERVIEW

The study corridor is served by three types of transit service: local service, provided by Marin Transit on seven routes which travel at least part of the corridor; commuter service, provided by three Golden Gate Transit routes; and a shuttle operated by Golden Gate Transit exclusively to and from the Larkspur Ferry Terminal on weekdays.

Most of the transit lines within the corridor do not serve the entire corridor, but rather, serve only one or two of three core transit segments:

- Sir Francis Drake Boulevard from west of Fairfax (Manor), through downtown Fairfax to the San Anselmo Hub
- The Miracle Mile (Red Hill Avenue/4th Street) from the San Anselmo Hub to the Bettini San Rafael Transit Center
- East Francisco Boulevard from the San Rafael Transit Center southeast through the Canal Area to Shoreline Parkway, which though adjacent to the core study area is nevertheless a significant transit trip generator

Figure 4-1 Overview of Marin Transit Service in the Corridor Vicinity



Source: Marin Transit

TRANSIT SERVICES IN THE CORRIDOR

As previously noted, the Fairfax-San Rafael corridor was developed around transit service. Today, transit continues to function as a backbone of the study corridor, although there are few routes that serve the corridor from end to end.

Figure 4-2 below provides a summary of key operating statistics for services along the corridor. A narrative discussion of this information follows the frequency maps below. Note: a route's productivity indicator is defined as the number of passengers it carries per each hour it is in revenue service, offering a snapshot of how people are currently using each transit route. This productivity indicator is only available for the entire route and may not represent ridership solely within the study corridor.

Figure 4-2 Summary of Transit Service in the Corridor

Route	Destinations	Corridor Segments	Frequency (minutes)	Span	Productivity (Passengers or Boardings per Revenue Hour)*	Notes
Golden Gate Transit						
24	Ross Valley – San Francisco	Manor – San Anselmo Hub	Peak: 10-20	From/to Ross Valley: 4:30 AM – 8:30 AM 2:25 PM – 7:00 PM	Southbound/AM Peak: 25 Northbound/PM Peak: 16 Average: 20	Peak only; to/from San Francisco
25	Manor – Larkspur Ferry via San Anselmo	Manor – San Anselmo Hub	Peak: 20-30	From/to Manor: 6:20 AM – 9:25 AM 4:05 PM – 7:05 PM	Eastbound/AM Peak: 8 Westbound/PM Peak: 18 Average: 13	Peak only; to/from Larkspur Ferry; branded The Wave

Route	Destinations	Corridor Segments	Frequency (minutes)	Span	Productivity (Passengers or Boardings per Revenue Hour)*	Notes
27	San Rafael – San Francisco; select trips to Sleepy Hollow	San Anselmo Hub – Downtown San Rafael	Peak: 15–45 (AM) 30-60 (PM)	From/to San Anselmo: 6:20 AM – 8:45am 4:00 PM – 6:35 PM	Southbound/AM Peak: 26 Northbound/PM Peak: 18 Average: 22	Peak only beyond San Rafael; one AM/PM trip to Sleepy Hollow
Marin Transit						
22	Marin City – San Rafael via San Anselmo Hub	Miracle Mile (San Anselmo Hub – Downtown San Rafael)	Peak: 30 Base: 60	Mon - Fri 5:30 AM – 11:55 PM Sat – Sun: 7 AM – 9:55 PM	Mon – Fri: 19.6 Sat: 15 Sun: 12 Average: 18.3	
23	Manor – Shoreline Parkway via Canal area	Entire study corridor (with exceptions – see Notes)	60	Mon – Fri: 5:50 AM – 10:45 PM Sat – Sun: 7:05 AM – 9:55 PM	Mon – Fri: 27 Sat: 24 Sun: 21 Average: 26.1	Weekends/ holidays operates downtown Fairfax to Shoreline Pkwy. only
29	Manor – San Rafael via Larkspur Ferry and Canal area	Manor – San Anselmo Hub & Canal area	Peak: 30 Base: 60	Mon – Fri: 6:30 AM – 9:05 PM	Average: 20.9	Weekend/holiday service provided by Route 228.
35	San Rafael – Canal area	San Rafael – Canal area	Peak: 10-30 Base: 30	Mon – Sun: 5:10 AM – 2:25 AM	Mon - Fri: 67 Sat: 69 Sun: 58	
36	Canal area – Marin City via San Rafael	San Rafael – Canal area	30	Mon – Fri: 6:55 AM – 9 AM 2:25 PM – 5:55 PM	Mon – Fri: 37	Peak only
68	Inverness – San Rafael	Manor – Downtown San Rafael	60-120	Mon – Fri: 6:15 AM – 10:40 PM Sat - Sun: 7:15 AM – 11:55 PM	Mon – Fri: 8.4 Sat: 7; Sun: 6	West Marin Stagecoach route
228	Manor –San Rafael via Larkspur Ferry	Manor – San Anselmo Hub	60	Sat, Sun, Holiday 6:40 AM – 8:25 PM	(Unavailable)	Weekday service provided by Route 29.

* Golden Gate Transit: Ridership from FY 2013-2014. Productivity defined as passengers or boardings per revenue hour Marin Transit: Ridership from FY 2013-2014.

Figure 4-3 illustrates the frequency of services in the corridor during weekday peak periods, with Figure 4-4 and Figure 4-5 depicting service frequency for all transit providers during weekday base (i.e., off-peak) times and on weekends, respectively. Because much of the transit service in the corridor operates only during commute hours, midday or base service is an indicator of the service available throughout the day.

As illustrated, frequency of service varies greatly among the three legs of the corridor, with the highest frequency from Fairfax to San Anselmo, and the lowest on the Miracle Mile between San Anselmo and San Rafael.

At some locations (like at the San Anselmo Hub), service along the corridor during weekday peak periods appears robust, with the combined frequency among all services under 10 minutes. While this gives the impression of quality transit service in the corridor, it is also misleading; only one of the ten transit routes providing service in the corridor, Marin Transit Route 23, travels the entire corridor every 60 minutes from Manor in Fairfax to Shoreline Parkway east of San Rafael. Half of the routes start in Fairfax and continue on Sir Francis Drake after the San Anselmo Hub, heading toward Highway 101 and the Larkspur Ferry. Likewise, service during off-peak times and on weekends is not as frequent or direct.

Generally, base (midday) service frequency between Manor, Fairfax, and the San Anselmo Hub, and along the Miracle Mile is 30 minutes, due to the combined effect of hourly Route 68 and 23 service (with the exception of two pulse periods). Likewise, midday Route 35 transit service operates every 30 minutes between San Rafael and the Canal area.

Figure 4-3 Weekday Peak Transit Frequency in the Fairfax–San Rafael Corridor

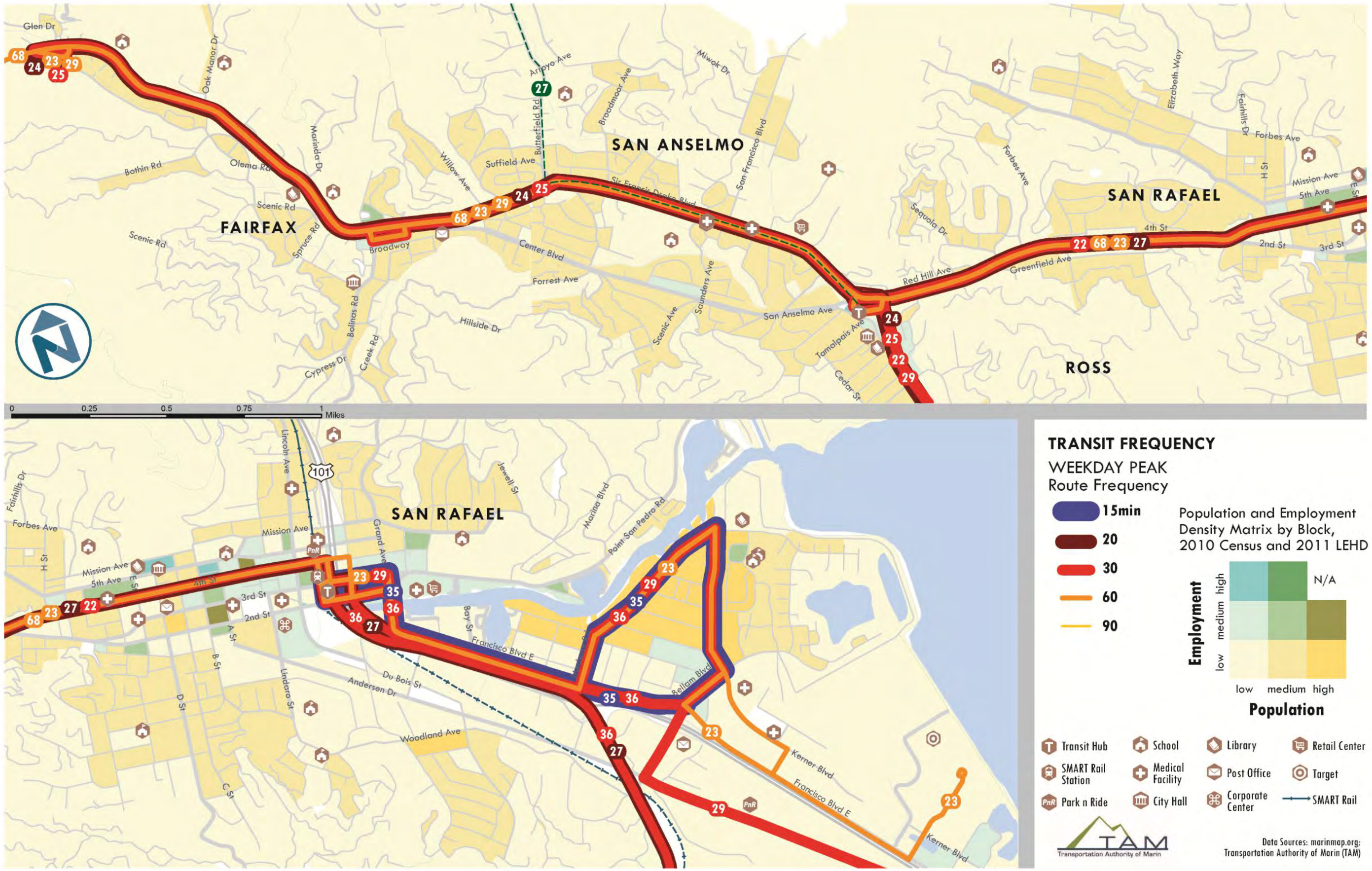


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Figure 4-4 Weekday Off-Peak (Base) Transit Frequency in the Fairfax–San Rafael Corridor

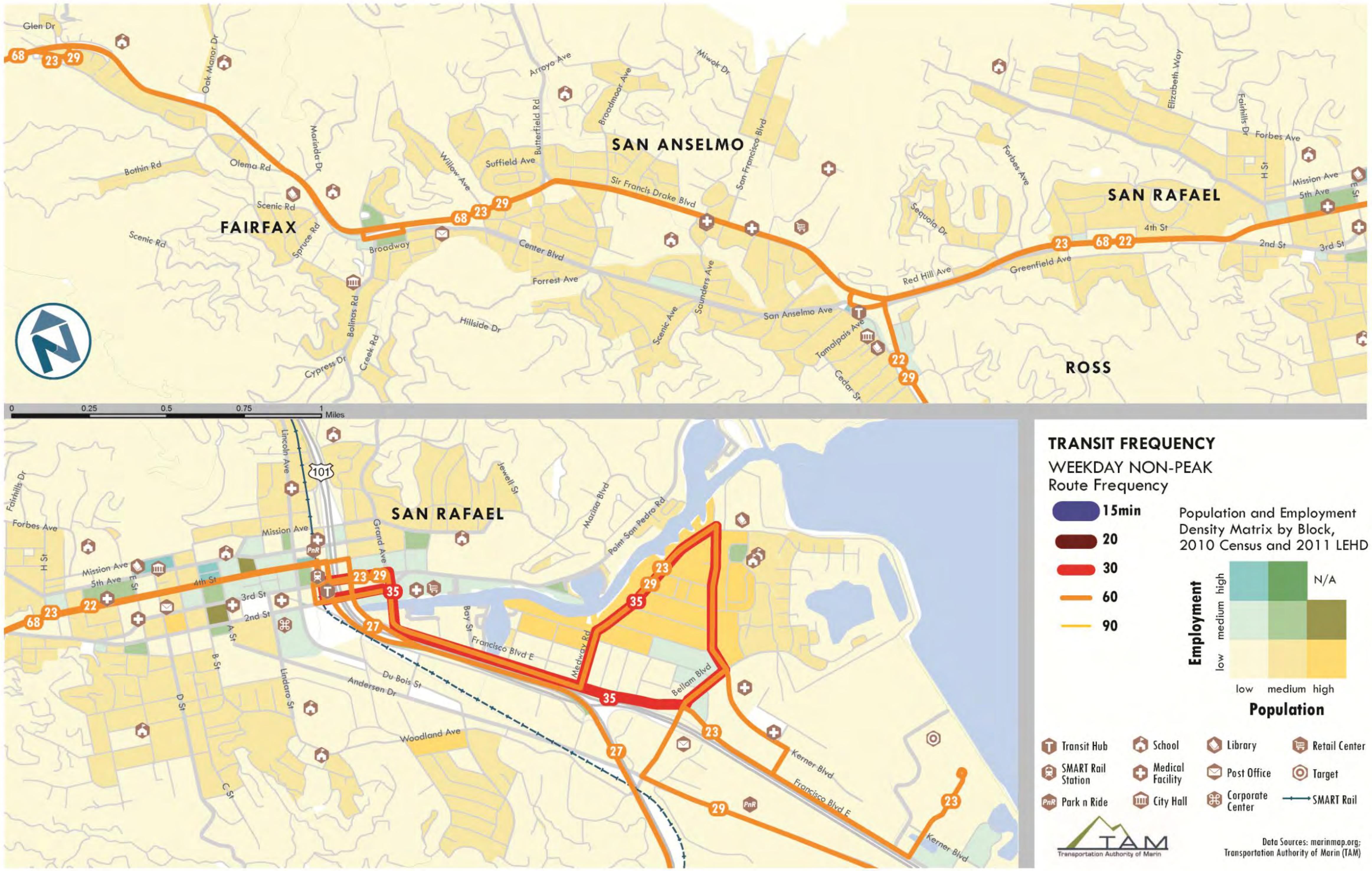

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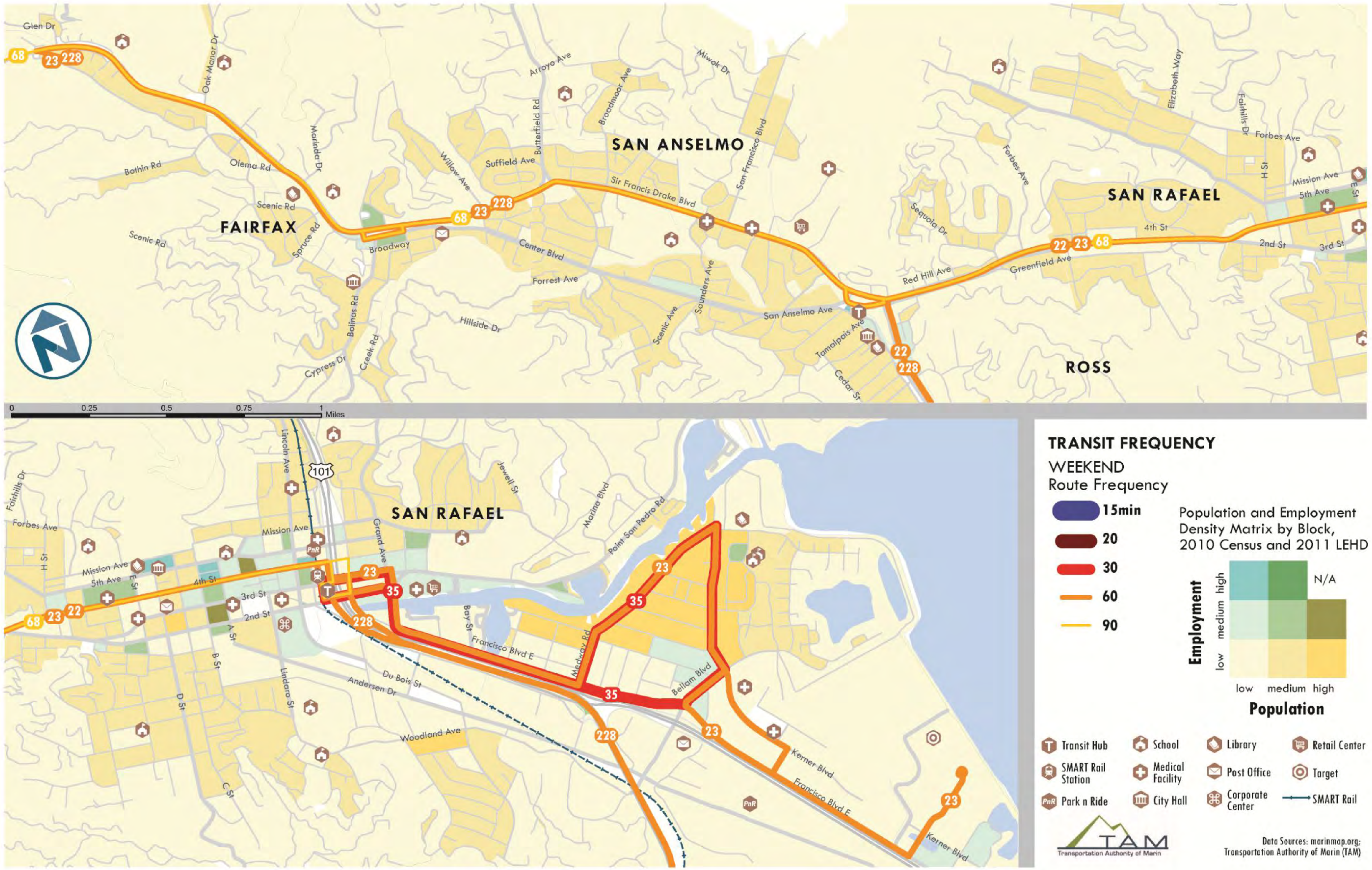
Figure 4-5 Weekend Transit Frequency in the Fairfax–San Rafael Corridor



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Marin Transit

Marin Transit provides local service in the study area via seven non-"tripper" (i.e., school service) routes serving various segments of the corridor, as described below. Information on rider demographic characteristics comes from an onboard survey conducted in 2013.

Note: Marin Transit also operates Route 125 as a "tripper" (i.e., school service) on school days only within the corridor between Lagunitas and San Rafael. This service is not evaluated in detail in this report.

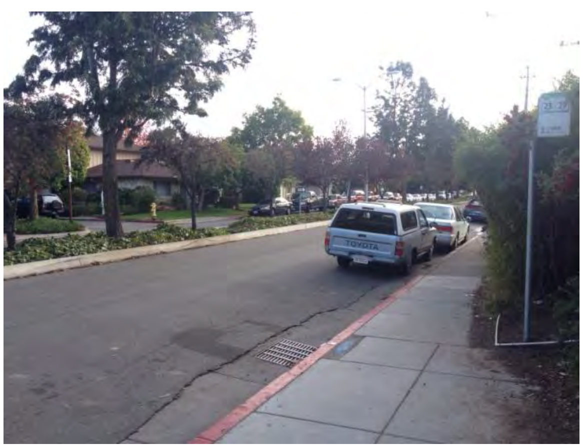
Route 22

Route 22 provides seven-day a week local service that only serves the Miracle Mile segment of the study corridor. Starting in Marin City, the route proceeds to Strawberry and Corte Madera, and then travels locally along Tamalpais Drive and Magnolia Avenue through Corte Madera and Larkspur to the College of Marin. From there it heads north via Sir Francis Drake Boulevard through Ross to San Anselmo. From here it heads east via the Miracle Mile to end at the San Rafael Transit Center.

Route 22 serves the College of Marin, and as such about 33% of riders are going to school and 33% are going to work. Another 8% take this route to go shopping. The route serves the Sir Francis Drake corridor west of College of Marin, and a number of local business centers including the Corte Madera Town Center.

Route 23

Route 23 serves the Fairfax-San Rafael-Canal area study corridor end-to-end seven days a week, providing service to Manor west of Fairfax on weekdays only. From the Fairfax area, Route 23 extends east along Sir Francis Drake Boulevard to the San Anselmo Hub, then along the Miracle Mile to the San Rafael Transit Center. It then continues southeast on Francisco Boulevard East to Medway, looping through the Canal area, before continuing on to Shoreline Parkway and the Target store.



Route 23 & 29 bus stop in the Canal area.

Per available data circa 2011, the route is busy along its entire length, with the highest number of boardings in downtown Fairfax and at the San Anselmo hub. In the eastbound direction, the peak load occurred on Fourth Street as the bus approaches the Transit Center. Westbound, the largest number of passengers boarded at the San Rafael Transit Center, with the peak load at the beginning of the trip on Fourth Street. Riders alight all along Sir Francis Drake Boulevard, with the largest number departing at Broadway and Bolinas Avenue in Fairfax. (Note: these data do not reflect current Route 23, which was extended to the Canal area and Shoreline Parkway in August 2013.)

This route carries more seniors; over 12% report being over age 65, nearly the highest percentage for all routes surveyed, compared to 7% systemwide. Over half of respondents report using the bus to go to work or to a work-related meeting or event.

Route 29

Route 29 runs on weekdays only, linking Fairfax with San Rafael but does not connect San Anselmo and central San Rafael directly. The line provides local service between the San Rafael Transit Center and Fairfax Manor, jogging north through the Canal area, then along Andersen Drive and Sir Francis Drake Boulevard through Larkspur, Ross, San Anselmo, and downtown Fairfax. Several early morning trips and mid-afternoon trips start and end at the San Anselmo Hub instead of Manor.[1]

Because Route 29 serves Marin General Hospital, it serves workers, students, and medical trips. Almost 44% of the riders report commuting to or from work, and 14% –twice the system average – use this route for medical or dental appointments.

Route 35

Route 35, the county's busiest route, is a link between San Rafael Transit Center and the Canal area via Francisco Boulevard. Starting at the Transit Center, the route runs on Francisco Boulevard East to Bellam Boulevard and Larkspur Street, where it loops through the Canal area on Kerner Boulevard and Canal Street before returning to the Transit Center. The entire loop takes approximately 25 minutes.

Approximately 1,300 riders arrive or depart the San Rafael Transit Center on Route 35 daily. Boardings are distributed in the Canal area with between 100 and 400 average daily boardings and alightings at most stops.

Marin Transit operating in downtown San Rafael.

Ridership on this route is more diverse than other routes; 83% identify as Hispanic or Latino, 30% reported that they do not speak English well, and 52% speak Spanish at home – over twice the system average for these last two factors. In addition, 6% of respondents identify as American Indian compared to 2% for the overall system. Route 35 riders have the lowest average incomes in the system, with nearly three-quarters (71%) of all riders indicating that they have household incomes under $25,000.

The route is identical to Route 36 on this segment, but Route 36 continues further south to Marin City (see description below). When Route 36 is not operating, Routes 23, 29, and 35 link the Canal area to San Rafael Transit Center for connections throughout the city and the region.

[1] Service along the study corridor is hourly all day, with 30-minute service available between the San Anselmo Hub and the Canal during the weekday peak only.

Route 36

Route 36, a weekday peak-hour service, travels from the Canal area to the San Rafael Transit Center and extends south via Highway 101 (stopping at bus pads) to Marin City. It provides a one-seat ride for Canal area passengers going to and from the south, with extensive local and regional connections at Marin City. When this route is not operating, Canal area passengers use Routes 23, 29, or 35 and transfer at San Rafael to reach southern destinations. Route 36 can be thought of as two routes: a combination of Route 35, which provides service in the Canal neighborhood, and the southern portion of Route 71, which provides service on Highway 101 between the San Rafael Transit Center and Marin City; it is not the sole service for any of the places it serves.

Characteristics of riders on the Route 36 are similar to those on the Route 35. Almost 60% of Route 36 respondents identify as Hispanic or Latino, and 32% reported speaking English "not well" or "not at all" with 33% speaking Spanish at home. Twenty percent of respondents identify as African American, almost twice the systemwide average. Over half of riders reported going to or from work and 18% were going to school, with very few riders using this route to go shopping.

Route 68 (West Marin Stagecoach)

Route 68 is one of two West Marin Stagecoach routes connecting the more urban Highway 101 corridor to the east with the rural western part of Marin County. It serves the western and central segments of the study corridor, connecting Inverness and Point Reyes Station with the San Rafael Transit Center via Fairfax and San Anselmo on Sir Francis Drake Boulevard, and central San Rafael via the Miracle Mile. The route takes approximately 80 minutes for a one-way trip.

While the Stage will stop at any Marin Transit stop, it is also a "flag service" (it will pick up and drop off at any safe location) along the portion of the route west of Manor.

Route 68 carries students from West Marin going to and from Drake High School (23%), working adult commuters (35%), and tourists going to and from West Marin (27%) for recreational trips.


Marin Transit West Marin Stagecoach (Route 68) on Sir Francis Drake Boulevard

Route 228

Community Shuttle Route 228 was initiated in February 2014 to replace the Route 28, and provides weekend and holiday service within the western segment of study. Starting at Manor, Route 228 stops in downtown Fairfax, proceeds to San Anselmo, and then stays on Sir Francis Drake Boulevard between San Anselmo and the Larkspur Ferry Terminal. It then turns around at Larkspur Landing Circle and heads north to the Transit Center in San Rafael on Highway 101. The majority of the route is identical to Route 29, which operates Monday – Friday only.

Since this route was instituted fairly recently, rider characteristics are not known.

Golden Gate Transit

Golden Gate Transit provides commuter bus service from Marin County and parts of Sonoma County to San Francisco. Sections of the study corridor are served by three Golden Gate routes: Route 24 and Route 25, connecting Manor and the San Anselmo Hub; and Route 27, which operates on the Miracle Mile between San Anselmo and the San Rafael Transit Center.

Route 24

Route 24 is a weekday only, peak hour commuter route taking Ross Valley residents to and from San Francisco. It serves the study corridor from Manor west of Fairfax to Highway 101 via Sir Francis Drake Boulevard. The route alignment is identical to Route 25 in the study area.

Route 25

Route 25, known as The Wave, began service in September 2013 as a shuttle for the Larkspur Ferry during weekday peak hours. The route starts at Manor, connecting Fairfax via San Anselmo to the Larkspur Ferry Terminal on Sir Francis Drake Boulevard. The route alignment is identical to Route 24 in the study area.

Route 27

Route 27 is a commuter route primarily connecting the San Rafael Transit Center with San Francisco. Seven morning trips and six evening trips extend to the San Anselmo Hub, traveling on the Miracle Mile In addition, one morning and one evening trip serve San Domenico School, at the end of Butterfield Road in Sleepy Hollow. Route 27 also provides hourly service during the midday.

GENERAL CHARACTERISTICS OF CORRIDOR TRANSIT SERVICES

Fares

While both Golden Gate Transit and Marin Transit accept fare payment using the regional Clipper card, each has its own fare system. Given its extensive service area, Golden Gate Transit uses a zone-based fare system. Fares vary according to the distance traveled and the number of fare zone boundaries crossed; there are seven fare zones in total. By contrast, Marin Transit charges a flat rate fee for trips on all routes; the adult cash fare is $2.00. Both transit systems offer discounted fares for youth, seniors, and people with disabilities. Marin Transit also offers stored value cards, discounted period passes (day, week, or month) and semester/annual youth passes for K-12 students.

Transfers

Marin Transit and Golden Gate Transit have a fully integrated transfer system that allows one-way trips during an allotted time period. Golden Gate Transit also provides transfer discounts to other transit systems in the region. Passengers who connect between Marin Transit and Golden Gate Transit routes pay their full fare on board the first bus they board and then request a transfer to complete their trip at no additional cost.

RIDERSHIP

Generally, ridership activity within the study area is clustered in the three major community and employment hubs along the corridor – San Rafael, San Anselmo, and Fairfax. Adjacent to the core study corridor, the Canal area also generates significant transit ridership. See below for additional detail about how and where transit demand is clustered throughout the corridor study area (and in the adjacent Canal area).

Passenger Boardings and Alightings

Figure 4-6 shows line-by-line total boardings and alightings (i.e., ons and offs) for each Marin Transit line in the corridor, per available data circa 2010-2011. (Therefore, this table does not include Route 23 ridership beyond the San Rafael Transit Center and excludes weekend-only Route 228, which was established in 2014.)

Figure 4-6 Total Weekday Marin Transit Ridership in Each Corridor Segment (Both Directions)

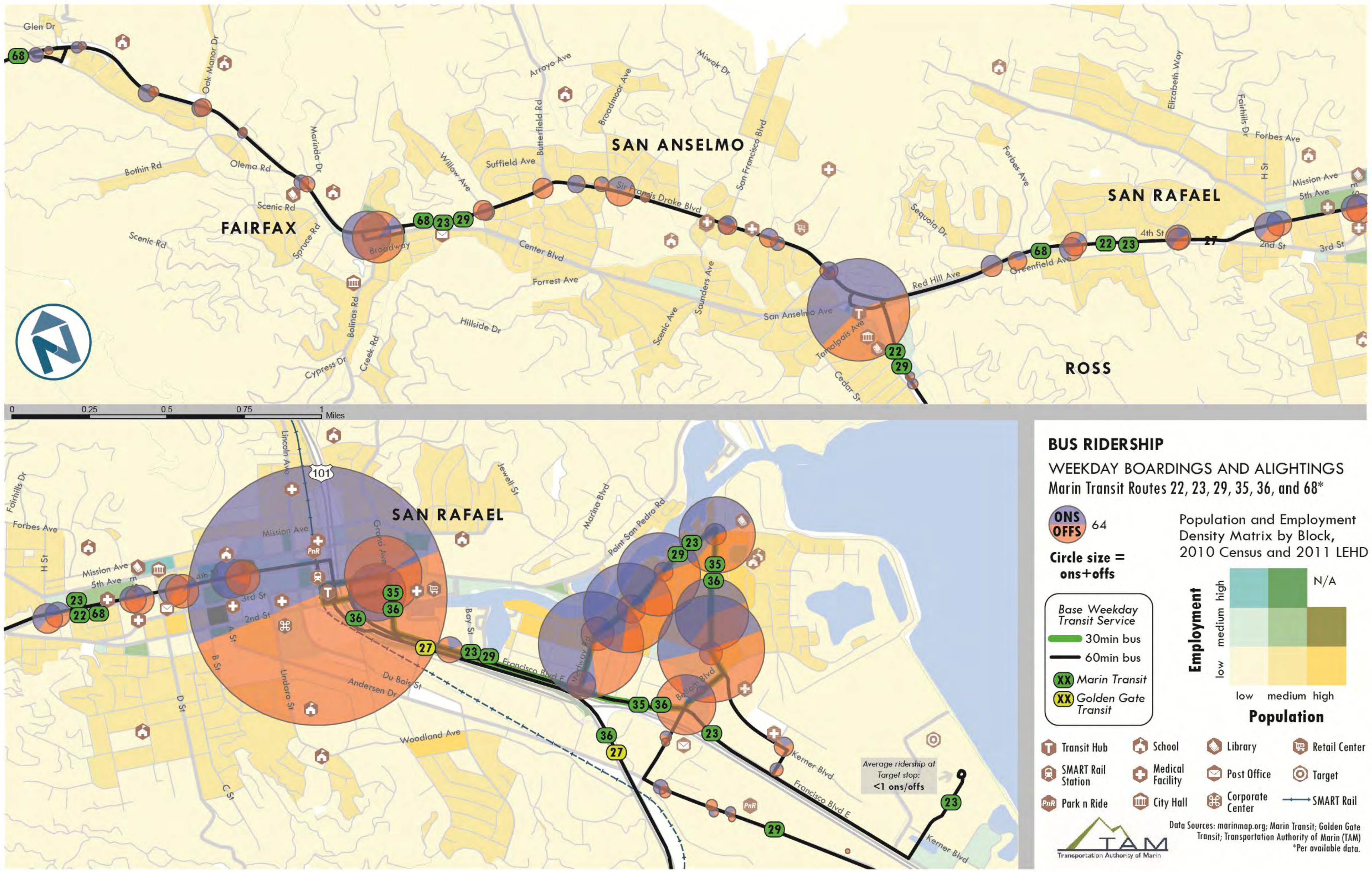
Route #	Manor-San Anselmo Hub		San Anselmo Hub		Miracle Mile and Downtown San Rafael		San Rafael Transit Center		Core Fairfax-San Rafael Corridor Total			Canal Area	
	On	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**On**	**Off**	**Total**	**On**	**Off**
22	-	-	146	121	136	179	330	267	612	567	1,179	-	-
23	157	159	74	48	77	114	155	129	463	450	913	N/A	N/A
29	57	79	46	32	-	-	208	238	311	349	660	279	268
68	31	33	13	12	1	0	30	39	75	84	159	-	-
Subtotal (Core Corridor, Excluding Canal)	*245*	*271*	*279*	*213*	*214*	*293*	*723*	*673*	*1,461*	*1,450*	*2,911*	*279*	*268*
35	-	-	-	-	-	-	646	766	-	-	-	1,158	1,062
36	-	-	-	-	-	-	233	121	-	-	-	203	152
Total (Including Canal)	**245**	**271**	**279**	**213**	**214**	**293**	**1,602**	**1,560**	**1,461**	**1,450**	**2,911**	**1,640**	**1,482**

These data indicate that total boardings in both directions on a typical weekday are fairly even in the Manor-San Anselmo and Miracle Mile segments. Additionally, Route 29 has fewer boardings than Route 23 between Manor and San Anselmo. In the Miracle Mile corridor (including the San Anselmo Hub), Route 22 has more boardings than Routes 23 and 68 combined.

Figure 4-7 depicts the weekday ridership by stop for transit routes with readily available ridership data. At this time, ridership data for Marin Transit Routes 22, 23, 29, 35, 36, and 68 are depicted. (Due to unavailability of total weekday data – i.e., for all daily runs – data for Route 23 in the Canal area are not illustrated.) Additionally, while total daily boardings data for Golden Gate

Transit data were unavailable and therefore are not included on this map, limited average boardings by stop data were available for Routes 24, 25, and 27. Reviewing these data indicates that the system indeed largely serves the commuter market, with very few trips (i.e., less than one on average) occurring wholly within the boundaries of the study area.

Figure 4-7 Weekday Ridership along the Fairfax–San Rafael Corridor



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These data show that the highest total boardings and alightings occur in the three major community and employment hubs along corridor – San Rafael, San Anselmo, and Fairfax. Consistent levels of daily activity occur along the connecting parts of the corridor such as the Miracle Mile and between Fairfax and San Anselmo.

Adjacent to the core study area, higher levels of transit activity are centered in the Canal area, particularly on Kerner Boulevard, Canal Street, and Medway Road, where there is higher residential density than farther inland along the corridor.[2]

Figure 4-8 presents the top 10 stops for boarding and alighting activity within the core study corridor, including the top five for each core study area segment, as well as the transit-supportive Canal area. These data represent ridership activity during an entire weekday.

Figure 4-8 Top Ridership Activity Stop Locations

Stop Location	Ons	Offs	Total Activity
Manor-San Anselmo			
Center Blvd & Bridge & Sir Francis Drake Blvd (San Anselmo Hub)	279	213	492
Broadway & Bolinas Ave (Downtown Fairfax)	12	112	124
Sir Francis Drake Blvd & Claus Dr (Downtown Fairfax)	107	3	110
Sir Francis Drake Blvd & Ash Ave (S.F.D. High School)	14	26	40
Sir Francis Drake Blvd & Oak Manor Dr	12	15	27
San Anselmo-San Rafael Transit Center (Miracle Mile)			
San Rafael Transit Center (Excluding Canal area Routes 35 & 36)	*723*	*673*	*1,396*
Fourth St & Court Street	64	64	132
Fourth St & C Street	35	63	128
Fourth St & E Street	26	47	73
Fourth St & Ida Street	37	33	70
Fourth St & Greenfield Ave	19	32	51
Fourth St & Santa Margarita Ave	19	32	51
Canal Area (Routes 29, 35, and 36)			
Medway Rd & Mill Street	371	148	519
Canal St & Novato Street	259	153	412
Canal St & Sonoma Street	206	135	341
Kerner Blvd & Larkspur Street	274	59	333
Third St & Grand Ave	9	272	281

[2] Based on a very limited sample of weekday and weekend Route 23 trips in 2013 and 2014, boarding and alighting data used to compute Passenger Miles Traveled indicate relatively little passenger activity at the Target on Shoreline Parkway, with an average of less than one weekday boarding and alighting at this location.

Origins and Destinations

Trip patterns for Golden Gate Transit and Marin Transit differ in that most if not all riders on Golden Gate Transit are travelling to and from San Francisco; while the route may go through central San Rafael, for most this is not their ultimate destination. Origin and destination pairs on Marin Transit's local service can shed light on current local trip patterns.

In late 2012, Marin Transit conducted a comprehensive onboard survey, ridecheck analysis of boardings and alightings, and gathered data on origins and destinations of Marin Transit passenger trips. Results of the ridecheck indicate that Downtown San Rafael is the top destination for all major population centers in the study corridor, including Manor, Fairfax, San Anselmo, the Canal area, and San Rafael East.

SMART is planning stations at the San Rafael Civic Center, within walking distance to the Northgate Shopping Center, a popular destination for trips originating on the study corridor with 18% of trips from East San Rafael, and 9% of trips from the Canal area, ending there. Depending on schedules and fares, these riders may choose SMART for the second leg of their trip. Additionally, two SMART stations are planned for Novato; however, neither station is in the downtown area, so the 6% of riders starting in Downtown San Rafael and headed for Downtown Novato are likely to continue using bus transit.

Figure 4-9 shows the top destinations for Marin Transit trips originating in the study corridor, in terms of percentage of trips. As pertains to the study corridor, a few key findings emerge:

- Over 33% of trips from Manor and Fairfax are destined for San Rafael.
- Few trips originating in the Canal area have destinations farther than Downtown San Rafael.
- There is demand for intra-corridor trips west of San Anselmo: 14.5% of trips originating in San Anselmo are bound for Manor, with 10.8% of trips beginning in Manor ending in San Anselmo.

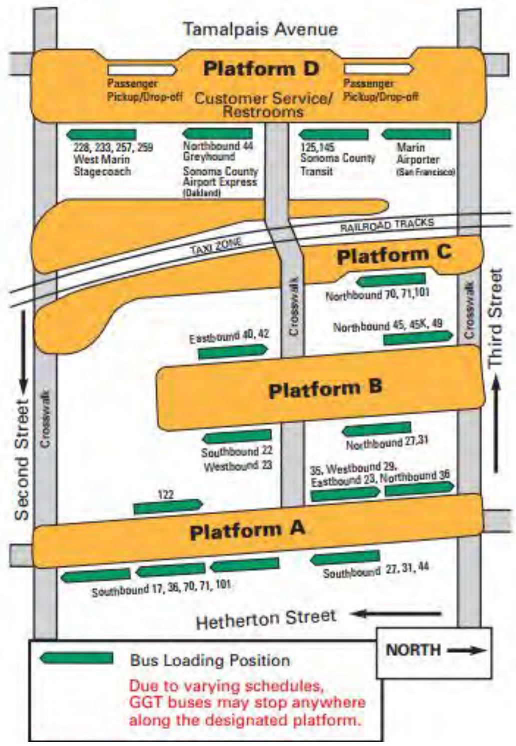
Figure 4-9 Study Corridor Origins and Destinations, 2013

DESTINATION	ORIGIN					
	Manor	Fairfax	San Anselmo	Downtown San Rafael	Canal	San Rafael East
Manor	0.0%	4.8%	14.5%	1.3%	0.0%	0.0%
Fairfax	1.5%	3.2%	8.6%	3.6%	2.6%	2.6%
San Anselmo	10.8%	4.8%	2.6%	3.6%	2.6%	2.6%
Downtown San Rafael	33.8%	33.3%	24.3%	12.5%	26.9%	15.4%
Canal	1.5%	4.8%	5.3%	12.5%	14.6%	10.3%
San Rafael East	0.0%	0.0%	0.7%	1.3%	1.9%	7.7%
Other Destinations						
Kentfield	7.7%	3.2%	2.6%	3.8%	4.9%	2.6%
Northgate	7.7%	7.9%	2.6%	10.0%	8.8%	17.9%
Mill Valley Tam Junction	6.2%	1.6%	3.9%	6.4%	4.2%	0.0%
Larkspur	4.6%	6.3%	3.9%	3.6%	4.2%	2.6%
North West Marin	4.6%	6.3%	15.1%	2.8%	0.3%	2.6%
Santa Venetia	1.5%	3.2%	0.7%	4.1%	3.9%	10.3%
Downtown Novato	0.0%	4.8%	1.3%	5.7%	2.3%	0.0%
East Corte Madera	0.0%	1.6%	2.0%	0.3%	1.6%	5.1%

Source: Marin Transit, 2012.

MAJOR TRANSIT FACILITIES

The C. Paul Bettini Transit Center in San Rafael functions as the central hub of the Golden Gate Transit and Marin Transit systems and is a major transfer point to intercity services including Sonoma County Transit, Marin Airporter, Sonoma County Airport Express, and Greyhound. 24 routes operated by three public transit providers and three private bus operators serve the Transit Center.



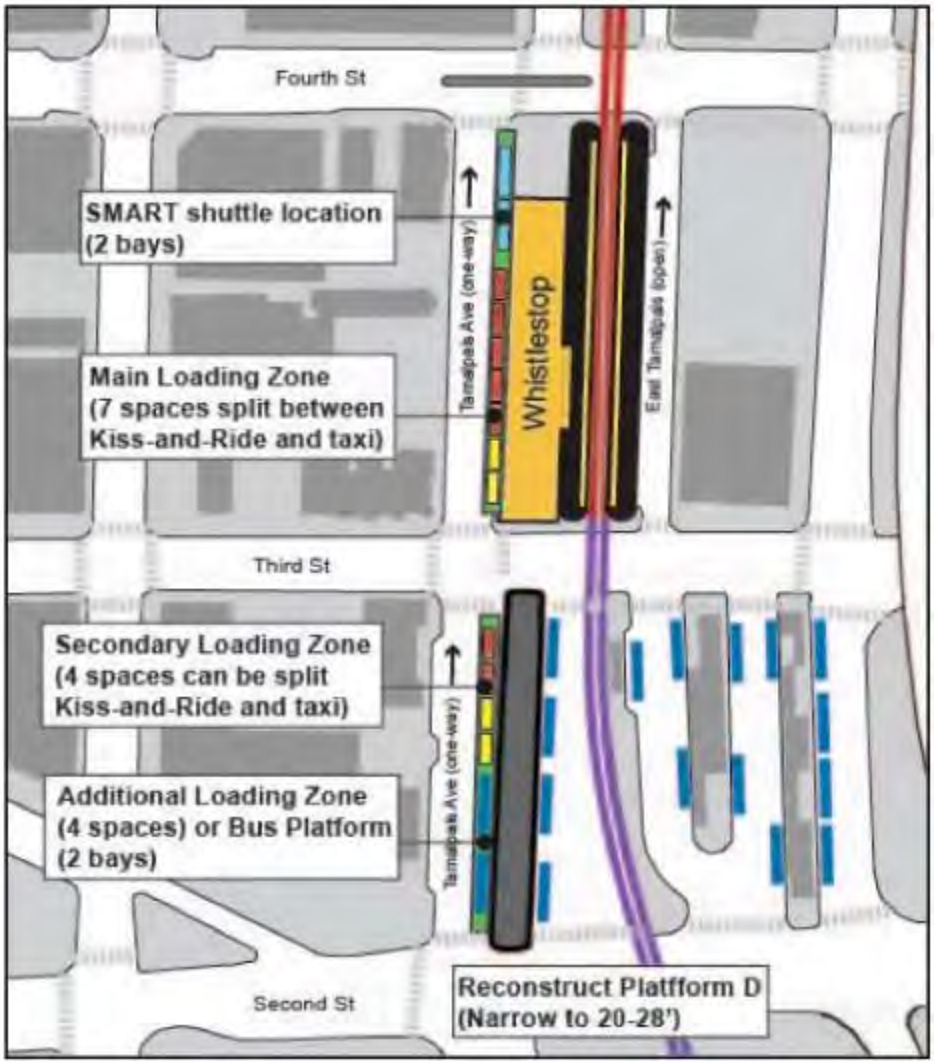
C. Paul Bettini (San Rafael) Transit Center; Bus Bay Map
Source: Nelson\Nygaard; Golden Gate Transit

The Bettini Transit Center is located on the corridor between Downtown San Rafael and the Canal area. Eastbound buses currently enter from 2nd Street on the south side of the transit center; westbound buses enter from 3rd Street on the north side of the facility.

Because it is located on the SMART right-of-way, there will be some basic operational changes at this location in the near future. Near-term changes, reproduced from the Downtown San Rafael Station Area Plan in Figure 4-10 below, include:

- Reconstruction of Platform D to provide additional right-of-way for bus circulation.
- Closing some on-street parking spaces in order to relocate services such as Kiss-and-Ride and taxis to accommodate new SMART shuttles.
- Improving signage and wayfinding in and around the area.
- Improving pedestrian and bicycle infrastructure and amenities around the transit center and SMART station area.

Figure 4-10 Near-Term Vision for San Rafael Transit Center



Source: San Rafael Station Area Plan (2012)

FUTURE TRANSIT SERVICE

Within three years, Marin County will see some significant changes to local and regional transportation as a new commuter rail service, Sonoma-Marin Area Rail Transit (SMART), comes online, and local bus service is adjusted to reduce redundant service and to provide feeder service to the rail stations. This section describes the current plans for implementation of SMART service.

SMART Rail Service

Sonoma-Marin Area Rail Transit (SMART) is a commuter rail system currently being built in Sonoma and Marin Counties. Funded by a quarter-cent sales tax measure passed in 2008, the initial service, from the Sonoma County Airport north of Santa Rosa to Downtown San Rafael, is expected to be operational in 2016. This 43-mile Initial Operating Segment (IOS) is expected to carry 70% to 80% of the estimated ridership for the full system.[3]

As of November 2014, SMART service operations are not fully planned. However, some basic service parameters are known:

- SMART will run 30-minute peak period frequency.
- Service span will be during commute periods: 6:30 a.m. to 10:00 a.m. and 3:00 p.m. to 7:00 p.m., with one midday trip.
- Plans currently call for 30 trips a day, with 15 southbound and 15 northbound trips.
- Weekend trips: four northbound and four southbound trips per day (evaluated in 2008 supplemental EIR).
- Service schedules will be matched to bus pulses at the Bettini Transit Center at San Rafael.
- The trip from San Rafael to Airport Boulevard is estimated to be 67 minutes.

As part of the implementation plan, SMART will work with local transit agencies to design feeder bus services to the stations. The planned Downtown San Rafael SMART station is adjacent to the San Rafael Transit Center, at the center of the corridor study area.

Because of a general economic downturn during the late 2000s, the IOS was reduced from the planned 71 miles to the 43-mile segment from the Sonoma Airport to central San Rafael. To mitigate this reduction, SMART is planning on operating express connector bus service between Santa Rosa and future station locations in Windsor, Healdsburg and Cloverdale, and between downtown San Rafael and the Larkspur Ferry. See Figure 4-11 for a map of SMART's two phases – the IOS (Phase I), and Phase II, which is currently being planned to include extensions to the north and south of the IOS.

[3] SMART website, www.sonomamarintrain.org, accessed November 5, 2014

Figure 4-11 Future SMART Service

Source: SMART website, sonomamarintrain.org, 12/02/14

Projected SMART Activity and Ridership

While its final operating schedules are still in development, it is expected that SMART will primarily function as a peak commuter service, with a majority of ridership commuting south to San Rafael and other job centers in the morning and returning northward in the evening.

As the SMART project was refined to adapt to changing economic conditions, a range of ridership estimates for the Downtown San Rafael station emerged from the planning process, each reflecting a different set of inputs and assumptions (such as the relocation of two stations and the adjustment of the IOS based on a downturn in tax revenue). Keeping these caveats in mind, projected boardings at the Downtown San Rafael station in 2035 range from just under 250 boardings per day to nearly 1,200 boardings per day.

Future Bus Transit Service

In response to the SMART service beginning in 2016, both Marin Transit and Golden Gate Transit are expected to adjust service. However, because SMART's operations plans are still being drafted, neither Golden Gate Transit (GGT) nor Marin Transit has made any decisions regarding adjustments in service.

Golden Gate Transit is in the process of finalizing a Short Range Transit Plan; the SRTP identifies the need to comprehensively review their service approximately six months after SMART starts. In addition, some minor changes may be implemented when SMART begins service. Because GGT commuter bus service and SMART both run in the Highway 101 corridor, it can reasonably be assumed that there will be some shift of passengers from GGT to SMART. This may result in more significant adjustments to GGT service, including geographic coverage, frequency, and span of hours.

Marin Transit is also working on the service plan for their SRTP, and has been considering ways to facilitate connections to future SMART service. Current bus service is coordinated with other transit at the San Rafael Transit Center. Since train service will also be timed to the pulse at the Transit Center, Marin Transit does not anticipate that significant changes will be needed to efficiently serve passengers getting to and from the SMART station in Downtown San Rafael. Marin Transit is also contemplating a potential express Route 23 for inclusion in its SRTP service plan, but this proposal is in draft form and subject to change as the planning process continues.

5 OPPORTUNITIES & CONSTRAINTS

This chapter presents a summary of the information presented in the previous chapters, highlighting the various opportunities and constraints of the corridor's existing conditions. Figure 5-1 describes these findings based on a review of all available existing conditions data.

Figure 5-1 Summary of Key Findings, Opportunities, and Constraints

Briefing Book Chapter	Opportunities	Constraints
Land Use and Demographics ▪ Corridor's land use patterns were partly shaped by natural topography and partly by historical rail service. ▪ San Rafael has a larger mix of land uses, with a mix of higher density residential, commercial, and industrial uses in downtown and in the adjacent Canal area. ▪ Lower density residential uses are designated adjacent to the corridor in some locations. ▪ Largely following prescribed land uses, population and employment density is highest in the traditional centers of Fairfax, San Anselmo, and San Rafael, with the corridor-adjacent Canal area being the most densely populated residential area. ▪ Within one-half mile of the corridor (including the adjacent, transit-supportive Canal area), 21% of the population are under 18, 10% are aged 65 and over, and 21% are characterized as "low income."	▪ The corridor connects three historic, pedestrian-friendly downtown areas – Fairfax, San Anselmo, and San Rafael – as well as a busy regional transit node (Bettini Transit Center), with the densest housing in the area within walking distance of existing transit services. ▪ The corridor is home to several important nodes and travel destinations, including hospitals, schools, and major employers.	▪ A standard walkshed pedestrian access to high-capacity transit is one-half mile, however the existing topography constrains access to transit nodes, particularly for seniors and transit riders with disabilities.

Briefing Book Chapter	Opportunities	Constraints
Multimodal Transportation ▪ The corridor is used regularly by people who walk, bike, and drive in addition to those who take transit. ▪ Automobile facilities vary by location, though most roadways outside of San Rafael are only one lane each way, and speed limits top out at 35 mph. ▪ For areas where data are available, auto LOS exceeds C in only one location: westbound Red Hill Avenue in the AM peak period. ▪ There is already a robust network of bicycle facilities and amenities for pedestrians, though some sidewalk gaps remain in the corridor. ▪ Corridor communities have identified several projects to improve bicycle and pedestrian networks in the corridor.	▪ Roadways in several parts of the corridor have medians, providing an opportunity for exclusive transit rights-of-way without eliminating travel lanes. ▪ Bicycle infrastructure improvements are being built and planned along routes that parallel the main corridor, helping to eliminate this potential source of conflict.	▪ N/A
Existing Transit Service ▪ The corridor was built by transit and continues to benefit from frequent service, particularly during peak hours. While a total of 11 bus routes operate within the corridor, only one (Route 23) makes the full trip from Manor to Shoreline Parkway in the adjacent Canal area. ▪ Base (midday) service frequency between Manor and San Rafael is a minimum of 60 minutes; between San Rafael and the Canal area, service operates at a 30 minute base frequency. During peak times, transit between San Rafael and the Canal area is available every 15 minutes. ▪ Ridership activity clusters in Fairfax, San Anselmo, and San Rafael, with consistent levels of daily activity observed along the Miracle Mile and between Fairfax and San Anselmo. Adjacent to the study area, higher levels of activity occur along routes operating in the Canal area. ▪ Origin-destination data reveals that over one-third of trips from Manor and Fairfax are going to San Rafael; few trips beginning in the Canal area have destinations beyond San Rafael; and there is demand for intra-corridor trips west of San Anselmo. ▪ Sonoma-Marin Area Rail Transit (SMART) is under construction, with completion expected in 2016. Expected ridership at Downtown San Rafael station is unknown but 2035 projections do not exceed 1,200 boardings per day.	▪ There is high existing demand for transit between the corridor-adjacent Canal area (and San Rafael High School) and downtown San Rafael. ▪ There are opportunities for serving short intra-corridor trips, particularly between Bettini Transit Center and the Canal area. ▪ As few trips beginning in the adjacent Canal area have destinations beyond San Rafael, job growth in the corridor west of San Rafael will largely determine whether demand will increase in the future. (Note: due to the unavailability of precise job growth data, this is also a constraint.) ▪ Sonoma Marin Area Rail Transit (SMART) service is under construction and on schedule, delivering high-quality and high-capacity transit between Santa Rosa and San Rafael beginning in 2016.	▪ With current transit services already designed to match existing demand, there appear to be few opportunities for additional corridor-length transit service. ▪ As few trips beginning in the adjacent Canal area have destinations beyond San Rafael, job growth in the corridor west of San Rafael will largely determine whether demand will increase in the future. (Note: due to the unavailability of precise job growth data, this is also an opportunity.) ▪ Future SMART service is important, but not expected to fundamentally change short-term demand in the corridor. It is unlikely that large numbers of San Rafael and Marin County residents will board SMART in the morning commute period. Most southbound SMART trips will likely end in San Rafael, with few continuing westward along the study corridor.

APPENDIX B

Summary of Case Studies

Transportation Authority of Marin

FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Summary of Peer Case Studies - Draft

December 2014

NELSON NYGAARD

In Association with
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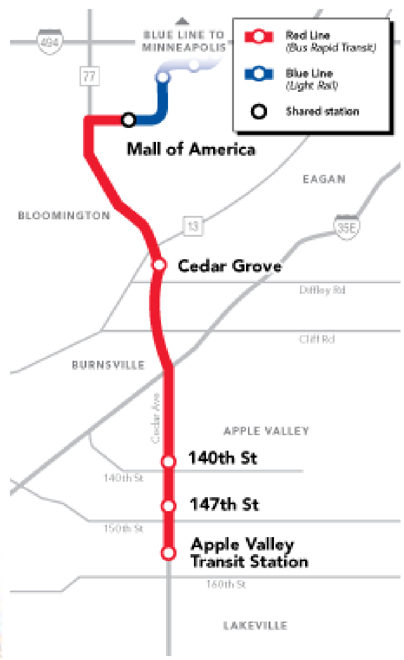
INTRODUCTION

This document presents a summary of peer case studies, which is intended to support the ongoing Fairfax-San Rafael Corridor Transit Feasibility Study by providing a context in which to discuss potential future transit investments in the study corridor. Together, these case studies show how similar cities have approached the opportunity to make a major transit investment along a key local and regional corridor (or multiple corridors). The peer case studies were chosen by the consultant team with input from the Technical Advisory Committee, and include examples of streetcar, Bus Rapid Transit (BRT), and traditional bus services. They generally fall into three categories:

- **Exclusive Right of Way** services are those that operate within their own exclusive trackway or roadway and largely do not share operating space with other vehicles. Peer examples in this category include the S-Line streetcar in Salt Lake City, Utah and the South Busway in the vicinity of Miami, Florida.
- **Enhanced Stations** services are those that operate in a mixed-flow lane but feature distinctive and enhanced stations. Peer examples in this category include the Portland (Oregon) Streetcar "CL" (Central Loop) Line and the Quickline BRT service in Houston, Texas.
- **Circulator** services are usually shuttles that circulate among key destinations, operating in mixed-flow lanes. They may be shorter in length than the other types of services described in this summary. Examples in this category include the Tacoma, Washington Streetcar and Irvine, California's iShuttle service.

A. EXCLUSIVE RIGHT OF WAY



1 S-LINE, SALT LAKE CITY, UTAH

Streetcar as Light Rail Feeder

This 2013 extension to the Salt Lake City Light Rail System operates with a mix of streetcar and light rail characteristics, mostly in a separate right-of-way. The S-Line is 2 miles long and connects to a development area southeast of downtown. Ridership has been below expectations, likely because the redevelopment of the Sugar House area has lagged.

FIGURE 1: SALT LAKE S-LINE
SOURCE: SHSTREETCAR.COM

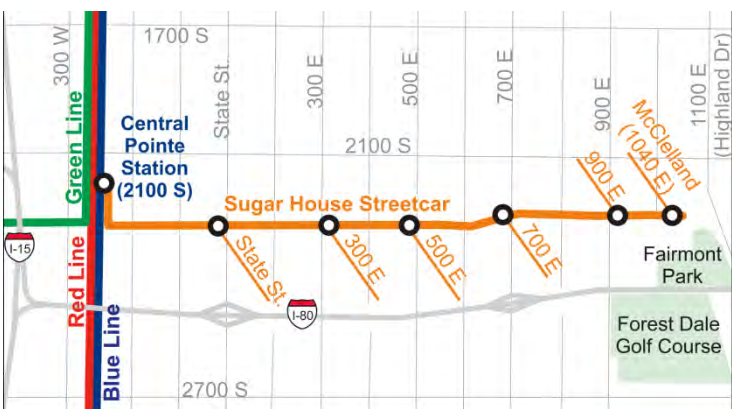


FIGURE 2: SUN LINK STREETCAR ROUTE MAP
SOURCE: HTTPS://WWW.DART.ORG/RIDING/MLINE.ASP

SYSTEM DESCRIPTION	
Phasing	Phase 1: April 2012: Construction begins; December 2013: Completion Phase 2: Under Alternative Analysis
Type of equipment	Siemens S70 Cars used on TRAX lines; electric power, steel wheels
Length	2 miles
Transit Connections	TRAX, regional rail transit at Central Pointe Station[i]
Intermodal Connections	Accommodates bikes on board

IMPLEMENTATION	
Date implemented	2013
Capital cost (in 2014 Dollars)	Total: $57.4M[ii] Per Mile: $28.7M
Annual revenue hours	$6,000 (estimate from available data)
Operating cost (annual)	$1.6M pre-opening LPA estimate[iii]

FEASIBILITY STUDIES	
Mode Selection	Best met the purpose and needs of the area: ▪ increases mobility, reduce congestion, and preserve the cultural identity ▪ provides a transit alternative to congested 2100 South ▪ integrates multi-modal travel choices ▪ supports community redevelopment ▪ fits the historic and small urban character of Sugar House34
Alternatives	Baseline alternative of enhanced bus service, BRT, modern streetcar, historic trolley, Light Rail Transit[iv]

FUNDING	
Capital	34% - UTA ($18.32M, land and vehicle purchase) 46% - TIGER II Grant ($26M, construction cost) 20% - Local partnership (Salt Lake City, South Salt Lake City, UTA)
Operating Expenses	Salt Lake City, South Salt Lake[v]

RIDERSHIP	
Ridership	Annual: 40,612 (2013)[vi]
Preceding system	#21 bus nearby
Impact on Ridership	Expected to alleviate pressure on an extremely congested 2100 South
Ridership Performance	26% of the projection for 2014 (780 vs. 3,000 passengers per day[vii])
Riders' Demographics	Work and school commuters[34]

MAINTENANCE	
Facilities	UTA is able to use the existing TRAX maintenance facilities
Cost	None

LESSONS LEARNED
Ridership has been much lower than originally estimates of 3,000 users per day in 2014—during first week of operation the streetcar had only an average of 781 riders per day. No ridership rates have since been reported (perhaps because of bad publicity). But the corridor is benefiting from nearby real estate development (about 1,000 new apartments and condominiums will soon open in Sugar House) Despite the low ridership, the Sugar S Line extension is being studied: The S Line is "part of a future-looking network that would give mass transit riders many choices" (Hutcheson, Transportation Director)[viii]

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[i] "Sugar House Streetcar." Sugar House Streetcar. Accessed November 24, 2014. http://www.shstreetcar.com/background.htm.
[ii] "Sugar House Streetcar." Sugar House Streetcar. Accessed November 24, 2014. http://www.shstreetcar.com/background.htm.
[iii] *Sugar House Transit Corridor Alternatives Analysis - Final Report*. 2008. Salt Lake City: UTA. http://www.rideuta.com/files/Sugar_House_Final_Report_0808.pdf.
[iv] *Sugar House Transit Corridor Alternatives Analysis - Final Report*. 2008. Salt Lake City: UTA. http://www.rideuta.com/files/Sugar_House_Final_Report_0808.pdf.
[v] *City Council Transmittal. 2011*. Salt Lake City: UTA. http://www.shstreetcar.com/files/masterstreetcartransmittal.pdf.
[vi] "New Streetcar Attracts a Fraction of Expected Ridership." The Salt Lake Tribute. Accessed November 23rd, 2014. http://www.sltrib.com/sltrib/mobile/57303501-68/development-grant-hutcheson-lake.html.csp.
[vii] "New Streetcar Attracts a Fraction of Expected Ridership." The Salt Lake Tribute. Accessed November 23rd, 2014. http://www.sltrib.com/sltrib/mobile/57303501-68/development-grant-hutcheson-lake.html.csp.
[viii] "All Aboard the S Line? Not Quite for the Salt Lake City Streetcar." The Salt Lake City Blog. Accessed November 18th, 2014. http://salt-lakecity.blogspot.com/2014/09/all-aboard-s-line-not-quite-for-salt_68.html.

2 CANAL STREETCARS, NEW ORLEANS, LA

Streetcar Expansion/Restoration

This 2004 restoration of two streetcar lines which had been converted to bus in 1964 uses historic replica trolleys in a median right-of-way. The line adds 5.5 miles to the city's streetcar system and is targeted toward both residents and tourists. Ridership has been healthy, driven by an expansion of the touristic area, despite an extended shutdown and recovery from Hurricane Katrina.

FIGURE 3: CANAL STREETCAR
SOURCE: FLICKR, MAY 18, 2010

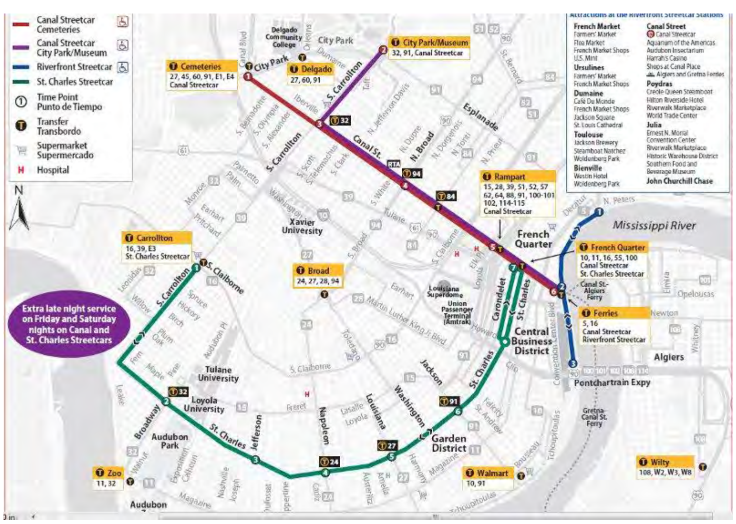

FIGURE 4: CANAL STREETCAR ROUTE MAP
SOURCE: KAYAKITIYAT

SYSTEM DESCRIPTION	
Phasing	1861-1964: Original streetcar system 2000-2004: Redesign and opening of the new Canal streetcars
Type of equipment	Replica streetcars
Length	5.5 miles, 1.2 mile extension begun 8/2011
Transit Connections	St. Charles Streetcar, local bus routes
Intermodal Connections	Park & Ride facilities

IMPLEMENTATION	
Date implemented	April 2004
Capital cost (in 2014 Dollars)	Total: $215.92M[ix] Per Mile: $39.3M
Annual revenue hours	93,624 (2009)[x]
Operating cost (annual)	$7M

FEASIBILITY STUDIES	
Mode Selection	Re-established the existing historical system
Alternatives	None

FUNDING		
Capital	$125.3M FTA's Section 5309 $27.1M Loan Funds	$3.2M in land donated by the City $1M Private donations[xi]
Operating Expenses	46% from passenger fares and RTA's operating budget	

RIDERSHIP	
Ridership	Annual: 1.6M (2014)[xii]
Preceding system	Existing RTA bus and streetcar network
Impact on Ridership	Heavy ridership has participated in slowing down operations
Ridership Performance	2015 Forecast: 31,400 average weekly boardings & 5,300 daily new riders[xiii]
Riders' Demographics	In 2011, 76% local, 24% visitors[xiv][xv]

MAINTENANCE	
Facilities	Separate storage/maintenance at an existing streetcar barn at Carrollton Station[xvi]
Cost	None

[ix] "New Orleans, Louisiana/Canal Streetcar Line". FTA DOT. Accessed November 18th, 2014. http://www.fta.dot.gov/printer_friendly/12304_3099.html.

[x] *RTA – Title VI and Environmental Justice Policy Manual.* 2013. New Orleans: Regional Transit Authority. http://www.norta.com/RTA/media/RTA-PDF-Files/Board%20Documents/RTA-TitleVI-PolicyManual03-13.pdf.

[xi] "September 2011 – RPC Origin-Destination Survey for RTA". NORTA. Accessed November 18th, 2014. http://www.norta.com/RTA/media/RTA-PDF-Files/News_and_Events/Vistors-and-Locals.pdf.

[xii]"New Orleans, Louisiana/Canal Streetcar Line". FTA DOT. Accessed November 18th, 2014. http://www.fta.dot.gov/printer_friendly/12304_3099.html

[xiii] "September 2011 – RPC Origin-Destination Survey for RTA". NORTA. Accessed November 18th, 2014. http://www.norta.com/RTA/media/RTA-PDF-Files/News_and_Events/Vistors-and-Locals.pdf.

[xiv]"New Orleans – Streetcar Justified". APTA Streetcar and Heritage Trolley Site. Accessed November 17th, 2014. http://www.heritagetrolley.org/existNewOrleansNews11.html.

[xv] "September 2011 – RPC Origin-Destination Survey for RTA". NORTA. Accessed November 18th, 2014. http://www.norta.com/RTA/media/RTA-PDF-Files/News_and_Events/Vistors-and-Locals.pdf.

[xvi] Hennick, Louis C.; E. Harper Charlton (1975). The Streetcars of New Orleans. Jackson Square Press.ISBN 978-1565545687.

3 UTA MAX, SALT LAKE CITY, UT

Exclusive ROW Bus as Light Rail Feeder

This 2008 Bus Rapid Transit extension to the Salt Lake Light Rail System is a mid-to-upper range example of BRT, with a mix of on-and off-board fare collection and much dedicated right-of-way. The line runs nearly 10 miles west with a healthy ridership driven by rapidly expanding communities. The line promotes that it runs as fast as safely possible, not waiting for scheduled departure times at intermediate stops.

FIGURE 5: UTA MAX
SOURCE: HTTP://UPLOAD.WIKIMEDIA.ORG/WIKIPEDIA/COMMONS/4/4D/35_MAX_-_MAGNA_TO_MILLCREEK_BUS.JPG

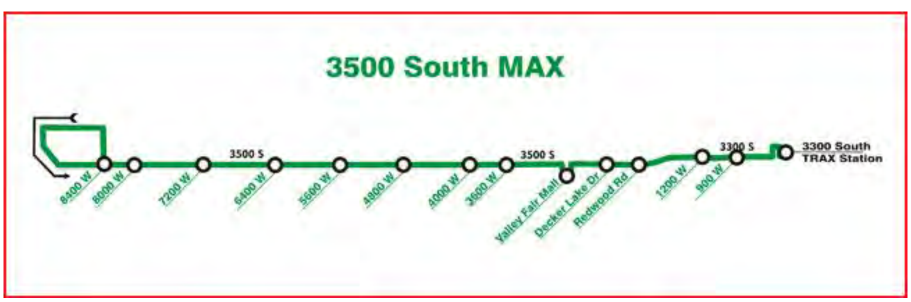

FIGURE 6: UTA MAX MAP
SOURCE: HTTP://WWW.RIDEUTA.COM/UPLOADS/MAXMAP2011.JPG

SYSTEM DESCRIPTION	
Phasing	Phase 1: ~10 miles[xvii]
Type of equipment	Van Hool A300L[xviii]
Length	~10 miles[xix]
Transit Connections	Light Rail at 3300 South Millcreek Station
Intermodal Connections	Bike racks on buses, bike lockers at stations[xx]

IMPLEMENTATION	
Date implemented	July 2008[xxi]
Capital cost (in 2014 Dollars)	Total: $18.75M[xxii] Per Mile: $1.87M
Annual revenue hours	30,000 (estimate from data available)[xxiii]
Operating cost (annual)	$3.1M (estimate from data available)[xxiv]

FEASIBILITY STUDIES	
Mode Selection	Bus chosen to avoid $100 cost of rail
Alternatives	Light Rail

FUNDING	
Capital	Mostly Federal
Operating Expenses	Local sales tax and Federal

RIDERSHIP	
Ridership	Annual: 390,000 (2008)[xxv]
Preceding system	Route 37[xxvi]
Impact on Ridership	Ridership doubled[xxvii]
Ridership Performance	4,100 per weekday compared to a projected 1,500[xxviii]
Riders' Demographics	Work and school commuters

MAINTENANCE	
Facilities	No separate facility required
Cost	None

LESSONS LEARNED
Reliability improvements caused ridership increase

[xvii] *UTA Network Study – Next Tier Program Final Report*. 2013. Salt Lake City: UTA. http://www.rideuta.com/uploads/FinalNetworkStudy_9Oct2013.pdf.

[xviii] "University of Minnesota Connects with its New Fleet". BUSRide. Accessed November 17th, 2014. http://busride.com/2009/07/university-of-minnesota-connects-with-its-new-fleet/.

[xix] "UTA's Rapid-Transit line MAX Starts Today". Deseret News. Accessed November 14th, 2014. http://www.deseretnews.com/article/700243131/UTAs-rapid-transit-line-MAX-starts-today.html?pg=all.

[xx] "All Things Bicycle". UTA Rideshare. Accessed November 26th, 2014. http://www.utarideshare.com/uploads/bicycle.pdf.

[xxi] "Bus Rapid Transit". Utah Transit Authority. Accessed November 19th, 2014. http://www.rideuta.com/uploads/BRT_factsheet452013.pdf.

[xxii] "UTA Set to Unveil Speedy MAX Bus Route". KSL. Accessed November 24th, 2014. http://www.ksl.com/?sid=3752722.

[xxiii] "UTA Set to Unveil Speedy MAX Bus Route". KSL. Accessed November 24th, 2014. http://www.ksl.com/?sid=3752722.

[xxiv] "UTA's Rapid-Transit line MAX Starts Today". Deseret News. Accessed November 14th, 2014. http://www.deseretnews.com/article/700243131/UTAs-rapid-transit-line-MAX-starts-today.html?pg=all.

[xxv] This should be considered a favorable or generous projection and is based on weekday service only.

[xxvi] "UTA Plans Bus Rapid-Transit Line". Deseret News. Accessed November 23rd, 2014. http://www.deseretnews.com/article/695249755/UTA-plans-bus-rapid-transit-line.html?pg=all.

[xxvii] "UTA Plans Bus Rapid-Transit Line". Deseret News. Accessed November 23rd, 2014. http://www.deseretnews.com/article/695249755/UTA-plans-bus-rapid-transit-line.html?pg=all.

[xxviii] *UTA Network Study – Next Tier Program Final Report*. 2013. Salt Lake City: UTA. http://www.rideuta.com/uploads/FinalNetworkStudy_9Oct2013.pdf.

4 SOUTH BUSWAY, MIAMI-DADE, FL

Busway as Heavy Rail Extension

This 1997 Busway extension to Miami's Metrorail system provides a mix of service dedicated to the busway and other routes which utilize parts of the busway. The design is more like late 20th century (Ottawa's and Pittsburgh's) busways, and unlike 21st Century Bus Rapid Transit, in that the right-of-way is not well integrated with the urban fabric. The 13 mile line has a healthy ridership.

FIGURE 7: MIAMI-DADE BUSWAY
SOURCE: MIAMITODAYNEWS.COM & MIAMIDADE.GOV

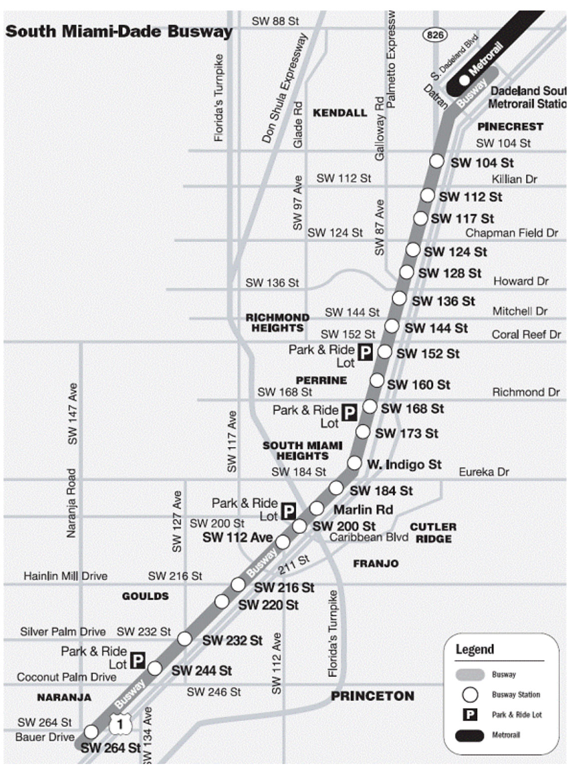

FIGURE 8: MIAMI-DADE BUSWAY MAP – PHASE 1
SOURCE: EDFSOUTHMIAMIDADE

SYSTEM DESCRIPTION	
Phasing	Phase 1: 1997 - Initial 8.3 miles Phase 2: 2005 - Extension to Florida City, +5 miles Phase 3: 2007 - Final Segment, +6.5 miles
Type of equipment	Both full-size articulated buses and minibuses operate on the Busway. No distinct logo for Busway services
Length	19.8 miles
Transit Connections	Six bus routes operate on all or part of the Busway; one of these, the Busway MAX, operates on an express schedule during peak periods. Route 38, or Busway MAX, operates on the entire busway line connecting the Dadeland South Metrorail Station to SW 344 Street in Florida City.
Intermodal Connections	All buses have bike racks. Bike parking and park-&-ride facilities are also available at stations

IMPLEMENTATION	
Date implemented	1997
Capital cost (in 2014 Dollars)	Phase 1: $55.36M[xxix] Phase 2 & 3: $125.13M[xxx] Total: $180.73M Per Mile: $9.13M
Annual revenue hours	100,000 (5 routes combined, 2002)[xxxi]
Operating cost (annual)	Actual cost for Phase 1 in 2001: $51-53/hour to operate full-size buses Projections for Phase 2 & 3: $4.90M/year

NOTE: For additional information, please contact, FTA recommends to contact Karen Facen karen.facen@dot.gov

FEASIBILITY STUDIES	
Mode Selection	Cost efficiency
Alternatives	First choice was a heavy rail with $300M from the Hurricane Andrew recovery fund, but judged too expensive[xxxii]

FUNDING[xxxiii]	
Capital	Phase 2: 70% - $61.3M FTA Section 5309 new Start 24% - $20.8M State for right-of-way purchase 6% - $5.7M CMAQ flexible funds
Operating Expenses	45% - $2.2M MDTA via Farebox recovery 39% - $1.7M Local revenue sources 18% - $0.9M unidentified in 1999

RIDERSHIP	
Ridership	Annual: 898,300 (2002)[xxxiv]
Preceding system	Existing freight railway but no transit option on the corridor, US Highway 1
Impact on Ridership	Within the first year, ridership increased nearly 50% on weekdays and more than 50% on weekends Between 1997 and 2002: ridership increased by 71% on weekdays and 130% on weekends[xxxv] In 2002, 50% of riders were not transit riders before the Busway implementation[77]
Ridership Performance	Ridership exceeded expectations in the first year, which led to the use of full-size buses instead of the originally planned mini-buses 2015 Forecast: 8,800 average weekday boardings[xxxvi]
Riders' Demographics	In 2002: 40% of the riders travel to work, 43% of riders who shift modes had household incomes below $15,000 in 2000, 44% of customers are between 25 and 44 years old[xxxvii]

MAINTENANCE	
Facilities	None
Cost	None

LESSONS LEARNED
- An at-grade "feeder" busway provides a cost-effective alternative to extending rail transit through low-density areas. However, the MDT found necessary to overlay the line-haul busway routes with services to residential areas, in order to minimize transfers - The railroad right-of-way provided an opportunity for building a low-cost, low-impact busway. In addition, Obtaining inexpensive right-of-ways is a challenge and yet essential to avoid alignments and implementation problems in the future - Wherever, the buses operate close to or crosses a major roadway, care must be exercised in coordinating traffic signals and ensuring safety of all users. Educational programs for transit riders and motorists are helpful - A fixed-transit facility with frequent and reliable service will increase ridership and encourage people to shift mode, even with no travel time advantage. Improved identity and amenities of the Busway, along with the provision of new services, have contributed to the ridership growth - Working in close relationship with planners, engineers and transit agencies allows more efficiency in the implementation process - Effective support from the state, regional and local government agencies as well as the public is essential[xxxviii]

[xxix] *South Miami-Dade Busway System Summary*. 2003. Tampa: Center for Urban Transportation Planning. http://www.nbrti.org/media/evaluations/mdt-5-03.pdf. p.4
[xxx] "Miami, Florida/South Miami-Dade Busway Extension". FTA DOT. Accessed November 16th, 2014. http://www.fta.dot.gov/12304_2934.html.
[xxxi] *South Miami-Dade Busway System Summary*. 2003. Tampa: Center for Urban Transportation Planning. http://www.nbrti.org/media/evaluations/mdt-5-03.pdf.
[xxxii] "Miami-Dade Transit Facilities Maintenance Division Equipment & Maintenance Plan". Miami Dade. Accessed November 16th, 2014. http://www.miamidade.gov/citt/pdf_library/strategic-financial-studies/2013/cost-other-studies/mandated-plan/2003-4%20FacMaintEquipPlan.pdf.

[xxxiii]"Miami-Dade Transit Facilities Maintenance Division Equipment & Maintenance Plan". Miami Dade. Accessed November 16th, 2014. http://www.miamidade.gov/citt/pdf_library/strategic-financial-studies/2013/cost-other-studies/mandated-plan/2003-4%20FacMaintEquipPlan.pdf.

[xxxiv] *South Miami-Dade Busway System Summary*. 2003. Tampa: Center for Urban Transportation Planning. http://www.nbrti.org/media/evaluations/mdt-5-03.pdf. p.8

[xxxv] *South Miami-Dade Busway System Summary*. 2003. Tampa: Center for Urban Transportation Planning. http://www.nbrti.org/media/evaluations/mdt-5-03.pdf., p. 7

[xxxvi] "Miami, Florida/South Miami-Dade Busway Extension". FTA DOT. Accessed November 16th, 2014. http://www.fta.dot.gov/12304_2934.html.

[xxxvii]Perk, V., Baltes, M., Perone, J. *Phase One Evaluation of the South Miami-Dade Busway (On-Board Survey)*.2002. Avilable at http://www.nctr.usf.edu/pdf/MDT%20Busway.pdf. page vii-viii

[xxxviii] *Miami, Florida, South Miami-Dade Busway*. 2001. Available at http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp90v1_cs/Miami.pdf.

5 RED LINE, MINNEAPOLIS, MN

Exclusive ROW Bus as Light Rail Extension

This 2003 extension to the Minneapolis Light Rail system uses dedicated lanes to connect congested suburbs to the Mall of America, and connects via LRT to the airport and downtown. This 11 mile route has achieved somewhat disappointing ridership, attributed to some awkward routings in and out of stations.

FIGURE 10: RED LINE MAP
SOURCE: METROTRANSIT.ORG

FIGURE 9: RED LINE
SOURCE: METROTRANSIT.ORG, METRO-MAGAZINE.COM

SYSTEM DESCRIPTION	
Phasing	Phase 1: 11 miles initially Phase 2: 16 miles in the future[xxxix]
Type of equipment	Nova LFX 40ft Buses[xl]
Length	11 miles[xli]
Transit Connections	Metro Blue Light Rail at Mall of America[xlii]
Intermodal Connections	Bike lockers, bike racks on buses[xliii]

IMPLEMENTATION	
Date implemented	June 2013[xliv]
Capital cost (in 2014 Dollars)	Total: $114.15M[xlv] Per Mile: $10.37M
Annual revenue hours	55,183[xlvi]
Operating cost (annual)	$3.2M[xlvii]

FEASIBILITY STUDIES	
Mode Selection	Flexible, less land impact, less expensive, quicker[xlviii]
Alternatives	Light Rail[xlix]

FUNDING	
Capital	Regional – State – Local[l] ▪ Minnesota Valley Transit Authority ▪ MPO Metropolitan Council ▪ County Transit Improvement Board ▪ Dakota County Regional Railway Authority
Operating Expenses	50% MPO + CMAQ[li]

RIDERSHIP	
Ridership	Annual: 218,140 (2013)[lii]
Preceding system	#442 Local[liii]
Impact on Ridership	Original ridership was 550, increased 55% to 850[liv]
Ridership Performance	Ridership was 14% below estimates
Riders' Demographics	Work commuters[lv]

MAINTENANCE	
Facilities	Shared with MVRTA Suburban System[lvi]
Cost	10% of existing garage[lvii]

LESSONS LEARNED
Ridership growth suppressed by slow trip off freeway to Cedar Station[lviii]

[xxxix] "METRO Red Line Project (Cedar Avenue BRT)". METRO Council. Accessed November 16th, 2014. http://metrocouncil.org/METC/files/18/187eab90-2feb-4364-bbbf-f2a811d00add.pdf.

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[xliii] "MVTA Expanded Services Q&A". Minnesota Valley Transit Authority. Accessed November 16th, 2014. http://www.mvta.com/uploads/brt_qa_broch_final.pdf.

[xliv]"METRO Red Line – A brand new way to travel". Outreach Program of I-494 Corridor Commission. Accessed November 16th, 2014. http://www.494corridor.org/pdf/METRO_redline_brochure_web.pdf.

[xlv] "METRO Red Line Project (Cedar Avenue BRT)". METRO Council. Accessed November 16th, 2014. http://metrocouncil.org/METC/files/18/187eab90-2feb-4364-bbbf-f2a811d00add.pdf.

[xlvi]"Service Descriptions – Transit Operating and Maintenance Services Including Facility Management, Operating and Maintenance Services". Accessed November 16th, 2014. http://www.mvta.com/uploads/rfp_exhibit_a_-_service_description.pdf.

[xlvii] "METRO Red Line Project (Cedar Avenue BRT)". METRO Council. Accessed November 16th, 2014. http://metrocouncil.org/METC/files/18/187eab90-2feb-4364-bbbf-f2a811d00add.pdf.

[xlviii]*2010 Cedar Avenue Transitway Implementation Plan Update – DRAFT REPORT FOR PUBLIC COMMENT*". 2010. Minneapolis: URS. Available at http://o1.aolcdn.com/hss/storage/patch/3a53a6d18ec3aaae3e0c621a2e3b4c68.

[xlix] *2010 Cedar Avenue Transitway Implementation Plan Update – DRAFT REPORT FOR PUBLIC COMMENT*". 2010. Minneapolis: URS. Available at http://o1.aolcdn.com/hss/storage/patch/3a53a6d18ec3aaae3e0c621a2e3b4c68.

[l]"MVTA Expanded Services Q&A". Minnesota Valley Transit Authority. Accessed November 16th, 2014. http://www.mvta.com/uploads/brt_qa_broch_final.pdf.

[li]"Transportation Committee – March 25, 2013". METRO Council. Accessed November 16th, 2014. http://www.metrocouncil.org/METC/files/d1/d1942ad1-deaf-4d06-8674-037760a6c82e.pdf.

[lii] "Red Line Bus is falling short of rider goal". StarTribune – South Metro. Accessed November 16th, 2014. http://www.startribune.com/local/south/267427891.html.

[liii] "Red Line opening brings changes to MVTA bus routes". StarTribune – Local. Accessed November 16th, 2014. http://www.startribune.com/local/blogs/212483061.html.

[liv] *2010 Cedar Avenue Transitway Implementation Plan Update – DRAFT REPORT FOR PUBLIC COMMENT*". 2010. Minneapolis: URS. Available at http://o1.aolcdn.com/hss/storage/patch/3a53a6d18ec3aaae3e0c621a2e3b4c68.

[lv]"Understanding the Red Line: Cedar Ave's new BRT system offers exciting new opportunities". Partnership for Regional Opportunity: Corridors of Opportunity. Accessed November 16th, 2014. http://www.corridorsofopportunity.org/Corridors_News/understanding-red-line-cedar-ave-new-brt-system-offers-exciting-new-opportunities.

[lvi] "Service Descriptions – Transit Operating and Maintenance Services Including Facility Management, Operating and Maintenance Services". Accessed November 16th, 2014. http://www.mvta.com/uploads/rfp_exhibit_a_-_service_description.pdf.

[lvii] "Service Descriptions – Transit Operating and Maintenance Services Including Facility Management, Operating and Maintenance Services". Accessed November 16th, 2014. http://www.mvta.com/uploads/rfp_exhibit_a_-_service_description.pdf.

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B. ENHANCED STATIONS

6 SUN LINK, TUCSON, AZ

Streetcar Starter Line

This 2014 new-start streetcar reaches beyond a role as a downtown circulator, and runs almost four miles to reach a nearby neighborhood and several eds-and-meds destinations. The American made streetcars are operated, under contract, by a subsidiary of the Paris Metro (RATP). Ridership has been above expectations.

FIGURE 11: SUN LINK STREETCAR
SOURCE: SUNLINKSTREETCAR.COM

FIGURE 12: SUN LINK STREETCAR ROUTE MAP
SOURCE: HTTPS://WWW.DART.ORG/RIDING/MLINE.ASP

SYSTEM DESCRIPTION	
Phasing	Phase 1: 3.9 miles Phase 2: Extension under study
Type of equipment	Unite Streetcar electric streetcars (low-floor doors on both sides, hold 148 passengers)
Length	3.9 miles
Transit Connections	Local bus service, Amtrak
Intermodal Connections	Streetcar vehicles can carry bikes

IMPLEMENTATION	
Date implemented	July 2014
Capital cost (in 2014 Dollars)	Total: $202.69M[lix] Per Mile: $51.97M
Annual revenue hours	25,242[lx]
Operating cost (annual)	$2.9M[lxi]

FEASIBILITY STUDIES	
Mode Selection	"Mayor and Council adopted the modern streetcar route as the 'locally preferred alternative' in 2006, citing the ridership potential and positive economic benefits."[lxii]
Alternatives	Historic trolley, rapid bus circulator[lxiii]

FUNDING		
Capital	$63M TIGER Grant $6M FTA's New Starts program $75M RTA	$10.6M Tucson Water $650,000 Pima County (Sewer Dptmt) $14M Luis G. Gutierrez Cushing Bridge $26.6M City of Tucson[lxiv] [lxv]
Operating Expenses	Local RTA[lxvi]	

RIDERSHIP	
Ridership	Annual: 1,825,000 (2014)[lxvii]
Preceding system	Many routes
Impact on Ridership	Restructured[lxviii]
Ridership Performance	+ 39% compared to expectations, which were 3,600 passenger/day
Riders' Demographics	"Families, young people, university students, working class, people who are attending events, social events, cultural events, athletic events"[lxix]

MAINTENANCE	
Facilities	A new 13,000sqft, LEED-Silver Maintenance and Storage Facility was build on city-acquired land
Cost	$19M[lxx]

LESSONS LEARNED
Officials have received complaints regarding passes, and are utilizing customer service to educate the public about how to purchase re-loadable passes[lxxi]

[lix]"Why do we need a streetcar?" Sun LINK – Tucson Streetcar. Accessed November 18th, 2014. http://www.sunlinkstreetcar.com/index.php?pg=24.

[lx] *Sun Link Pre-Revenue Service Implementation Fare and Service Equity Analysis – Update Report*. 2014. Tucson: Sun Tran. Available at http://www.sunvan.com/docs/Sun_Link_Pre-Revenue_Service_Updated_April2014.pdf.

[lxi] "Some observations on Tucson's $33 million budget deficit". Arizona Daily Independent. Accessed November 18th, 2014. http://www.arizonadailyindependent.com/2014/02/10/some-observations-on-tucsons-33-million-budget-deficit/.

[lxii] "Why do we need a streetcar?" Sun LINK – Tucson Streetcar. Accessed November 18th, 2014. http://www.sunlinkstreetcar.com/index.php?pg=24.

[lxiii] "The Modern Streetcar – A 'Game Changer' for Tucson". Sun LINK Streetcar. Accessed November 18th, 2014. http://www.sunlinkstreetcar.com/documents/2_TRENDMarch2010.pdf.

[lxiv]"US grants Tucson $63M for streetcar". Arizona Daily Star. Accessed November 17th, 2014. http://tucson.com/news/local/govt-and-politics/article_b12c97f3-22cd-57ff-9c5e-84b579cbb303.html.

[lxv] "Why do we need a streetcar?" Sun LINK – Tucson Streetcar. Accessed November 18th, 2014. http://www.sunlinkstreetcar.com/index.php?pg=24.

[lxvi] "Transit Working Group – September 12, 2013" Pima Association of Governments – Regional Transportation Authority. Accessed November 17th, 2014. http://www.pagnet.org/documents/committees/twg/2013/PAGTWG-2013-09-12-Packet.pdf.

[lxvii] "Tucson Streetcar Ridership Exceeds Expectations". Arizona Public Media. Accessed November 18th, 2014. https://news.azpm.org/p/bus-econ-news/2014/9/24/44867-tucson-streetcar-riders-nearly-double-since-opening/.

[lxviii] *Sun Link Pre-Revenue Service Implementation Fare and Service Equity Analysis – Update Report*. 2014. Tucson: Sun Tran. Available at http://www.sunvan.com/docs/Sun_Link_Pre-Revenue_Service_Updated_April2014.pdf.

[lxix]"Tucson Streetcar Ridership Exceeds Expectations". Arizona Public Media. Accessed November 18th, 2014. https://news.azpm.org/p/bus-econ-news/2014/9/24/44867-tucson-streetcar-riders-nearly-double-since-opening/.

[lxx] "Tucson Sun Link Modern Streetcar MSF". Maintenance Design Group. Accessed November 17th, 2014. http://maintenancedesigngroup.com/projects/tucson-az-streetcar-msf/.

[lxxi] "Tucson Streetcar Ridership Exceeds Expectations". Arizona Public Media. Accessed November 18th, 2014. https://news.azpm.org/p/bus-econ-news/2014/9/24/44867-tucson-streetcar-riders-nearly-double-since-opening/.

7 CL LINE, PORTLAND, OR

Streetcar Extension

This 2012 extension to the Portland Streetcar system extended this combination circulator and local transit service to the less-developed east side of the Willamette River. The line is about 4 miles long and has approximately met ridership projections. It also acts as a "last-mile" connector to the city's light rail system.

FIGURE 13: PORTLAND CL LINE
SOURCE: HTTP://UPLOAD.WIKIMEDIA.ORG/WIKIPEDIA/COMMONS/

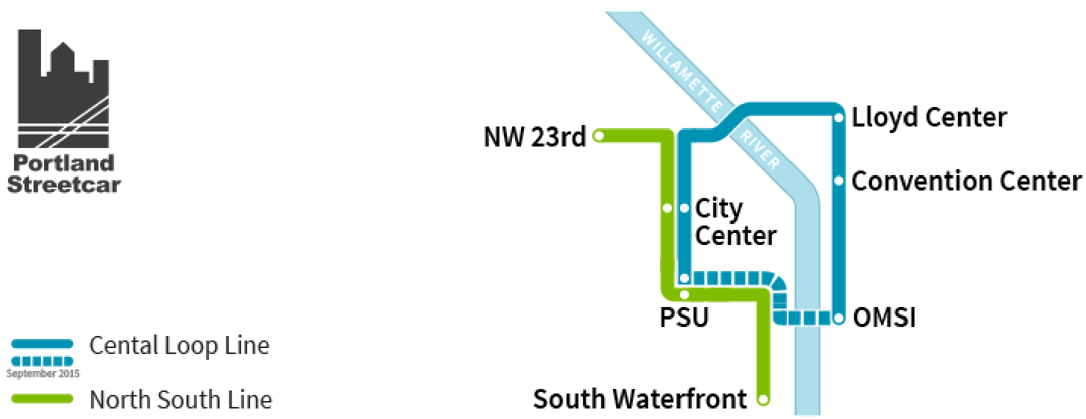

FIGURE 14: PORTLAND CL ROUTE MAP
SOURCE: HTTP://TRIMET.ORG/STREETCAR/INDEX.HTM

SYSTEM DESCRIPTION	
Phasing	Phase 1: 2001 - North-South Line Phase 2: 2012 - Central Loop Line
Type of equipment	66ft long, modern Škoda-Inekon streetcar
Length	3.3 miles
Transit Connections	Existing streetcar on SW 10th & 11th at Market
Intermodal Connections	Accommodates for bikes

IMPLEMENTATION	
Date implemented	September 2012
Capital cost (in 2014 Dollars)	Total: $153.36M[lxxii] Per Mile: $46.43M
Annual revenue hours	6,006
Operating cost (annual)	$3.5-5.5M[lxxiii] [lxxiv]

FEASIBILITY STUDIES	
Mode Selection	Expansion of existing streetcar
Alternatives	None

FUNDING		
Capital	$28M Urban Renewal Fund (TIF) $15.5M Local Improvement District $6.1 City of Portland $3.6M Regional Transportation Funds[lxxv] [lxxvi]	$45M FTA's Small Smarts $30M US DOT $0.4M Stimulus Fund $20M State Fund for Vehicles
Operating Expenses	In 2014: 50% TriMet, 50% City of Portland, PSI, Energy Funds, others [lxxvii]	

RIDERSHIP	
Ridership	Annual: 5.67M (2014) [lxxviii]
Preceding system	North-South streetcar and TriMet buses
Impact on Ridership	+70% in 2 years (+8,000 passenger/weekday[lxxix], i.e. 471 pph in 2014)
Ridership Performance	Ridership numbers in 2014 have exceeded 2005 predictions for 2025 by roughly 100 riders per day[lxxx]
Riders' Demographics	Data aggregated with other streetcar lines; Fewer work – home trips than system average[lxxxi]

MAINTENANCE	
Facilities	Uses the existing maintenance yards, the Portland Streetcar Yards (Under I-405 at 16th Street)
Cost	None

[lxxii] "Portland Streetcar's eastside loop gets off to hobbled start Saturday". The Oregonian. Accessed November 19th, 2014. http://blog.oregonlive.com/commuting/2012/09/portland_streetcars_eastside_l.html.
[lxxiii] "Steve Duin: Closing the loop on the Portland Streetcar". The Oregonian. Accessed November 19th, 2014. http://www.oregonlive.com/news/oregonian/steve_duin/index.ssf/2012/09/steve_duin_closing_the_loop_on.html.
[lxxiv] *Brooklyn Streetcar – Feasibility Study*. New York: URS. Available at: http://www.nyc.gov/html/dot/downloads/pdf/101222_redhook_sc_casestudies.pdf.
[lxxv] *Portland Streetcar: City bears financial burden and operational risk while relying on outside partners*. 2014. Portland: Office of City Auditor. Available at http://www.portlandonline.com/auditor/index.cfm?a=487580&c=64479. p.9
[lxxvi] "Feds give $75 million for Oregon streetcar". Portland Business Journal. Accessed November 19th, 2014. http://www.bizjournals.com/portland/stories/2009/04/27/daily46.html?surround=lfn.
[lxxvii] *Portland Streetcar: City bears financial burden and operational risk while relying on outside partners*. 2014. Portland: Office of City Auditor. Available at http://www.portlandonline.com/auditor/index.cfm?a=487580&c=64479 p10
[lxxviii] "Portland Streetcar – Annual Ridership". Portland Streetcar. Accessed November 19th, 2014. http://www.portlandstreetcar.org/pdf/annual_ridership_201410.pdf.
[lxxix] "Portland Streetcar – Annual Ridership". Portland Streetcar. Accessed November 19th, 2014. http://www.portlandstreetcar.org/pdf/annual_ridership_201410.pdf.
[lxxx] "Welcome to Portland Streetcar". Portland Streetcar. November 19th, 2014. http://www.portlandstreetcar.org/
[lxxxi] *Portland Streetcar: The Central City Transit Market*. 2005. Portland: TriMet. Available at: http://www.railvolution.org/rv2005_pdfs/rv2005_202c.pdf.

8 QUICKLINE, HOUSTON, TX

Arterial BRT as Light Rail Feeder

This 2009 Bus Rapid Transit connection to the Houston Light Rail line is defined by multiple branding, where it is known as "Signature 402 QL Bellaire Quickline" service. The line has enhanced stations, but mostly runs in shared lanes with some signal priority. The line exceeded ridership goals in this established transit corridor.

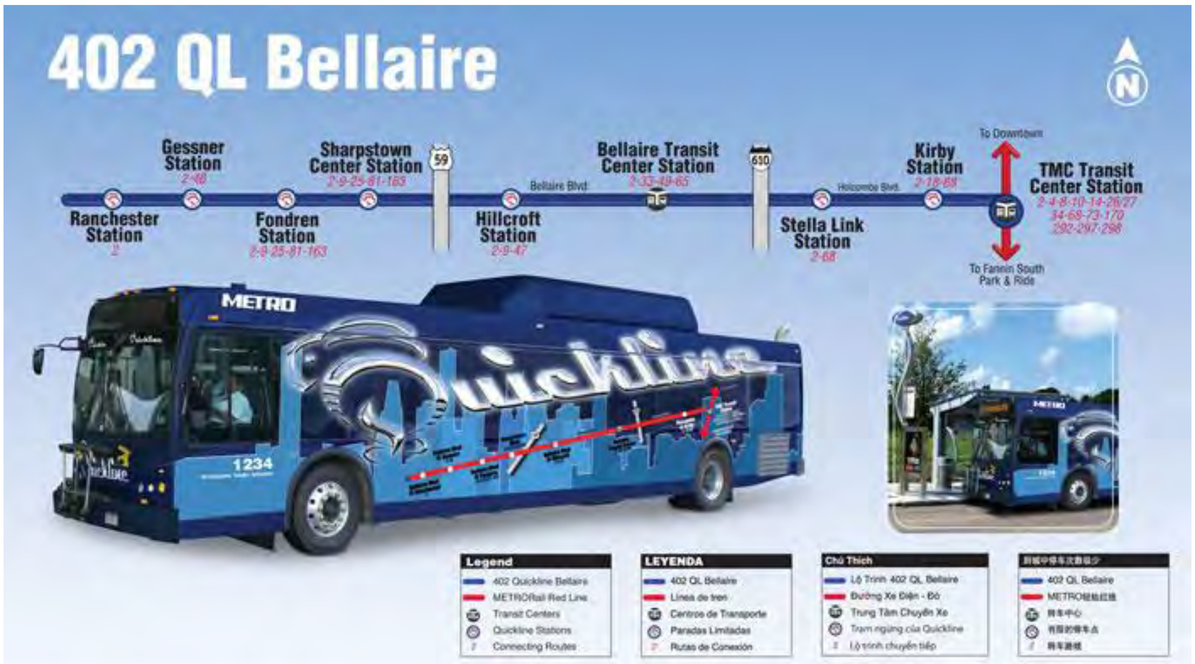

FIGURE 15: QUICKLINE
SOURCE: RIDEMETRO.ORG

FIGURE 16: QUICKLINE
SOURCE: FTA.DOT.GOV

SYSTEM DESCRIPTION	
Phasing	The Quickline Bellaire is the first of, in theory, multiple Quicklines throughout Houston.[lxxxii] Originally the Quickline only ran during rush hours, but METRO added midday service.
Type of equipment	New Flyer 40ft hybrid-electric buses[lxxxiii]
Length	9 miles[lxxxiv]
Transit Connections	Local bus service (routes 2,9,18,25,33,46,47,49,65,68,81,163), TMC Transit Center Station[lxxxv]
Intermodal Connections	Buses have bike racks

IMPLEMENTATION	
Date implemented	June 2009[lxxxvi]
Capital cost	Total: $4.258M[lxxxvii] Per Mile: $473,111
Annual revenue hours	12,750 (estimate from available data)
Operating cost (annual)	$2,004,757 (FY2014)[lxxxviii]

FEASIBILITY STUDIES	
Mode Selection	Mode was implemented as the result of a referendum.
Alternatives	None

FUNDING	
Capital	JARC (FTA's Job Access Reverse Commute)[lxxxix]
Operating Expenses	Fare revenue, Subsidy, JARC[xc]

RIDERSHIP	
Ridership	Annual: 170,720 (FY2014)[xci]
Preceding system	Yes, regular bus service, the 2 Bellaire[xcii]
Impact on Ridership	Ridership on the local line (running the same route as the Quickline) also "crept up a few percentage points"[xciii]
Ridership Performance	Ridership exceeded expectations at its debut[xciv]
Riders' Demographics	Work commuters (operates only during the work week and only during rush hours)

MAINTENANCE	
Facilities	Uses existing facilities
Cost	None

LESSONS LEARNED
Officials have received complaints regarding passes, and are utilizing customer service to educate the public about how to purchase re-loadable passes[xcv].
Aesthetics are overrated. METRO could have spent less on capital (stations) and branding and received comparable ridership and fare revenue.
METRO: a) eliminated most discounted fare media by March 2008; and b) increased local base fares from $1.00 to $1.25 in November 2008. These fare changes had a significant impact on expected ridership on the Quickline as well as existing ridership on Route 2 Bellaire whose passengers had a low average household income.
Deferring until time savings can be achieved is more important than opening early. METRO implemented the service when construction was still ongoing on Bellaire with the thought that any time savings would be appreciated. However, the effect was to minimize the actual potential time savings by breaking the savings into two intervals. By the time real time savings were realized, many customers had already decided that the service didn't save time and reverted back to the Bellaire[xcvi]

[lxxxii] "Bellaire Quickline Bus Service Starts June 1". HoustonTomorrow. Accessed November20th, 2014. http://www.houstontomorrow.org/livability/story/bellaire-quickline-service-starts-june-1/.
[lxxxiii] "402 QL Bellaire". Metropolitan Transit Authority of Harris County, Houston, Texas. Accessed November 20th, 2014. http://www.ridemetro.org/Services/Bus/Quickline_SignatureService.aspx.
[lxxxiv] "402 QL Bellaire". Metropolitan Transit Authority of Harris County, Houston, Texas. Accessed November 20th, 2014. http://www.ridemetro.org/Services/Bus/Quickline_SignatureService.aspx.
[lxxxv] "401 Quickline Bellaire". Metropolitan Transit Authority of Harris County, Houston, Texas. Accessed November 20th, 2014. https://www.ridemetro.org/SchedulesMaps/Pdfs/402-quicklinebellaire.pdf.
[lxxxvi] "Walk Like MADD". Write on Metro – Blog of Metropolitan Transit Authority. Accessed November 20th, 2014. http://blogs.ridemetro.org/blogs/write_on/archive/2009/04/09/Walk-Like-MADD-.aspx.
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[lxxxix] *Projects Eligible for JARC Funding*. 2013. Metropolitan Transit Authority of Harris County. Available at http://ridemetro.granicus.com/MetaViewer.php?view_id=5&clip_id=544&meta_id=3458.
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[xci] Archer, Jim, Director Service Planning , Scheduling, and Evaluation Division, METRO, email message to Morgan Campbell, December 4th, 2014.
[xcii] *Tales of Buses and Bunnies: The Houston Quickline*. 2009. METRO. Available at: http://www.apta.com/mc/multimodal/previous/2009/presentations/Lists/list_of_presentations_09/Attachments/10/s8_j_archer_web.pdf.
[xciii] "Metro riders cotton to new bunny line". The Houston Chronicle. Accessed November 20th, 2014. http://www.chron.com/news/houston-traffic/article/Metro-riders-cotton-to-new-bunny-line-1723451.php.
[xciv] "Metro riders cotton to new bunny line". The Houston Chronicle. Accessed November 20th, 2014. http://www.chron.com/news/houston-traffic/article/Metro-riders-cotton-to-new-bunny-line-1723451.php.
[xcv] "Tucson Streetcar Ridership Exceeds Expectations". Arizona Public Media. Accessed November 18th, 2014. https://news.azpm.org/p/bus-econ-news/2014/9/24/44867-tucson-streetcar-riders-nearly-double-since-opening/.
[xcvi] Archer, Jim, Director Service Planning , Scheduling, and Evaluation Division, METRO, email message to Morgan Campbell, December 4th, 2014.

9 BREEZE RAPID, ESCONDIDO, CA

Arterial BRT as DLR (Diesel Light Rail) Feeder

This 2011 Bus Rapid Transit connection to Escondido's Sprinter diesel light rail system is a modest BRT with enhanced stations. The 6 mile line also connects to Del Lago Transit station, south of downtown Escondido, where direct bus service to San Diego is available. It replaced a previous local bus line, and there is no data available on how much additional ridership was attracted.

FIGURE 18: NCTD ESCONDIDO BREEZE RAPID MAP
SOURCE: HTTP://WWW.SANDAG.ORG/PROGRAMS/TRANSPORTATION/PUBLIC_TRANSIT/ERB/ERB.PDF

FIGURE 17: NCTD ESCONDIDO BREEZE
SOURCE: GONCTD.COM/BREEZE

SYSTEM DESCRIPTION	
Phasing	Preliminary: 2006 - Rapid Bus project approved Phase 1: 2011 - Initial Phase (Years 1-2) – Improvements such as signal priority, provide visible near-term benefits without significant implementation concerns. Phase 2: Mid-Term Phase (Years 3-5) – Improvements provide additional benefits, but require a more detailed review and engineering process, or they are related to the opening of the Del Lago Bus Rapid Transit Station and the start of the I-15 Bus Rapid Transit service. Phase 3: Future Phase (Years 5+) – Improvements can provide benefits, but may best be implemented in coordination with other trans[xcvii]
Type of equipment	New Flyer C40LF low floor buses
Length	6 miles
Transit Connections	SPRINTER rail system, I-15 Express Bus service, and Bus Rapid Transit system at Escondido Transit Center, Metropolitan Transit System at Del Lago Transit Station.
Intermodal Connections	Bike racks on buses[xcviii]

IMPLEMENTATION	
Date implemented	July 2011
Capital cost (in 2014 Dollars)	Total: $5.65M (3 phases together)[xcix] Per Mile: $942,194
Annual revenue hours	14,000 (estimated from data available)
Operating cost (annual)	Data only available for Breeze as a whole

FEASIBILITY STUDIES	
Mode Selection	The project corridor is identified in the 2030 Regional Transportation Plan, the region's long-term transportation plan, for improved local and rapid bus services The rapid bus was able to - improve the travel time (by 16%[c]) and reliability of Route 350 without adversely impacting the local transportation system[ci] - provide consistent and lower operations costs
Alternatives	Enhanced bus service recommended in the Regional Plan

FUNDING	
Capital	Data only available for Breeze as a whole
Operating Expenses	Data only available for Breeze as a whole

NOTE: NCTD does not release data specific to the Breeze Rapid line but only for Breeze as a whole

RIDERSHIP	
Ridership	Data only available for Breeze as a whole
Preceding system	Breeze Rapid replaces the previous local line 350
Impact on Ridership	Data only available for Breeze as a whole
Ridership Performance	Data only available for Breeze as a whole
Riders' Demographics	School commuters

MAINTENANCE	
Facilities	Data only available for Breeze as a whole
Cost	Data only available for Breeze as a whole

[xcvii] *Escondido Rapid Bus Transit Priority Concept Study, Final Report*. 2006. San Diego: IBI Group. Available at: http://www.sandag.org/uploads/publicationid/publicationid_1248_5782.pdf.
[xcviii] *Rider's Guide – Your Complete Guide to Public Transit in North County*. 2014. Escondido: North County Transit District. http://www.gonctd.com/wp-content/uploads/2014/07/Riders-Guide-Aug2017-w-rev3.pdf
[xcix] *Escondido Rapid Bus Transit Priority Concept Study, Final Report*. 2006. San Diego: IBI Group. Available at: http://www.sandag.org/uploads/publicationid/publicationid_1248_5782.pdf.
[c] "Escondido Breeze Rapid Fact Sheet". Sandag. Accessed November 18th, 2014. http://www.sandag.org/uploads/publicationid/publicationid_1324_7266.pdf.
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10 FREE METRORIDE, DENVER, CO

Arterial BRT as Light Rail Feeder

This 2014 downtown circulator provides a peak hour alternative for commuters to the 16th Street Mall Ride, which is heavily used by shoppers and tourists. The 1 1/2 mile line connects to downtown's light rail, commuter bus stations and future commuter trains. Ridership is not recorded on this completely free link.

FIGURE 19: DENVER FREE METRORIDE
SOURCE: HTTP://WWW.RTD-DENVER.COM/FREEMETRORIDE.SHTML

FIGURE 20: DENVER FREE METRORIDE ROUTE MAP
SOURCE: HTTP://WWW.RTD-DENVER.COM/FREEMETRORIDE.SHTML

SYSTEM DESCRIPTION	
Phasing	3 miles
Type of equipment	60' articulated, low-floor buses
Length	3 miles (1.5 in each direction)
Transit Connections	Downtown light rail stations, the future commuter rail station at Union Station, Free MallRide
Intermodal Connections	All buses are equipped with bike racks on the front of the bus, **except** for the 16th Street Free MallRide and Free MetroRide.

IMPLEMENTATION	
Date implemented	May 2014
Capital cost (in 2014 Dollars)	Total: $16.9M Per Mile: $5.6M[cii]
Annual revenue hours	About 5,000 (estimate from data available)
Operating cost (annual)	No source found

FEASIBILITY STUDIES	
Mode Selection	Recommended by Denver Multimodal Access Plan[ciii]
Alternatives	None

FUNDING	
Capital	$5.2M Discretionary grant funding $0.8M Homeland Security grants[civ]
Operating Expenses	No source found

RIDERSHIP	
Ridership	No source found
Preceding system	Metroride bus system, including lines 83L, 79L, and 3L serving downtown Denver
Impact on Ridership	No source found
Ridership Performance	No source found
Riders' Demographics	Designed for work commuters

MAINTENANCE	
Facilities	No source found
Cost	No source found

[cii] *RTD FasTracks – 2014 FasTracks Baseline Report to DRCOG and RTP Submittal*. 2014. Denver: Regional Transportation District. Available at: https://drcog.org/sites/drcog/files/resources/2014%20RTD%20FasTracks%20Baseline%20Report.pdf.

[ciii] *RTD FasTracks – 2014 FasTracks Baseline Report to DRCOG and RTP Submittal*. 2014. Denver: Regional Transportation District. Available at: https://drcog.org/sites/drcog/files/resources/2014%20RTD%20FasTracks%20Baseline%20Report.pdf.

[civ] *RTD FasTracks – 2014 FasTracks Baseline Report to DRCOG and RTP Submittal*. 2014. Denver: Regional Transportation District. Available at: https://drcog.org/sites/drcog/files/resources/2014%20RTD%20FasTracks%20Baseline%20Report.pdf. p9

C. CIRCULATOR

11 TECO LINE STREETCAR, TAMPA, FL

Historic Replica Streetcar Circulator

This 2002 line is run by replica streetcars and is a downtown circulator oriented toward tourists. The line is just under 3 miles long and links downtown and the waterfront to historic Ybor City. Its ridership has been strong, and the station design is keyed to the adjacent land use.

FIGURE 21: TAMPA TECO STREETCAR
SOURCE: GOHART.ORG

FIGURE 22: TAMPA TECO STREETCAR ROUTE MAP
SOURCE:LIGHTRAILNOW.ORG

SYSTEM DESCRIPTION	
Phasing	Phase 1: 2.3 miles of service, began in 10/2002 Phase 2: Additional 1/3rd mile into central business district began in 12/2010
Type of equipment	Ten historic replica streetcars: nine Birney streetcars and one breezer-style (open-air) car purchased from the Gomaco Trolley Company. Steel Uni-body, 46ft long, 44 passenger (seated) load, max speed: 33mph
Length	2.7 miles
Transit Connections	Marion Transit Center, Local buses (Routes 4,8,12,18,19,30), Dick Greco Plaza (transportation center), Port Authority[cv]
Intermodal Connections	None

IMPLEMENTATION	
Date implemented	October 2002[cvi]
Capital cost (in 2014 Dollars)	Total: $49.2M Per Mile: $18.24M[cvii]
Annual revenue hours	14,385[cviii]
Operating cost (annual)	$2.58M or $3.27 per passenger mile[cix]

FEASIBILITY STUDIES	
Mode Selection	TECO streetcar line was promoted by nonprofit Railway Society specifically to bring back streetcars to Tampa's downtown.[cx]
Alternatives	None

FUNDING	
Capital	City, State, Federal + Harbor Island Endowment[cxi]
Operating Expenses	$2.13M (farebox revenues, CRA contributions, and a Special Assessment)[cxii]

RIDERSHIP	
Ridership	Annual: 366,808 (FY 2011)[cxiii]
Preceding system	No source found
Impact on Ridership	No source found
Ridership Performance	Ridership was 25% above projections when implemented[cxiv]
Riders' Demographics	Majority of ridership is tourism, 61% of trips happen on weekends[cxv]

MAINTENANCE	
Facilities	The Rail Barn – Ybor Station – houses Maintenance, operations
Cost	7.3 miles including station[cxvi]

LESSONS LEARNED
Real estate impact greater than expected[cxvii]

[cv] "Downtown Network of Services". TECO Line Streetcar System. Accessed November 20th, 2014. http://www.tecolinestreetcar.org/about/maps/downtown_network.pdf.

[cvi] "Streetcars Return to Tampa". LightRailNow. Accessed November 20th, 2014. http://www.lightrailnow.org/news/n_tam001.htm.

[cvii] *River Rail Economic Enhancement Study*.2013. Central Arkansas Transit Authority. Available at: http://www.cat.org/wp-content/uploads/2013/05/River-Rail-Economic-Enhancement-Study.pdf .

[cviii] *Adopted Operating and Capital Budgets*. 2013. Tampa: Hillsborough Area Regional Transit Authority. Available at: http://www.gohart.org/departments/finance/budget/fy2013_adopted_budget.pdf.

[cix] Brown, J. *The Modern Streetcar in the U.S.: An Examination of Its Ridership, Performance, and Function as a Public Transportation Mode*. 2013. Florida State University. Available at: http://www.nctr.usf.edu/wp-content/uploads/2013/12/jpt16.4_Brown.pdf.

[cx] "Streetcars Return to Tampa". LightRailNow. Accessed November 20th, 2014. http://www.lightrailnow.org/news/n_tam001.htm.

[cxi] *Anaheim Streetcar Economic Impact & Development Study*. 2013. Anaheim: GB Place Making. Available at: http://www.anaheimfixedguideway.com/assets/docs/library/Anaheim-Streetcar-Report/03_What_is_the_Experience_with_Streetcars.pdf.

[cxii] *Tampa Historic Streetcar, Inc. Fiscal year 2013 in Review*. 2013. Tampa: Tampa Historic Streetcar, Inc. Available at: http://www.tecolinestreetcar.org/about/streetcar_assessment_district.pdf.

[cxiii] *Adopted Operating and Capital Budgets*. 2013. Tampa: Hillsborough Area Regional Transit Authority. Available at: http://www.gohart.org/departments/finance/budget/fy2013_adopted_budget.pdf.

[cxiv] *Tampa's TECO Line Streetcar System*. 2003. Tampa: Tampa Historic Streetcar, Inc. Available at: ftp://metrostlouis.org/Loop%20Trolley/LOOP%20TROLLEY%20CO.-1/Loop%20Trolley/inventing_the_future.pdf.

[cxv] *Hillsborough Area Regional Transit Teco Line Streetcar System*. 2004. Tampa: Hillsborough Area Regional Transit Authority. Available at: http://www.heritagetrolley.org/images/APTAPresentation07.pdf.

[cxvi] "Grand Opening for Tampa's New Streetcar System". TECO Line Streetcar System. Accessed November 20th, 2014. http://www.tecolinestreetcar.org/news/whats_new_r.html.

[cxvii] *Anaheim Streetcar Economic Impact & Development Study*. 2013. Anaheim: GB Place Making. Available at: http://www.anaheimfixedguideway.com/assets/docs/library/Anaheim-Streetcar-Report/03_What_is_the_Experience_with_Streetcars.pdf.

12 TACOMA LINK, TACOMA, WA

Last Mile Streetcar to Commuter/Intercity Rail Station

This 2003 "last-mile" connector links the commuter rail and Amtrak station to downtown Tacoma using light rail vehicles in a streetcar environment. The 1 1/2 mile line has had lower than expected ridership, due to declining employment in downtown Tacoma.

FIGURE 24: TACOMA LINK LIGHT RAIL
SOURCE: LIGHTRAILNOW.ORG

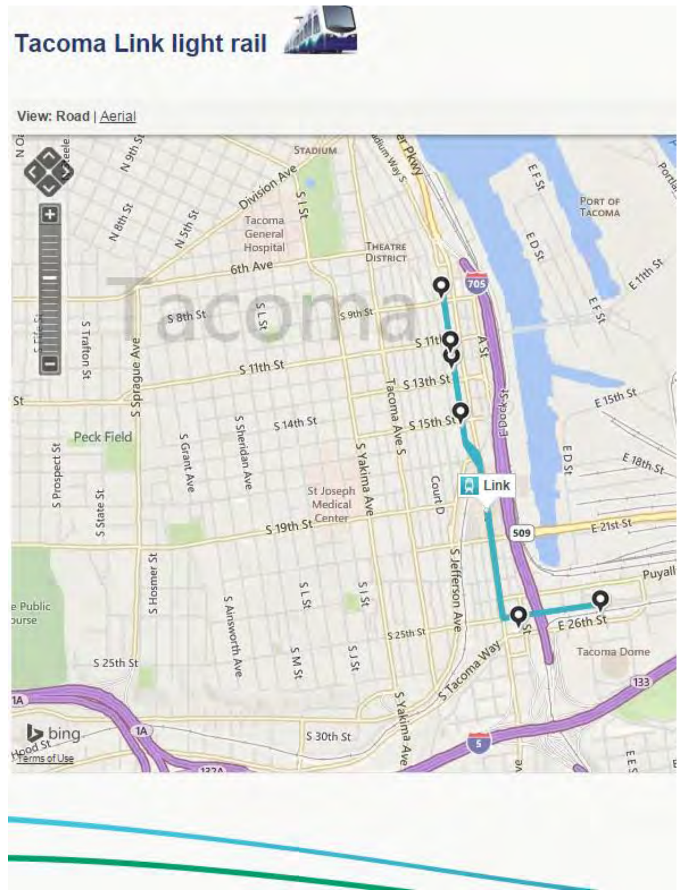

FIGURE 23: TACOMA LINK LIGHT RAIL ROUTE MAP
SOURCE: HTTP://WWW.SOUNDTRANSIT.ORG/SCHEDULES/TACOMA-LINK-LIGHT-RAIL?TAB=MAP

SYSTEM DESCRIPTION	
Phasing	Phase 1: 2003 - Initial segment opens Phase 2: 2011 - Addition of the Commerce St/s. 11th St infill station
Type of equipment	66-foot-long air-conditioned electric streetcars by Skoda
Length	1.6 miles
Transit Connections	Sounder commuter train service, local and regional buses, Amtrak at the Tacoma Dome Station[cxviii]
Intermodal Connections	Cars have two bike hooks per car

IMPLEMENTATION	
Date implemented	September 2003
Capital cost (in 2014 Dollars)	Initial segment: $103.23M[cxix], i.e. $64.52M/mile Extension: $155.12M[cxx], i.e. $97.21M/mile planned
Annual revenue hours	64,100
Operating cost (annual)	$1.5M

FEASIBILITY STUDIES	
Mode Selection	Light rail was chosen over BRT because of route restrictions (LRT would provide a better connection downtown and to the Tacoma Dome Station without transfers) and the ability of LRT to spur private investment[cxxi]
Alternatives	BRT, as a rubber-tired vehicle that would operate in a shared lane with traffic, would serve substantial transit stations, and would have distinctive branding, low-floor boarding, and transit signal priority, and initially a TSM mode (not evaluated) [cxxii]

FUNDING	
Capital	Planned as follows: $50M Local revenue capital $50M Small Starts Grant (not granted yet) $50M Partnerships $80M – Federal, State, Local[cxxiii]
Operating Expenses	$2.5 M[cxxiv]

RIDERSHIP	
Ridership	Annual: 925, 284 (2014)[cxxv]
Preceding system	Sound Transit bus system
Impact on Ridership	No direct comparison
Ridership Performance	-6% between 2013 & 2014 "Tacoma Link did not meet the targets for boardings […] due to fewer Tacoma events and relocation of two major Downtown Tacoma employers to King County"[cxxvi]
Riders' Demographics	Last mile riders

MAINTENANCE	
Facilities	Yes, at Tacoma Dome Station[cxxvii]
Cost	Not broken out

LESSONS LEARNED
Sound Transit is betting that passengers will be attracted not just by the convenient route, but by the fast, comfortable service provided by the 21st-century, state-of-the-art electric streetcars which will glide up and down the route.[cxxviii]

[cxviii] "Link Light Rail". Sound Transit. Accessed November 19th, 2014. http://www.soundtransit.org/Documents/pdf/projects/link/Tacoma/Tacoma%20Link%20Expansion/FLY_TacLink.pdf.
[cxix] "Tacoma Link Light Rail Streetcar Line Heads Toward Startup". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/news/n_tac001.htm.
[cxx] "Link Light Rail". Sound Transit. Accessed November 19th, 2014. http://www.soundtransit.org/Documents/pdf/projects/link/Tacoma/Tacoma%20Link%20Expansion/FLY_TacLink.pdf.
[cxxi] *Tacoma Link Expansion Alternatives Analysis Report and SEPA Addendum*. 2013. Tacoma: Sound Transit. Available at: http://www.soundtransit.org/Documents/pdf/projects/link/Tacoma/Tacoma%20Link%20Expansion/ExpansionAlternativesAnalysisRpt_and_SEPAAddendum/201305_TLE_AAReptandSEPAAddendum_Main.pdf.
[cxxii] *Tacoma Link Expansion Alternatives Analysis Report and SEPA Addendum*. 2013. Tacoma: Sound Transit. Available at: http://www.soundtransit.org/Documents/pdf/projects/link/Tacoma/Tacoma%20Link%20Expansion/ExpansionAlternativesAnalysisRpt_and_SEPAAddendum/201305_TLE_AAReptandSEPAAddendum_Main.pdf.
[cxxiii] "Streetcars in Other Cities". The Loop Trolley. Accessed November 22nd, 2014. http://looptrolleytdd.org/city_trolleys.html.
[cxxiv] *Inner-City Streetcar Downtown Circulator Study – Feasibility Report*. 2008. San Antonio: Jacobs. Available at: http://www.smartwaysa.com/Documents/SCStudy/03%20Supportive%20Streetcar%20Initiatives.pdf.
[cxxv] Based on 2014 third quarter findings.
[cxxvi] "Second Quarter 2014 – Service Delivery Quarterly Performance Report". SoundTransit. Accessed November 19th, 2014. http://www.soundtransit.org/Documents/pdf/rider_news/ridership/Q3%202014%20Service%20Delivery.pdf
[cxxvii] "Tacoma Link Operations and Maintenance Facility". SubwayNut. Accessed November 21st, 2014. http://subwaynut.com/pnw/tacoma_link/operations/index.php.
[cxxviii] "Tacoma Link Light Rail Streetcar Line Heads Toward Startup". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/news/n_tac001.htm.

13 RIVER RAIL, LITTLE ROCK, AR

Historic Replica Streetcar Circulator

This 2004 replica trolley operation serves as a circulator in downtown Little Rock and also a transit link to a developing area in North Little Rock. It is designed to appeal to tourists and downtown residents. Ridership has been strong, including service to the Clinton Presidential Library.

FIGURE 25: RIVER RAIL
SOURCE: CAT.ORG

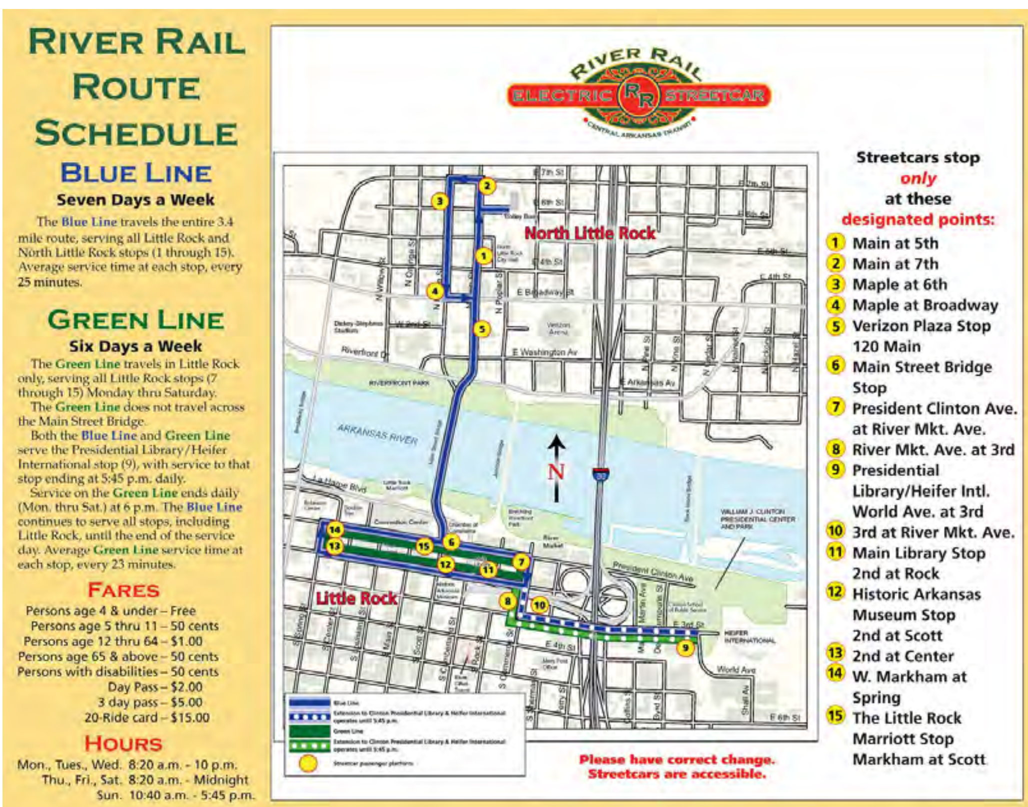

FIGURE 26: RIVER RAIL SYSTEM MAP
SOURCE: HTTP://WWW.CAT.ORG/WP-CONTENT/UPLOADS/RIVER-RAIL-SYSTEM-MAP.PNG

SYSTEM DESCRIPTION	
Phasing	Preliminary: 1997 - Feasibility Study Phase 1: 2004 - Completed (in North Little Rock off of Main Street) Phase 2: 2007 - Completed (double track section between Commerce and 2nd Streets and the Clinton Presidential Library via 3rd Street)
Type of equipment	3 replica streetcar; overhead power supply
Length	2.5 miles extended to 3.4 miles
Transit Connections	Local buses
Intermodal Connections	No source found

IMPLEMENTATION	
Date implemented	November 2004
Capital cost (in 2014 Dollars)	Total: $30.58M[cxxix] Per Mile: $8.99M
Annual revenue hours	12,369 in 2011 (Operates 85 hours a week; fare is $1)
Operating cost (annual)	$0.96M in 2011, i.e. $17.14/mile

FEASIBILITY STUDIES	
Mode Selection	"The idea and intention of the streetcar system was for the River Rail to enhance the revitalization efforts by serving as an attractive, historic transportation connector for tourists, visitors, and locals to the major art and entertainment venues, restaurants, museums, parks, shops, libraries, and neighborhoods located in the downtowns."[cxxx]
Alternatives	No source found

FUNDING	
Capital	80% - $16M FTA's New Start program 20% - $4M Local matching grant split between Pulaski County, Little Rock and North Little Rock[9]
Operating Expenses	Three affected municipalities[cxxxi]

RIDERSHIP	
Ridership	Annual: 100, 402 (2011)[cxxxii]
Preceding system	Local buses only
Impact on Ridership	N/A
Ridership Performance	Ridership exceeded projections, 3x higher[cxxxiii]
Riders' Demographics	Convention visitors, tourists, downtown residents

MAINTENANCE	
Facilities	A maintenance and storage facility was built in North Little Rock off of Main Street
Cost	$1.1million (2002 bid)[cxxxiv]

LESSONS LEARNED
In addition of the high ridership, within six months of opening the line, over $80M in new development was announced along the line and more recently a new $28M ballpark in North Little Rock was built within several blocks of the line as well as a large executive corporate residence complex.[cxxxv] CATA organizes seasonal events and rents streetcars in order to increase revenue

[cxxix] *River Rail Economic Enhancement Study*.2013. Central Arkansas Transit Authority. Available at: http://www.cat.org/wp-content/uploads/2013/05/River-Rail-Economic-Enhancement-Study.pdf p3
[cxxx] *River Rail Economic Enhancement Study*.2013. Central Arkansas Transit Authority. Available at: http://www.cat.org/wp-content/uploads/2013/05/River-Rail-Economic-Enhancement-Study.pdf. p8
[cxxxi]"Little Rock River Rail Project". FTA DOT. Accessed November 19th, 2014. http://www.fta.dot.gov/12304_2832.html.
[cxxxii] *River Rail Economic Enhancement Study*.2013. Central Arkansas Transit Authority. Available at: http://www.cat.org/wp-content/uploads/2013/05/River-Rail-Economic-Enhancement-Study.pdf
[cxxxiii] "Streetcar Proposal: Comparing Boise's Dream with Little Rock's Reality, Part 2". Idaho Freedom Foundation. Accessed November 20th, 2014. http://idahofreedom.org/streetcar-proposal-comparing-boises-dream-with-little-rocks-reality-part-2/.
[cxxxiv] "Little Rock – Bridge Contract". APTA Streetcar and Heritage Trolley Site. Accessed November 21st, 2014. http://www.heritagetrolley.org/planLittleRockRTOL8.htm.
[cxxxv]*Missoula Urban Transportation District Urban Streetcar Study – Final Report*. 2012. Missoula: Nelson\Nygaard. Available at: http://www.mountainline.com/wp-content/uploads/2013/04/Missoula-Streetcar-Final-Report_Dec-2012-2.pdf.

14 M-LINE TROLLEY, DALLAS, TX

Historic Streetcar Circulator

This 1989 historic trolley operation is run primarily by a museum, but has received increased public money to enhance service and connectivity. It connects a successful redevelopment area to Dallas' light rail system and to within walking distance of downtown Dallas. It plays primarily a circulator role and, as a free service, does not collect ridership data, but is considered successful.

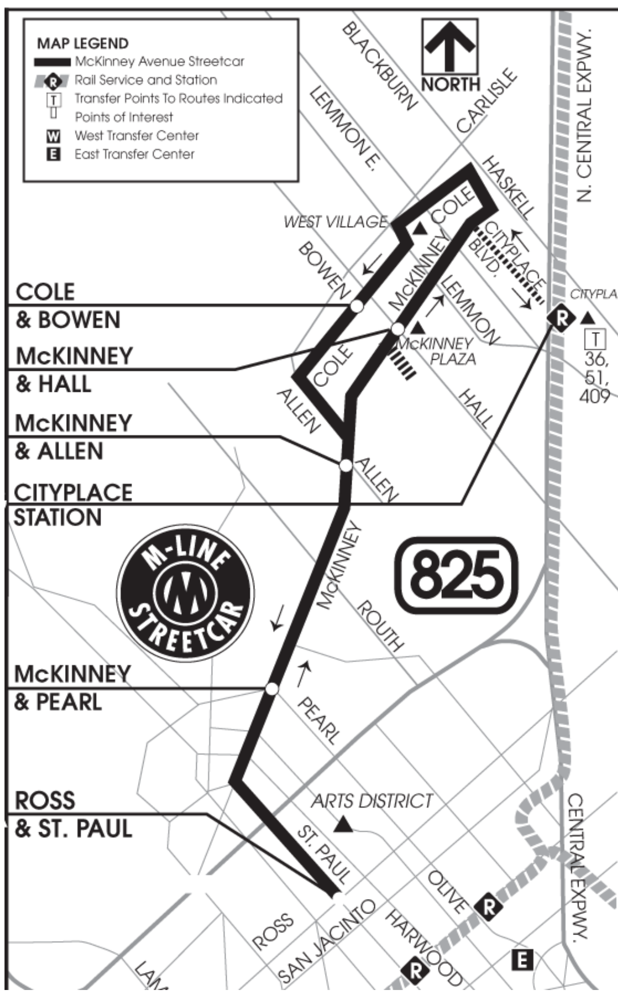

FIGURE 28: M-LINE TROLLEY ROUTE MAP
Source: https://www.dart.org/riding/mline.asp

FIGURE 27: M-LINE TROLLEY
SOURCE: FLICKR, AUGUST 3, 2010

SYSTEM DESCRIPTION	
Phasing	Phase 1: 1989 - MATA starts operating the McKinney Avenue trolley Phase 2: 2002 - First expansion to DART's Cityplace station; The line is renamed M-Line Phase 3: 2014 - Extension along Olive Street through Klyde Warren Park to near Pearl/Arts District Station.[cxxxvi]
Type of equipment	"Vintage streetcars"
Length	2.8 miles + 1 mile extension
Transit Connections	DART Rail at Cityplace/Uptown Station and Arts District Station
Intermodal Connections	No source found

IMPLEMENTATION	
Date implemented	1989
Capital cost (in 2014 Dollars)	Initial segment: $1.9M, $678,571 per mile 2014 Extension: $9.9M[cxxxvii], $9.9M per mile
Annual revenue hours	126,000
Operating cost (annual)	$250,000 (2002: many volunteer staff, shorter line)[cxxxviii]

FEASIBILITY STUDIES	
Mode Selection	An Alternative Analysis stated that the trolley option met best the objectives for the projects: "enhance mobility, strive for regional consensus, be fiscally responsible, consider appropriate technologies, consider effects on the corridor"[cxxxix]
Alternatives	Initial segment: Historic vehicle Extension: Light Rail, Modern Streetcar, Trolley, Bus[cxl]

FUNDING (EXTENSION)	
Capital	$4.9M Urban Circulator Grant from the US DOT $5M from the North Central Texas Council of Governments[cxli]
Operating Expenses	DART and Public Improvement Districts[cxlii]

RIDERSHIP	
Ridership	Annual: 433,108 (2012) [cxliii]
Preceding system	None
Impact on Ridership	No comparison
Ridership Performance	No comparison
Riders' Demographics	Neighborhood + tourists

MAINTENANCE	
Facilities	Cars are stored and maintained or restored in the MATA barn[cxliv]
Cost	No source found

[cxxxvi] "M-Line Trolley". Dallas Area Rapid Transit. Accessed November 18th, 2014. https://www.dart.org/riding/mline.asp.

[cxxxvii] "Dallas – Downtown Expansion Delayed". Heritage Trolley. Accessed November 18th, 2014. http://www.heritagetrolley.org/existDallasMATANews07.htm.

[cxxxviii] "When Novelties Become a Nuisance". VPostrel. Accessed November 18th, 2014. http://vpostrel.com/articles/when-novelties-become-a-nuisance.

[cxxxix] *Downtown Dallas Transit Study*. 2010. Dallas: Dallas Area Rapid Transit. Available at: http://www.dart.org/ShareRoot/about/expansion/d2aadeis/D2DEISMarch2010.pdf .

[cxl] *Streetcar Action Plan.* Dallas: forwardDallas. Available at: http://www.dallascityhall.com/forwarddallas/pdf/Streetcar.pdf.

[cxli] *Downtown Dallas Transit Study*. 2010. Dallas: Dallas Area Rapid Transit. Available at: http://www.dart.org/ShareRoot/about/expansion/d2aadeis/D2DEISMarch2010.pdf.

[cxlii] "M-Line Trolley – Linking the Past to the Present". McKinney Avenue Transit Authority. Accessed November 18th, 2014. http://www.mata.org/newsinformation/questionsandanswers.html.

[cxliii] Pearson B. *McKinney Avenue Trolley Sets Ridership Records*. 2013. D Magazine. Available at: http://frontburner.dmagazine.com.

[cxliv] "Ask a Motorman". McKinney Avenue Trolley. Accessed November 18th, 2014. http://mckinney-avenue-trolley.tumblr.com/.

15 STREETCAR, KENOSHA, WI

Historic Streetcar Circulator

This 2000 circulator was designed to promote development in a waterfront area near downtown by connecting to the commuter rail station. It uses mid-20th century PCC streetcars and is a 2 mile loop. Ridership has been considered successful, although seasonal.

FIGURE 29: KENOSHA ELECTRIC STREETCAR
SOURCE: HTTP://WWW.VISITKENOSHA.COM/ATTRACTIONS/TOP-ATTRACTIONS/ELECTRIC-STREETCAR-CIRCULATOR

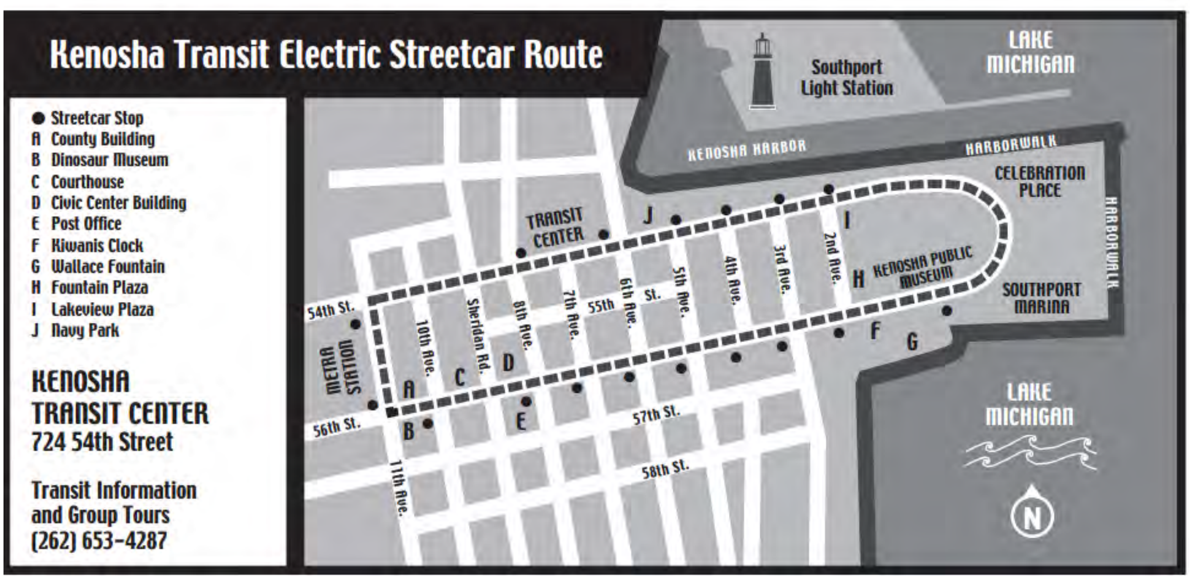

FIGURE 30: KENOSHA ELECTRIC STREETCAR ROUTE MAP
Source: http://www.visitkenosha.com/sites/default/files/pdf/streetcarschedule2014.pdf

SYSTEM DESCRIPTION	
Phasing	Phase 1: 1.7miles[cxlv]
Type of equipment	PCC Streetcar
Length	1.9 miles[cxlvi]
Transit Connections	Metra
Intermodal Connections	No

IMPLEMENTATION	
Date implemented	June 2000[cxlvii]
Capital cost (in 2014 Dollars)	Total: $6.08M[cxlviii] Per Mile: $3.16M
Annual revenue hours	2,500[cxlix]
Operating cost (annual)	328,000 (2011)[cl]

FEASIBILITY STUDIES	
Mode Selection	Harborfront TOD[cli]
Alternatives	None

FUNDING	
Capital	Federal[clii]
Operating Expenses	State – Federal – City[cliii]

RIDERSHIP	
Ridership	Annual: 67,600 (2003)[cliv]
Preceding system	No circulator
Impact on Ridership	No baseline
Ridership Performance	Ridership was higher than estimates[clv]
Riders' Demographics	Visitors

MAINTENANCE	
Facilities	A separate facility was required[clvi]
Cost	$1M[clvii]

LESSONS LEARNED
Lift on board saves station cost.[clviii]

[cxlv]"Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/facts/fa_ken_2005-01.htm.

[cxlvi] "Kenosha". TrainWeb. Accessed November 19th, 2014. http://www.trainweb.org/twerhs/kenosha.html.

[cxlvii] "Kenosha". TrainWeb. Accessed November 19th, 2014. http://www.trainweb.org/twerhs/kenosha.html.

[cxlviii] "Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/facts/fa_ken_2005-01.htm.

[cxlix]"Electric Streetcar Circulator". Kenosha Area Convention and Visitors Bureau. Accessed November 19th, 2014. http://www.visitkenosha.com/attractions/top-attractions/electric-streetcar-circulator.

[cl]"Streetcar expansion isn't worth the money". Kenosha News. Accessed November 19th, 2014. http://www.kenoshanews.com/opinion/streetcar_expansion_isnt_worth_the_money_468886189.html.

[cli] "Kenosha Transit System". APTA Streetcar and Heritage Trolley Site. Accessed November 19th, 2014. http://www.heritagetrolley.org/existKenoshaOverview.htm.

[clii] "Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/facts/fa_ken_2005-01.htm.

[cliii]*Kenosha County Transit Development Plan: 2012 – 2016*. 2011. Kenosha: Southeastern Wisconsin Regional Planning Commission. Availabla at: http://www.sewrpc.org/SEWRPCFiles/Publications/ppr/2011-03-kenosha-co-transit-dev-plan-newsletter-1.pdf.

[cliv] Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.heritagetrolley.org/existKenoshaOverview.htm

[clv] "Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/facts/fa_ken_2005-01.htm.

[clvi] "Kenosha Transit System". APTA Streetcar and Heritage Trolley Site. Accessed November 19th, 2014. http://www.heritagetrolley.org/existKenoshaOverview.htm.

[clvii]"Kenosha Transit System". APTA Streetcar and Heritage Trolley Site. Accessed November 19th, 2014. http://www.heritagetrolley.org/existKenoshaOverview.htm.

[clviii] "Kenosha, Wisconsin Streetcar System: Workable Light Rail Meets Small-Town Mobility and Urban Development Needs". LightRailNow. Accessed November 19th, 2014. http://www.lightrailnow.org/facts/fa_ken_2005-01.htm.

16 iSHUTTLE, IRVINE, CA

Last Mile Commuter Shuttle

This 2008 minibus system is a combination last-mile and circulator system, connecting the local buses, commuter rail station and Airport to a range of suburban land uses (retail, office, homes, etc.) and the University of California. There are four routes, about 20 route miles, and mostly peak hour service. Ridership has oscillated from high to low to intermediate levels over the past 6 years.

FIGURE 31: iShuttle
SOURCE: FLICKR, APRIL 27, 2012

FIGURE 32: iShuttle Map
SOURCE: HTTP://WWW.CITYOFIRVINE.ORG/CITYHALL/PW/ISHUTTLE/DEFAULT.ASP

SYSTEM DESCRIPTION	
Phasing	Routes A and B have been in operation since June 2008 Routes C and D have been in operation since October 2011
Type of equipment	17 El Dorado Minibus shuttle buses, 5 of which have 30 seats, the other 12 have 20 seats
Length	Route A: 6.4 miles Route B: 5.9 miles Route C: 3.9 miles Route D: 3.5 miles[clix]
Transit Connections	OCTA bus system, UC Irvine housing circulator, Route A & B connect to the Tustin Metrolink station, Route C & D allow transfers at the Irvine station, John Wayne Airport
Intermodal Connections	Riders can load their bike onto the iShuttle and Metrolink

IMPLEMENTATION	
Date implemented	June 2008
Capital cost (in 2014 Dollars)	Total: $2.5M[clx] Per mile: $127,531
Annual revenue hours	17,000
Operating cost (annual)	$2.89M (FY '12 –'13)[clxi]

FEASIBILITY STUDIES	
Mode Selection	No evidence other modes considered
Alternatives	No evidence other modes considered

FUNDING	
Capital	Intergovernmental, Investment Income, Charges for services , Proposition 116[clxii]
Operating Expenses	Orange County Transportation Authority (as of 2011). City is expected to pay 10% of operating costs.[clxiii]

RIDERSHIP	
Ridership	Annual: 111,694 (2011)[clxiv]
Preceding system	OCTA
Impact on Ridership	Nothing comparable
Ridership Performance	Ridership hit peaks during 1st year but then dropped dramatically, drawing criticism. Now more or less as estimated (see above).[clxv]
Riders' Demographics	Mainly Metrolink riders coming to Irvine for work[clxvi]

MAINTENANCE	
Facilities	Shuttle buses use contractor's facility[clxvii]
Cost	None

[clix] *iShuttle Expansion Study: Draft Report*. 2013. Irvine: Fehr & Peers. Available at: https://ocpolitical.files.wordpress.com/2013/03/item5-1report.pdf.

[clx] *Reconsideration of Expanded iShuttle Services*. 2013. City of Irvine: City Council. Available at: https://ocpolitical.files.wordpress.com/2013/03/item5-1report.pdf.
[clxi] *City of Irvine, Comprehensive Annual Financial Report*. 2013. Irvine: City of Irvine. Available at: http://www.cityofirvine.org/civica/filebank/blobdload.asp?BlobID=24045.
[clxii] *City of Irvine, Comprehensive Annual Financial Report*. 2013. Irvine: City of Irvine. Available at: http://www.cityofirvine.org/civica/filebank/blobdload.asp?BlobID=24045.
[clxiii] "Irvine's iShuttle to be funded through exchange with OCTA". Orange County Register. Accessed November 18th, 2014. http://www.ocregister.com/articles/city-277453-irvine-year.html.
[clxiv] *Irvine Snapshots – An overview of the trends shaping Irvine today*. 2012. Irvine: City of Irvine. Available at: http://www.cityofirvine.org/civica/filebank/blobdload.asp?BlobID=21281.
[clxv] "Irvine's iShuttle to be funded through exchange with OCTA". Orange County Register. Accessed November 18th, 2014. http://www.ocregister.com/articles/city-277453-irvine-year.html.
[clxvi] Francine Verbag, Interviewed by Eric Hall, https://www.youtube.com/watch?v=rRTxpkC3G1o
[clxvii] "Irvine eyes $6.5 million iShuttle contract extension". Orange County Register. Accessed November 18th, 2014. http://www.ocregister.com/articles/city-388151-ishuttle-transportation.htmlg.

17 EMERY GO-ROUND, EMERYVILLE, CA

Community Circulator

This 1995, free minibus service acts as a circulator and a last-mile connection for Amtrak and BART trains. The system is about 7 1/2 route miles and serves mixed land uses, including outside Emeryville. Ridership levels are very successful and constantly growing.

FIGURE 33: EMERY GO-ROUND
SOURCE: EMERYGOROUND.COM

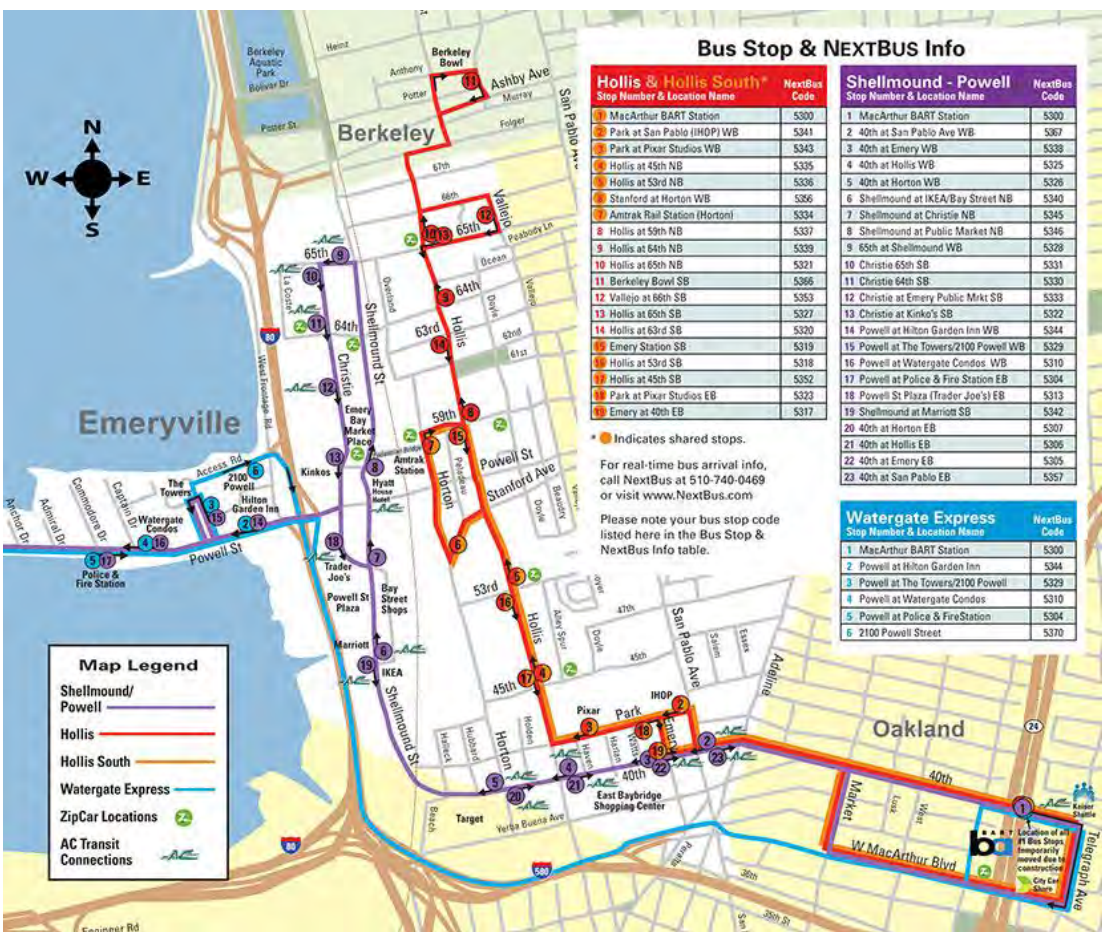

FIGURE 34: EMERY GO-ROUND SYSTEM MAP
Source: emerygoround.com

SYSTEM DESCRIPTION	
Phasing	Emery-Go-Round started as a privately-owned service: "Business owners have pooled their resources to provide free shuttle service on what they call the Emery Go-Round." "As of March 2013, three public and private entities joined as partners in the management and operation of the Emery Go-Round. The Emeryville Transportation Management Association (TMA) and its board contracted with Gray-Bowen Consulting, Walnut Creek, CA, to oversee the Emery Go-Round service. Gray-Bowen in turn subcontracted with MV Transportation, Dallas, TX, for the physical operation of the service."[clxviii]
Type of equipment	13 buses with 24 to 36 seats, 1 9-seat mini van
Length	7.6 miles approximately
Transit Connections	Amtrak, BART, AC Transit
Intermodal Connections	Bikes racks on each vehicle. Bikes are permitted inside during off-peak hours.

IMPLEMENTATION	
Date implemented	1995
Capital cost (in 2014 Dollars)	Operates leased buses[clxix]
Annual revenue hours	30,000[clxx]
Operating cost (annual)	$3.3M[clxxi]; cost per passenger trip was $1.52 in 2009

FEASIBILITY STUDIES	
Mode Selection	Intent was to mimic existing independent shuttle services in the area[clxxii]
Alternatives	None

FUNDING	
Capital	Citywide transportation business improvement district[clxxiii]
Operating Expenses	Free of charge - 2011: "Vast majority" – Commercial property owners $43K - City of Emeryville $28K - Emery School District $9K - City Redevelopment Agency[clxxiv]

RIDERSHIP	
Ridership	Annual: >1.6M (2014)[clxxv]
Preceding system	Some private shuttles transporting employees throughout the area
Impact on Ridership	Increased from 300 passenger/day to 3,000 within the first 6 months[clxxvi] Ridership has grown steadily since service began in 1997
Ridership Performance	Ridership exceeded projections in FY 2008 with 1.3M passenger trips and an 18% growth in ridership in 2007-2008.
Riders' Demographics	More than 90% of riders commute to work, 6% travel to school (AM only)

MAINTENANCE	
Facilities	Maintenance is provided through full operating leases and contract maintenance with Idealease and Penske Truck Leasing.[clxxvii]
Cost	No source found

LESSONS LEARNED
Approximately 80% of all Emery Go-Round trips begin or end at MacArthur BART Station, supporting a significant increase in patronage at the station and a shift in primary mode of access.[52]

[clxviii] "Private business launched Emery Go Round as a public service". BUSride. Accessed November 17th, 2014. http://busride.com/2014/02/transit-authority-5/.
[clxix] "Emeryville Transportation Management Authority – Board of Directors Meeting – August 21, 2014". Emery Go-Round. Accessed November 17th, 2014. http://www.emerygoround.com/assets/aug2014agendapacket.pdf.
[clxx] "Emeryville Transportation Management Authority – Board of Directors Meeting – March 12, 2014". Emery Go-Round. Accessed November 17th, 2014. http://www.emerygoround.com/assets/special-meeting-march-12-2014-1.original.pdf. p21
[clxxi] "Emeryville Transportation Management Authority – Board of Directors Meeting – October 16, 2014". Emery Go-Round. Accessed November 17th, 2014. http://www.emerygoround.com/assets/agendapacket20141016_r1.pdf. p6,9
[clxxii] "How a Free Bus Shuttle Helped Make a Small Town Take Off". NPR. Accessed November 19th, 2014. http://www.npr.org/2013/11/13/243955769/how-a-free-bus-shuttle-helped-make-a-small-town-take-off.
[clxxiii] "Route Map". Emery Go-Round. Accessed November 18th, 2014. http://www.emerygoround.com/.
[clxxiv] "Funding: Emery-Go-Round Is Dragged, Kicking & Screaming". Emeryville Tattler. Accessed November 19th, 2014. http://emeryvilletattler.blogspot.com/2012/05/emery-go-round-back-peddles-on-funding.html.
[clxxv] "Emeryville Transportation Management Authority – Board of Directors Meeting – August 21, 2014". Emery Go-Round. Accessed November 17th, 2014. http://www.emerygoround.com/assets/aug2014agendapacket.pdf. p3
[clxxvi] "How a Free Bus Shuttle Helped Make a Small Town Take Off". NPR. Accessed November 19th, 2014. http://www.npr.org/2013/11/13/243955769/how-a-free-bus-shuttle-helped-make-a-small-town-take-off.
[clxxvii] *Emeryville Sustainable Transportation Background Report*. 2011. City of Emeryville. Available at: http://www.emeryville.org/DocumentCenter/Home/View/1672 p2,2

18 TRI-RAIL SHUTTLE BUSES, SOUTH FLORIDA

Commuter Rail Feeder Network

This 1989 feeder and last mile system oriented to a commuter rail line consists of about 20 routes (167 route miles), many cross marketed with and operated by local transit agencies. It is an essential element of the rail system, where stations are almost never within walking distance of land use. It is considered a necessary and successful service.

FIGURE 35: TRI-RAIL SHUTTLE
SOURCE: TRI-RAIL.COM

SYSTEM DESCRIPTION	
Phasing	Started with 3 routes, now 20+ (in partnership with local systems)
Type of equipment	Mixed types and brands, from 22 passenger capacities to45 passengers[clxxviii]
Length	167 route miles[clxxix]
Transit Connections	Tri-Rail trains
Intermodal Connections	Bike lockers at stations and allowed in the train[clxxx]

IMPLEMENTATION	
Date implemented	January 1989[clxxxi]
Capital cost (in 2014 Dollars)	Total: $5.89M[clxxxii] Per Mile: $35,269
Annual revenue hours	67,000[clxxxiii]
Operating cost (annual)	$4.8M[clxxxiv]

FEASIBILITY STUDIES	
Mode Selection	Last mile, first mile issues
Alternatives	Considered an alternative to I-95 during construction

FUNDING	
Capital	FTA, FDOT, ARRA[clxxxv]
Operating Expenses	South Florida RTA, FDOT, FTA, JARC[clxxxvi]

RIDERSHIP	
Ridership	Annual: 935,919 (2011)[clxxxvii]
Preceding system	None
Impact on Ridership	N/A
Ridership Performance	N/A
Riders' Demographics	Work commuters

MAINTENANCE	
Facilities	Contracted with local agencies overseeing their fleets[clxxxviii]
Cost	None

[clxxviii]"More people hop on Tri-Rail buses". SunSentinel. Accessed November 20th, 2014. http://articles.sun-sentinel.com/2012-07-31/news/fl-tri-rail-shuttles-20120730_1_tri-rail-officials-tri-rail-stations-bonnie-arnold.

[clxxix]*South Florida Regional Transportation Authority Forward Plan: A Transit Development Plan for SFRTA – Final Report.* 2013. Pompano Beach: Tindale-Oliver & Associates, Inc. http://www.browardmpo.org/userfiles/files/TDP-SFRTA-FY2014-2024-FINAL.pdf.

[clxxx]"Bicycle Information". Tri-Rail. Accessed November 20th, 2014. http://www.tri-rail.com/bicycle-information.

[clxxxi] *South Florida Regional Transportation Authority Forward Plan: A Transit Development Plan for SFRTA – Final Report.* 2013. Pompano Beach: Tindale-Oliver & Associates, Inc. Available at: http://www.browardmpo.org/userfiles/files/TDP-SFRTA-FY2014-2024-FINAL.pdf.

[clxxxii] "More people hop on Tri-Rail buses". SunSentinel. Accessed November 20th, 2014. http://articles.sun-sentinel.com/2012-07-31/news/fl-tri-rail-shuttles-20120730_1_tri-rail-officials-tri-rail-stations-bonnie-arnold.

[clxxxiii]*South Florida Regional Transportation Authority – Transit Development Plan Annual Update.* 2012. Pompano Beach: South Florida Regional Transportation Authority. Available at: http://www.sfrta.fl.gov/docs/planning/TDP/TDP_Annual_Update_FY_2013.pdf.

[clxxxiv] *South Florida Regional Transportation Authority – Transit Development Plan Annual Update.* 2012. Pompano Beach: South Florida Regional Transportation Authority. Available at: http://www.sfrta.fl.gov/docs/planning/TDP/TDP_Annual_Update_FY_2013.pdf.

[clxxxv] *South Florida Regional Transportation Authority – Transit Development Plan Annual Update.* 2012. Pompano Beach: South Florida Regional Transportation Authority. Available at: http://www.sfrta.fl.gov/docs/planning/TDP/TDP_Annual_Update_FY_2013.pdf.

[clxxxvi] *South Florida Regional Transportation Authority – Transit Development Plan Annual Update.* 2012. Pompano Beach: South Florida Regional Transportation Authority. Available at: http://www.sfrta.fl.gov/docs/planning/TDP/TDP_Annual_Update_FY_2013.pdf.

[clxxxvii] *South Florida Regional Transportation Authority Forward Plan: A Transit Development Plan for SFRTA – Final Report.* 2013. Pompano Beach: Tindale-Oliver & Associates, Inc. http://www.browardmpo.org/userfiles/files/TDP-SFRTA-FY2014-2024-FINAL.pdf. p3-48

[clxxxviii]"Tri-Rail: Miami, FL". Transdev. Accessed November 20th, 2014. http://www.transdevna.com/Rail/Commuter-Rail/Case-Studies/Miami.aspx.

19 DOWNTOWN & WATERFRONT SHUTTLES, SANTA BARBARA, CA

Tourist-Oriented Circulator

This 1990 circulator system uses customized electric minibuses to provide circulator service in and near downtown Santa Barbara. The system consists of about 3 route miles and is considered a permanent fixture in the transit system.

FIGURE 36: SANTA BARBARA DOWNTOWN & WATERFRONT SHUTTLE
SOURCE: BUILDABETTERBURB.ORG

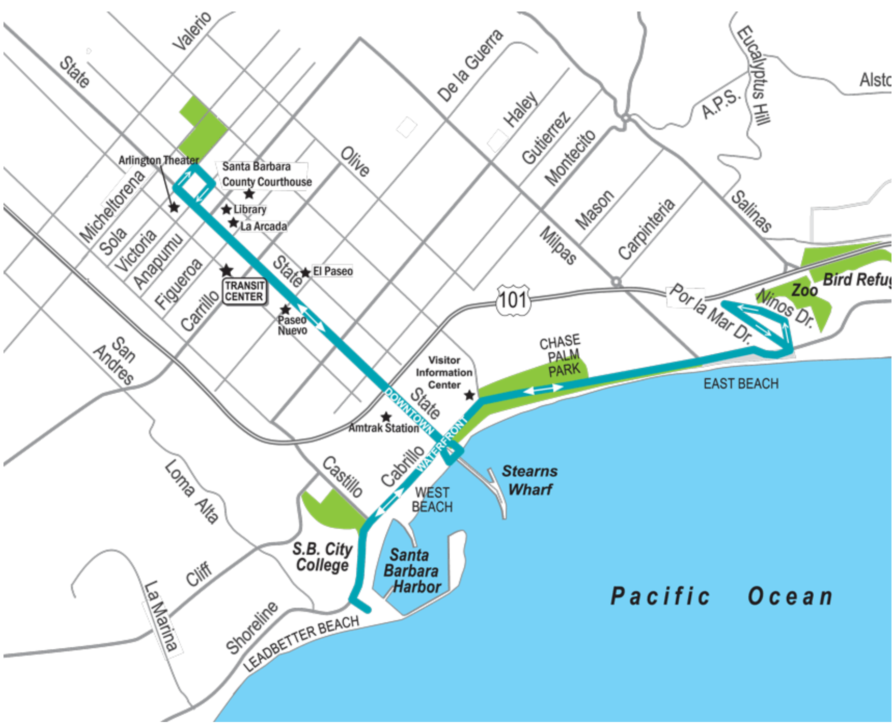

FIGURE 37: SANTA BARBARA DOWNTOWN & WATERFRONT SHUTTLE
SOURCE: SBMTD.GOV

SYSTEM DESCRIPTION	
Phasing	No source found
Type of equipment	22ft EBus electric shuttles
Length	~3 miles
Transit Connections	Downtown – Connections to the Santa Barbara Transit Center; Amtrak Station Waterfront – Connections to Bus Routes 24, 22[clxxxix]
Intermodal Connections	The shuttles cannot carry bicycles[cxc]

IMPLEMENTATION	
Date implemented	1990
Capital cost (in 2014 Dollars)	Total: $2.93M[cxci] (Annual Vehicle Replacement) Per Mile: $975,081
Annual revenue hours	15,372
Operating cost (annual)	$1.75M (FY 2013)

FEASIBILITY STUDIES	
Mode Selection	No source found
Alternatives	No source found

FUNDING	
Capital	No source found
Operating Expenses	Farebox revenue: $165,080 City Fare-Buydown Subsidy: $1,029,051 MTD Subsidy: $557,255

RIDERSHIP	
Ridership	Annual: 423,927 (FY 2013)[cxcii]
Preceding system	Local buses
Impact on Ridership	No source found
Ridership Performance	No source found
Riders' Demographics	Tourists, local residents who are shopping, dining, or sightseeing.[cxciii]

MAINTENANCE	
Facilities	No separate facility
Cost	No separate facility

[clxxxix]"MTD Santa Barbara Route Map". Santa Barbara Metropolitan Transit District. Accessed November 19th, 2014. http://www.sbmtd.gov/lib/img/map/SantaBarbara.gif.

[cxc]*Schedule Guide*. 2014. Santa Barbara: SBMTD. Available at: http://www.sbmtd.gov/download/CompleteBook2014.pdf.

[cxci]*Santa Barbara Metropolitan Transit District – Adopted Budget FY 2012 – 2013*. 2012. Santa Barbara: SBMTD. Available at: http://www.sbmtd.gov/download/publications/Miscellaneous/SBMTDAdoptedBudgetFY2012-13.pdf.

[cxcii] *MTD Report to Santa Barbara on the Downtown-Waterfront Shuttle – Annual Report FY 2013*. 2013. Santa Barbara: SBMTD. Available at: http://www.santabarbaraca.gov/SBdocuments/Advisory_Groups/Transportation_and_Circulation_Committee/Archive/2014_Archives/03_Staff_Reports/2014_01_23_January_23_2014_Item_3_MTD_Reports_.pdf.

[cxciii] *MTD Report to Santa Barbara on the Downtown-Waterfront Shuttle – Annual Report FY 2013*. 2013. Santa Barbara: SBMTD. Available at: http://www.santabarbaraca.gov/SBdocuments/Advisory_Groups/Transportation_and_Circulation_Committee/Archive/2014_Archives/03_Staff_Reports/2014_01_23_January_23_2014_Item_3_MTD_Reports_.pdf.

20 WAVE TROLLEY, MONTEREY, CA

Tourist-Oriented Circulator

This 2003 seasonal circulator system is oriented to tourists and extends about 2 route miles. The system uses customized "trolley" livery vehicles and also serves a park-once role for the city's downtown. The trolley only runs from late May to early September .

FIGURE 39: WAVE TROLLEY ROUTE MAP
SOURCE: MONTEREY.ORG

FIGURE 38: WAVE TROLLEY
SOURCE: MONTEREY.ORG

SYSTEM DESCRIPTION	
Phasing	Phase 1: 2003 - Creation of the historic trolley line serving tourist destinations Phase 2: 2011 - Improvements and extensions Phase 3: 2015 - Introduction of WAVE, wireless charging technology for new electric vehicles
Type of equipment	EBus Trolley + Chance Trolley[cxciv]
Length	~2 miles
Transit Connections	MST Local Bus
Intermodal Connections	No accommodation for bikes, Departs from downtown parking garage

IMPLEMENTATION	
Date implemented	2003
Capital cost (in 2014 Dollars)	Total: $2.1M[cxcv] Per Mile: $1.05M
Annual revenue hours	8,000
Operating cost (annual)	No source found

FEASIBILITY STUDIES	
Mode Selection	Reconnect with the local identity and preserve the historic heritage[cxcvi]
Alternatives	No source found

FUNDING	
Capital	*2003 Historic Trolley:* 20% - $325,000 City of Monterey 80% FTA *2011 Improvements:* MST & Monterey Bay Aquarium[cxcvii] *WAVE technology:* 81% - $1.67M FTA Clean Fuels Grant from 19% - $0.40M State of California Toll credits[cxcviii]
Operating Expenses	No source found

RIDERSHIP	
Ridership	Annual: 99,221 (2013)[cxcix] (Runs only late May – Early September)
Preceding system	Four 1992-diesel trolleys
Impact on Ridership	100,000 (2012)[cc]
Ridership Performance	No source found
Riders' Demographics	Tourists

MAINTENANCE	
Facilities	No source found
Cost	No source found

LESSONS LEARNED

- Monterey-Salinas Transit (MST) is planning to reduce emissions by 30% and noise pollution thanks to a new electric trolley powered by the WAVE 50kW wireless charging system
- The financing structure ensures that no local tax dollars or passenger fares will be used to fund this infrastructure improvement project[cci]
- The new 32-foot vehicles will last about two years and 50,000 miles longer than MST's old 17-passenger minibuses. They will also provide greater capacity and flexibility and can be used on busy routes that don't have quite enough riders to require larger standard coaches[ccii]

[cxciv] "Board of Directors Regular Meeting – December 17th, 2012". Monterey-Salinas Transit. Accessed November 18th, 2014. https://www.mst.org/wp-content/media/Agenda_MST_Dec2012.pdf.

[cxcv] *Putting Transit to Work in Main Street America: How Smaller Cities and Rural Places Are Using Transit and Mobility Investments to Strengthen Their Economies and Communities*. 2012. Reconnecting America. Available at: http://reconnectingamerica.org/assets/PDFs/201205ruralfinal.pdf.

[cxcvi] *Putting Transit to Work in Main Street America: How Smaller Cities and Rural Places Are Using Transit and Mobility Investments to Strengthen Their Economies and Communities*. 2012. Reconnecting America. Available at: http://reconnectingamerica.org/assets/PDFs/201205ruralfinal.pdf.

[cxcvii] *Putting Transit to Work in Main Street America: How Smaller Cities and Rural Places Are Using Transit and Mobility Investments to Strengthen Their Economies and Communities*. 2012. Reconnecting America. Available at: http://reconnectingamerica.org/assets/PDFs/201205ruralfinal.pdf.

[cxcviii] "Monterey Trolley". WAVE IPT. Accessed November 19th, 2014. http://www.waveipt.com/project/monterey-trolley.

[cxcix] "Agenda #11-1 – November 4, 2013 Meeting". Monterey-Salinas Transit. Accessed November 18th, 2014. http://www.mst.org/wp-content/media/GMReport_Nov2014.pdf.

[cc] "Agenda #11-1 – November 4, 2013 Meeting". Monterey-Salinas Transit. Accessed November 18th, 2014. http://www.mst.org/wp-content/media/GMReport_Nov2014.pdf.

[cci] "Monterey Trolley". WAVE IPT. Accessed November 19th, 2014. http://www.waveipt.com/project/monterey-trolley.

[ccii] *Monterey-Salinas Transit 2012 Annual Report*. 2012. Monterey: Monterey-Salinas Transit. Available at: http://38.106.5.85/Modules/ShowDocument.aspx?documentid=5560.

D. SUMMARY TABLE

The following table (Figure 40) presents a summary of all relevant capital and operating statistics from the peer case studies. Please note: due to unavailability of data at this time, the Breeze Rapid BRT (Escondido, California) and Free Metroride bus (Denver, Colorado) services are omitted from this table. Other, isolated instances of data unavailability are noted with "N/A."

FIGURE 40 SUMMARY TABLE

System	Mode	Miles	Ridership/mile (1,000s)	Operating Cost/mile ($, 1,000s)	Operating Cost/rider ($)	Capital Cost/mile ($, 1,000s)	Capital Cost/rider ($)
Exclusive Right of Way							
S-Line, Salt Lake City, UT	Streetcar	2.0	135	$800	$5.92	$28,700	$212.22
Canal Streetcars, New Orleans, LA	Streetcar	5.5	291	1,273	4.38	39,300	135.09
UTA MAX, Salt Lake City, UT	BRT	10.0	39	310	7.95	1,870	47.95
South Busway, Miami-Dade, FL – Initial Segment	BRT/Bus	8.3	108	N/A	N/A	6,670	61.63
Red Line, Minneapolis, MN	BRT	11.0	20	291	14.67	10,370	523.29
Enhanced Stations							
Sun Link, Tucson, AZ	Streetcar	3.9	468	744	1.59	51,970	111.06
CL Line, Portland, OR	Streetcar	3.3	1,706	1,667	0.98	46,430	27.21
Quickline, Houston, TX	BRT	9.0	19	223	11.74	473	24.94
Circulator							
TECO Line Streetcar, Tampa, FL	Streetcar	2.7	136	956	7.03	18,240	134.26
Tacoma Link, Tacoma, WA	Streetcar	1.6	304	938	3.09	64,520	212.49
River Rail, Little Rock, AR	Streetcar	3.4	30	282	9.56	8,990	304.44
M-Line Trolley, Dallas, TX	Streetcar	2.8	155	89	0.58	679	4.39

System	Mode	Miles	Ridership/mile (1,000s)	Operating Cost/mile ($, 1,000s)	Operating Cost/rider ($)	Capital Cost/mile ($, 1,000s)	Capital Cost/rider ($)
Streetcar Circulator, Kenosha, WI	Streetcar	1.9	36	173	4.85	3,160	88.82
iShuttle, Irvine, CA	Bus	19.7	8	147	17.50	128	15.21
Emery Go-Round, Emeryville, CA	Bus	7.6	211	434	2.06	N/A	N/A
Tri-Rail Shuttle Buses, South Florida	Bus	167	6	29	5.13	35	6.29
Downtown & Waterfront Shuttles, Santa Barbara, CA	Bus	3.0	141	583	4.13	975	6.90
Wave Trolley, Monterey, CA	Bus	2.0	50	N/A	N/A	1,050	21.16

Appendix C

Travel Market Assessment

Transportation Authority of Marin

FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Travel Market Assessment – Final Draft

April 2015

NELSON NYGAARD
In Association with
Fehr & Peers | Parisi Transportation Consulting | URS

Table of Contents

Table of Figures

1 INTRODUCTION

This report evaluates the potential transit travel market of the corridor based on the existing built environment, socio-economic factors, travel demand, and existing riders. Section 2 presents a transit likelihood index which evaluates whether existing built environment and socio-economics of the area provide a supportive base for transit use. Section 3 looks at existing and forecast travel demand across the corridor and region in order to understand the potential market for transit trips between various origins and destinations. Section 4 evaluates Marin Transit Route 23 riders as a basis for understanding the characteristics of current transit users in the study corridor.

This is a preliminary assessment of the travel market based on three data sources, intended to inform the development of alternatives. A more extensive assessment will be prepared as part of the ridership forecasts prepared for the evaluation process. Each data source presents information on a part of the travel market picture. Some data summaries are more extensive than others and thus present a more accurate representation. The limitations of each of the data sources are noted.

Overall there appears to be a high demand for trips with both an origin and a destination within the study corridor, although a small share of these trips are currently made by transit. This suggests the potential to shift some trips to transit through providing the right services. Downtown San Anselmo, Downtown San Rafael and the Canal areas in particular have a strong base of built environment characteristics to support higher levels of transit ridership. Existing riders in the corridor tend to be transit dependent, including primarily low income residents with no access to a car and limited alternatives to transit. However, the potential exists to increase the share of riders who are not transit dependent, often referred to as “choice” riders, who have access to a car for their travel needs. Many are currently making short trips within the study corridor by car, which could be served by transit. Markets with potential for this shift include trips between Downtown San Rafael and the Canal, between Downtown San Rafael and Downtown San Anselmo and between Downtown San Anselmo and Downtown Fairfax. Furthermore, with the opening of Sonoma-Marin Area Rail Transit (SMART), with planned service between the Larkspur Ferry Terminal and Cloverdale, with a stop in Downtown San Rafael, demand for transit service to and from the Downtown San Rafael Station is expected to increase.

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2 BUILT ENVIRONMENT AND SOCIO-ECONOMICS

The built environment and socio-economic factors of the existing population can be used as a base for determining locations at which transit is most likely to be effective. Research has examined how various principle dimensions, often referred to as "D" variables, effect trip rates and mode choice. Higher levels of D variables such as density, diversity of land uses, pedestrian-oriented designs and certain socio-economic factors have been shown to encourage transit use. Several D variables were evaluated and combined into a transit likelihood index, which measures the propensity for transit use in an area based on the built environment and socio-economics. A market assessment of existing Marin Transit riders in 2013 found that zero-car households and low income households in particular have a propensity to ride transit.[1] These two factors are included in the transit likelihood index, in addition to other variables as summarized in Figure 2-1. Figure 2-2 visualizes the index across the study corridor.

Figure 2-1 Transit Likelihood Index Input Variables

D Category	Variable	Variable Description	Source
Density	Population Density	Population density in persons/acre	2010 Census[1]
Density	Employment Density	Employment density in jobs/acre	2010 LEHD[2]
Diversity	Diversity of Land Use	Deviation of Census Block Group ratio of jobs/ population from regional average of jobs/population	SLD[3]
Design	Intersection Density	Street intersection density in intersections/acre	Fehr & Peers
Demographics	Low Vehicle Availability	Density of households owning zero cars in households/acre	SLD[3]
Demographics	Low Income	Number of residents earning $1,250/month or less in persons/acre	2010 LEHD[2]
Distance to Transit	Distance to Transit	Distance to closest bus or rail stop in feet	Fehr & Peers

1 United States Census, http://www.census.gov/2010census/

2 Longitudinal Employer-Household Dynamics, http://lehd.ces.census.gov/data/

3 Smart Location Database, http://www.epa.gov/smartgrowth/smartlocationdatabase.htm

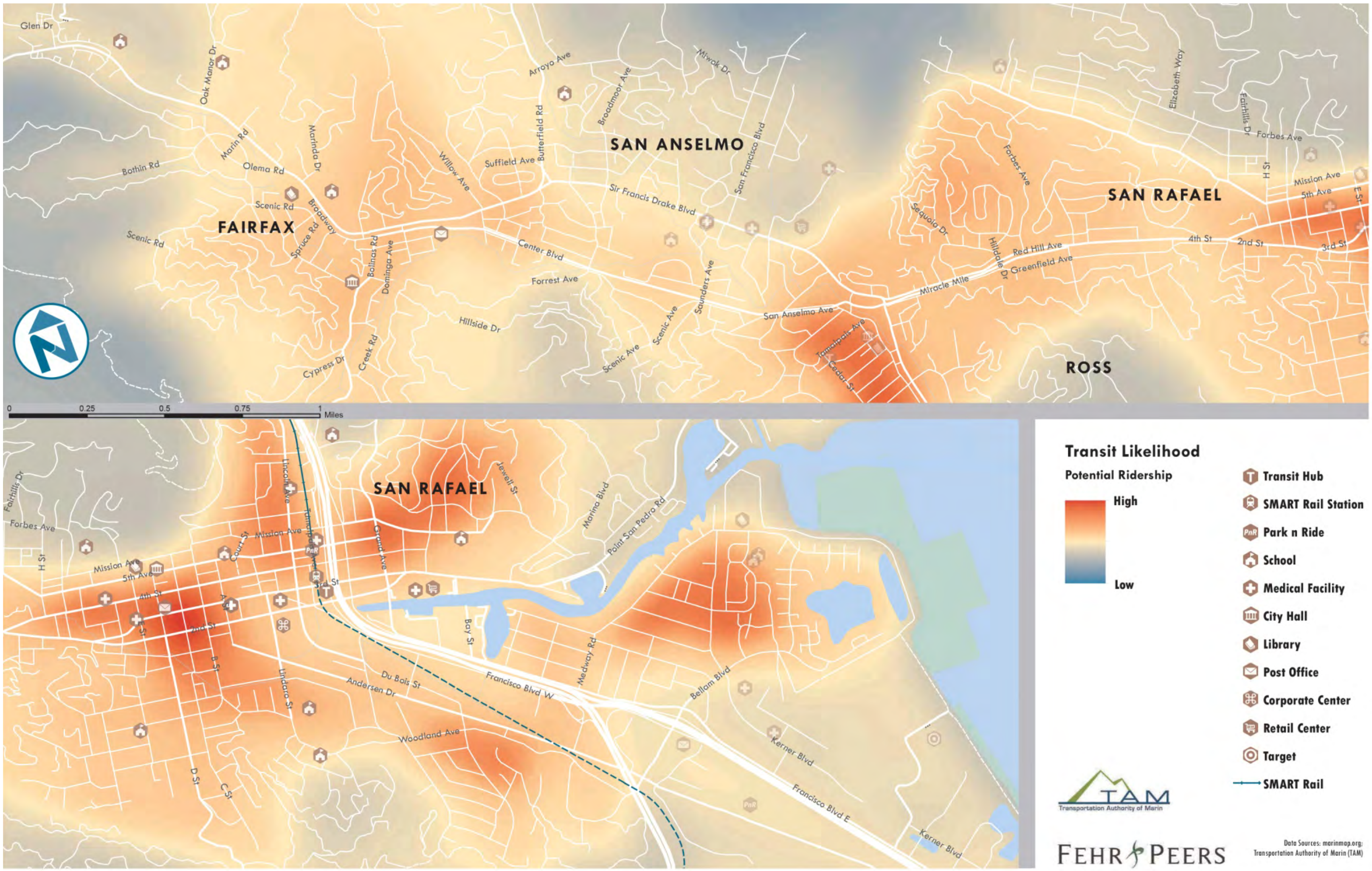
[1] Nelson\Nygaard, "Countywide Transit Market Assessment: Final Market Assessment" Memorandum presented to Marin Transit in June, 2013

This initial analysis is meant to show where the existing built environment and socio-economics are likely to be supportive of transit use, regardless of type or mode of transit investment or level of service. Those factors will have an influence on potential ridership and will be evaluated once alternatives have been developed.

As Figure 2-2 shows, transit propensity based on built environment and socio-economic factors is highest in Downtown San Anselmo, Downtown San Rafael and the Canal area. Propensity in the downtown areas is primarily driven by high concentrations of households and employment while propensity in the Canal is due to the higher density of low income residents and zero vehicle households in the area, although the employment density and pedestrian scale design are lower in this area. Transit likelihood is slightly lower in Fairfax and the propensity in downtown Fairfax is not as concentrated as in other downtown areas.

Data sources used to develop the transit likelihood index include the following: United States Census, Longitudinal Employer-Household Dynamics (LEHD), and the Smart Location Database (SLD). The 2010 Census is a comprehensive survey of the US population and provides information at the Census block level. The LEHD program is part of the Center for Economic Studies at the US Census Bureau and provides statistics on employment for different demographic groups. The data are also provided at the Census block level and are organized both based on place of work and place of residence. The SLD is a nationwide geographic data resource for measuring location efficiency developed by the US Environmental Protection Agency. It includes more than 90 attributes summarizing characteristics such as housing density, diversity of land use, and demographics. The SLD uses both the 2010 Census and LEHD, in addition to other data sources. The variables in the SLD are provided at the Census block group level, a more aggregate level than the block level, which is why for several of the transit likelihood index input variables we used 2010 Census and LEHD data directly rather than using the SLD.

Figure 2-2 Transit Likelihood Index



3 TRAVEL FLOWS

This chapter describes the overall travel patterns and transit travel patterns in the corridor. Understanding the demand for travel between various origin-destination (OD) pairs within both the corridor and the region can help us to understand the potential demand for transit. Daily travel to and from the following five locations along the corridor were evaluated using the Metropolitan Transportation Commission Regional Travel Demand Model (MTC Model): 1) Fairfax, 2) San Anselmo, 3) Miracle Mile, 4) San Rafael, and 5) Canal. The MTC Model is described in more detail below. The analysis also looks at travel from these locations to other parts of the region including to the north, to other areas along the SMART corridor (including Novato, Wood Acre, Petaluma, Cotati, Rohnert Park, Santa Rosa, Winsor, Healdsburg, and Cloverdale), to the East Bay, to other areas in South Marin County, and to San Francisco and San Mateo County.

Figures 3-1 through 3-3 show the current daily travel flows along the corridor. For trips originating in each segment of the corridor, the percent breakdown in trip destinations across the corridor and region are shown.

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Figure 3-1 Fairfax and San Anselmo Travel Demand – Existing Conditions

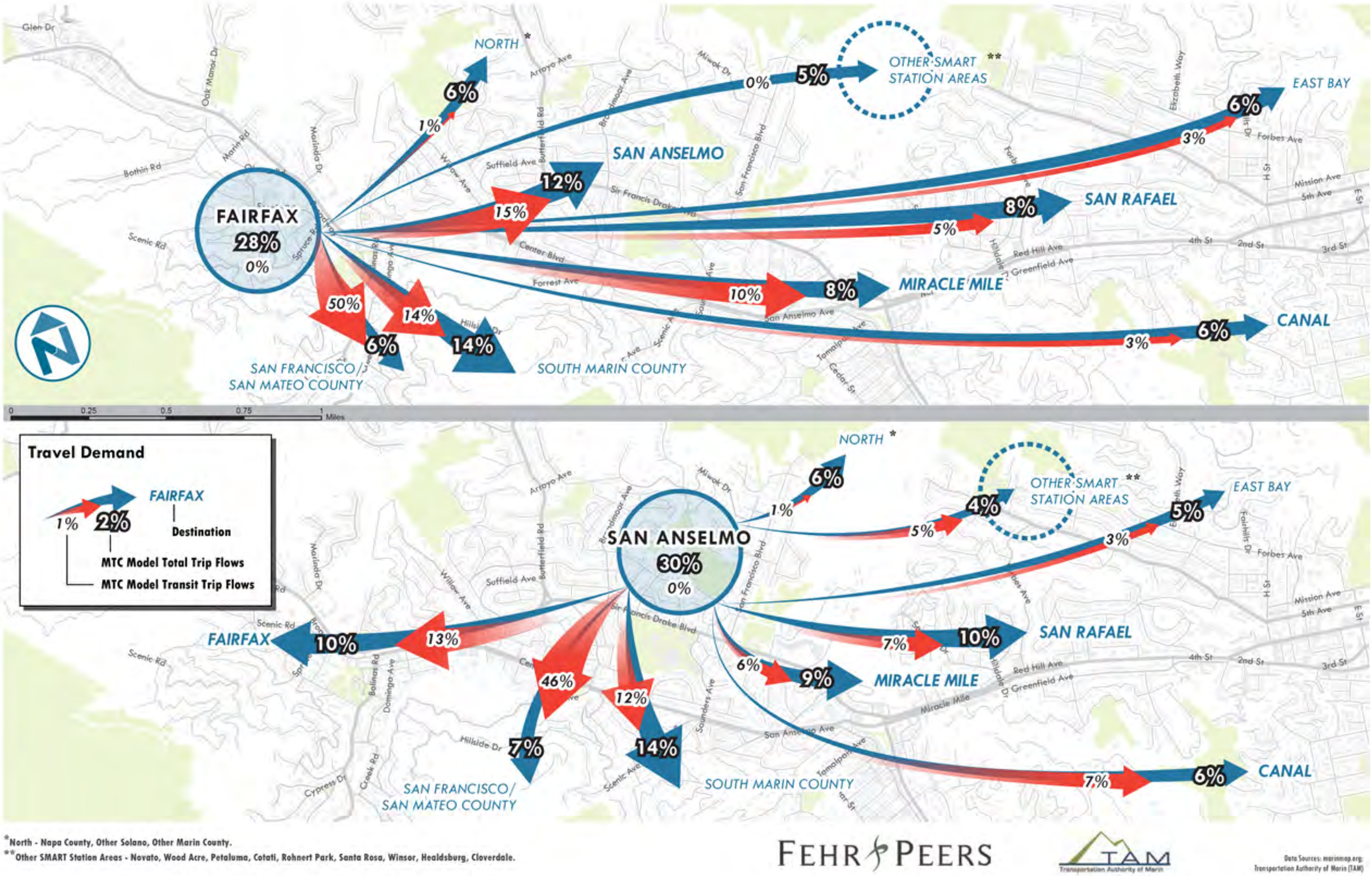


Figure 3-2 Miracle Mile and San Rafael Travel Demand – Existing Conditions

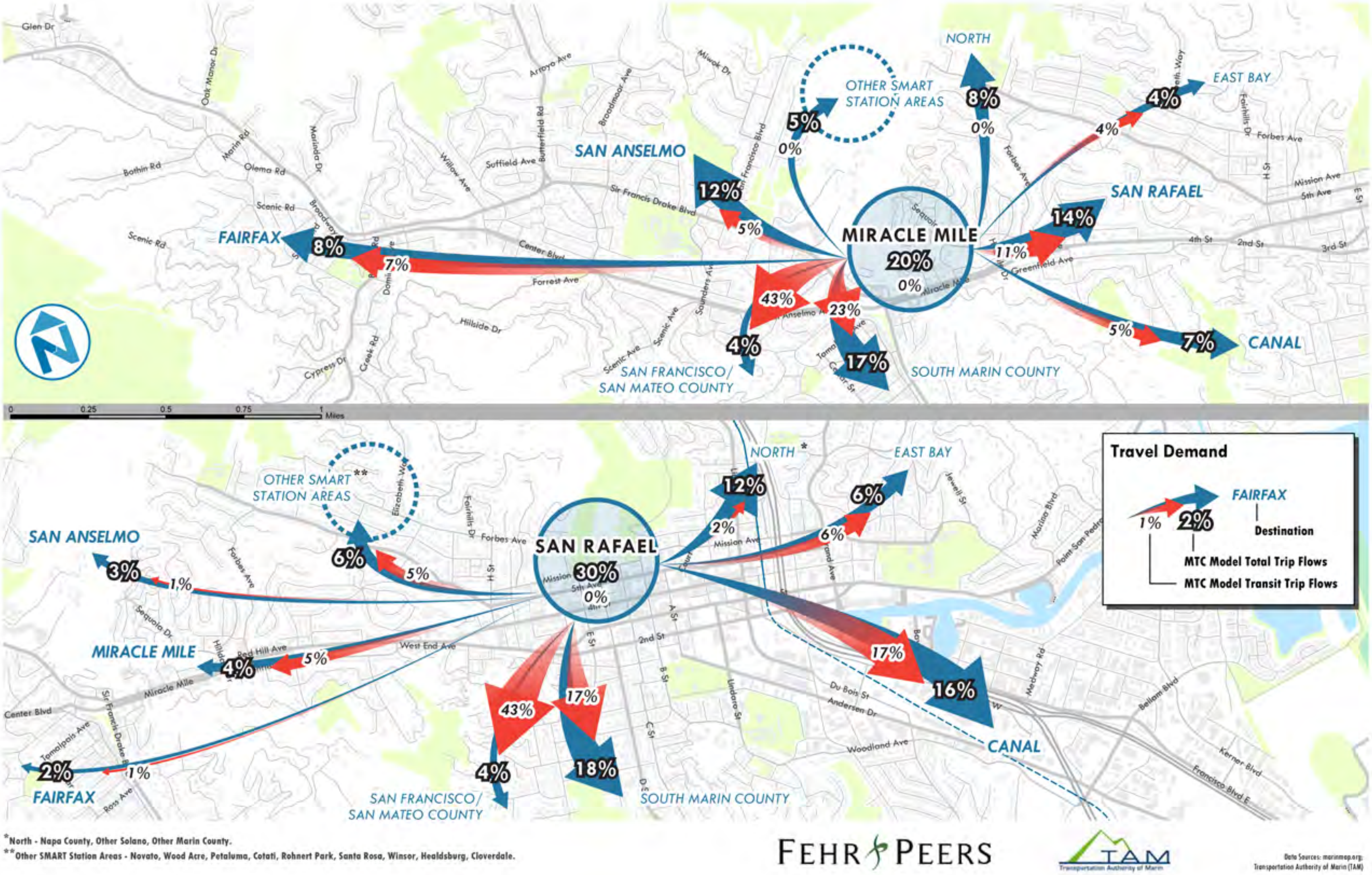
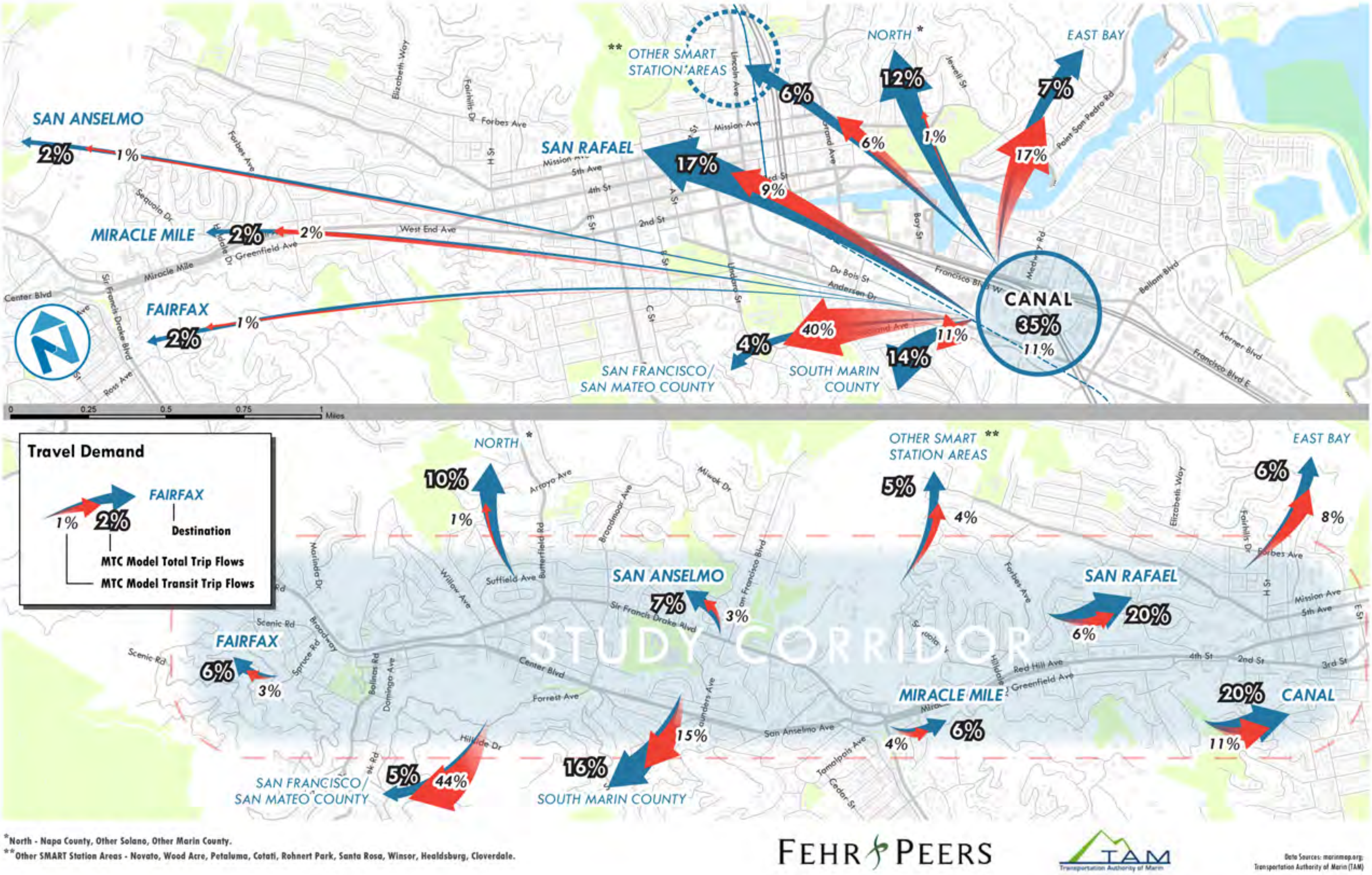


Figure 3-3 Canal and Study Corridor Travel Demand – Existing Conditions



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MTC MODEL

The MTC Model is an activity-based travel demand model, developed for the nine-county San Francisco Bay Area by the Metropolitan Transportation Commission (MTC) in 2005. The model estimates trips throughout the region by various modes of travel, including transit. The model is sensitive to multiple factors including population and employment, auto ownership rates, demographics (age, income level, household size, etc.), and transit network connections.

After building the model structure and implementing the initial specification, MTC calibrated the model to match observed data for the Bay Area.[2] The total number of daily boardings by transit mode were calibrated through a process to match existing data and provide aggregate numbers within a reasonable range. Overall, all boardings were within five percent of the observed amount and all modes were within eight percent of the observations. However, in some cases modeled boardings per system operator differ from observed boardings by a larger percent. Figure 3-4 shows the observed versus modeled systemwide daily boardings for Marin Transit and Golden Gate transit for the base MTC Model, year 2000, and for 2005, as reported in the Travel Market Development: Calibration and Validation report prepared by MTC.[2] The model underestimated Marin Transit boardings by 38 percent and Golden Gate Transit by four percent for 2000. The model underestimated Marin Transit boardings by 59 percent and Golden Gate Transit boardings by 26 percent for 2005.

Figure 3-4 MTC Model Observed Versus Modeled Daily Systemwide Transit Boardings

System Operator	Year	Observed Boardings	Modeled Boardings	Difference	% Difference
Marin Transit	2000	7,179	4,481	-2,698	-38%
Golden Gate Transit	2000	26,204	25,251	-953	-4%
Marin Transit	2005	12,197	5,056	-7,141	-59%
Golden Gate Transit	2005	17,930	13,299	-4,631	-26%

Source: MTC, 2012

The MTC Model is most appropriate for performing regional level analysis. It is validated to regional facilities but not to individual local bus lines. The model does a better job of estimating ridership on Golden Gate Transit given the regional nature of its routes. It does not do as well at estimating Marin Transit ridership. Therefore, we use available data from Marin Transit studies to describe the local travel market for transit. Use of the MTC Model to estimate ridership in the study corridor would require an extensive sub-area validation process.

The MTC Model estimates travel between Traffic Analysis Zones (TAZs). The nine-county Bay Area is represented by 1454 TAZs. The large size of TAZs limited the level of analysis that could be conducted. The study corridor was divided into the following five areas: 1) Fairfax, 2) San Anselmo, 3) Miracle Mile, 4) San Rafael, and 5) Canal, and travel originating in each of these areas was evaluated. It should be noted that some of this travel may be located outside the immediate project corridor and would therefore have lower transit accessibility.

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[2] Travel Model Development: Calibration and Validation, Technical Report, Metropolitan Transportation Commission with Parsons Brinckerhoff, Inc., May 17, 2012

We used outputs from a 2010 version of the MTC Model to represent existing conditions and the 2040 Regional Transportation Plan version of the model to represent future year conditions with SMART. Since the MTC Model under-estimated Marin Transit boardings for the year 2000 by 38 percent and for 2005 by 59 percent (as reported in the Travel Model Development: Calibration and Validation report), we compared 2010 transit boardings estimates along the study corridor from the model to observed Marin Transit boardings along the study corridor and created adjustment factors to account for the systematic under-estimation of Marin Transit boardings. These adjustment factors were applied to both the 2010 and the 2040 MTC Model outputs. The following analysis includes these factored results.

OVERALL TRAVEL

According to the MTC Model, among all daily trips currently originating in each of the five segments of the study corridor (Fairfax, San Anselmo, Miracle Mile, San Rafael, and Canal) the majority of trips also have a destination within the study corridor, as summarized in Figure 3-5. Figures 3-1 through 3-3 provide more details on the breakdown of trip destinations. A few key highlights are described below:

- For trips originating in Fairfax, a large portion (28 percent) also have a destination within Fairfax, and 12 percent have a destination in San Anselmo
- For trips originating in San Anselmo, 30 percent also have a destination within San Anselmo, 10 percent have a destination in Fairfax and 10 percent have a destination in San Rafael
- For trips originating in Miracle Mile, 20 percent also have a destination within Miracle Mile and 14 percent have a destination in San Rafael
- For trips originating in San Rafael, 30 percent also have a destination within San Rafael and 16 percent have a destination in the Canal
- For trips originating in the Canal, 35 percent also have a destination within the Canal and 17 percent have a destination in San Rafael

Figure 3-5 Percent of Overall Travel Originating in each Segment with a Destination within the Study Corridor – Existing Conditions

	Fairfax	San Anselmo	Miracle Mile	San Rafael	Canal
Destination within the Study Corridor	62%	63%	61%	55%	58%
Total Daily Trips*	20,000	25,000	21,000	83,000	77,000

* Values included for order of magnitude comparison purposes. Validation of volumes has not been conducted.

Source: MTC Model, Fehr & Peers

The same analysis was performed using 2040 outputs from the MTC Model. While the total volume of daily trips originating along the corridor increase by approximately seven percent between present day and 2040, the percent breakdown of trip destinations does not change by more than one percent for any of the OD pairs shown in Figures 3-1 through 3-3.

TRANSIT TRAVEL

Among all daily transit trips originating in the study corridor, the MTC model shows that the majority are destined for San Francisco, while more than a quarter have a destination within the study corridor, as summarized in Figure 3-6. These results are based on the adjusted MTC Model outputs and includes all transit trips including riders using Golden Gate Transit and Marin Transit. Golden Gate Transit is a more regional provider which primarily serves longer distance trips from Marin County to San Francisco, while Marin Transit provides local service within the county. Figures 3-1 through 3-3 provide more details on the breakdown of transit trip destinations. A few key highlights are described below:

- For transit trips originating in Fairfax, 15 percent have a destination in San Anselmo
- For transit trips originating in San Anselmo, 13 percent have a destination in Fairfax
- For transit trips originating in Miracle Mile, 11 percent have a destination in San Rafael
- For transit trips originating in San Rafael, 17 percent have a destination in the Canal
- For transit trips originating in the Canal, 11 percent also have a destination within the Canal and 9 percent have a destination in San Rafael

Figure 3-6 Percent of Overall Transit Travel Originating in each Segment with a Destination within the Study Corridor or San Francisco – Existing Conditions

	Fairfax	San Anselmo	Miracle Mile	San Rafael	Canal
Destination within the Study Corridor	33%	33%	28%	26%	24%
Destination in San Francisco	50%	46%	43%	43%	40%
Total Daily Transit Trips*	516	549	407	1,413	1,092

* Total transit trip values obtained from present day MTC Model outputs with preliminary adjustments applied, however does not include route specific validation.

Source: MTC Model, Fehr & Peers

The same analysis was performed using adjusted 2040 outputs from the MTC Model. The total volume of daily transit trips originating along the corridor is forecast to increase by approximately 52 percent between present day and 2040. However, nearly all of the increase forecast by the MTC Model is for travel from the study corridor to either San Francisco or areas along the SMART corridor. Transit travel from the study corridor to other areas along the study corridor is only projected to increase by ten percent. This analysis does not consider Marin Transit level of service improvements, which will be evaluated further in the ridership forecasting task.

MARIN TRANSIT TRAVEL

Looking at Marin Transit ridership data from a recent on-board survey, we can see more specifically the existing transit ridership along the study corridor. As seen in Figure 3-7, nearly half of Marin Transit trips originating in study corridor also have a destination within the study corridor.[3] Furthermore, for all segments of the study corridor, downtown San Rafael is the top destination.

Figure 3-7 Study Corridor Origins and Destinations, 2013

DESTINATION	ORIGIN					
	Manor	Fairfax	San Anselmo	Downtown San Rafael	Canal	San Rafael East
Manor	0.0%	4.8%	14.5%	1.3%	0.0%	0.0%
Fairfax	1.5%	3.2%	8.6%	3.6%	2.6%	2.6%
San Anselmo	10.8%	4.8%	2.6%	3.6%	2.6%	2.6%
Downtown San Rafael	33.8%	33.3%	24.3%	12.5%	26.9%	15.4%
Canal	1.5%	4.8%	5.3%	12.5%	14.6%	10.3%
San Rafael East	0.0%	0.0%	0.7%	1.3%	1.9%	7.7%
Other Destinations						
Kentfield	7.7%	3.2%	2.6%	3.8%	4.9%	2.6%
Northgate	7.7%	7.9%	2.6%	10.0%	8.8%	17.9%
Mill Valley Tam Junction	6.2%	1.6%	3.9%	6.4%	4.2%	0.0%
Larkspur	4.6%	6.3%	3.9%	3.6%	4.2%	2.6%
North West Marin	4.6%	6.3%	15.1%	2.8%	0.3%	2.6%
Santa Venetia	1.5%	3.2%	0.7%	4.1%	3.9%	10.3%
Downtown Novato	0.0%	4.8%	1.3%	5.7%	2.3%	0.0%
East Corte Madera	0.0%	1.6%	2.0%	0.3%	1.6%	5.1%

Source: Marin Transit, 2013.

TRANSIT MARKET SHARE

When considering all trips originating in the five areas studied, the share of those trips which are made by transit is only two percent, according to the adjusted MTC Model outputs. Figure 3-8 summarizes the transit market share for each origin-destination (OD) pair within the corridor, and Figure 3-9 summarizes the relative volumes of daily trips between each OD pair.

[3] Information also summarized in Figure 4-9 in the Existing Conditions Briefing Book

Figure 3-8 Transit Market Share of Daily Trips per OD Pair – Existing Conditions

DESTINATION	ORIGIN				
	Fairfax	San Anselmo	Miracle Mile	San Rafael	Canal
Fairfax	0%	3%	3%	2%	1%
San Anselmo	3%	0%	1%	2%	3%
Miracle Mile	2%	1%	0%	1%	1%
San Rafael	1%	1%	3%	0%	2%
Canal	1%	1%	1%	1%	0%

Source: MTC Model, Fehr & Peers

Figure 3-9 Relative Volume of Total Daily Trips between each OD Pair – Existing Conditions

DESTINATION	ORIGIN				
	Fairfax	San Anselmo	Miracle Mile	San Rafael	Canal
Fairfax	5,700	2,400	1,600	1,700	1,100
San Anselmo	2,400	7,500	2,300	2,400	1,400
Miracle Mile	1,700	2,400	4,100	3,000	1,500
San Rafael	1,800	2,400	3,000	24,700	13,200
Canal	1,200	1,500	1,500	13,200	27,000

Note: Values included for order of magnitude comparison purposes. Validation of volumes has not been conducted.

Source: MTC Model, Fehr & Peers

This analysis suggests the potential to increase the transit mode share across the study corridor. While the majority of trips originating in the study corridor also have a destination within the study corridor, only two percent of these trips are made by transit. The potential exists to shift some trips from auto to transit. The potential increase in market share will depend on transit service enhancements and transit competitiveness with auto. Cost and travel time are key factors influencing travel decisions. The level of improvements in these areas will impact the relative shift in travel mode from auto to transit. These factors will be further defined through the development of alternative corridor alignments and the potential impact on market share will be assessed during the development of ridership forecasts.

The travel flows analyzed include all trip purposes. Different trip purposes tend to have different transit market penetration rates. For example, home-based work trips tend to have higher transit mode shares since these trips typically occur during peak hours when transit is most competitive with auto due to higher traffic congestion levels making auto less attractive and higher transit service frequencies making transit more attractive. Ridership potential by trip purpose will also be evaluated during the ridership forecasting task.

TRAVEL TO FUTURE SMART STATION CATCHMENT AREAS

While Figures 3-1 through 3-3 show existing travel demand, travel flows were also pulled from the MTC Model representing 2040 RTP conditions, once SMART is in place and operational. While these results can be used to create a general understanding of the potential impacts of SMART, it is important to keep in mind that the MTC Model was built to evaluate regional travel flows and is not fully calibrated to provide detailed analysis of corridor-specific transit flows. Additionally, SMART planning has gone through several iterations and the version of SMART coded in the 2040 RTP scenario may not be the latest preferred alternative of SMART.

According to the model, in 2040 the share of total trips originating in the study corridor with a destination in a SMART station area outside the study corridor (including Novato, Petaluma, Cotati, Rohnert Park, Santa Rosa, Winsor, Healdsburg, or Cloverdale) would remain about the same as today at about 5 percent of trips. However, among transit trips, the share would increase from one percent today to four percent in 2040. The transit market share for trips from each segment of the study corridor to other SMART station areas (i.e., those outside the study area), under both current and 2040 conditions, are shown in Figure 3-10. The key increases are from Fairfax and Miracle Mile, from which transit market share to other SMART station areas would increase from less than one percent to four percent, and from San Rafael, from which transit market share would increase from two percent to five percent. This increase in transit market share suggests some mode shift, primarily from auto to transit, due to the introduction of SMART, which would enable people to either take transit or walk to the Downtown San Rafael SMART Station and then take SMART to another destination along the SMART corridor. This demonstrates a potential increase in transit demand along the study corridor to the Downtown San Rafael Station once SMART opens.

Figure 3-10 Transit Market Share of Daily Trips per OD Pair

DESTINATION	ORIGIN				
	Fairfax	San Anselmo	Miracle Mile	San Rafael	Canal
Other SMART Station Areas, Current	>1%	2%	>1%	2%	2%
Other SMART Station Areas, 2040	4%	4%	4%	5%	3%

Source: MTC Model, Fehr & Peers

4 LOCAL BUS TRAVELER CHARACTERISTICS

Since Marin Transit Route 23 serves the entire study corridor, characteristics of its riders are reviewed here to provide an idea of existing riders along the study corridor. This data is sourced from the Marin Transit 2012 Systemwide Onboard Survey. A summary of Route 23 service is provided in Figure 4-1.

Figure 4-1 Summary of Route 23 Service (FY 2013-2014)

Route	Destinations	Corridor Segments	Frequency (minutes)	Span	Productivity (Passengers per Revenue Hour)	Notes
23	Manor – Shoreline Parkway via Canal area	Entire study corridor (with exceptions – see Notes)	60	Mon – Fri: 5:50 AM – 10:45 PM Sat – Sun: 7 AM – 9:55 PM	Mon – Fri: 27 Sat: 24 Sun: 21 Average: 26.1	Weekends/ holidays operates downtown Fairfax to Shoreline Pkwy. only

In order to provide a comparison to a service with potentially more choice riders, characteristics of riders of Golden Gate Transit (GGT) are also reviewed, sourced from the Golden Gate Transit 2013 Passenger Study Final Survey Findings Report. The report divides GGT riders into two categories: 1) Basic, and 2) Commuter. Basic routes offer service throughout the day and evening on both weekdays and weekends while commute routes provide service only on weekday mornings and evenings.

EXISTING RIDERSHIP

Figure 4-2 shows existing ridership along Route 23, as provided in Figure 4-6 of the Existing Conditions Briefing Book. The data were repurposed from the 2013 Marin Transit Countywide Transit Market Assessment and include Route 68 data from 2010, as well as Routes 22, 23, 29, 35, and 36 data from 2011. “Tripper” service data were not included. The route is busy along its entire length, with the highest number of boardings in downtown Fairfax and at the San Anselmo hub. In the eastbound direction, the peak load occurs on Fourth Street as the bus approaches the Transit Center. Westbound, the largest number of passengers board at the San Rafael Transit Center, with the peak load at the beginning of the trip on Fourth Street. Riders alight all along Sir Francis Drake Boulevard, with the largest number departing at Broadway and Bolinas Avenue in Fairfax.

Figure 4-2 Total Weekday Marin Transit Ridership in Each Corridor Segment (Both Directions)

Route #	Manor-San Anselmo Hub		San Anselmo Hub		Miracle Mile and Downtown San Rafael		San Rafael Transit Center		Core Fairfax-San Rafael Corridor Total			Canal Area	
	On	Off	On	Off	On	Off	On	Off	On	Off	Total	On	Off
23	157	159	74	48	77	114	155	129	463	450	913	N/A	N/A

DEMOGRAPHICS

Figure 4-3 provides a summary of the age range of Marin Transit Route 23 riders, GGT basic riders and GGT commuter riders. Marin Transit and GGT used different age categories in their surveys, so the categories do not line up directly. Route 23 has a higher proportion of senior riders than GGT basic or commuter riders. Over a quarter of Route 23 riders are over the age of 55. Twenty-nine percent of Route 23 riders are under 25 (not including “Tripper” service), and 45 percent are between the ages of 25 and 55. The age distribution of GGT basic riders is similar to that of Route 23 riders. However, GGT commuter service tends to have a much lower share of youth and senior riders; three-quarters of riders are between the ages of 30 and 60.

Figure 4-3 Summary of Rider Ages

Marin Transit Age Category	Percent of Marin Transit Route 23 Riders	GGT Age Category	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Under 18	8%	Under 20	6%	1%
18-24	21%	20-29	27%	8%
25-34	13%	30-39	16%	18%
35-44	17%	40-49	13%	27%
45-54	15%	50-59	20%	30%
55+	27%	60+	17%	17%

Figure 4-4 provides a summary of the income levels of Marin Transit Route 23 riders, GGT basic riders and GGT commuter riders. Route 23 riders have much lower income levels than GGT riders. Three-quarters of Route 23 riders have annual household incomes under $50,000 compared to 56 percent of GGT basic riders and 10 percent of GGT commuter riders. Just over half of Route 23 riders have household income levels under $25,000. These statistics highlight the different markets currently served by the various services. GGT commuter service, which provides higher frequency service during peak hours only, serves a much higher income demographic. The majority of riders have annual household income levels over $100,000 and likely represent choice riders who have alternative options but choose to take transit. Certain factors contribute to the ability to attract choice riders which are specific to GGT’s service territory, including the high density of well-paid jobs in San Francisco, and the geography of the area limiting the number of roadways accessing San Francisco.

Figure 4-4 Summary of Household Income Levels of Riders

Annual Household Income	Percent of Marin Transit Route 23 Riders	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Under $50k	75%	56%	10%
$50k - $75k	8%	16%	12%
$75k - $99k	10%	9%	16%
$100k - $149k	6%	10%	34%
$150k +	2%	9%	29%

ACCESS MODES

Figure 4-5 shows the modes by which riders access Route 23, GGT basic service and GGT commuter service. The majority of Route 23 and GGT basic riders walk to their bus stop. Less than 10 percent of Route 23 riders use a car to access the bus stop, while nearly half of GGT commuter riders access transit either by driving, carpooling or being dropped off. Nearly 20 percent of Route 23 riders transfer from another bus. The GGT survey asked about bus to bus transfers in a separate question, which asked "How many transfers are needed to complete your trip?" Half of GGT basic riders make at least one transfer while only 14 percent of GGT commuter riders make a transfer. Some riders are likely traveling between the two systems to get between their ultimate origin and destination points.

Figure 4-5 Summary of Rider Access Modes

Mode of Access	Percent of Marin Transit Route 23 Riders	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Walked all the way	67%	77%	49%
Drive alone / carpool	5%	10%	43%
Dropped off	3%	7%	5%
Transfer to/from another bus	19%	NA*	NA*
Bike	6%	7%	3%

*Note: GGT survey asks "How do you get from your home to your first boarding point?" so question does not consider transfers from other buses

TRIP PURPOSE

As shown in Figure 4-6, 40 percent of Route 23 trips are work trips compared to 64 percent for GGT basic riders and 95 percent of GGT commuter riders. GGT commuter service is targeted at the commuter market and nearly all of its trips serve this market. Route 23 has a higher percentage of work related trips than GGT service, suggesting that many may be using the route during the day to travel within or between downtown centers for work related meetings or lunches. The share of school trips and social trips is higher for Route 23 than for GGT basic or commuter service, suggesting that Route 23 is used for a more diverse array of trip purposes than GGT, which tends to be more commute-focused.

Figure 4-6 Summary of Rider Trip Purposes

Trip Purpose	Percent of Marin Transit Route 23 Riders	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Work	40%	64%	95%
Work related event/meeting	13%	5%	1%
School	12%	8%	1%
Medical/dental	6%	4%	0%
Social, recreational, entertainment	16%	12%	1%
Shopping	6%	4%	0%
Other	7%	3%	2%

TRANSIT DEPENDENCY

As Figure 4-7 shows, nearly half of Route 23 riders stated that Marin Transit is their only travel option, and as shown in Figure 4-8, 37 percent of riders stated that they do not have a car available. This suggests that Route 23 riders are strongly transit dependent and that not having access to a car is a strong driver in transit use. By comparison, GGT riders are much less transit dependent. Among GGT commuter riders, 96 percent have access to a car and just over half would drive or carpool if GGT were not an option.

Figure 4-7 Summary of Rider Alternative Options

Alternative Options	Percent of Marin Transit Route 23 Riders	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Marin Transit / GGT is my only option	47%	32%	10%
Drive / carpool	21%	40%	52%
Ferry	0%	6%	26%
Bike	22%	2%	1%
Walk	6%	2%	1%
Other	4%	18%	10%

Figure 4-8 Summary of Drivable Vehicles Available to Riders

Drivable Vehicles Available to Household	Percent of Marin Transit Route 23 Riders	Percent of GGT Basic Riders	Percent of GGT Commuter Riders
Zero	37%	27%	4%
One	35%	34%	29%
Two	20%	23%	49%
Three or More	7%	16%	18%

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5 OPPORTUNITIES & CONSTRAINTS

A summary of the general findings of the travel market assessment is provided in Figure 5-1. Based on this analysis, the OD pair with the highest potential for increased transit ridership is between Downtown San Rafael and the Canal. The potential for increased ridership between Downtown San Rafael and Downtown San Anselmo is also high. Potential also exists, although at a lower volume, for increased transit ridership between Downtown San Anselmo and Downtown Fairfax. The demand for transit travel from one end of the corridor to the other is expected to be low.

Figure 5-1 Summary of Key Findings, Opportunities, and Constraints

Travel Market Aspect	Opportunities	Constraints
Transit Likelihood Index	The following areas have the strongest base of built environment and socio-economic characteristics to support higher levels of transit ridership: ▪ Downtown San Anselmo ▪ Downtown San Rafael ▪ The Canal	Built environment and socio-economic characteristics supportive of transit use are less concentrated in Fairfax, suggesting more limited potential demand for transit except for around specific activity generators, such as schools and medical facilities.
Transit Market Share	Many short trips are being made within the corridor and only a small share of these are made on transit, suggesting an opportunity to shift some trips from auto to transit, particularly between the following OD pairs: ▪ Downtown San Rafael / Canal ▪ Downtown San Rafael / Downtown San Anselmo ▪ Downtown San Anselmo / Downtown Fairfax	The potential to shift trips from auto to transit depends on the competitiveness of transit with autos. This will depend on many factors including congestion levels along the corridor, transit versus auto speeds, transit service levels, quality of transit service amenities and transit priority treatments.
Rider Analysis	Current riders along the corridor are transit dependent. There is potential to increase the number of “choice” riders by providing improved transit services able to be more competitive with auto travel.	Current transit provision along the corridor has not been able to attract “choice” riders. Considering current levels of congestion along the corridor, it may be difficult to implement measures to make transit service more competitive in terms of travel time, which is a the key factor in attracting choice riders.

Travel Market Aspect	Opportunities	Constraints
Travel to Future SMART Station Catchment Areas	Preliminary analysis shows potential for introduction of SMART to shift some trips between the study corridor and areas along the SMART corridor from auto to transit. This would increase transit demand along the corridor to and from the Downtown San Rafael SMART Station, meaning local transit could be used as a feeder system for SMART travel.	Demand for transit may be impacted by the level of park-and-ride and feeder bus service provided at SMART stations at either end of the trip.

APPENDIX D

Initial Alternatives Summary

Transportation Authority of Marin

FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Initial Alternatives Summary – Revised Draft

April 2015

NELSON NYGAARD

Table of Contents

Table of Figures

1 INTRODUCTION

This report – the **Initial Alternatives Summary** – constitutes the third major deliverable prepared for the Fairfax-San Rafael Corridor Transit Feasibility Study. The purpose of this report is to summarize the range of viable alignment options within the study corridor, which were developed in the wake of findings from the Existing Conditions Briefing Book and the Travel Market Analysis, and guided by direction from the Technical Advisory Committee (TAC). With additional feedback gathered from the TAC, this report identifies two draft "build" alternatives to study in more detail in subsequent project phases.

At this stage in the study, this report does not contain cost or ridership projections, nor does it offer specific recommendations. Rather, it explores the high-level feasibility of several preliminary concepts, using simple maps and diagrams to illustrate conceptual operating characteristics. Additional details, including station locations will be developed in subsequent tasks, once the draft alternatives are finalized and potential locations can be vetted in more detail.

Looking ahead, the next steps include examining more detailed examination of the multimodal impacts of the draft alternatives, with refinements as determined by staff and the TAC, along with ridership forecasts. From that point, the consultant team will work with staff and the TAC to develop corridor operating plans for up to two build alternatives (plus a "no-build" alternative). As the final step in the process, we will develop a funding and a delivery plan for up to two alternatives; the ultimate goal of this study is to develop feasible alternatives that can be further analyzed in a public process consistent with funding requirements.

EVALUATION CRITERIA

At its outset, the Fairfax-San Rafael Corridor Transit Feasibility Study was shaped by the goals outlined by the TAC in its original scope of services. They were:

- Identify connections to and from new SMART Rail service
- Identify connections to other regional transit services
- Improve mobility for all modes in the Corridor
- Reduce local congestion in the Corridor
- Achieve mode shift to transit in the Corridor/attract auto-dependent and choice riders
- Improve peak travel times for transit in the Corridor

Subsequently, at the project kick-off in late 2014, the TAC developed and confirmed the following project vision and goals, building on the original set of project goals to provide the foundation of this planning effort, offering the means of evaluating and refining the draft alternatives:

Vision Statement

Improve the quality of life for residents, employees and visitors throughout the corridor through the implementation of a transit investment that will incentivize transit mode shift, maximize mobility for all modes, provide seamless connectivity with SMART and other transit modes and support local communities in their goals for complete streets and sustainability.

Project Goals

1. Maximize transit ridership
2. Connect the Sonoma-Marin Area Rail Transit (SMART) station and San Rafael (Bettini) Transit Center with residential and employment opportunities throughout the corridor
3. Reduce greenhouse gas emissions
4. Reduce transit travel times in the corridor
5. Enhance transit reliability in the corridor
6. Maintain or improve conditions for all other modes and goods movement

2 CORRIDOR ALIGNMENT OPTIONS

As a whole, the Fairfax-San Rafael corridor constitutes a complex transit operating environment, with individual parts of the corridor posing unique challenges and opportunities for the implementation of high-capacity transit service. Figure 2-1 on the following page identifies each of the segments used to develop alignment options. The key segments, from east to west, are:

- Manor (Segment A)
- Downtown Fairfax (Segment B)
- Fairfax-San Anselmo Hub (Segment C)
- Miracle Mile (Segment D)
- Downtown San Rafael (Segment E)
- Montecito Plaza/Canal Area (Segment F)

For each corridor segment, a variety of different alignment options were developed, considering the needs of both bus and streetcar options. These options are examined in more detail below, along with specific opportunities and constraints associated with each option. Generally speaking, the greatest challenges common to both modes within the corridor include:

- Right-of-way constraints, particularly on Sir Francis Drake Boulevard between Fairfax and San Anselmo.
- Potential need for replacement parking.
- Reintroduction of service along historical rail corridor (i.e., Center Boulevard) and impacts on residents.

A major constraint for rail (streetcar) service only is the high cost and feasibility of crossing the SMART tracks. Due to freight restrictions, rail services are assumed to end at the San Rafael (Bettini) Transit Center, and a suitable turnaround option must be identified as part of identifying an alignment in downtown San Rafael (Segment E).

Figure 2-2 presents an overview of the various alignment options for both bus and streetcar services in each major corridor segment. This "kit of parts" represents the range of transit implementation options that we have deemed viable for the corridor at a high level, forming the foundation on which corridor alternatives may be developed. These options are also summarized in tabular form in Figure 2-1.

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Figure 2-1 Fairfax-San Rafael Corridor: Map of Alignment Options by Corridor Segment

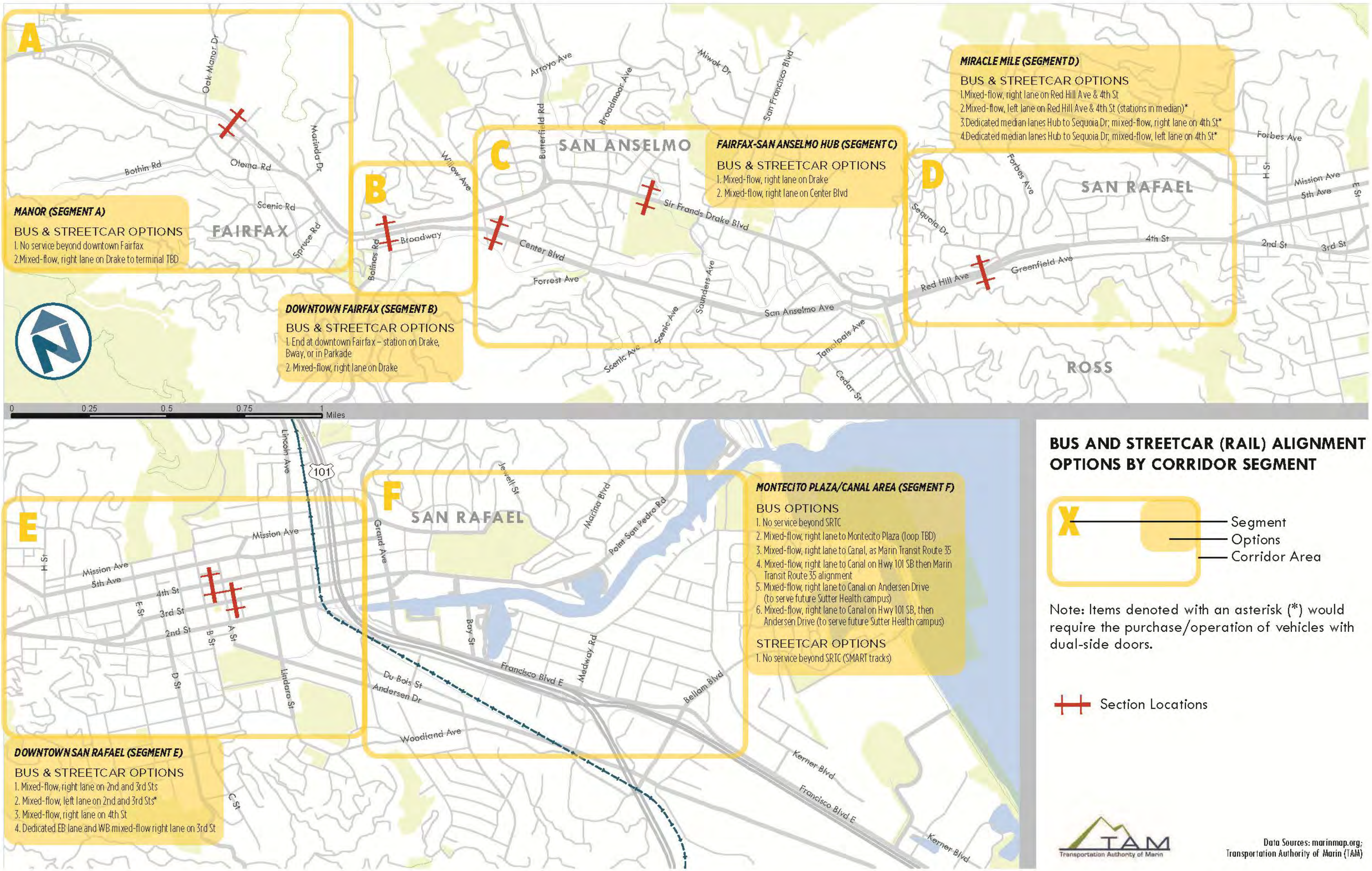

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Figure 2-2 Fairfax-San Rafael Corridor: Viable Alignment Options by Corridor Segment

Corridor Segment	Bus Options	Streetcar (Rail) Options
Manor (Segment A) *Cross-section: Drake at Oak Tree Lane*	1. No service beyond downtown Fairfax. 2. Mixed-flow, right lane on Drake to terminal TBD.	1. No service beyond downtown Fairfax. 2. Mixed-flow, right lane on Drake to terminal TBD.
Downtown Fairfax (Segment B) *Cross-section: Drake and Broadway at the Parkade/Fairfax Theater*	1. End at downtown Fairfax – station on Drake, Bway, or in Parkade. 2. Mixed-flow, right lane on Drake.	1. End at downtown Fairfax – station on Drake, Bway, or in Parkade. 2. Mixed-flow, right lane on Drake.
Fairfax-San Anselmo Hub (Segment C) *Cross-sections: Drake at SFD HS; Center at Pastori Avenue*	1. Mixed-flow, right lane on Drake. 2. Mixed-flow, right lane on Center Blvd.	1. Mixed-flow, right lane on Drake. 2. Mixed-flow, right lane on Center Blvd.
Miracle Mile (Segment D) *Cross-section: 50 feet west of Red Hill Ave/Sequoia Dr intersection*	1. Mixed-flow, right lane on Red Hill Ave and 4th St. 2. Mixed-flow, left lane on Red Hill Ave and 4th St (stations in median). 3. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, right lane on 4th St.* 4. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, left lane on 4th St.*	1. Mixed-flow, right lane on Red Hill Ave and 4th St. 2. Mixed-flow, left lane on Red Hill Ave and 4th St (stations in median). 3. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, right lane on 4th St.* 4. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, left lane on 4th St.*
Downtown San Rafael (Segment E) *Cross-section: 3rd Street 50 feet east of A Street; 4th Street 200 feet west of A Street*	1. Mixed-flow, right lane on 2nd and 3rd Sts. 2. Mixed-flow, left lane on 2nd and 3rd Sts. 3. Mixed-flow, right lane on 4th St. 4. Dedicated EB lane and WB mixed-flow right lane on 3rd St.	1. Mixed-flow, right lane on 2nd and 3rd Sts. 2. Mixed-flow, left lane on 2nd and 3rd Sts. 3. Mixed-flow, right lane on 4th St. 4. Dedicated EB lane and WB mixed-flow right lane on 3rd St.
Montecito Plaza/Canal Area (Segment F) *Cross-section: N/A*	1. No service beyond SRTC. 2. Mixed-flow, right lane to Montecito Plaza (loop TBD). 3. Mixed-flow, right lane to Canal, as Marin Transit Route 35. 4. Mixed-flow, right lane to Canal on Hwy 101 SB then Marin Transit Route 35 alignment. 5. Mixed-flow, right lane to Canal on Andersen Drive. (To serve future Sutter Health campus.) 6. Mixed-flow, right lane to Canal on Hwy 101 SB, then Andersen Drive. (To serve future Sutter Health campus.)	1. No service beyond SRTC (SMART tracks).

CORRIDOR SEGMENT ANALYSIS

This section examines each alignment option by corridor segment. Note: for all corridor segments except the Canal area (i.e., Segments A-E), the bus and streetcar options are essentially the same and are therefore only described once.

The following components are included:

- A discussion of opportunities and constraints pertaining to geometry, market potential, and/or other contextual factors;
- For all segments except the Canal area (Segment F), cross-section illustrations for a significant location within the segment. This is typically a pinch-point, but may also show a unique opportunity within the corridor. *Please note that the type of transit vehicle shown in the cross-section is illustrative and not reflective of a design recommendation.*

Segment A: Manor to Downtown Fairfax

This segment stretches from the intersection of Olema Road and Sir Francis Drake Boulevard in Manor to downtown Fairfax. Surrounding land uses include relatively low density housing and some commercial uses closer to downtown Fairfax.

Alignment Options

Option	Risks	Opportunities
A-1. No service beyond downtown Fairfax.	▪ N/A	▪ N/A
A-2. Mixed-flow, right lane to terminal location TBD.	▪ Lower ridership potential; existing development is not particularly transit supportive ▪ Constrained right-of-way in places	Potential to replace Route 23 service in this area, allowing for reallocation of those hours elsewhere

Segment A: Cross-Sections

Figure 2-4 presents a cross-section of existing conditions at Sir Francis Drake Boulevard and Oak Tree Lane, a particularly narrow location in this segment (see Figure 2-3 for a context map of this location). A cross-section of what Option A-2 would look like for both buses and streetcars at this location follows in Figure 2-5.

Figure 2-3 Segment A Cross-Section Context Map

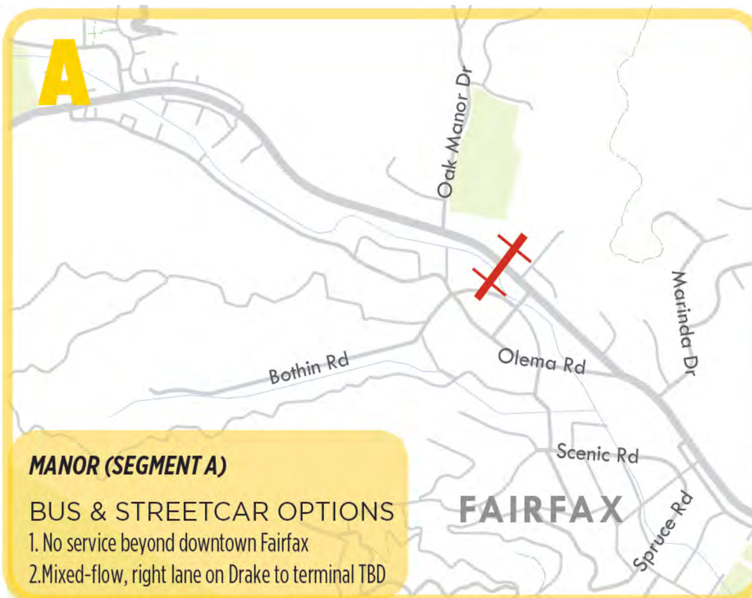


Figure 2-4 Segment A (Manor-Fairfax) Pinch Point: Sir Francis Drake & Oak Tree Lane – Existing Conditions

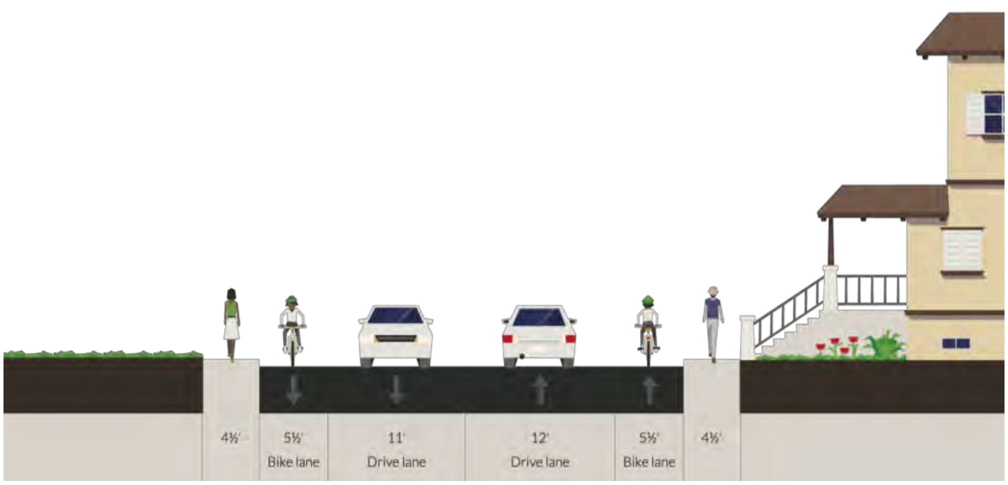
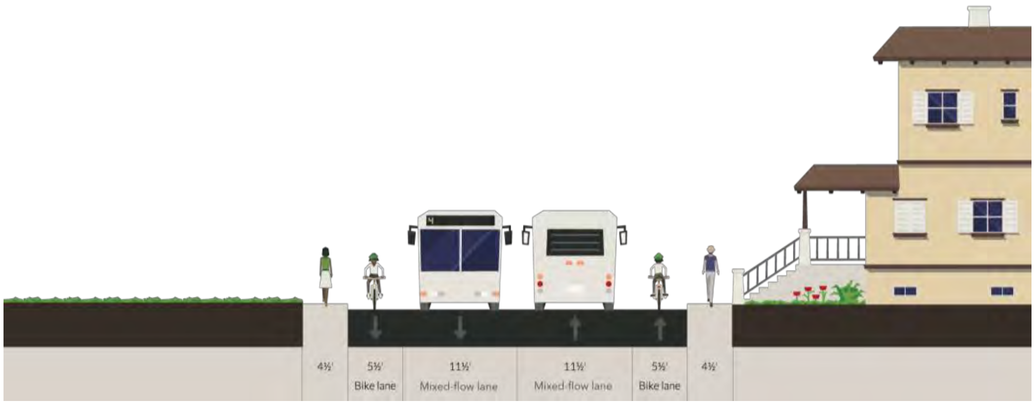
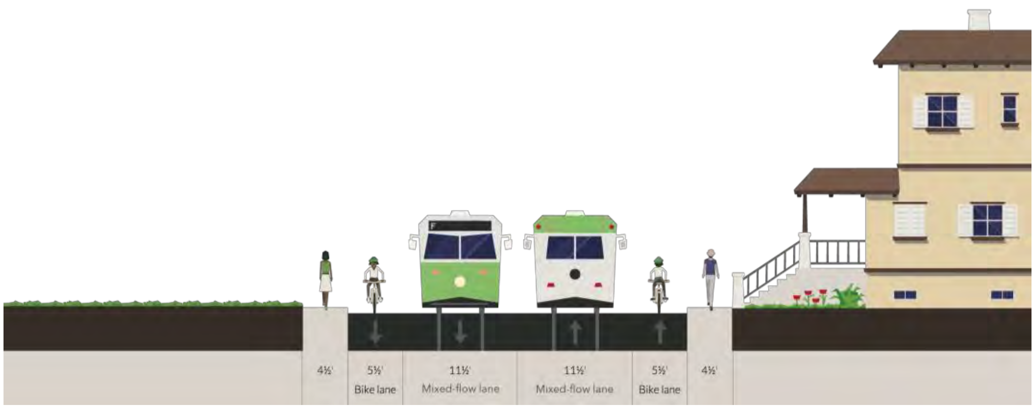


Figure 2-5 Segment A (Manor-Fairfax) Pinch Point: Option A-2 (Bus & Streetcar)





Segment B: Downtown Fairfax

This segment includes downtown Fairfax, a relatively dense, mixed-use, walkable town center. Historically, interurban trains stopped at a station where the parking lot now exists in the Parkade (Figure 2-6).

Figure 2-6 Historic Fairfax Rail Station

Alignment Options

Option	Risks	Opportunities
B-1. End at downtown Fairfax – station on Drake, Broadway, or in the Parkade.	Rail station in current Parkade parking lot would result in parking loss (~20-25 spaces); additional study needed to identify "no net parking loss" strategies. Bus station on Broadway would require mitigation for bike lanes proposed at this location as part of the Parkade study.	Rail option ending in downtown Fairfax could utilize Parkade parking area, improving traffic flow and creating new public space at historic station location.
B-2. Mixed-flow, right lane on Drake.	Lower ridership potential; existing development beyond downtown Fairfax is not particularly transit supportive.	Alignment would remain on Sir Francis Drake, increasing speed and reliability service through the area by bypassing Broadway. Most of existing parking supply would be retained, pending identification of station location.

Segment B: Cross-Sections

Figure 2-8 presents an existing cross-section of downtown Fairfax at the eastern end of the Parkade, adjacent to the Fairfax cinema (see Figure 2-7 for a context map of this location). Figure 2-9 shows bus option B-1, which assumes buses make a clockwise loop around the Parkade with a potential station location on Broadway. Figure 2-10 depicts rail option B-1, with a rail terminal in the Parkade. (Note that the cross-section for this option shows minor modifications to Sir Francis Drake Boulevard lane widths to accommodate additional pedestrian amenities in the Parkade. This is for illustrative purposes only.)

Figure 2-11 and Figure 2-12 depict bus and streetcar option B-2, with service continuing on to Manor. A downtown Fairfax station would be located on Sir Francis Drake Boulevard at a location to be determined, using station bulbs.

Note: all future alignment options are assumed to be constructed in a manner consistent with the recommendations of the Parkade Area Circulation Study (2010).

Figure 2-7 Segment B Cross-Section Context Map

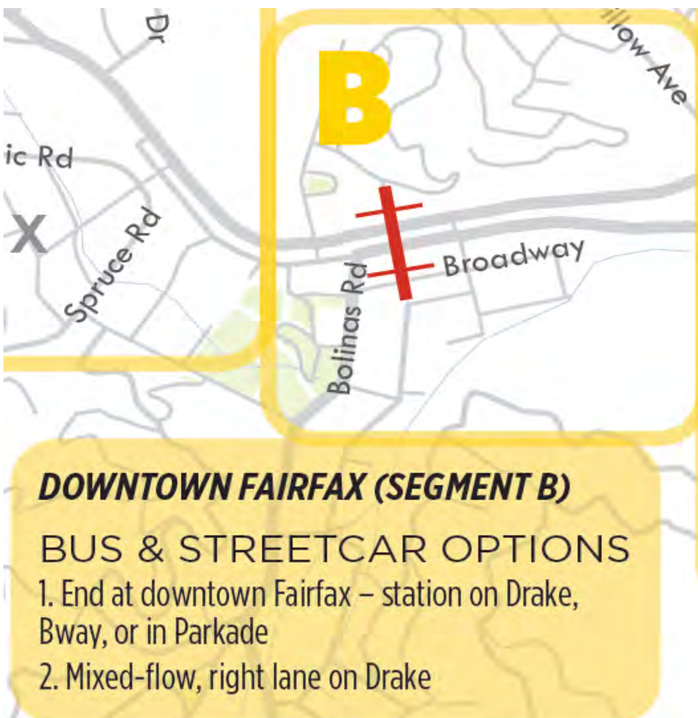


Figure 2-8 Segment B (Downtown Fairfax) Pinch Point: Broadway, the Parkade, and Sir Francis Drake Boulevard at the Fairfax Cinema – Existing Conditions

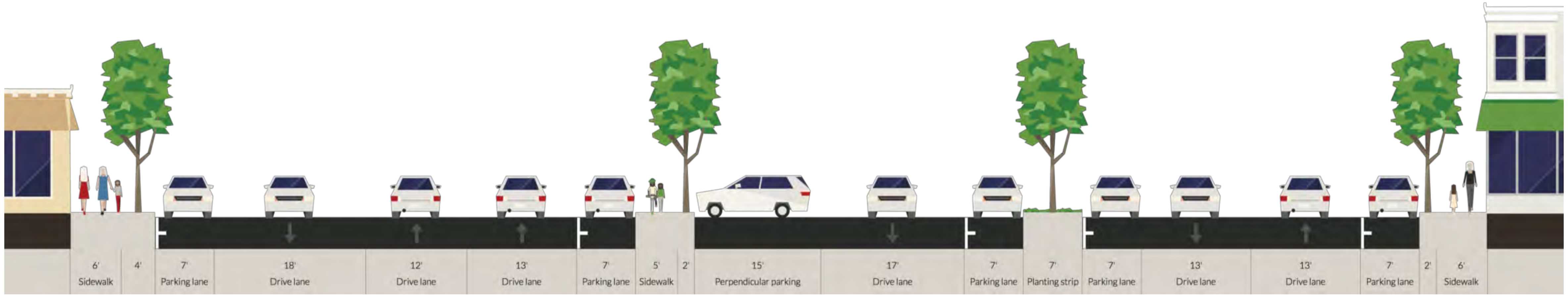


Figure 2-9 Segment B (Downtown Fairfax) Pinch Point: Bus Option B-1 (End at Downtown Fairfax with Clockwise Loop and Station on Broadway)

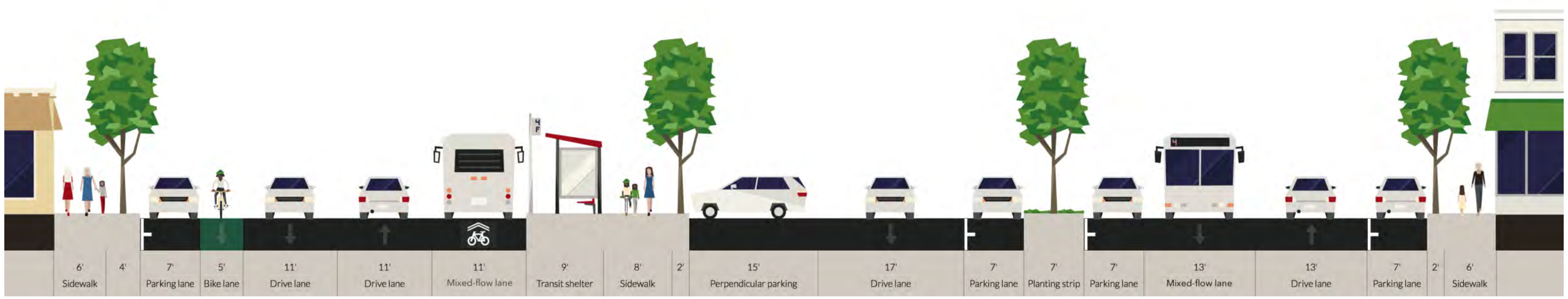


Figure 2-10 Segment B (Downtown Fairfax) Pinch Point: Rail Option B-1 (End at Downtown Fairfax with Station in Parkade)

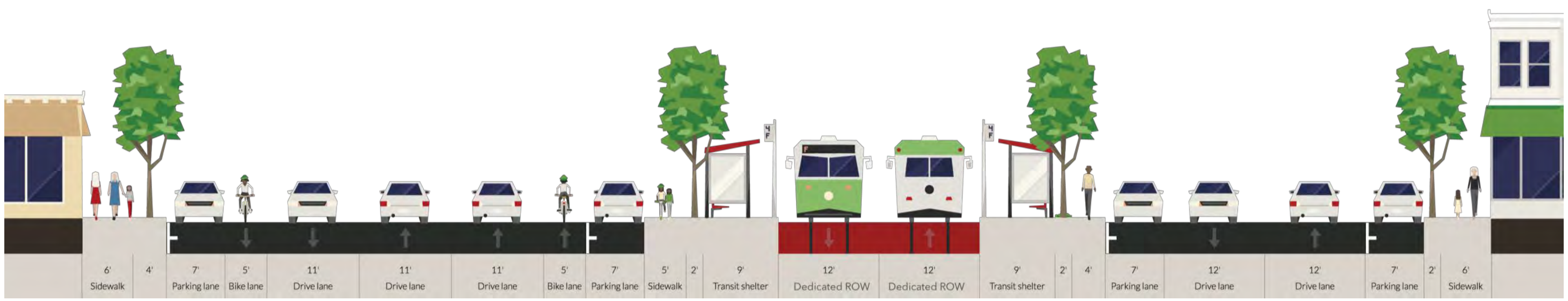


Figure 2-11 Segment B (Downtown Fairfax) Pinch Point: Bus Option B-2 (Continue in Mixed-Flow Lanes to Manor)

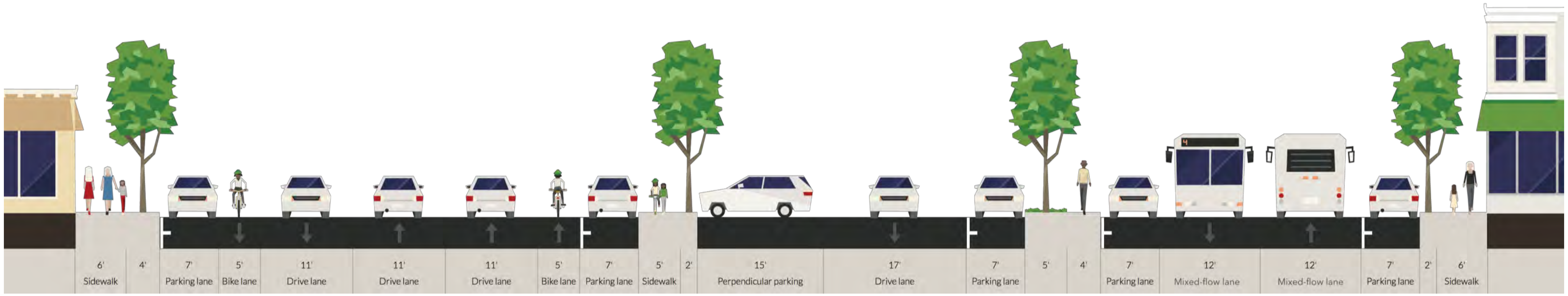
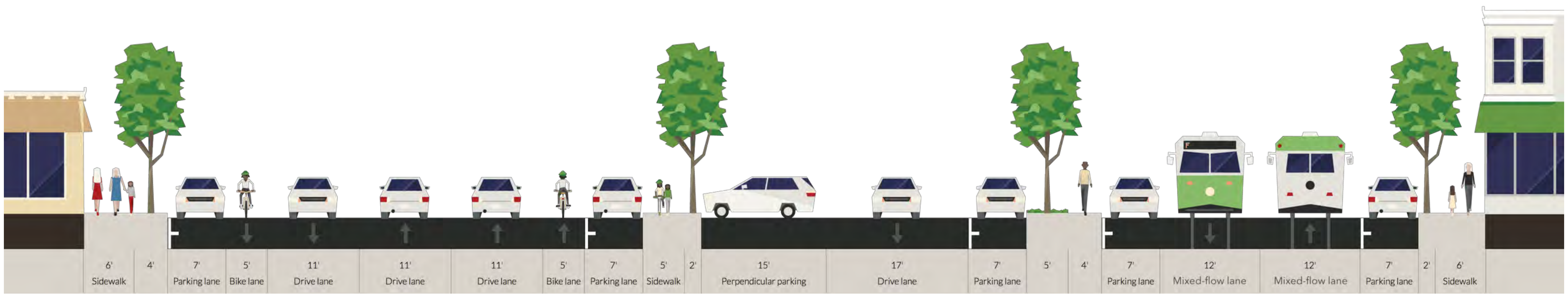


Figure 2-12 Segment B (Downtown Fairfax) Pinch Point: Rail Option B-2 (Continue in Mixed-Flow Lanes to Manor)



Segment C: Fairfax to San Anselmo

Segment C is relatively complex, offering two distinct potential transit alignments: to the north, Sir Francis Drake Boulevard; and to the south, Center Boulevard, built on the historic rail right-of-way. Land uses include a mix of low and medium density residential, commercial, and institutional, with key transit generators being Sir Francis Drake High School, Red Hill shopping center, and the San Anselmo Hub transit center.

Alignment Options

Option	Risks	Opportunities
C-1. Mixed-flow, right lane on Drake.	▪ Sir Francis Drake is less desirable for more frequent service, due to congestion during peak times as traffic would come to a stop behind transit vehicle ▪ Extremely constrained right-of-way (10-foot lanes) would require reconstruction at points, particularly for streetcars, which require 11-foot minimum lane widths.[1]	▪ Consistency with existing transit routes along this alignment. ▪ Improvements developed for new transit service (i.e., converting bus turn-outs to transit station bulbs; implementing queue jump lanes; exploring signal priority) would be shared with other Drake transit services. ▪ A bus service could be implemented at a lower cost than streetcar as reconstruction would likely only be required at station locations.
C-2. Mixed-flow, right lane on Center Blvd.	▪ Constrained right-of-way may require reconstruction at stations, possibly including retaining walls at some locations (i.e., potential station at Pastori Avenue). ▪ Center Boulevard bridge just west of the Hub will be reconstructed in 2016, with plans to be finalized in late 2015. These plans would need to take into account new transit service to optimize alignment. ▪ Center Boulevard corridor is farther from key transit generators along Sir Francis Drake Boulevard. ▪ Instatement of transit service on Center Boulevard may be difficult for adjacent residents, particularly along embankment sections. ▪ Narrow right-of-way (i.e., closeness between Center Boulevard and adjacent houses) in some locations may create concerns about noise and vibration.	▪ Center Boulevard alignment/bypass of Drake would create impression of faster/more direct service, potentially attracting choice riders. ▪ A rail service would be most appropriate along this alignment, as Center Boulevard's existing lane widths (minimum 11-foot) could accommodate streetcars without major modifications.

Segment C: Cross-Sections

The two cross-section locations below were chosen to highlight different spatial constraints on Drake and Center Boulevards. See Figure 2-13 for a context map of these locations. Figure 2-14 depicts a pinch point on Sir Francis Drake Boulevard at Aspen Lane (Sir Francis Drake High

[1] *Modern Streetcar Vehicle Guidance*, American Public Transportation Association, 2003, p. 5.

School). Figure 2-15 and Figure 2-16 depict bus and streetcar operations at this location; a potential station is shown to highlight spatial constraints. Given the streetcar's need to operate in lanes with a minimum width of 11 feet, substantial reconstruction would be needed to accommodate this option.

Figure 2-13 Segment C Cross-Section Context Map

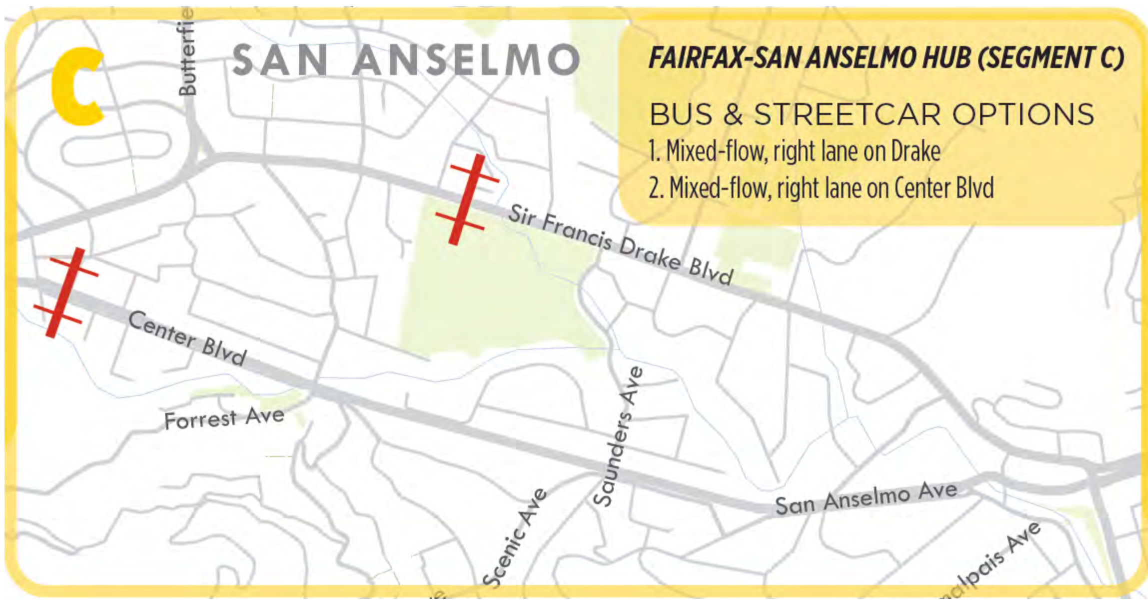


Figure 2-14 Segment C (Fairfax to San Anselmo) Sir Francis Drake Boulevard Pinch Point: Sir Francis Drake High School/Aspen Lane - Existing

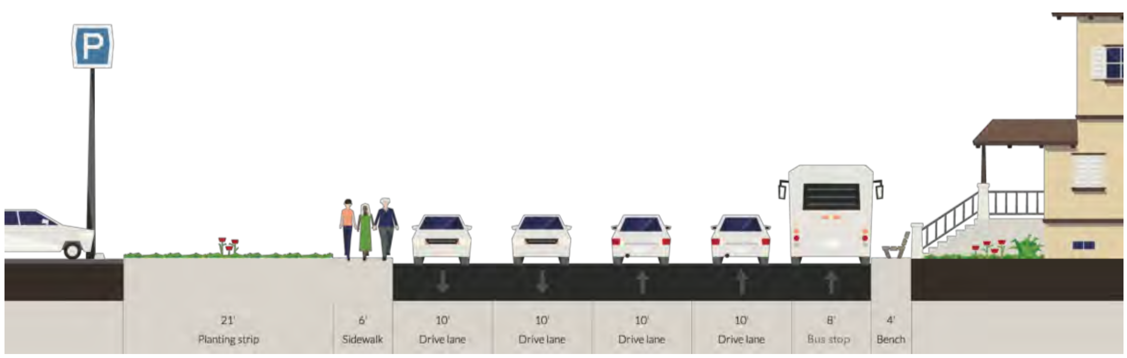


Figure 2-15 Segment C (Fairfax to San Anselmo) Drake Pinch Point: Bus Option C-1 (Mixed-Flow, Right Lane)

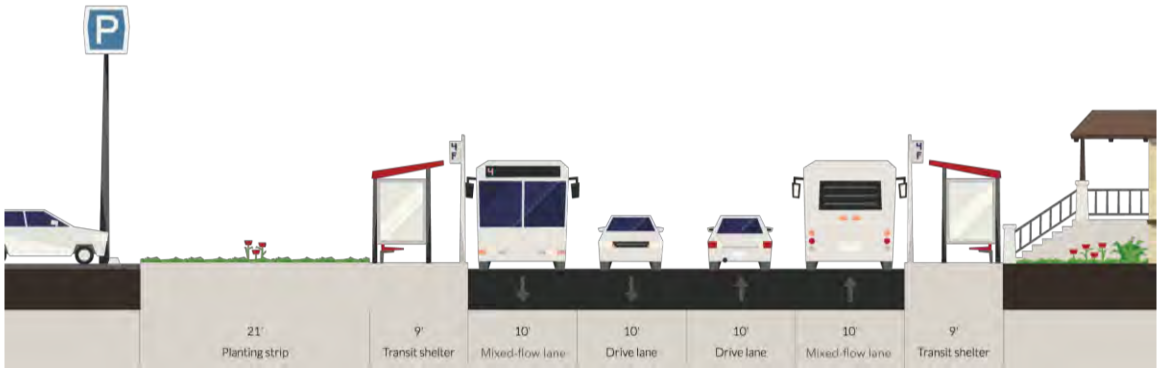


Figure 2-16 Segment C (Fairfax to San Anselmo) Drake Pinch Point: Rail Option C-1 (Mixed-Flow, Right Lane)

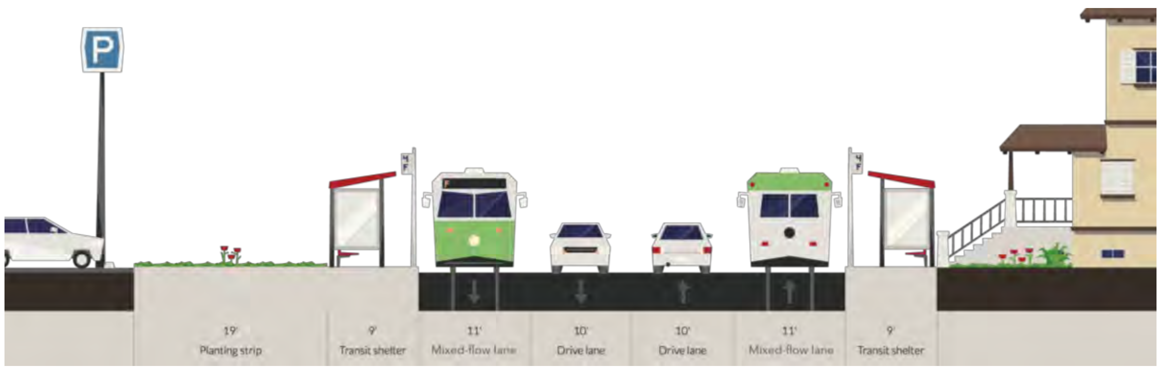


Figure 2-17 illustrates a pinch point on Center Boulevard, just east of Pastori Avenue. Please note that there is an elevation difference at this location of approximately seven feet. Figure 2-18 depicts rail service options at this location, with Figure 2-19 showing how a station at this location might require widening of the roadway embankment and/or construction of retaining walls. (A bus option would require similar modifications but is not shown.)

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Figure 2-17 Segment C (Fairfax to San Anselmo) Center Boulevard Pinch Point: At Pastori Avenue- Existing

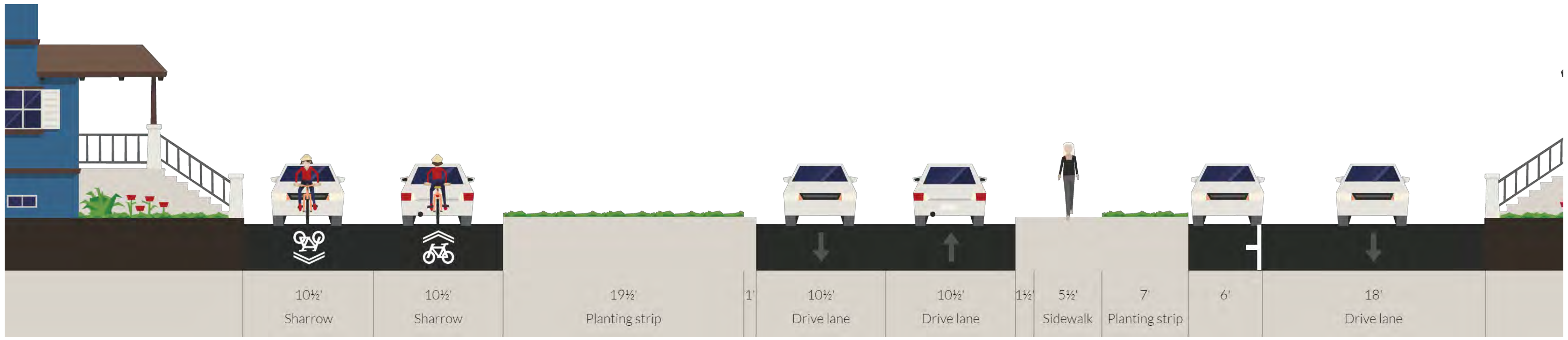


Figure 2-18 Segment C (Fairfax to San Anselmo) Center Boulevard Pinch Point: Rail Option C-2 (Mixed-Flow, Right Lane)

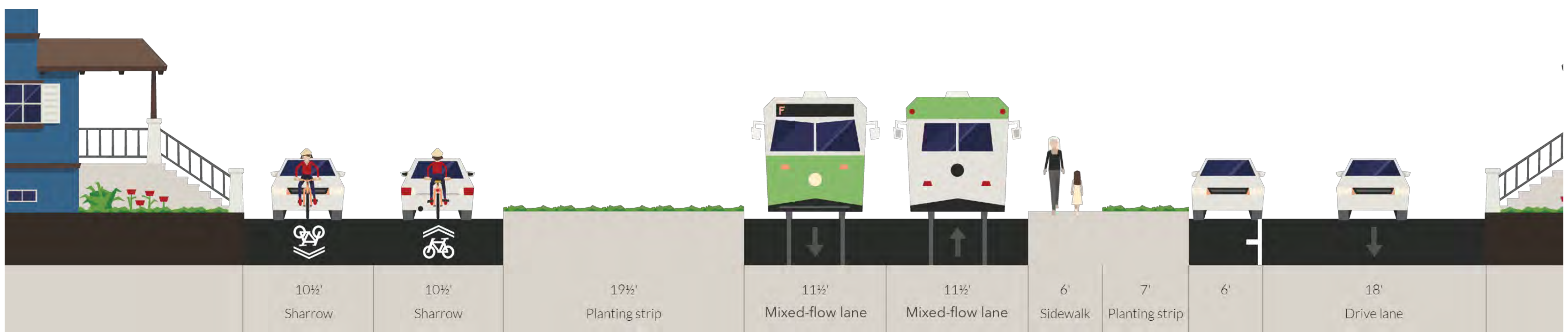
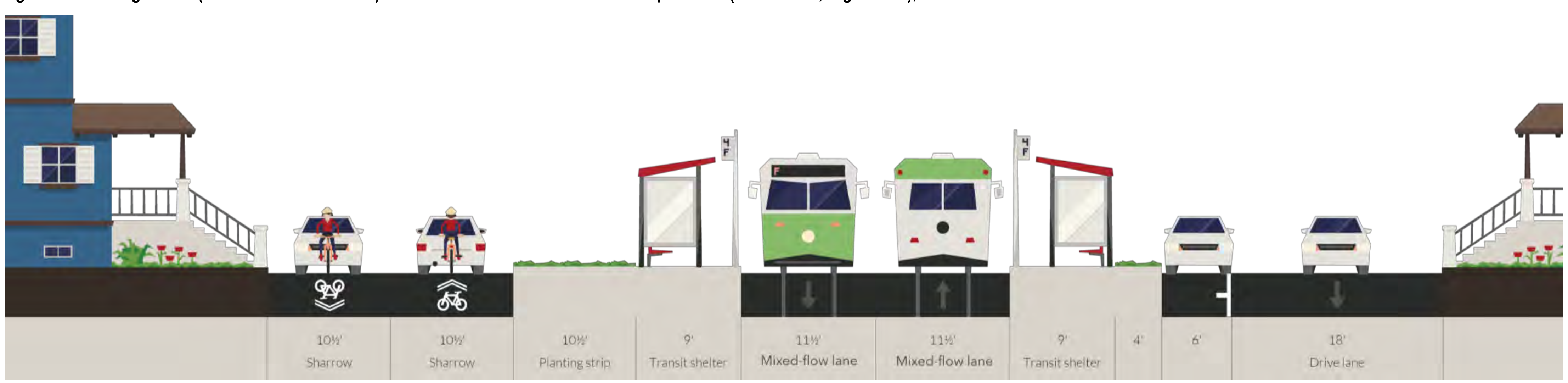


Figure 2-19 Segment C (Fairfax to San Anselmo) Center Boulevard Pinch Point: Rail Option C-2 (Mixed-Flow, Right Lane), with Station



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Segment D: The Miracle Mile (Red Hill Avenue & 4th Street)

Segment D extends along Red Hill Avenue and 4th Street from the San Anselmo Hub to the intersection of 4th and 2nd Streets in the West End area of San Rafael. Along some stretches, the Miracle Mile features a wide median, a remnant of the segment's history as a rail right-of-way. Land uses include a mix of low and medium density residential and commercial.

Alignment Options

Option	Risks	Opportunities
D-1. Mixed-flow, right lane on Red Hill Ave and 4th St.	▪ Not as reliable as median dedicated lanes as transit vehicles are subject to traffic congestion.	▪ Does not require vehicles with dual-side doors. May be the only option for buses which require uniformity with existing fleet. ▪ Would feature in-line station bulbs that would be available for use by other transit services as well.
D-2. Mixed-flow, left lane on Red Hill Ave and 4th St (stations in median).	▪ Requires transit vehicles with dual-side doors. ▪ Requires targeted left-hand turn restrictions for safety and reliability. ▪ Left-hand stops would not be able to be used by other transit services.	▪ Use of median dedicated lanes may improve transit speed and reliability. ▪ Median stations allow for reduced crossing distance, improving safety for people trying to cross Red Hill Avenue or 4th Street.
D-3. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, right lane on 4th St.	▪ Requires transit vehicles with dual-side doors. ▪ Requires targeted left-hand turn restrictions for safety and reliability. ▪ Left-hand stops would not be able to be used by other transit services.	▪ Use of median dedicated lanes may improve transit speed and reliability. ▪ Median stations allow for reduced crossing distance, improving safety for people trying to cross Red Hill Avenue or 4th Street.
D-4. Dedicated median lanes Hub to Sequoia Dr; mixed-flow, left lane on 4th St.	▪ Requires transit vehicles with dual-side doors. ▪ Requires targeted left-hand turn restrictions for safety and reliability. ▪ Left-hand stops would not be able to be used by other transit services.	▪ Use of median dedicated lanes may improve transit speed and reliability. ▪ Median stations allow for reduced crossing distance, improving safety for people trying to cross Red Hill Avenue or 4th Street.

Segment D: Cross-Sections

The cross-section shown depicts spatial constraints at the narrowest point of the Miracle Mile, on Red Hill Avenue 300 feet west of Sequoia Drive. See Figure 2-20 for a context map of this location. Figure 2-21 illustrates current conditions. Note that the segment is constrained at this point due to the encroachment of a bluff to the north, which is indicated by the seven-foot "planting strip" at the right. Also note that the paved buffer immediately to the left of this bluff is technically a parking lane (signed for four-hour parking), but is not conducive to parking both now and in the future due to the lack of safe ways to access nearby trip generators. Figure 2-22 depicts the only viable bus option, Option D-1; Options D-2, D-3, and D-4 require transit vehicles with dual-side doors, so only rail vehicles are shown for these options.

Figure 2-20 Segment D Cross-Section Context Map

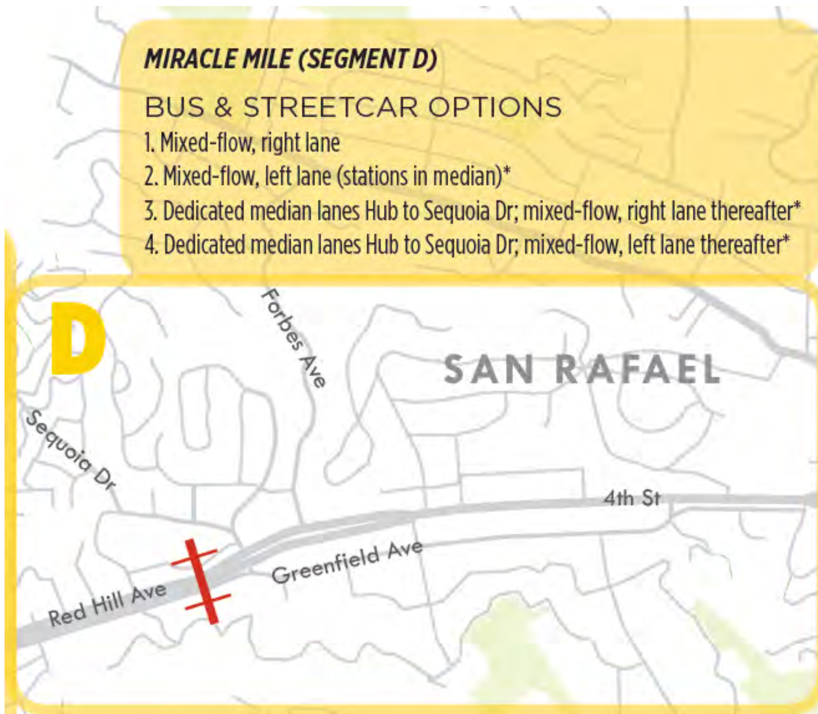


Figure 2-21 Segment D (Miracle Mile) Pinch Point: Red Hill Avenue, 300 Feet West of Sequoia Drive - Existing

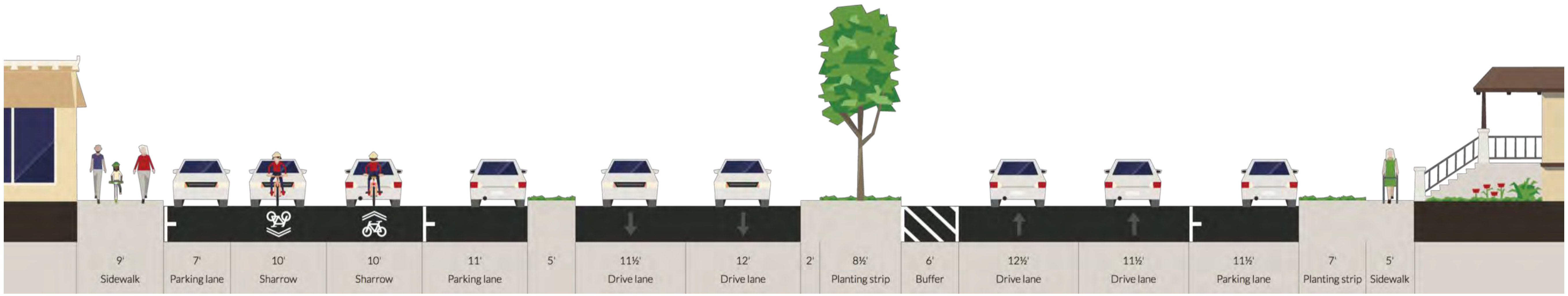


Figure 2-22 Segment D (Miracle Mile) Pinch Point: Bus Option D-1 (Mixed-Flow, Right Lane)

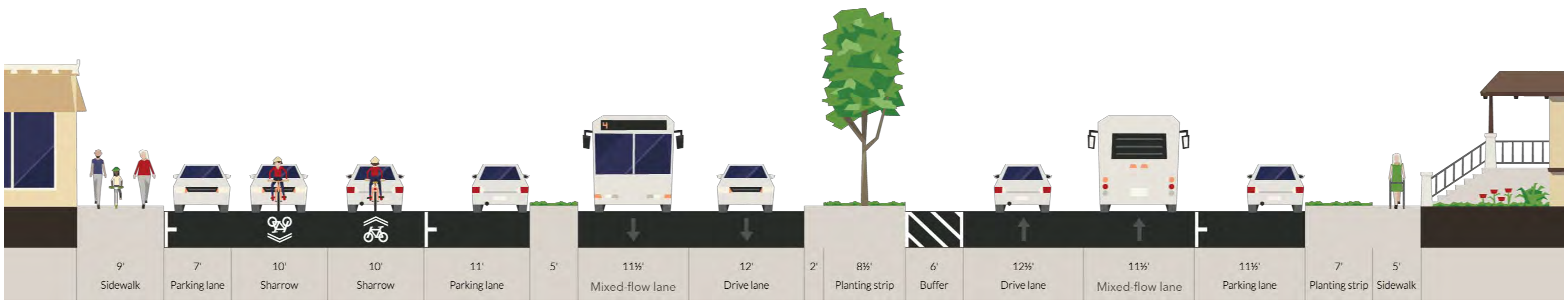


Figure 2-23 Segment D (Miracle Mile) Pinch Point: Rail Option D-2 (Mixed-Flow, Left Lane – Stations in Median)

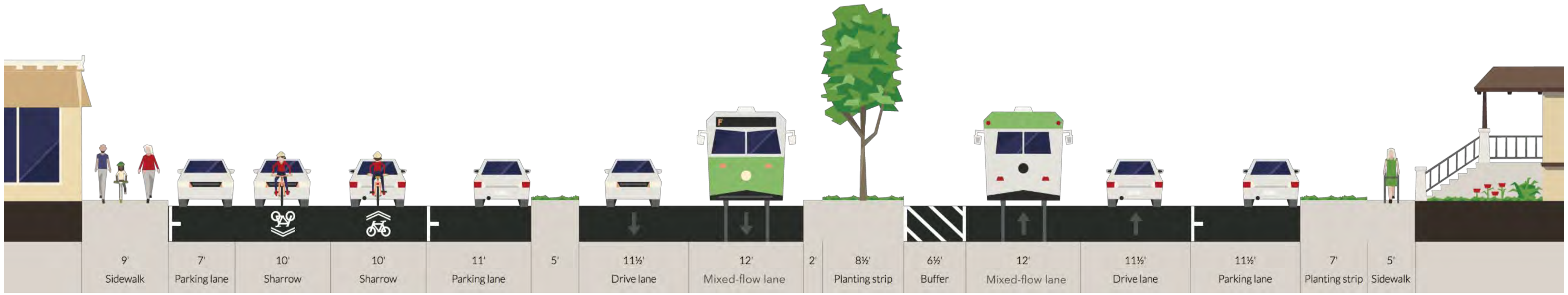
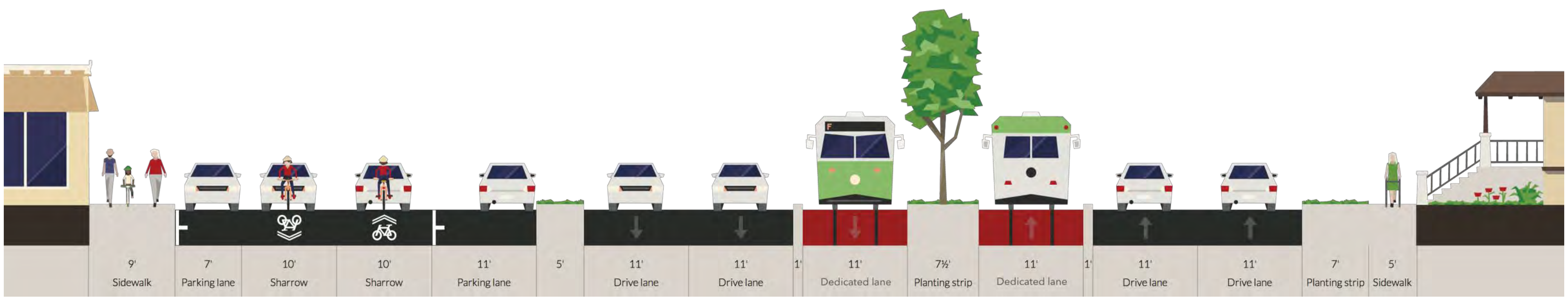


Figure 2-24 Segment D (Miracle Mile) Pinch Point: Rail Options D-3, D-4 (Dedicated Median Lanes Hub to Sequoia Drive; Mixed-Flow Lanes Thereafter)



Segment E: Downtown San Rafael

There are four alignment options in downtown San Rafael, including a new alignment option for mixed-flow lanes on 4th Street. Roadway conditions, particularly existing lane widths, vary widely within downtown San Rafael. On 3rd Street in particular, lane widths range from 15-foot side/12-foot middle lanes at the Bettini Transit Center to 11-foot and 12-foot side/10-foot middle lanes at Brooks Street, where an eight-foot south side parking lane is provided. Despite these variances, the overall widths of streets in downtown San Rafael provide an opportunity for accommodating new high-capacity transit services on a variety of alignments. In some cases, such as on 4th Street, accommodating new transit services in mixed flow operation would not require substantial reallocation of roadway width; however, in the case of option E-4, delivering the transit reliability and speed benefits of an eastbound dedicated lane on 3rd Street would require more substantive trade-offs.

While these alignment options are largely similar between bus and rail modes in this segment, as a reminder, bus alignments may continue beyond the Bettini Transit Center while all rail services would terminate west of the SMART tracks.

Alignment Options

Option	Risks	Opportunities
E-1. Mixed-flow, right lane on 2nd and 3rd Sts.	▪ Does not offer same level of increased speed and reliability as other options. ▪ Located along different alignment than other transit services in area, potentially causing confusion among users.	▪ Does not require vehicles with dual-side doors. ▪ Would feature in-line station bulbs or curbside stops that would be available for use by other transit services as well. ▪ Less potential for induced traffic congestion (i.e., queuing behind transit vehicles) at station stops. ▪ May offer a simpler turnaround option for streetcar services (i.e., tentatively, use Tamalpais Avenue to complete loop).
E-2. Mixed-flow, left lane on 2nd and 3rd Sts.	▪ Potential for parking loss at station locations on 3rd Street. ▪ Requires transit vehicles with dual-side doors. Not suitable for current bus fleet. ▪ Requires targeted left-hand turn restrictions for safety and reliability. ▪ Left-hand stops would not be able to be used by other transit services. ▪ Located along different alignment than other transit services in area, potentially causing confusion among users.	▪ Less potential for induced traffic congestion (i.e., queuing behind transit vehicles) at station stops. ▪ May offer a simpler turnaround option for streetcar services (i.e., tentatively, use Tamalpais Avenue to complete loop).

Option	Risks	Opportunities
E-3. Mixed-flow, right lane on 4th St.	▪ Potential for parking loss at station locations. ▪ Potential for increased traffic congestion as transit vehicles stopped at stations would require that all traffic stop in one direction (i.e., no passing lanes).	▪ Does not require vehicles with dual-side doors. ▪ Would feature rebuilt, in-line station bulbs or curbside stops that would be available for use by other transit services as well. Of particular note, 4th Street already features mid-block bulbouts that could be repurposed for use as transit stations. ▪ Located along alignment of existing transit services, offering continuity and convenience for the casual transit user.
E-4. Dedicated EB lane and WB mixed-flow right lane on 3rd St.	▪ Major parking loss required for construction of dedicated EB lane. ▪ Could require minor reduction in sidewalk width (or loss of through lane) to accommodate dedicated lane. ▪ Requires targeted left-hand turn restrictions for safety and reliability. ▪ Located along different alignment than other transit services in area, potentially causing confusion among users.	▪ Does not require vehicles with dual-side doors. ▪ Would feature in-line station bulbs or curbside stops that would be available for use by other transit services as well. ▪ Dedicated lane could improve speed and reliability of transit serving as feeder to SMART service.

Segment E: Cross-Sections

See Figure 2-25 for a context map of cross-section locations in Segment E. Alignment Option E-3 is new, having been added at the recommendation of the TAC. In contrast to the cross-section for the four other alternative alignments (examined in more detail below), the cross-section provided for this option illustrates a unique opportunity rather than a constraint. At various points along 4th Street, sidewalk bulb-outs already provide opportunities for businesses to extend into the public way. While occurring at staggered locations along the 4th Street corridor, they nevertheless offer natural locations for mid-block stations, with minor modifications.

Figure 2-26 illustrates 4th Street between A and B Streets, where one such bulbout exists on the north side of the street. Figure 2-27 shows how this bulbout may be extended slightly to accommodate a transit station.

Figure 2-25 Segment E Cross-Section Context Map

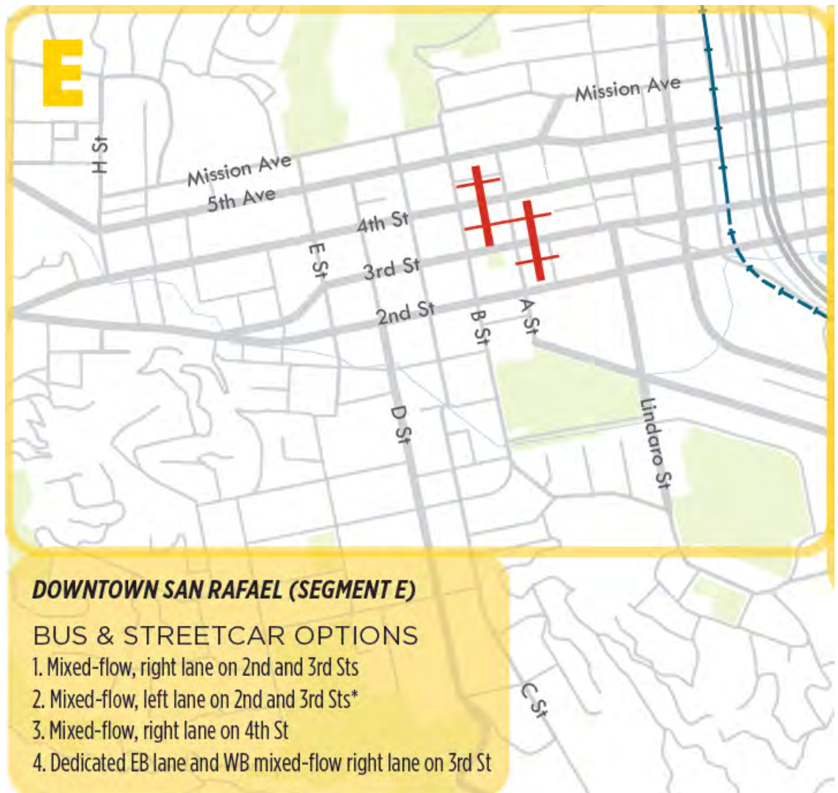


Figure 2-26 Segment E (Downtown San Rafael) Opportunity: 4th Street, 200 Feet West of A Street – Existing

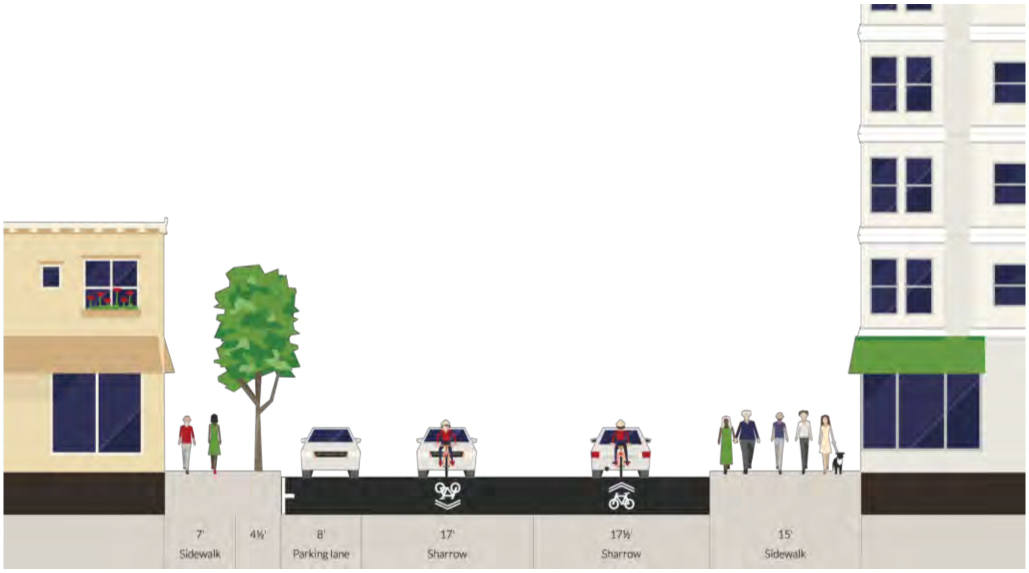
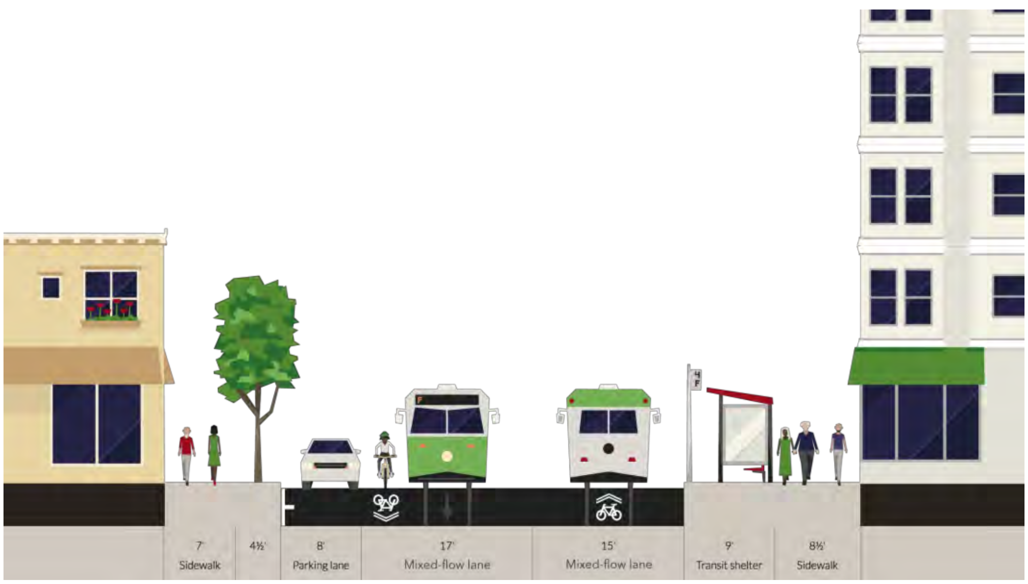
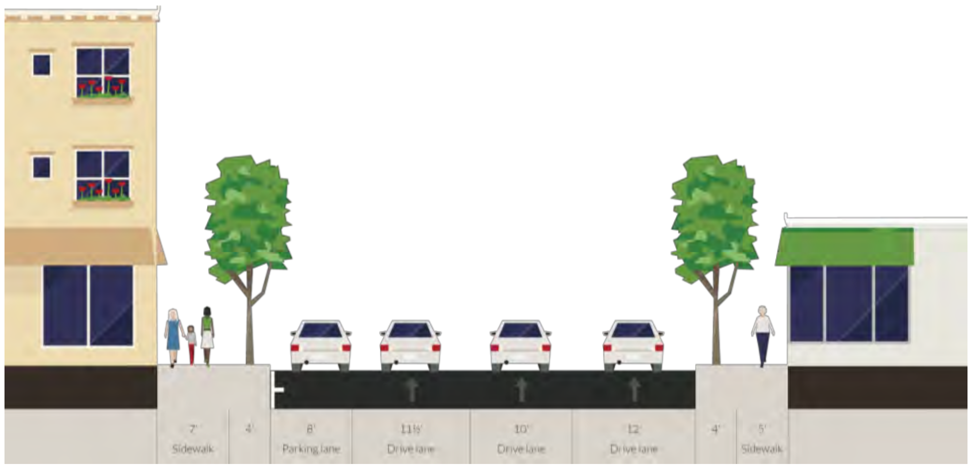


Figure 2-27 Segment E (Downtown San Rafael) Opportunity: Rail Option E-3 (Mixed-Flow, Right Lane on 4th Street)



Cross-sections for alignment options E-1, E-2, and E-4 are shown at 3rd Street just east of A Street. Figure 2-28 depicts the existing conditions at this location. Since bus and rail options are largely the same in Segment E, for simplicity only rail options are shown. For each 3rd Street option, a cross-section with and without a station is shown to illustrate how space might be allocated in each case.

Figure 2-28 Segment E (Downtown San Rafael) Pinch Point: 3rd Street, 50 Feet East of A Street – Existing



For Option E-1, mixed-flow, right lane operation would not result in reconstruction of existing sidewalks, except at potential station locations (Figure 2-30). Stations would also be able to be used by other transit services, as applicable.

Figure 2-29 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-1 (Mixed-Flow, Right Lane on 2nd and 3rd Streets)

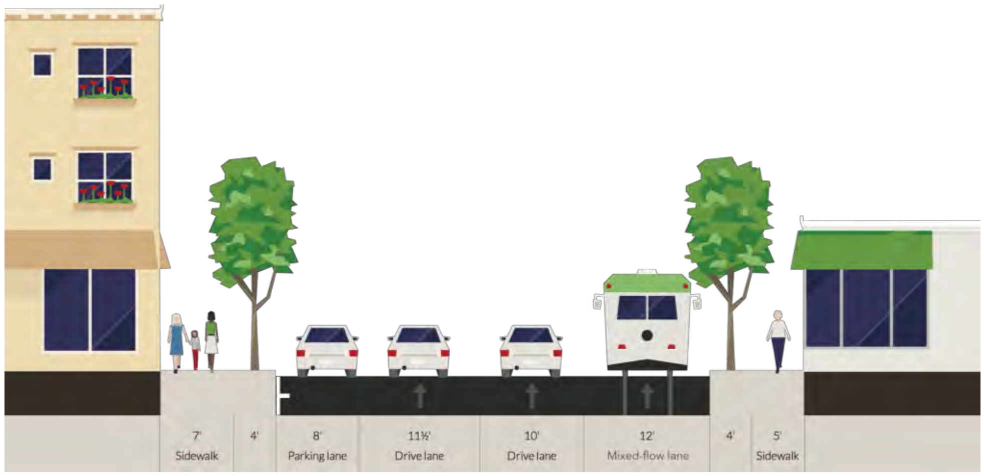
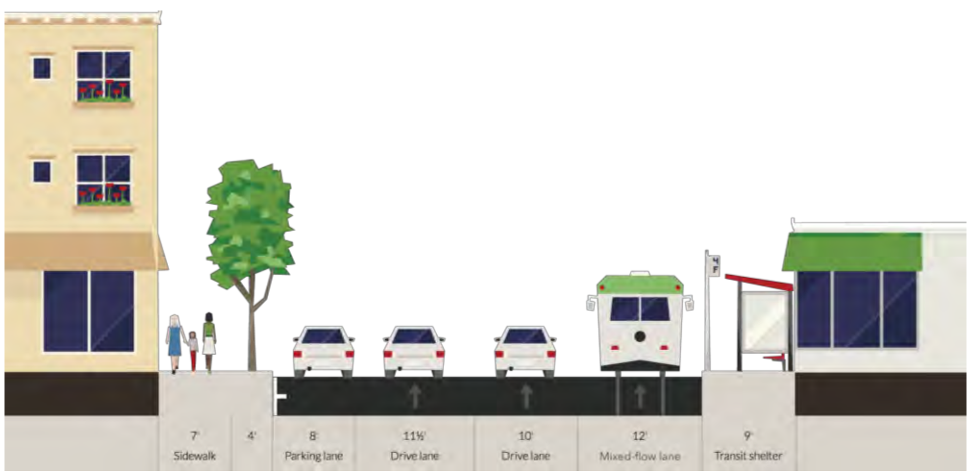


Figure 2-30 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-1 (Mixed-Flow, Right Lane on 2nd and 3rd Streets) with Station



For Option E-2, left lane operation would require the use of transit vehicles with dual-side doors, precluding the ability of other transit services to use the new stops, as applicable. On 3rd Street, stops would utilize the parking lane, leading to minor loss of parking (approximately 2-3 spaces) at these locations.

Figure 2-31 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-2 (Mixed-Flow, Left Lane on 2nd and 3rd Streets)

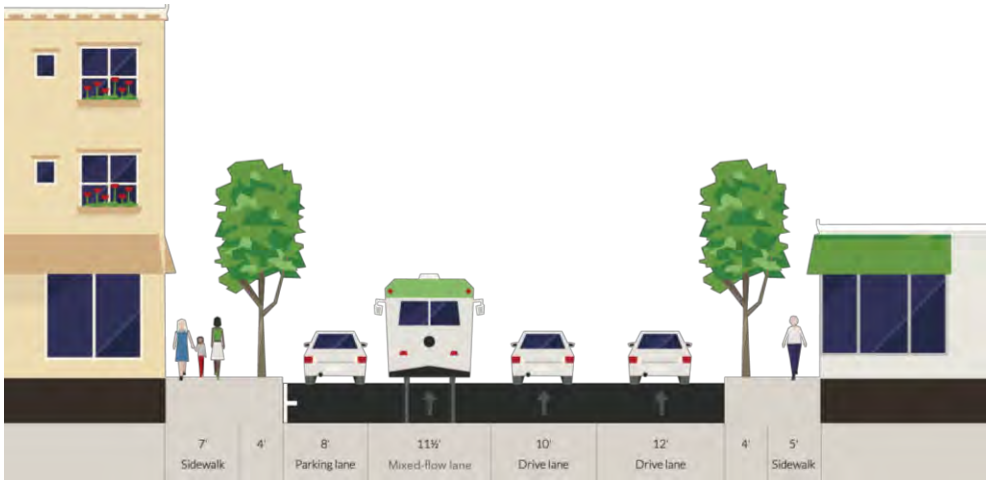
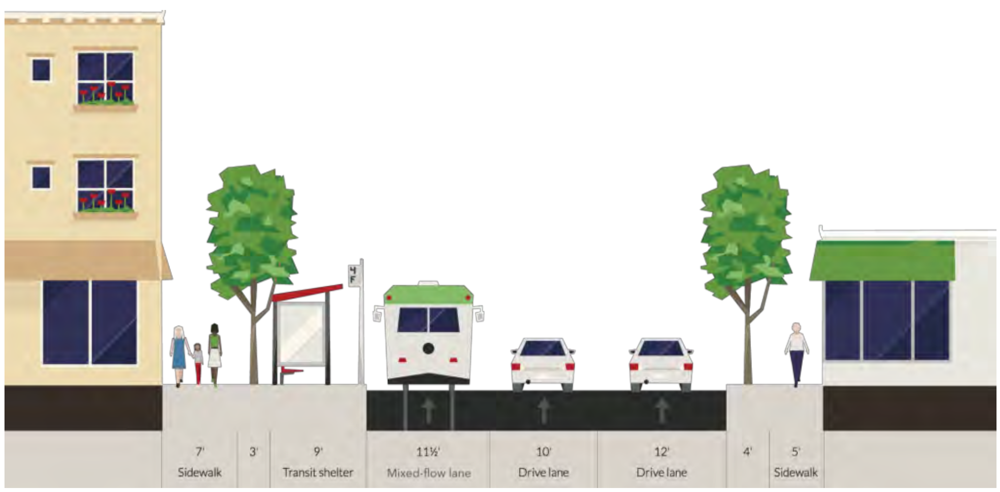


Figure 2-32 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-2 (Mixed-Flow, Left Lane on 2nd and 3rd Streets) with Station



Option E-4 is an example of a higher risk, higher reward investment, offering the potential of increased transit reliability in the eastbound direction with trade-offs of slight sidewalk narrowing and the loss of parking on 3rd Street. Option E-4 would not require dual-side transit vehicles, as all stops would be on the right side.

Figure 2-33 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-4 (Dedicated Eastbound Lane and Westbound Mixed-Flow, Right Lane on 3rd Street)

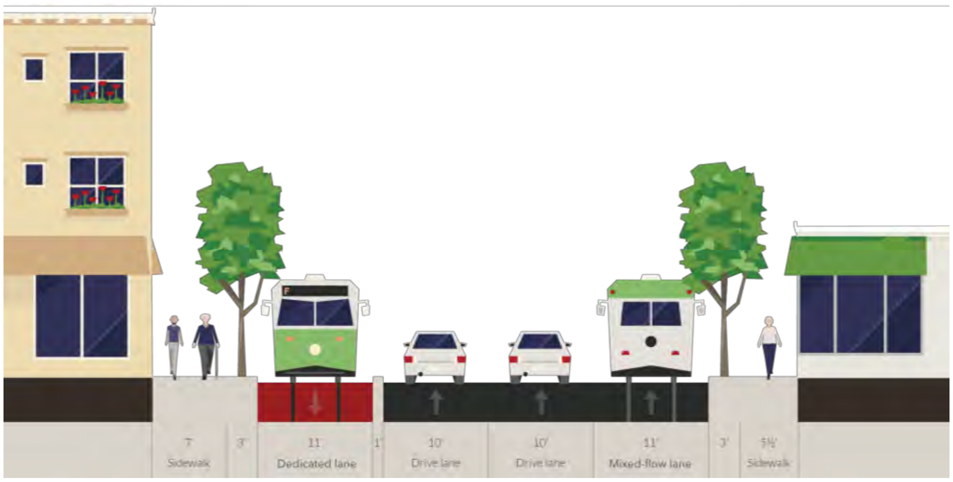
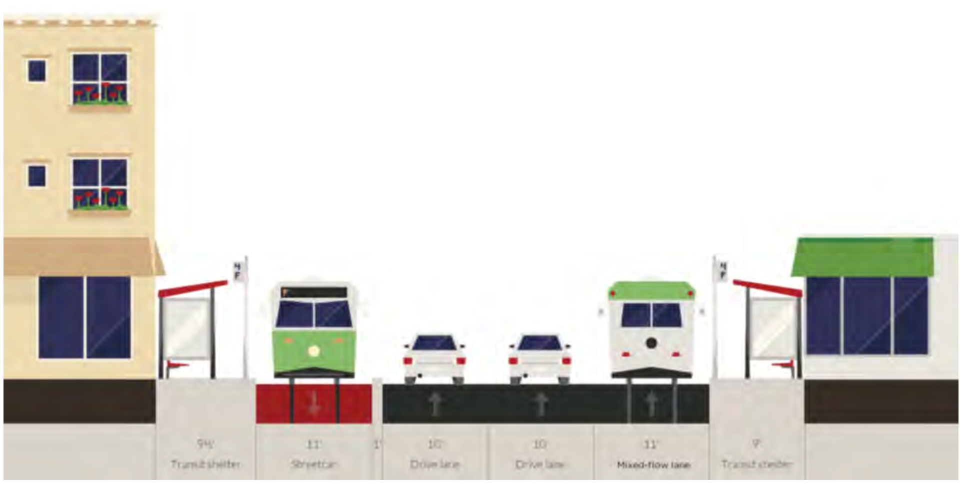


Figure 2-34 Segment E (Downtown San Rafael) Pinch Point: Rail Option E-4 (Dedicated Eastbound Lane and Westbound Mixed-Flow, Right Lane on 3rd Street) with Station



Segment F: Montecito Plaza/ Canal Area

Though not part of the core Fairfax-San Rafael corridor, the Canal area is a strong transit-supportive market, adjacent to the primary corridor. It has a wide variety of land uses, ranging from medium/high density residential to light industrial and commercial uses, all in a relatively compact area bordered by highways, arterials, and San Francisco Bay.

Rail alternatives cannot serve the Canal area, as it would not be practical to cross the SMART tracks at grade. Therefore, it is recommended that any bus alternative include service to the Canal area. Due to a disjointed road network between downtown San Rafael and the Canal area, there are several options that may be considered. Since the first draft of this memorandum, two alignment options have been added, largely due to anticipation of the redevelopment of the Marin Square Shopping Center into a Sutter Health hospital complex (timeline to be determined). Cross-sections have not been developed for these alignment options.

Alignment Options

Option	Risks	Opportunities
F-1. No service beyond SRTC.	▪ Does not serve the Canal area, a very strong transit market.	▪ None.
F-2. Mixed-flow, right lane to Montecito Plaza (loop TBD).	▪ According to feedback from Marin Transit, an alternative extending to Montecito Plaza "is only 3-4 minutes and [there is no suitable place] to layover."	▪ Serves shopping destinations and San Rafael High School.
F-3. Mixed-flow, right lane to Canal, as Marin Transit Route 35.	▪ No suitable southbound stop locations and few destinations on Francisco Boulevard East between Montecito Plaza and Bellam Boulevard.	▪ Ability to supplement and/or replace existing Route 35 service, allowing these hours to be reallocated elsewhere in Marin County.
F-4. Mixed-flow, right lane to Canal on Hwy 101 auxiliary lane SB then Marin Transit Route 35 alignment.	▪ Would not serve Montecito Plaza area in the southbound direction.	▪ Speed and reliability improvements due to Highway 101 operation in the southbound direction (bypassing Francisco Boulevard East segment).
F-5. Mixed-flow, right lane to Canal on Andersen Drive. (To serve future Sutter Health campus.)	▪ Timeline for reconstruction of Marin Square Shopping Center uncertain.	▪ Would serve new Sutter Health campus and other redevelopment opportunities along Anderson Drive.
F-6. Mixed-flow, right lane to Canal on Hwy 101 SB, then Andersen Drive. (To serve future Sutter Health campus.)	▪ Timeline for reconstruction of Marin Square Shopping Center uncertain. ▪ Potential for on-time performance issues during peak hours, due to need to merge from auxiliary lane to reach Andersen Drive exit.	▪ Would serve new Sutter Health campus and other redevelopment opportunities along Anderson Drive.

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3 DRAFT ALTERNATIVES FOR FURTHER STUDY

With basic parameters set by the TAC, and using the findings of the Existing Conditions Briefing Book and the Travel Markets Analysis as context, we developed a total of four initial draft alternatives designed to maximize existing resources within the corridor and meet key project goals. Two bus and two rail alternatives were proposed, differentiated by the level of investment required to implement them. (Details of these four initial alternatives will be provided as an appendix in the final report.) At and following the March 11th TAC meeting, feedback was provided on these initial alternatives, including identification of additional corridor opportunities and constraints.

The following revised draft alternatives reflect a thorough, though high-level, analysis of the corridor alignment options provided in Chapter 2. We feel that these constitute the best "Build" alternatives for each mode. The two revised alternatives presented here are also base alternatives, leaving room for additional flexibility. For example, in the downtown San Rafael and Canal area segments, further study is needed; in Task 4, our team will conduct a multimodal analysis of these segments to help identify a preferred alignment. There may also be opportunities for a phased approach to implementing these alternatives. Finally, all alternatives are able to be further modified/refined using the "kit of parts" provided in Chapter 2.

The revised "build" alternatives include:

- **Lower Investment.** This alternative utilizes bus technology, providing service between downtown Fairfax and the Canal area. It would operate in right side, mixed-flow lanes along Sir Francis Drake Boulevard and along the Miracle Mile, and providing service to the Canal area along the existing Route 35 loop. Precise operating characteristics in downtown San Rafael and between Bettini Transit Center and the Canal area are to be determined.
- **Higher Investment.** This alternative utilizes rail technology, providing streetcar service between downtown Fairfax and the Bettini Transit Center. Constituting a new fleet, rail vehicles would feature dual-side doors. From a station in the Fairfax Parkade to the San Anselmo Hub, streetcars would operate in mixed-flow lanes on the historic rail alignment, Center Boulevard. Along the Miracle Mile, transit would operate in median dedicated lanes from the Hub to Sequoia Drive, after which it would operate in the leftmost mixed-flow lane. Precise operating characteristics in downtown San Rafael are yet to be determined.

Going forward, with additional feedback from the TAC and using the findings from Task 4, we will introduce a third alternative for consideration. This alternative, tentatively titled **Enhanced "No Build,"** will feature targeted improvements to improve the user experience and reliability of existing transit services in the corridor.

COMMONALITIES AMONG THE "BUILD" ALTERNATIVES

This section discusses characteristics that are shared between the two proposed "build" alternatives throughout the corridor.

- **Operating service characteristics.** Tentatively, transit service would operate at a minimum on 15-minute peak and 20-minute base (off-peak) headways between 6 a.m. and 11 p.m., all week. However, a further analysis of each alternative's impacts on the transit network will be included in the next phase of work, as alternatives are refined.
- **Shared transit enhancements.** To the extent possible, the alternatives would seek to extend service reliability and user experience enhancements to other transit services within the corridor. For example, any queue jump lanes (such as one at Butterfield Road heading westbound on Sir Francis Drake Boulevard), right-side bus/rail station bulbs/shelters, or transit signal priority investments developed for this project would also be able to be used by local Marin Transit or Golden Gate Transit services, further increasing the attractiveness of transit within the corridor.
- **Station styles.** At a minimum, each alternative will feature distinctive station styles, helping differentiate the enhanced service from typical transit services. Depending on location and/or width constraints, stations would feature shelters, enhanced signage with wayfinding elements and/or system branding. As shown in Figure 3-1, typical station styles can be both modern and stylish, accommodating a host of rider amenities in a small overall profile. (Note: this quality of streetcar station design does come at a higher cost in resources, which is why streetcar technology is being considered as the "higher investment" alternative.) Terminal and/or other key wayside stations may have enhanced treatments that may be determined later in the process.

Figure 3-1 Potential Station Styles – Cincinnati & Portland Streetcars

Source: City of Cincinnati; Steve Morgan/Wikipedia

- **Commitment to community vitality, multimodal access, and sustainability.** Each alternative is designed to maximize the benefits of transit within corridor communities, creating a more socially equitable transportation system that can be used by all, including choice riders-- as well as riders who depend on transit. Each alternative also represents a unique opportunity to enhance multimodal access within the corridor. Such enhancements aim to improve the walkability and sustainability of adjacent communities. To the extent possible, and with the collaboration of relevant municipalities and agencies along the corridor, each alternative will feature bike parking, an improved pedestrian and bicycle orientation around stations, and/or other amenities. Finally, these alternatives may be seen as investments in the livability of Marin County, including improvements in the safety, sense of belonging, economic vitality, and mobility within the corridor.

THE REVISED ALTERNATIVES IN DETAIL

Lower Investment Alternative

***Goal**: This alternative proposes a lower cost high-capacity transit service for the study corridor, with buses operating from Fairfax to the Canal area largely in mixed-flow lanes.*

Basic Alignment: Beginning as a clockwise loop in Fairfax with a station bulb on Broadway adjacent to the Parkade, this alternative continues in mixed-lanes along Sir Francis Drake Boulevard to the San Anselmo Hub. In the Miracle Mile, transit operates in the right side mixed-flow lane. In the Canal area, buses follow the existing counterclockwise Marin Transit Route 35 loop. However, at this time, the precise alignments in downtown San Rafael and between Bettini Transit Center and the Canal area are to be determined. See Figure 3-2.

Phased Approach: If desired, this alternative could be completed in phases. Initial phases could include (either/or):

- Beginning as an "Enhanced No Build" alternative by developing transit reliability improvements for existing transit routes between Fairfax and the San Anselmo Hub along Sir Francis Drake Boulevard.
- Upgrading service between the Canal area and downtown San Rafael with improved station stops, reliability, and/or frequency.
- Improving the connection between the Canal area and the San Anselmo Hub with more frequent and high-quality service.

Limitations

- During peak times, in-line station stops on Sir Francis Drake Boulevard could cause additional delay as vehicles will need to wait behind transit vehicles.

Opportunities

- Phased approach could introduce transit reliability and user experience improvements in the short-term.
- The Canal area is a strong transit market.
- Opportunity to replace and expand Marin Transit Route 23 service to Target by sending every third bus to serve Shoreline Parkway (bypassing the Canal). (Please note that a further analysis of each alternative's impacts on the transit network will be included in the next phase of work, as alternatives are refined.)

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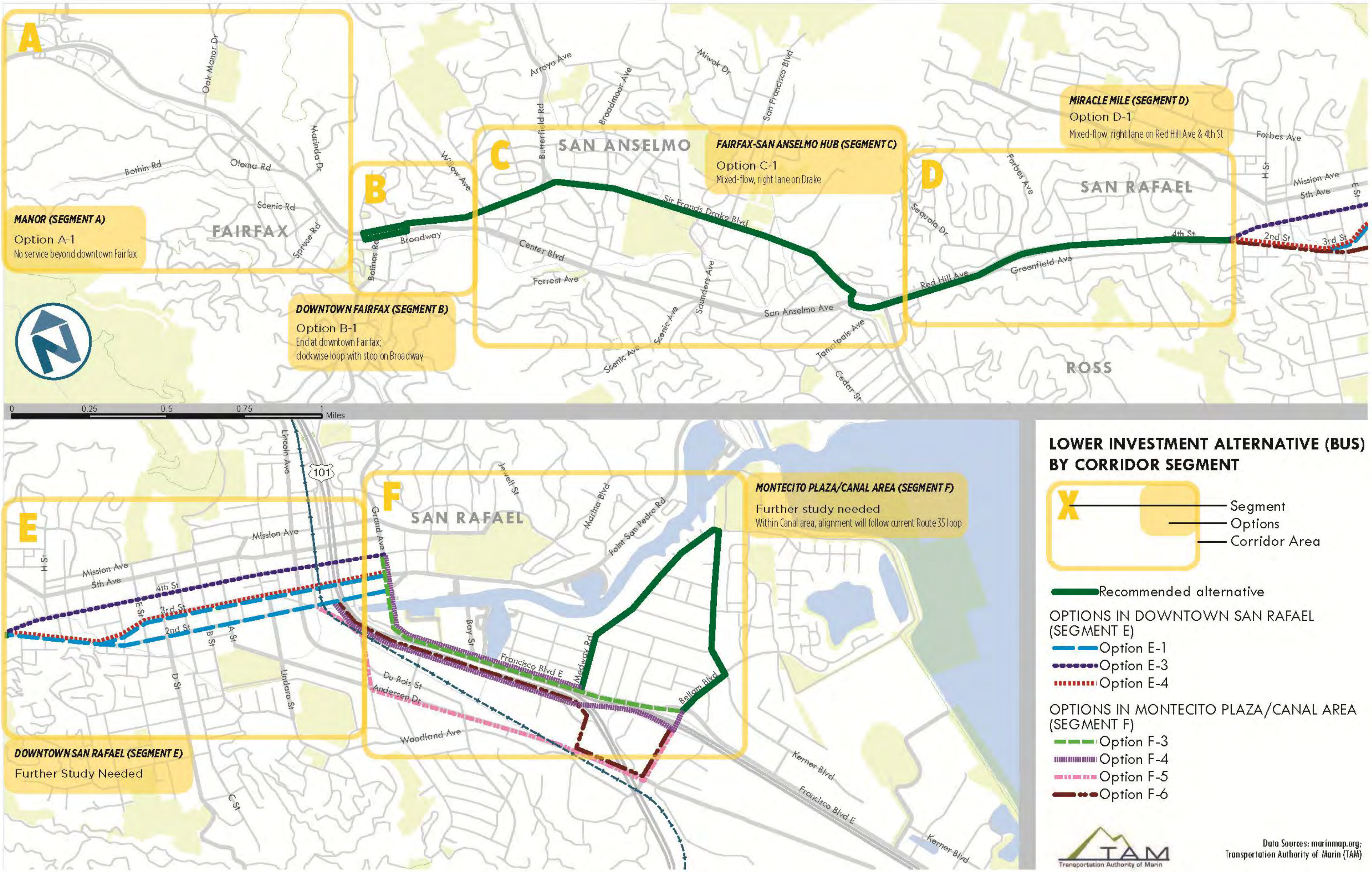
Figure 3-2 Lower Investment Alternative



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Higher Investment Alternative

Goal: *Provide the highest quality streetcar service within the Fairfax-San Rafael corridor.*

Basic Alignment: From a distinctive terminal station located within the Fairfax Parkade, streetcars would operate in mixed-lane traffic along Center Boulevard, directly serving the San Anselmo Hub. In the Miracle Mile, streetcars would operate in dedicated lanes in the median of Red Hill Avenue from the Hub to Sequoia Drive, after which point transit would share the leftmost lane with stations in the median. The precise alignment and method of turnaround in downtown San Rafael is to be determined. See Figure 3-3.

Phased Approach: If desired, this alternative could be completed in phases, with a first phase extending from downtown San Rafael to the San Anselmo Hub.

Limitations:

- Inability to cost-effectively cross the SMART tracks, due to freight rail restrictions. As a result, a rail alternative must end at the San Rafael Transit Center.
- Overhead wires, if conventional streetcars are determined to be the most feasible option (i.e., as opposed to wireless and/or battery-powered streetcars). It is important to note that while this alternative is designed for urban streetcar operations, no specific vehicle or technology is selected at this time.
- The need for a maintenance facility, presumably to be located west of the SMART tracks.

Opportunities:

- **Flexible vehicle design.** This alternative assumes the purchase and operation of rail vehicles with doors on both left and right sides. This allows for median stations along the Miracle Mile and, if chosen, left-side curbside stations on 2nd and 3rd Street in San Rafael (Option E-2).
- **Bypass of Sir Francis Drake Boulevard.** While potential operations on Center Boulevard pose challenges, bypassing busy Sir Francis Drake Boulevard could offer faster and more reliable transit service. The promise (or appearance) of more direct service between the population and job centers of Fairfax and San Anselmo, as well as the SMART station could also help attract new riders.
- **Ridership implications.** Pending further study, this is likely to be the highest ridership alternative given the permanence and clarity of a rail alignment that features dedicated lanes, operates on the historic rail alignment, directly links major nodes, and bypasses busy Sir Francis Drake Boulevard.

Notes:

Left-turn modifications in the Miracle Mile. To improve travel time and reliability, three left turns along Red Hill Avenue and the Miracle Mile would be eliminated to improve safety for median and/or left mixed-lane operation: Essex Avenue, Ancho Vista Avenue, and Alexander Avenue. The first two of these left-turn locations are notable in the corridor as they do not feature protected left-turn lanes; the Alexander Avenue access point is redundant with Crescent Drive providing access to this neighborhood from the west. Also notable is the Red Hill Avenue and Sequoia Drive intersection, which would need to be reconfigured to 1) modify existing left-turn lanes and 2) accommodate the alignment's transition from the median to mixed-flow lanes. While improving safety along the corridor, overall access is not reduced with these proposed closures due to U-turn availability, but travel time may be slightly longer for some users.

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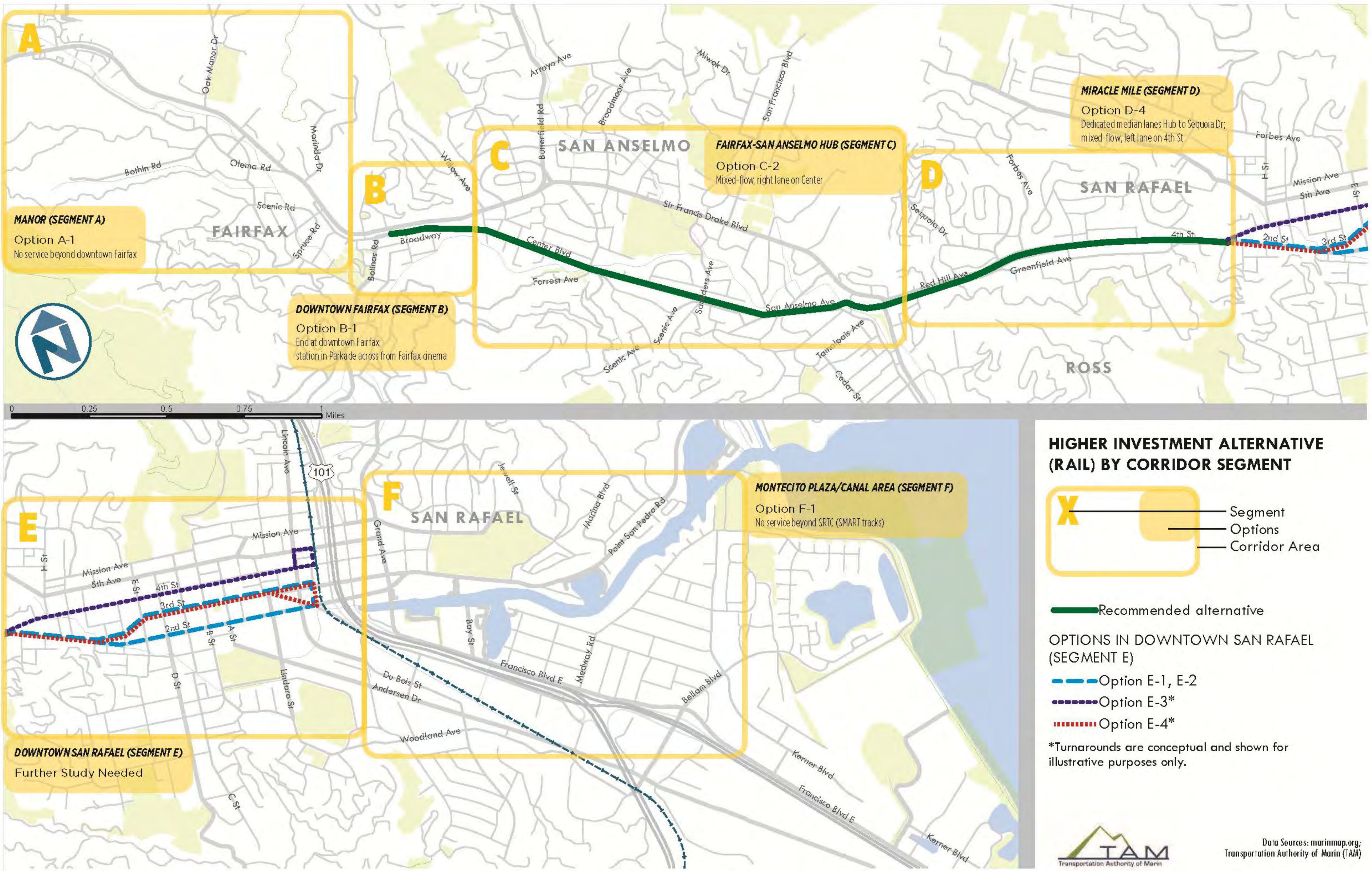
Figure 3-3 Higher Investment Alternative



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4 NEXT STEPS

The following items will be addressed in the next phase of this study.

- **Evaluate the multimodal impacts of draft alternatives**, particularly within the downtown San Rafael and Canal area segments. Use these findings to identify two final draft alternatives.
- **Confirm minimum lane widths and right-of-way limitations.** This set of draft alternatives is based on a combination of aerial photograph and/or GIS analysis and measurements, as well as high-level field observations. Further refinement of these alternatives must include confirming 1) the spatial requirements of transit vehicles and 2) the limitations of existing rights-of-way.
- **Identify additional low-cost strategies to improve speed and reliability.** Even a "no-build" alternative may include some capital improvements to enhance speed and reliability. For example, a corridor-wide reconsideration of the use of turning lanes, including allowing transit through-use, could be pursued at key locations. Notable locations include:
  - 4th Street at Ross Valley Drive
  - Sir Francis Drake Boulevard at Butterfield Road
  - Red Hill Avenue and Sequoia Drive (westbound)
  - Red Hill Avenue and Sir Francis Drake Boulevard (westbound)
- **Consider high-level improvements to key intersections and/or other pinch points**,[2] including:
  - *San Anselmo Hub* – there may be an opportunity for transit-only lanes or other treatments to improve transit service at this location.
  - *Red Hill Avenue & Sequoia Drive* – would require redesign of left turn lanes to enable median station stops and the transition from dedicated median lanes to left curbside mixed-lane operation for the Higher Investment alternative.
  - *4th Street & 2nd Street in San Rafael* – depending on the preferred alignment option in San Rafael and pending City staff input, the current intersection could be modified for improved transit operation and safety.
- **Evaluate implementation of transit signal priority (TSP) at key intersections.** (Given that east-west traffic is likely already given priority at many major corridor intersections, this may not be as effective as in peer systems.).
- **Identify potential locations for a streetcar maintenance facility, including track access and non-revenue routing to the facility.**

[2] Note: the scope of this project does not include redesigning intersections. Any improvements will be conceptual and/or planning-level recommendations.

Appendix E

Ridership Analysis

Transportation Authority of Marin

FAIRFAX-SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Ridership Analysis – Draft

August 2015

30TH

NELSON
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Table of Contents

Table of Figures

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1 INTRODUCTION

This report summarizes the ridership forecasts developed for the Farifax-San Rafael Corridor Transit Feasibility Study. Forecasts were developed for two different alternatives: a Low Investment Alternative and a High Investment Alternative. The Low Investment Alternative would use enhanced bus technology, and would be 5.85 miles from end to end, running between Fairfax and the Canal. The High Investment Alternative would use streetcar technology and would be 4 miles from end to end, running between Fairfax and the San Rafael Transit Center. More details on each alternative are provided in Section 2.

Many factors influence transit ridership including population and employment densities along the transit corridor, connecting transit, competing transit, vehicle technology, vehicle comfort, travel time, frequency of service, service span, reliability, ease of boarding, and other on-board or station area amenities. These factors were evaluated when developing the ridership forecasts for the two alternatives. The ridership forecasting methodology is described in more detail in Section 3.

Section 4 summarizes the ridership forecasting results and breaks down the results into different market segments including peak versus off-peak ridership, geographic markets, and transit dependent versus choice riders. Since the alignment of the Low Investment Alternative is longer than that of the High Investment Alternative, the section of the Low Investment Alternative running between Fairfax and the San Rafael Transit Center was evaluated separately in order to make an apples to apples comparison with the High Investment Alternative ridership forecasts. A summary of the daily ridership forecasts is provided in Figure 1-1.

Figure 1-1 Daily Ridership Forecasts

Alternative	Study Segment	Daily Boardings	Daily Boardings per Route Mile	Route Miles
Low Investment Alternative (partial route)	Fairfax – San Rafael Transit Center	1,400 – 1,800	180-230	8.0
High Investment Alternative (full route)	Fairfax – San Rafael Transit Center	1,690 – 2,200	210-270	8.0
Low Investment Alternative (full route)	Fairfax – The Canal	3,300 – 3,900	280 - 330	11.7

The High Investment Alternative is forecast to have between 1,690 – 2,200 daily boardings. This is approximately 22 percent higher than the ridership that would be expected if the same portion of the alignment were served by the Low Investment Alternative. Rail service is viewed as being more attractive than bus service, adding a certain rail attractiveness factor which can provide a bump in ridership. Research on ways to quantitatively measure this "bump" is limited. The ridership forecasts in this report incorporate a streetcar attractiveness factor based on an equivalent in-vehicle travel time reduction value (described in more detail in the following section). This represents the additional amount of travel time travelers would be willing to spend on a streetcar rather than on a bus or in a car. When forecasting ridership, this value was applied to the streetcar alternative, reducing the (perceived) travel time of travelers, and making the streetcar alternative more competitive with auto, thus shifting travelers in the corridor from car to streetcar and therefore "bumping" streetcar ridership. This factor was only applied for the streetcar mode, which explains why the High Investment Alternative has higher ridership forecasts than the Low Investment Alternative for this segment.

One major difference between the streetcar and enhanced bus modal options is that the streetcar tracks would not be able to cross the SMART tracks, thus preventing the streetcar from extending to the Canal area, while the enhanced bus could serve this area.

For the full alignment, the Low Investment Alternative is forecast to have 3,300 – 3,900 daily boardings. Ridership on this alignment is expected to be much higher because the route would serve the Canal area, which was identified in the travel market analysis as an area with high transit likelihood due to its density of households, low income residents and lower car ownership rates. Existing ridership data also confirms that transit ridership in this area is high, so it is expected that providing enhanced, more frequent service will attract many riders in this area, although many may be existing riders who would shift from using other services. Therefore, extension of service into the Canal area is seen as extremely beneficial from a ridership perspective.

These forecasts are in line with daily boardings per mile of similar existing systems. Streetcar systems in Little Rock, Memphis and Tampa have average daily boardings per route mile of 40-290. This is in the same range as the forecast daily boardings per route mile for the High Investment Alternative of 210-270. These boarding rates per route mile are lower than ridership levels seen on streetcars in Seattle, Portland and Tacoma. Streetcars in these three cities serve areas with much higher employment and residential densities as well as numerous activities centers or special generators.

Rapid bus routes operated by AC Transit (in Alameda and Contra Costa counties) and in Seattle have average daily boardings per route mile of 260-350. This is a similar range as the forecast daily boardings per route mile for the full alignment of the Low Investment Alternative of 280-330.

2 ALTERNATIVES EVALUATED

Two proposed transit alternatives were evaluated: a Low Investment Alternative and a High Investment Alternative. Alignment details for the two alternatives are summarized in Figure 2-1 below.

Figure 2-1 Alignment Details for Proposed Transit Alternatives

	Low Investment Alternative	High Investment Alternative
Route	Fairfax – Canal via Center Blvd. and 2nd / 3rd Streets in San Rafael	Fairfax – San Rafael via Center Blvd. and 4th Street in San Rafael
Route Length (round trip)	11.7 miles	8 miles
Goal	Express service within corridor, particularly downtown San Rafael	Circulator service within corridor, particularly downtown San Rafael
Stop Spacing	Between 0.5 – 1 mile	~ 0.25 – 0.5 miles (closer together in downtown San Rafael
Stop Locations	▪ Downtown Fairfax ▪ Saunders Ave & Center Blvd (Yolanda Station) – for SFD HS ▪ San Anselmo Hub ▪ Ross Valley Dr/Crescent Dr & 4th St ▪ C St & 2nd/3rd Sts ▪ SRTC ▪ Bellam & Francisco (bus only) ▪ Kerner & Fairfax " " ▪ Canal & Sonoma " " ▪ Medway & Francisco " " ▪ SRTC & return	▪ Downtown Fairfax ▪ Center Blvd & Pastori Ave ▪ Center Blvd & San Anselmo Ave (Lansdale Station) ▪ Center Blvd & Saunders Ave (Yolanda Station) ▪ San Anselmo Hub ▪ Red Hill Ave & Sequoia Dr ▪ 4th St & Ross Valley Dr/Crescent Dr ▪ 4th St & Greenfield Ave ▪ 4th St & H St ▪ 4th St & E St ▪ 4th St & C St ▪ 4th St & A St ▪ SRTC
Dedicated Lane Locations	None	Red Hill Avenue between Hub intersection and Sequoia Drive
Queue Jump Lane Locations (tentative)	Hub intersection	Hub intersection
Transit Signal Priority Locations (tentative)	Hub intersection	All major signalized intersections along alignment: Claus & SFD, Hub intersection, Red Hill Ave & Sequoia Dr, 4th & Ross Valley Drive, 4th & Greenfield Ave, 4th & 2nd , 4th & H Sts, 4th & E Sts, 4th & D Sts, 4th & C Sts, 4th & B Sts, 4th & A Sts, 4th & City Plaza, 4th & Lootens, 4th & Cijos, 4th & Lincoln

A key difference between the low and high investment alternatives evaluated in the ridership analysis are that the Low Investment Alternative would use enhanced bus transit technology while the High Investment Alternative would use streetcar technology. The tracks of the High Investment, streetcar, Alternative would not be able to cross the SMART tracks at the San Rafael Transit Center (SRTC). Therefore, the High Investment Alternative has a shorter alignment with a round trip length of 8 miles and does not serve the Canal area. The Low Investment, enhanced bus, Alternative does serve the Canal area and therefore has a longer alignment of 11.7 miles round trip.

Many factors influence transit ridership including population and employment densities along the transit corridor, connecting transit, competing transit, vehicle technology, vehicle comfort, travel time, frequency of service, service span, reliability, ease of boarding, and other on-board or station area amenities. A comparison of these factors between the two alternatives is provided in Figure 2-2.

Figure 2-2 Factors that Influence Ridership for Proposed Transit Alternatives

	Low Investment Alternative	High Investment Alternative
Population and Employment Density	Higher – longer route, includes Canal (higher ridership potential)	Lower – shorter route, does not include Canal
Connecting Transit	SMART, Marin Transit, Golden Gate Transit	SMART, Marin Transit, Golden Gate Transit
Competing Transit	More competing transit between SRTC and the Canal, which is already well-served by transit	Some competing transit but at very low frequencies
Vehicle Comfort	Good comfort level	High comfort level (higher ridership potential)
Vehicle Technology	Enhanced bus	Streetcar (higher ridership potential)
Stations	Lower investment in station design, wayfinding and amenities	Higher quality station design, wayfinding and amenities (higher ridership potential)
Fare Payment	On-board fare payment only	Both on-board and off-board fare payment options (higher ridership potential)
Ease of Boarding	Near-level boarding	Level boarding (higher ridership potential)
Travel Time	No major differences between alternatives	
Frequency	No major differences between alternatives – 4 transit vehicles/hour (15 minute headways)	
Service Span	No major differences between alternatives	

As discussed, a major difference between the alternatives is that the low investment alternative will serve the Canal area, which currently has a much higher demand for transit than the rest of the corridor. This larger service territory will therefore increase the ridership potential of the low investment alternative.

Both alternatives have a similar level of connecting transit and will both serve as a connection point to SMART at the SRTC, which will increase ridership potential. Competing transit is discussed in more detail in the following section. Some competing transit currently serves the corridor between Fairfax and the SRTC, particularly Marin Transit Route 23, however current service frequencies along this portion of the corridor are much lower (60 min headways) compared to the proposed transit alternatives which would provide 15 minute headways. The increase in service frequency would increase ridership potential for both alternatives. However, the segment of the corridor between the SRTC and the Canal, which would only be served by the low investment alternative, is currently well-served by transit, so the added service would have a smaller proportional impact on increasing ridership.

The high investment alternative would have several attributes making it more attractive than the low investment alternative, including: higher level of vehicle comfort; more attractive vehicle technology (streetcar); higher quality station design, wayfinding and amenities; off-board fare payment; and easier boarding. These attributes and their relative influence on ridership were considered in the ridership analysis as described in Section 3.

While the High Investment Alternative provides several measures to reduce travel time, including transit only lanes, queue jump lanes, and transit signal priority, it also has more stops between Fairfax and the SRTC than the Low Investment Alternative. Adding stops would increase travel time across the corridor. Therefore the travel time enhancement measures applied along the High Investment Alternative would balance the increased travel time due to more frequent stops of the High Investment Alternative. The net effect is that the travel time between the two alternatives would be comparable. Therefore no ridership increases due to travel time savings were applied to either alternative.

Similarly, while increases in service span (hours per day the transit service is in operation) would increase ridership potential, since both alternatives would provide the same service span, no increases in ridership due to service span were applied to either alternative.

3 DESCRIPTION OF METHODOLOGY

The ridership forecasting analysis builds off of the travel market analysis conducted for the travel market assessment and existing ridership data from Marin Transit and Golden Gate Transit. The analysis used outputs from the MTC Model to evaluate both overall travel and transit travel along the study corridor. Transit travel estimates were then compared to existing transit demand in order to make adjustments to the initial model results. Transit trips were then assigned to each alternative, taking into consideration connecting and competing transit. Ridership forecasts were then adjusted to account for the increased frequency of the new alternatives and other enhancements or amenities such as added comfort, more attractive vehicle technology, ease of boarding, and off-board fare payment. Each of these steps are described in more detail below.

REVIEW OF EXISTING RIDERSHIP

Various sections of the study corridor are currently served by several Golden Gate Transit and Marin Transit routes. Figure 3-1 shows a map of transit routes operating in the project vicinity. Golden Gate Transit, the regional transit provider, offers several routes providing service connecting the study area to San Francisco and the East Bay. These routes and the average daily weekday riders per route are summarized in Figure 3-2.

Five Marin Transit routes operate along the study corridor. Figure 3-3 summarizes these routes, daily riders on each route, and estimated riders boarding within the study corridor, based on on-board survey data provided by Nelson\Nygaard (CTMA Survey Data, 2013).

Route 22 provides service along the study corridor between the SRTC and San Anselmo, and connects to Marin City, south of the study area. Based on analysis of the on-board survey data, it is estimated that just over 60 percent of daily riders on this route board within the study corridor. The majority of these riders travel between the study corridor and Marin City.

Route 23 provides service along the entire study corridor between Fairfax and the Canal. Of the total daily ridership approximately 400 are riders using the school tripper service to While Hill Middle School.[1] The remainder of riders have both a boarding and alighting within the study corridor.

Route 29 provides service between the SRTC and the Canal and between San Anselmo and Fairfax. It is estimated that nearly 70 percent of daily riders on this route board within the study corridor. While some of these riders are likely to be traveling between the SRTC and the Canal, the majority of riders boarding within the corridor are estimated to be traveling to locations outside the study corridor.

Route 35 offers exclusive service between the SRTC and the Canal. Service is provided throughout the day and at 15 minute headways during peak hours. Demand for this service is high, as is

[1] Robert Betts, Marin Transit

demonstrated by the fact that ridership on this route is higher than the other four Marin Transit routes providing service within the study corridor, despite the route length being the shortest of the five routes reviewed. All of these riders have both a boarding and alighting within the study corridor.

Route 36 provides peak hour only service connecting the SRTC, the Canal and Marin City. Approximately half of daily riders on this route are estimated to board within the study corridor, but the majority of these are likely traveling between the study corridor and Marin City or other destinations south of the study corridor. Some riders may use this service to travel between the SRTC and the Canal, but this connection is more frequently served by Route 35.

Overall it is estimated that approximately 400 - 600 current daily transit riders have both an origin and destination within the study corridor between Farifax and the SRTC. It is estimated that fewer than 200 daily riders travel between the Canal and the western part of the corridor (Farifax to Miracle Mile). An estimated 2,100 – 2,400 daily riders (the majority of riders traveling within the corridor) are estimated to be traveling between the SRTC and the Canal. This includes all 1,800 daily riders on Route 35 plus 300 – 600 daily riders on other routes connecting the two areas.

Figure 3-1 Existing Transit Routes in Project Vicinity

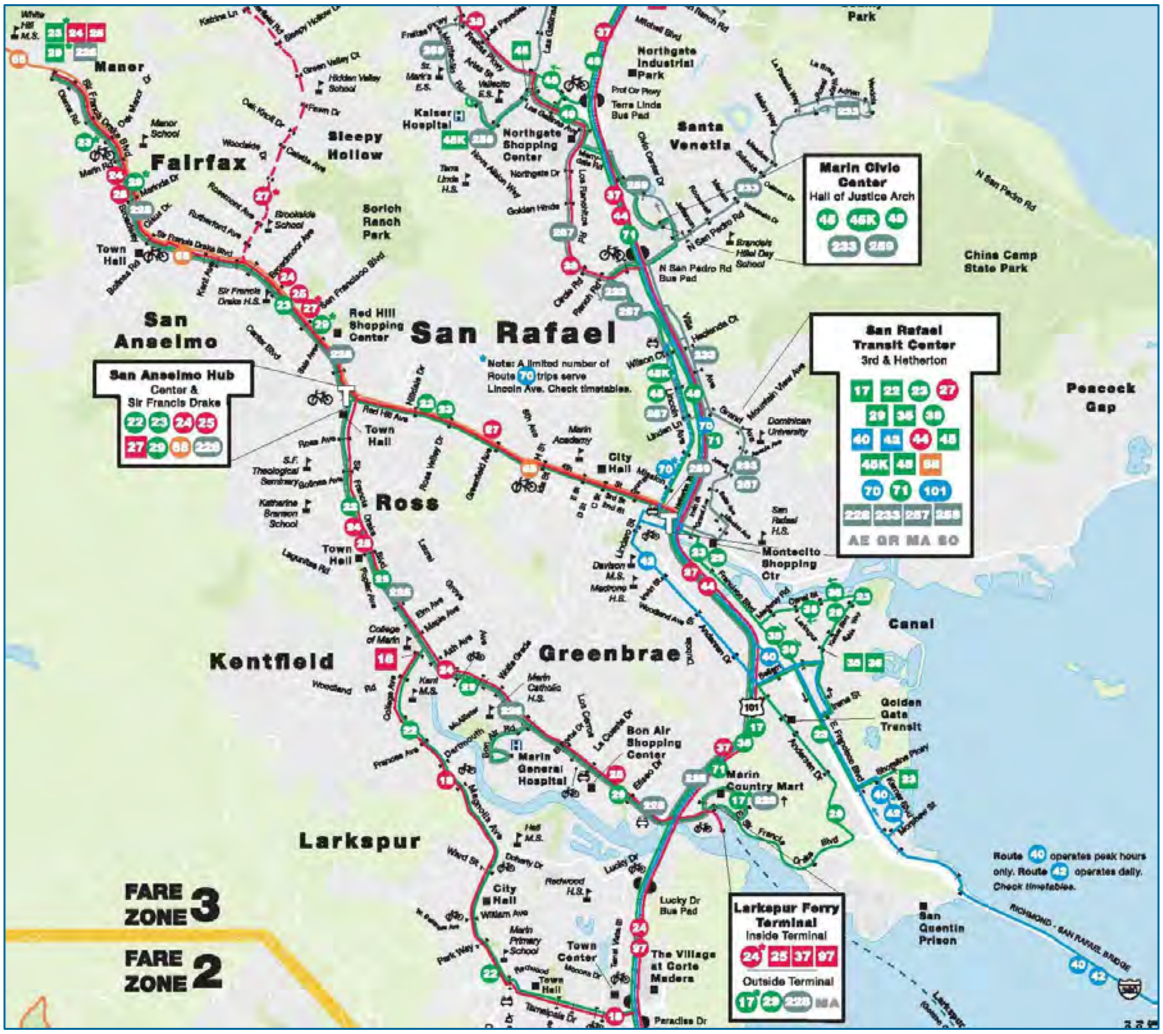


Figure 3-2 Golden Gate Transit Routes Serving Study Corridor

Route	Type	Description	Weekday Daily Riders
To San Francisco			
24	Commute	Fairfax – San Francisco (via Sir Francis Drake, Hwy. 101)	750
25	Shuttle	Fairfax – Larkspur Terminal (via Sir Francis Drake)	150
27	Commute	San Anselmo – San Francisco (via SRTC)	400
44	Commute	Lucas Valley – San Francisco (via SRTC)	100
70	Regional	Novato-SRTC-San Francisco (via Highway 101)	2,150
101	Regional	Santa Rosa-Novato-SRTC-San Francisco (via Highway 101)	1,500
To East Bay			
40	Regional	SRTC-Del Norte BART	200
42	Regional	SRTC-Del Norte and Richmond BART	700

Source: Golden Gate Transit Short Range Transit Plan FY 2015-2024

Figure 3-3 Marin Transit Routes Serving Study Corridor

Route	Description	Average Weekday Peak Frequency (headway)	Total Daily Riders	Daily Riders Boarding in Corridor
22	Corte Madera-San Anselmo Hub-SRTC	30 min	930	600
23	Fairfax (Manor)-SRTC-Canal	60 min	1,060	650
29	Fairfax (Manor)-Larkspur Ferry Terminal-Canal-SRTC	30 min	880	600
35	SRTC-Canal	15 min	1,800	1,800
36	SRTC-Canal-Marin City	30 min	410	205

Source: Marin Transit System Performance Summary for FY 2013-14

MTC MODEL TRANSIT TRAVEL ESTIMATES

The MTC Model is an activity-based travel demand model, developed for the nine-county San Francisco Bay Area by the Metropolitan Transportation Commission (MTC) in 2005. The model estimates trips throughout the region by various modes of travel, including transit. The model is sensitive to multiple factors including population and employment, auto ownership rates, demographics (age, income level, household size, etc.), and transit network connections. The MTC Model estimates travel between Traffic Analysis Zones (TAZs). The nine-county Bay Area is represented by 1454 TAZs. The study area was divided into areas for analysis based on the TAZ definitions in the MTC Model.

The study corridor was divided into the following five catchment areas: 1) Fairfax, 2) San Anselmo, 3) Miracle Mile, 4) San Rafael, and 5) Canal. The remainder of the region was divided into the following five areas: 1) SMART Station Areas North of the Study Corridor, 2) Other Northern Marin and Sonoma County, 3) South Marin County, 4) San Francisco and San Mateo Counties, 5) East Bay. Figure 3-4 provides a map of the zone definitions. Travel between each of these areas was evaluated using the 2040 RTP version of the model with the SMART system in place. It should be noted that SMART planning has gone through several iterations and the version of SMART coded in the 2040 RTP scenario may not be the latest preferred alternative of SMART.

Both overall trips and transit trips were analyzed. Transit trips would primarily be taken by Marin Transit, Golden Gate Transit and SMART. Travel during both peak and off peak periods was evaluated. Peak period travel would represent primarily commute trips and would have a higher share of choice riders who choose to take transit but have other options available. Off peak trips tend to have a higher share of transit dependent riders.

DEVELOPMENT OF MTC MODEL ADJUSTMENT FACTORS

As discussed in the Travel Market Assessment, the MTC Model tends to underestimate transit trips in the study area. Therefore existing Marin Transit and Golden Gate Transit ridership in the study corridor were analyzed and compared to MTC Model results for transit ridership. Adjustment factors were developed to account for these differences. These adjustment factors were applied to transit trip forecasts produced by the 2040 MTC Model. While the adjustment factors were developed based on Marin Transit and Golden Gate Transit ridership, the same factors were applied to SMART ridership since it was assumed that the model would systematically under predict SMART ridership similar to how it under predicted Marin Transit and Golden Gate Transit Ridership.

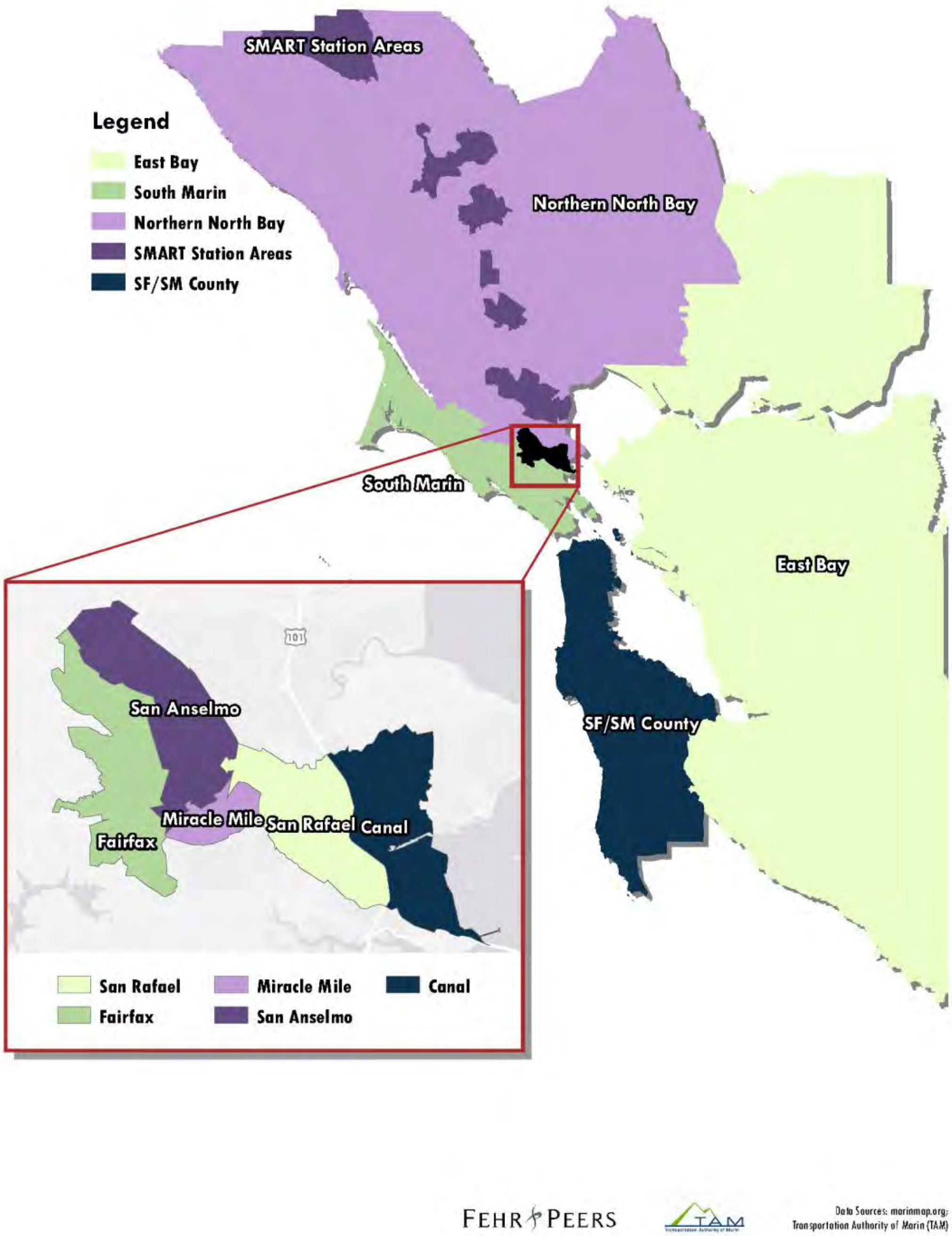
TRANSIT ASSIGNMENT TO ALTERNATIVES

The adjusted transit trips produced by the MTC Model were then assigned to the study corridor under two scenarios separately. The first assignment assumed the study corridor will extend from Fairfax to the Canal, as would be the case with the enhanced bus Low Investment Alternative. The second assignment assumed the study corridor will extend from Fairfax to the SRTC, as would be the case with the streetcar High Investment Alternative. The assignment considered other competing transit routes which might share demand with the new alternative. For assignment purposes it was assumed that Marin Transit Route 23 would be replaced by the new alternative. The assignment also considered connecting transit transfer opportunities. For example, riders with an origin along the study corridor and a destination near a SMART Station were assumed to take the new alternative to the SRTC and then transfer to SMART.

ENHANCED TRANSIT ADJUSTMENT FACTORS

The results of the analysis described above were estimates of the number of transit trips along each of the two proposed alternatives corridors, assuming the transit network included in the 2040 RTP version of the MTC Model. This version includes SMART, but does not include the increased transit frequencies or other premium transit service enhancements which would be provided by the two proposed alternatives. Therefore adjustments were made to these initial ridership forecasts to account for these service enhancements.

Figure 3-4 Study Area Zones



Frequency Adjustments

Current transit service along the study corridor operates at approximately 60 minute headways between Fairfax and the SRTC. More transit service is provided between the SRTC and the Canal, offering higher frequencies. The proposed alternatives would operate at 15 minute headways, increasing the frequency of transit service along the corridor, particularly in the segment between Fairfax and San Rafael. As discussed, the Low Investment Alternative would provide service between Fairfax and the Canal, while the High Investment Alternative would provide service between Fairfax and the SRTC.

Research on the impact of transit frequency changes on ridership have shown that transit headway elasticities of ridership can vary between -0.2 and-0.8, meaning that as headways (the time between bus arrivals) decrease by 10 percent, ridership can increase between 2-8 percent.[2] Various factors can influence where within this range a transit system might fall. For example, research indicates a greater sensitivity to transit frequency changes in cases where prior service was infrequent. A transit headway of ridership elasticity of -0.4 was applied to the ridership forecasts on the segment between Fairfax and the SRTC, and an elasticity of -0.2 was applied to the segment of the corridor between the SRTC and the Canal, to account for the increased ridership potential due to the more frequent service provided by the proposed alternatives.

Premium Transit Service Adjustments

Research has also found that other characteristics of premium transit services beyond travel time and cost can affect mode choice.[3] Findings indicate that providing enhanced transit characteristics can encourage some travelers to shift from driving to transit, thus increasing ridership potential. Research documented in TCRP 166 evaluated several premium transit service characteristics based on the metric of in vehicle travel time equivalents. This metric equates to the additional amount of travel time travelers would be willing to spend on transit in order to have transit service with the premium characteristic. Various characteristics were studied, and the range of travel time equivalents for each was documented. Commute trips and non-commute trips were evaluated separately since certain transit service attributes may have a different impact on the commuter market versus the non-commuter market. Figure 3-5 summarizes the range of values for equivalent minutes of in-vehicle travel time found through the TCRP 166 research, for both commute trips and non-commute trips, for the premium transit attributes that would be in place for the High Investment Alternative. Compared to the Low Investment Alternative, the High Investment Alternative would have higher quality stations, higher on-board seating comfort, enhanced wayfinding, easier boarding, and off-board fare payment available.

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[2] TCRP (Transit Cooperative Research Program) 95, Transit Scheduling and Frequency: Traveler Response to Transportation System Changes. Transportation Research Board, Washington DC, 2004.

[3] TCRP 166, Characteristics of Premium Transit Services that Affect Choice of Mode. Transportation Research Board, Washington DC, 2014.

Figure 3-5 Importance of Premium Transit Service Attributes (equivalent minutes of in-vehicle travel time)

Attribute	Commute Trips	Non-Commute Trips
Station/Stop Security	0.6 – 0.88	0.22 – 1.56
Station/Stop Shelter	0.64 – 1.1	0.37 – 1.57
On-Board Seating Comfort	0.51 – 0.77	0.41 – 1.39
Route Name/Number Identification	0.57 – 0.63	0.58 – 1.23
Ease of Boarding	0.08 – 0.21	0.25 – 3.02
Off-Board Fare Payment	0.60 – 0.78	0.72 – 1.40

Source: TCRP 166

From this analysis we can see that the perceived benefits of the premium transit attributes are much more variable for the non-commuter market than for the commuter market. Commuters tend to value station enhancements and off-board fare payment slightly more highly than on-board seating comfort and wayfinding information. However, for commuters, on average, each of these categories had an equivalent in-vehicle travel time of just under a minute. Ease of boarding, which can be enhanced through low-floor, or platform level vehicles, had a much lower in-vehicle travel time equivalent for commuters, of just under 10 seconds on average. Non-commuters, on the other, hand, valued ease of boarding much more highly, on average, with an average in-vehicle travel time equivalent of just over a minute and a half. The value of other attributes varied, but on average were valued slightly higher for non-commuters than for commuters at around one minute per attribute. For our analysis we used an average of the high and low values from each category to estimate the equivalent minutes of in-vehicle travel time when evaluating mode shift.

The TCRP 166 research did not evaluate the impact of transit technology on mode shift. However, other sources have suggested that rail transit is likely to attract significantly more riders than equivalent bus service.[4] Based on evidence from these sources and the range of values documented in TCRP 166 for non-traditional transit service attributes, the streetcar mode technology was given an in-vehicle travel time equivalent of 5 minutes. This means travelers would be willing to spend an extra 5 minutes on transit if the transit mode is streetcar.

Research on the influence of reduced transit travel time on travelers' willingness to shift to transit was also evaluated in order to measure the increase in transit ridership resulting from the premium transit attributes. For each origin-destination (OD) pair along the route, the transit mode share was calculated as the share of all travel between that OD pair which would use the High Investment Alternative, after applying the frequency adjustment discussed above. The transit travel time for each OD pair was calculated and then reduced by the equivalent in vehicle travel time reductions (perceived travel time reductions) which would be realized by the premium transit service enhancements for the High Investment Alternative. The reduced transit travel time, relative to the auto travel time for the same OD pair, was then used to estimate the resulting mode shift from auto to transit. The mode shift was converted into additional transit trips on the High Investment Alternative due to the premium characteristics of the service.

[4] Tennyson, Edson, Impact on Transit Patronage of Cessation or Inauguration of Rail Service, Transportation Research Record 1221, Washington DC, 1986.

4 RESULTS AND DISCUSSION

This chapter summarizes the ridership forecasts. First overall ridership forecasts are presented. These forecasts are then broken down by market segment including peak versus off-peak, geographic markets, and transit dependent versus choice riders. Finally, ridership benefits to the overall corridor are discussed.

RIDERSHIP FORECASTS

Figure 4-1 summarizes the ridership forecasts for the two alternatives. Since the Low Investment Alternative has a longer alignment than the high investment alternative, the ridership on the segment between Fairfax and the SRTC are compared for both alternatives in order to provide an apples to apples comparison. The full ridership of the entire Low Investment Alternative alignment is also provided.

The High Investment Alternative is forecast to have 1,690 – 2,200 daily boardings, and 210 – 270 daily boardings per route mile. For just the segment between Fairfax and the SRTC, the High Investment Alternative is expected to have about 22 percent higher ridership than the Low Investment Alternative. However, serving the Canal area would more than double ridership on the Low Investment Alternative. Transit demand in the Canal area is already high, and the opening of the SMART station at the SRTC will increase transit demand between the Canal and the SRTC. Although the segment between the SRTC and the Canal is already well-served by transit, the Low Investment Alternative would provide a high frequency, attractive alternative and would therefore attract a substantial share of that ridership.

Figure 4-1 Daily Ridership Forecasts

Alternative	Study Segment	Daily Boardings	Daily Boardings per Route Mile	Route Miles
Low Investment Alternative (partial route)	Fairfax – San Rafael Transit Center	1,400 – 1,800	180-230	8.0
High Investment Alternative (full route)	Fairfax – San Rafael Transit Center	1,690 – 2,200	210-270	8.0
Low Investment Alternative (full route)	Fairfax – The Canal	3,300 – 3,900	280 - 330	11.7

Comparison to Direct Ridership Forecasting Technique

Fehr & Peers has also conducted extensive research on direct ridership forecasting methods for forecasting transit ridership. Direct ridership forecasting models are based on regression analysis, which measures empirical relationships through statistical analysis of station ridership and local station service characteristics. They are used to predict ridership at individual stations based on local station area and system characteristics. Fehr & Peers used data from three existing streetcar systems in Seattle, Portland, and Tacoma, to develop three direct ridership forecasting models specific to streetcar systems. The following factors were found to have an influence on streetcar ridership, and variables from these categories are included in the models: line configuration, system characteristics, transit network connectivity, built environment factors, and special generators. More details on these models can be found in the article "Factors that Influence Urban Streetcar Ridership in the United Stations" in *Transportation Research Record* Issue Number 2353, 2013. The three models discussed in the article were applied to the High Investment Alternative alignment, and the models predicted average daily boardings for the streetcar alternative to be in the range of 1,640 – 2,310. This matches almost exactly with the range of values forecast through the process described in Section 3. This helps to confirm that the ridership forecasts are reasonable given the characteristics of the corridor.

Comparison to Existing Transit Systems

Figure 4-2 provides a summary of ridership on existing streetcar and enhanced bus lines as a comparison to show the levels of ridership comparable systems have experienced. High density streetcar corridors with multiple activity centers, such as those in Portland, Seattle, and Tacoma, can reach ridership levels as high as 1,500 daily boardings per route mile. The Fairfax to SRTC corridor, however, has much lower densities and fewer activity centers. The ridership forecasts for the High Investment (streetcar) Alternative are within the range of boardings per mile reported by similar, low density streetcar corridors, such as those in Little Rock, Memphis and Tampa.

Bus Rapid Transit (BRT) systems with rail-like qualities such as dedicated lanes and level boarding, tend to generate higher ridership than rapid or enhanced buses, particularly when operating in high density corridors. The boardings per mile for the full alignment of the Low Investment (enhanced bus) Alternative falls in line with ridership levels of existing rapid bus systems, such as those in Seattle and those operated by AC Transit.

Figure 4-2 Ridership on Existing Transit Systems

Mode	Description	Lines	Daily Average Boardings per Route Mile
Streetcar	Modern streetcars, high density corridors	Portland, Seattle, Tacoma	1,040 – 1,500
Streetcar	Historic streetcars, low density corridors	Little Rock, Memphis, Tampa	40 – 290
BRT	Dedicated lanes, enhanced buses and stops	Cleveland, Eugene, LA Orange Line	600 – 1,800
Rapid Bus	Enhanced buses and stops, longer routes (16-30 route miles)	AC Transit; Seattle	260 - 350

MARKET SEGMENTS

Ridership forecasts were broken down by various market segments in order to get a better idea of ridership differences by time of day and by location.

Peak vs. Off-Peak

Transit ridership is generally highest during peak periods, primarily because these are the times when most people are commuting to or from work. Most Golden Gate Transit service is actually only in operation during peak periods, with a heavy focus on serving the commuter market between the North Bay and San Francisco. Marin Transit service has historically been less commuter-focused, and rider surveys have found that a higher share of Marin Transit riders have a trip purpose other than work, than for Golden Gate Transit riders.[5]

However, the enhanced transit features of the proposed alternatives and higher service frequencies, paired with the opening of SMART are expected to increase the commuter market and peak period ridership along the corridor. As transit service along the corridor is improved, more commuters are expected to shift from driving to taking transit. Furthermore, the opening of SMART will provide a more attractive transit alternative to driving for commute trips between the SMART corridor and the study corridor. The proposed alternatives would provide a first or last mile connection with SMART at the SRTC.

Figure 4-3 summarizes the peak and off-peak period ridership on the two alternatives. The peak period includes both the AM peak period (6-10AM) and the PM peak period (4-8PM). For both the low and high investment alternative on the study segment between Fairfax and the SRTC, approximately 76 percent of daily boardings are expected to occur during these peak periods, which include eight hours of the day. For the full alignment of the Low Investment Alternative, approximately 72 percent of daily boardings are expected to occur during the peak period.

Figure 4-3 Peak vs. Off-Peak Ridership

Alternative	Study Segment	Peak Period Boardings (6-10AM and 4-8PM)	Off-Peak Boardings (10AM-4PM and after 8PM)
Low Investment Alternative	Fairfax – San Rafael Transit Center	1,100 – 1,400	320 - 430
High Investment Alternative	Fairfax – San Rafael Transit Center	1,300 – 1,650	390 – 520
Low Investment Alternative	Fairfax – The Canal	2,400 – 2,800	940 – 1,100

Geographic Markets

Geographic markets were evaluated in order to evaluate where people would travel to and from and to get a sense of the overall transit market share and the transit market share of the proposed alternatives. The geographic markets evaluated were: 1) within the study corridor meaning riders have both an origin and destination within the study corridor, 2) between the SMART corridor

[5] Marin Transit 2012 Systemwide Onboard Survey, Golden Gate Transit 2013 Passenger Study Final Survey Findings Report

and the study area, 3) between San Francisco and the study area, and 4) between the East Bay and the study area.

For each geographic market, all trips being made by transit on any provider (including Marin Transit, Golden Gate Transit and SMART) were reviewed and compared to all travel between those geographic market areas in order to estimate the share of travel that would be made on transit. The share of overall transit which would be made on the proposed alternatives was also reviewed and compared to all travel in order to estimate the alternative's share of overall travel for each geographic market. These results are summarized in Figure 4-4 and Figure 4-5.

Figure 4-4 summarizes the results for the entire alignment of the Low Investment Alternative from Fairfax to the Canal. For trips with both an origin and destination within the study corridor, approximately 3,500 are forecast to be made on transit, which about 2 percent of all trips. About half of these transit trips would be on the Low Investment Alternative. The other half of transit trips would be made on one of the other transit routes serving the area, most of which would likely be on Marin Transit Route 35, which would serve the high demand corridor between the SRTC and the Canal and at the same frequency as the Low Investment Alternative. Therefore riders traveling between these two locations would likely take which ever vehicle comes first once they arrive at the stop.

Between SMART station areas and the study corridor, approximately 3,600 daily trips are forecast to be made on transit, which is about 18 percent of all trips. This high transit share indicates the high level of competitiveness SMART has with auto. Approximately 35 percent of these transit trips are forecast to be made on the Low Investment Alternative, nearly all of which would be expected to use the Low Investment Alternative as a first or last mile connection, transferring to or from SMART at the SRTC.

Between San Francisco and the study corridor, approximately 5,500 daily trips are forecast to be made on transit, which is about 24 percent of all trips. This high transit share indicates the high level of competitiveness between Golden Gate Transit and auto. Approximately 9 percent of these transit trips are forecast to be made on the Low Investment Alternative, nearly all of which would be expected to use the Low Investment Alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor could likely board a Golden Gate Transit route directly without needing to transfer.

Between the East Bay and the study corridor, approximately 1,150 daily trips are forecast to be made on transit, which is about 4 percent of all trips. This low transit share indicates the low level of competitiveness between Golden Gate Transit and auto between these locations. Approximately 6 percent of these transit trips are forecast to be made on the Low Investment Alternative, nearly all of which would be expected to use the Low Investment Alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor would likely either board a Golden Gate Transit route directly without needing to transfer or would not take transit if a transfer were needed.

Figure 4-4 Geographic Market Share: Low Investment Alternative

Geographic Market	Description	All Transit Providers	Low Investment Alternative
Within Study Corridor	Daily transit trips with both an origin and destination within the study corridor	3,500	1,700 – 1,900
	Share of all trips with both an origin and destination within the study corridor	2%	1%
SMART Station Areas	Daily transit trips between study corridor and SMART Station areas	3,600	1,200 – 1,300
	Share of all trips between study corridor and SMART Station areas	18%	6%
San Francisco	Daily transit trips between study corridor and San Francisco	5,500	300 – 700
	Share of all trips between study corridor and San Francisco	24%	2%
East Bay	Daily transit trips between study corridor and East Bay	1,150	50-90
	Share of all trips between study corridor and East Bay	4%	0.3%

* Study corridor includes the Canal

Figure 4-5 summarizes the results for the alignment of the High Investment Alternative from Fairfax to the SRTC. For trips with both an origin and destination within the study corridor, approximately 800 are forecast to be made on transit, which about 1 percent of all trips. The majority, about 80 percent of these transit trips, would be on the High Investment Alternative.

Between SMART station areas and the study corridor, approximately 2,200 daily trips are forecast to be made on transit, which is about 18 percent of all trips. This high transit share indicates the high level of competitiveness SMART has with auto. Approximately 34 percent of these transit trips are forecast to be made on the High Investment Alternative, nearly all of which would be expected to use the High Investment Alternative as a first or last mile connection, transferring to or from SMART at the SRTC.

Between San Francisco and the study corridor, approximately 4,200 daily trips are forecast to be made on transit, which is about 25 percent of all trips. This high transit share indicates the high level of competitiveness between Golden Gate Transit and auto. Approximately 10 percent of these transit trips are forecast to be made on the High Investment Alternative, nearly all of which would be expected to use the High Investment Alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point. This number is fairly low, since most riders in the corridor could likely board a Golden Gate Transit route directly without needing to transfer.

Between the East Bay and the study corridor, approximately 550 daily trips are forecast to be made on transit, which is about 4 percent of all trips. This low transit share indicates the low level of competitiveness between Golden Gate Transit and auto between these locations.

Approximately 17 percent of these transit trips are forecast to be made on the High Investment Alternative, nearly all of which would be expected to use the High Investment Alternative as a first or last mile connection, transferring to or from a Golden Gate Transit route at a transfer point.

Figure 4-5 Geographic Market Share: High Investment Alternative

Geographic Market	Description	All Transit Providers	High Investment Alternative
Within Study Corridor	Daily transit trips with both an origin and destination within the study corridor	800	600 – 700
	Share of all trips with both an origin and destination within the study corridor	1%	1%
SMART Station Areas	Daily transit trips between study corridor and SMART Station areas	2,200	720 – 760
	Share of all trips between study corridor and SMART Station areas	18%	6%
San Francisco	Daily transit trips between study corridor and San Francisco	4,200	300 – 590
	Share of all trips between study corridor and San Francisco	25%	3%
East Bay	Daily transit trips between study corridor and East Bay	550	70 – 120
	Share of all trips between study corridor and East Bay	4%	0.7%

* Study corridor does not include the Canal

Transit Dependent vs. Choice Riders

What are commonly referred to as choice riders are those riders who have an alternative to taking transit (typically auto) but choose to take transit. Transit dependent riders, on the other hand, are those who are largely dependent on transit. Transit dependency of Marin Transit was evaluated in the Travel Market Assessment based on responses of riders to an on-board survey. According to the survey, approximately 47 percent of Marin Transit Route 23 riders do not have an alternative to transit for trips made on transit, and 37 percent do not have access to a car. Furthermore, 75 percent of Route 23 riders are low income, earning less than $50,000 per household. These results show that a large share of current transit riders in the study corridor are transit dependent. It is likely that most transit dependent riders are already using the services available and that enhancements to this service may not be able to attract a large number of new transit dependent riders. However, service enhancements would have the potential to attract more choice riders to shift from driving to taking transit.

In order to estimate the number of choice versus transit dependent riders on the new alternatives, we assumed that 70 of riders, before enhancements, are transit dependent. Remaining riders and riders gained through frequency and premium service enhancements would be choice riders.

Table 4-6 summarizes the number of transit dependent and choice riders on each alternative. While currently, at baseline, we estimate that about 30 percent of daily riders are transit dependent (either have no alternative to transit, not access to a car, or are low income), under the High Investment Alternative it is expected that the percent of daily riders who are choice riders would increase to approximately 52 percent. Across the full length of the Low Investment Alternative, it is expected that the percent of riders who are choice riders would increase to 38 percent of daily riders.

Figure 4-6 Transit Dependent vs. Choice Ridership

Alternative	Study Segment	Choice Rider Daily Boardings	Transit Dependent Rider Daily Boardings
Low Investment Alternative	Fairfax – San Rafael Transit Center	600 - 800	800 – 1,050
High Investment Alternative	Fairfax – San Rafael Transit Center	850 – 1,200	800 – 1,050
Low Investment Alternative	Fairfax – The Canal	1,250 – 1,500	2,050 – 2,400

CORRIDOR RIDERSHIP BENEFITS

Provision of enhanced transit service would have benefits for the entire transit corridor. The new service would not only provide benefits to existing riders, but would also attract new riders and increase ridership on other transit services by providing better connections. This section describes the net new riders expected on the corridor, and the ridership benefits to Golden Gate Transit service.

Total New Transit Trips

Many of the riders served on the two alternatives would be existing riders who would shift from taking the current Marin Transit 23 (which is assumed to be discontinued with implementation of either proposed alternative) or from other existing routes. However, the enhanced service would also attract new riders who would shift from driving to taking transit. Figure 4-7 summarizes the net new transit riders forecast to be generated by the new service. The Low Investment Alternative is expected to generate 380-460 new transit trips per day. The High Investment Alternative is expected to generate 520 – 680 new transit trips per day.

Figure 4-7 New Transit Trips Generated

Alternative	Net New Transit Trips
Low Investment Alternative	380 – 460
High Investment Alternative	520 - 680

Benefits to GGT Routes

Many riders would use the proposed alternatives to connect to Golden Gate Transit. Figure 4-4 and Figure 4-5 show the number of trips on each alternative that would be traveling between the study corridor and San Francisco and between the study corridor and the East Bay. Nearly of of these trips would be expected to include a transfer to Golden Gate Transit in order to reach San Francisco or the East Bay. Many of these would be existing riders who are currently making this trip. Figure 4-8 shows the new riders expected to be riding Golden Gate Transit as a result of the enhanced transit service on the proposed alternatives. Golden Gate Transit could expect 50-100 additional daily boardings on San Francisco routes with the Low Investment Alternative and 10-20 additional daily boardings on East Bay routes. With the High Investment Alternative, Golden Gate Transit could expect 90-190 additional daily boardings on San Francisco routes and 30 – 50 additional daily boardings on East Bay routes.

Figure 4-8 New Transit Trips Generated on GGT Routes

Alternative	Net New Transit Trips on San Francisco Routes	Net New Transit Trips on East Bay Routes
Low Investment Alternative	50-100	10-20
High Investment Alternative	90-190	30-50

Appendix F

Transitions and Multimodal Analysis

Memo

To: Steve Boland / Nelson Nygaard

From: David Parisi and Ashley Tam / Parisi Transportation Consulting

Date: September 29, 2015

Re: Bus and Streetcar Route Transition Concepts for Fairfax-San Rafael Corridor Transit Feasibility Study

As part of the Fairfax-San Rafael Corridor Transit Feasibility Study, Parisi Transportation Consulting has prepared conceptual alignment drawings for potential bus route and streetcar track transitions at select locations along the Technical Advisory Committee's (TAC's) preferred corridor alignments.

The intent of the drawings is to assist the TAC in understanding potential multi-modal effects, including opportunities and constraints.

Based on input received at TAC meetings, the following transition and alignment areas were selected for depicting potential routing for the Lower Investment Alternative (bus) and the Higher Investment Alternative (streetcar):

- Transit turnaround options in downtown Fairfax
- Transit queue jumper lane opportunities on Center Boulevard
- Routing options through Center Boulevard bridge area, including a potential roundabout alternative
- Routing options through San Anselmo's Hub, including a potential roundabout alternative
- Routing transitions into and out of Miracle Mile's center median
- Routing transitions between Miracle Mile and Fourth Street
- Routing options through downtown San Rafael
- Transit turnaround concepts in downtown San Rafael

The concepts were developed to scale using AutoCAD, and are based on the conceptual alignment cross-sections presented to the TAC, as well as on design standards for busways and streetcar lines, e.g., APTA's modern streetcar guidelines.

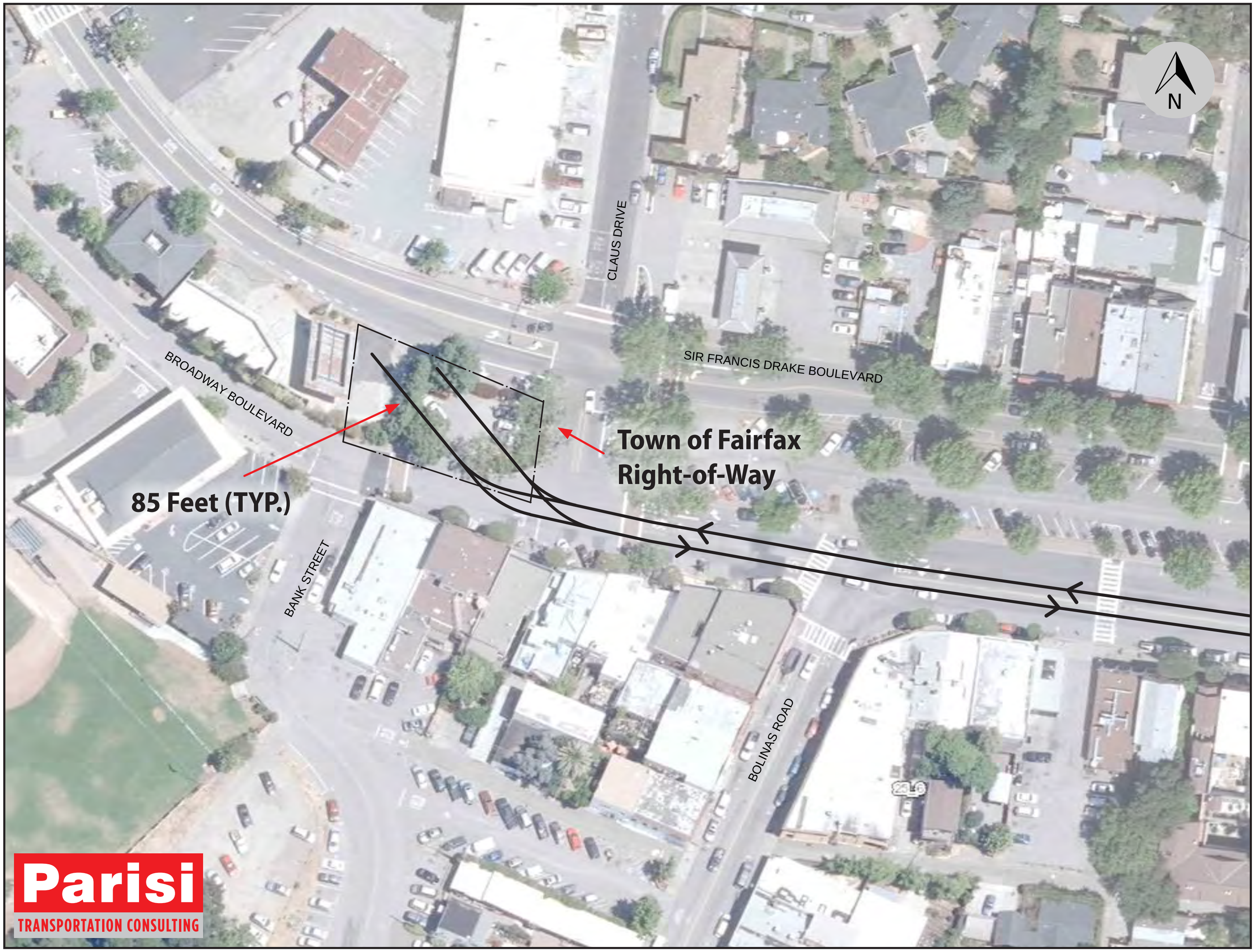
Parisi TRANSPORTATION CONSULTING

A high-level assessment was done for each transition and alignment location concept in relation to potential multimodal impacts. Table 1 shows potential impacts that could result from the Lower and Higher Investment Alternatives, rated on a scale of Low, Medium, or High potential impact.

Considerations were made for pedestrians, bicyclists, transit interface, motorists, parking, and truck loading. An example of an alignment with a medium impact is the Bank Street Turnaround High Investment alternative, which would affect the parking supply in downtown Fairfax. A turnaround at Third Street in San Rafael would have a high impact on motorists because the track alignment would be on the left lane and affect traffic operations. If existing bus routes remain along their current alignments, the Fourth Street High Investment alignment would have a medium impact on existing transit since current bus routes could experience greater delay on a two-lane roadway. The San Rafael High Investment Turnaround alignments would have low impact on existing and planned transit due to the potential benefit resulting from the proximity to transit centers such as the SMART station.

Table 2 of potential impacts provides details explaining the effect on each category.

Potential Streetcar Turn-Around at Bank Street in Fairfax



SEPTEMBER 2015

Potential Bus Turn-Around Via Pacheco Avenue and Sir Francis Drake Boulevard in Fairfax

SEPTEMBER 2015

FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Bus or Streetcar Turn-Around Via Bank Street and Bolinas Road in Fairfax

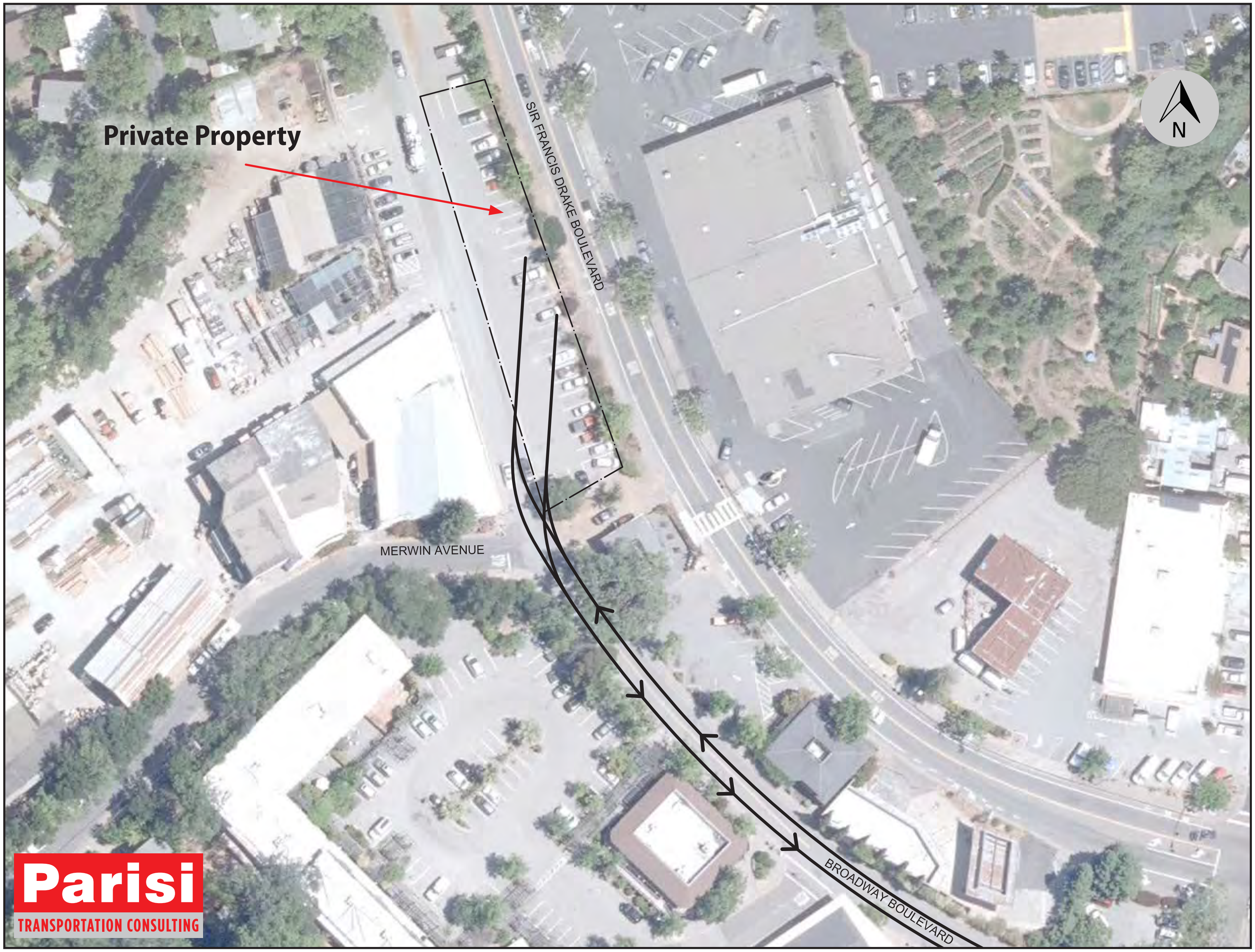
SEPTEMBER 2015

Potential Streetcar Turn-Around Via Merwin Avenue in Fairfax

SEPTEMBER 2015

FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Streetcar Turn-Around East of Lumberyard in Fairfax



SEPTEMBER 2015

Potential Bus or Streetcar Queue Jumper Lane on Center Boulevard in San Anselmo

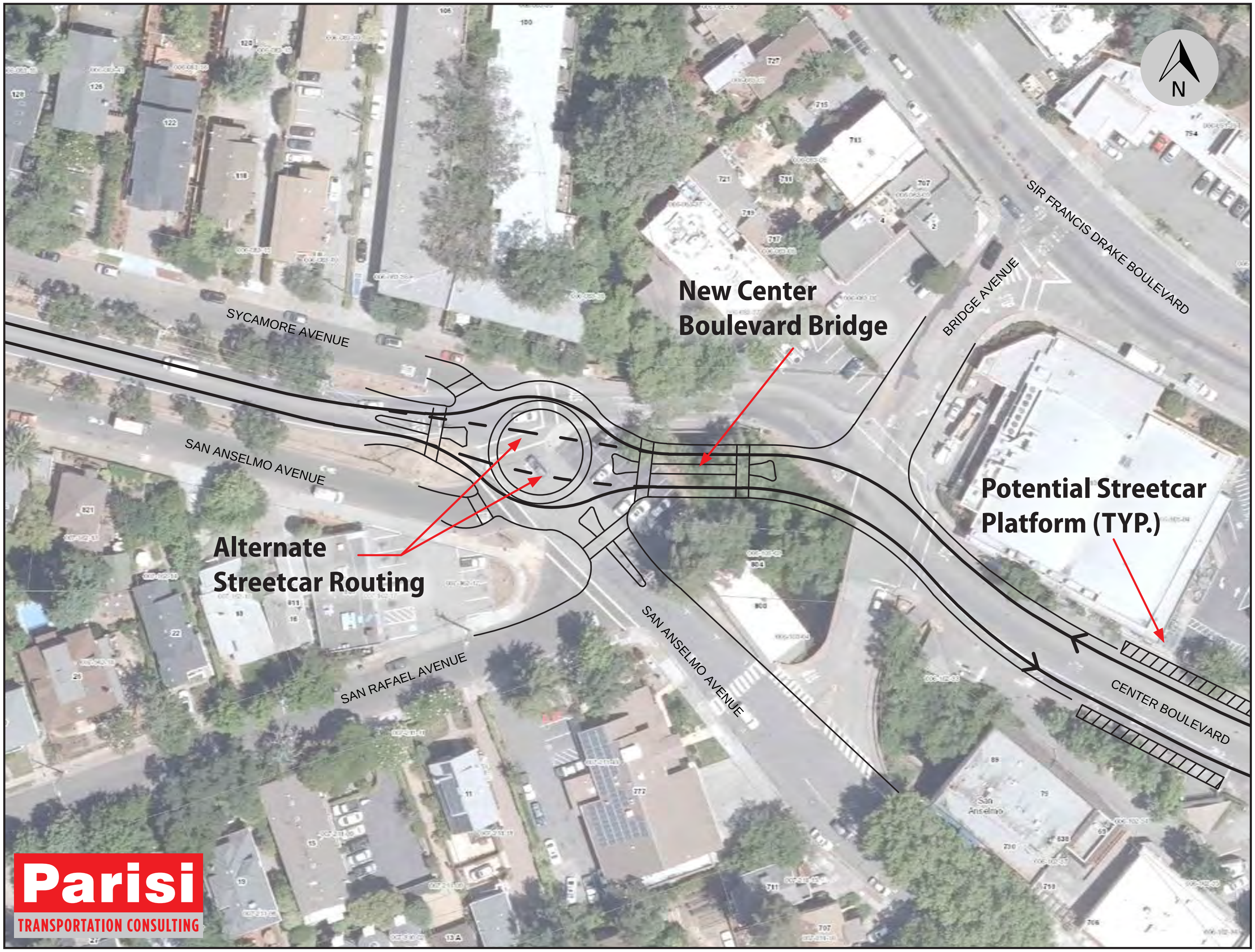
SEPTEMBER 2015

Potential Bus or Streetcar Routing on Center Boulevard at San Anselmo Avenue in San Anselmo

SEPTEMBER 2015

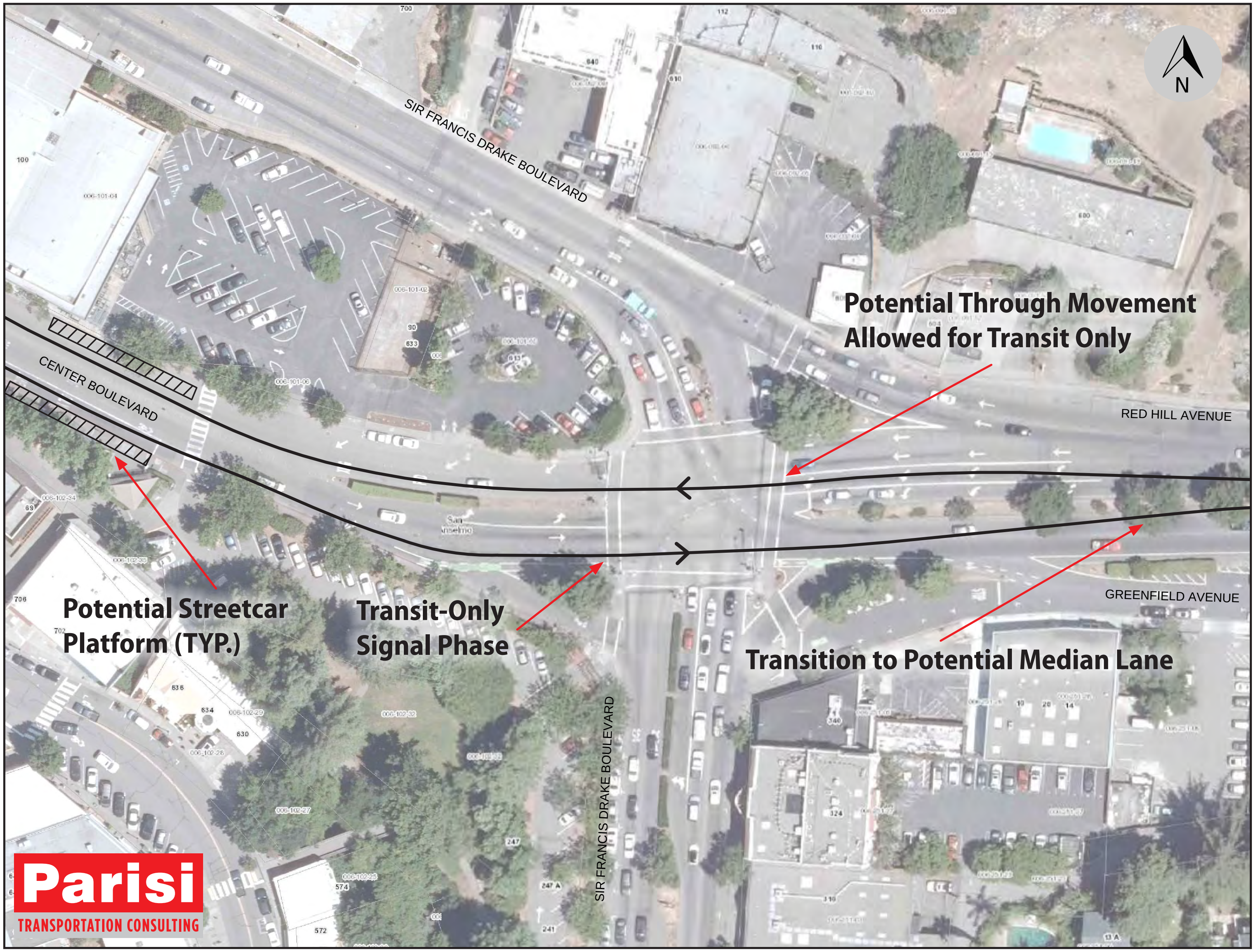
FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Bus or Streetcar Routing with Roundabout at Center Blvd / San Anselmo Ave. in San Anselmo



SEPTEMBER 2015

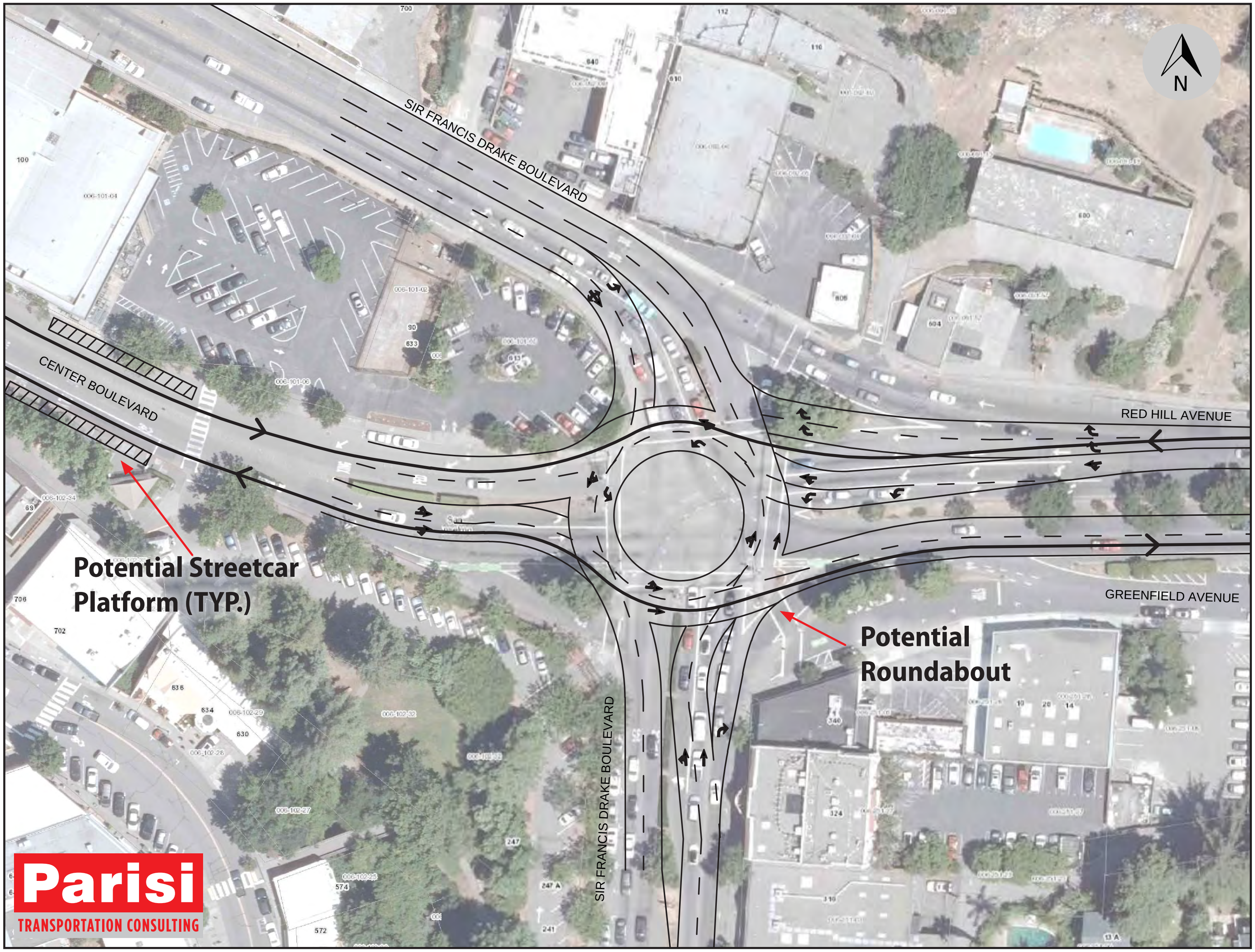
Potential Bus or Streetcar Routing Through The Hub in San Anselmo



SEPTEMBER 2015

FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

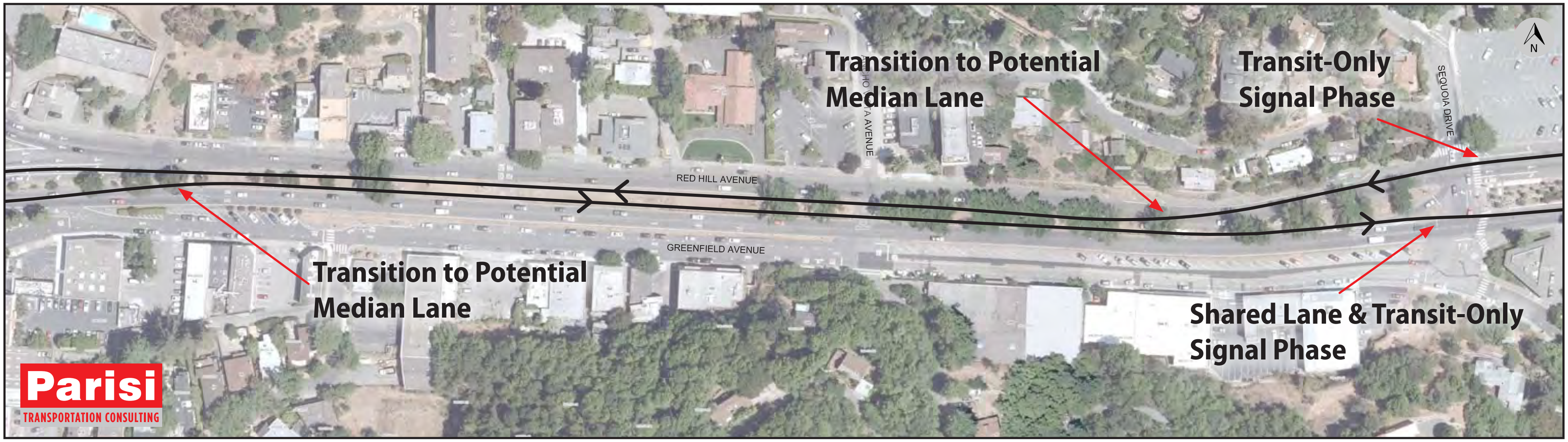
Potential Bus or Streetcar Routing Through Roundabout at The Hub in San Anselmo



SEPTEMBER 2015

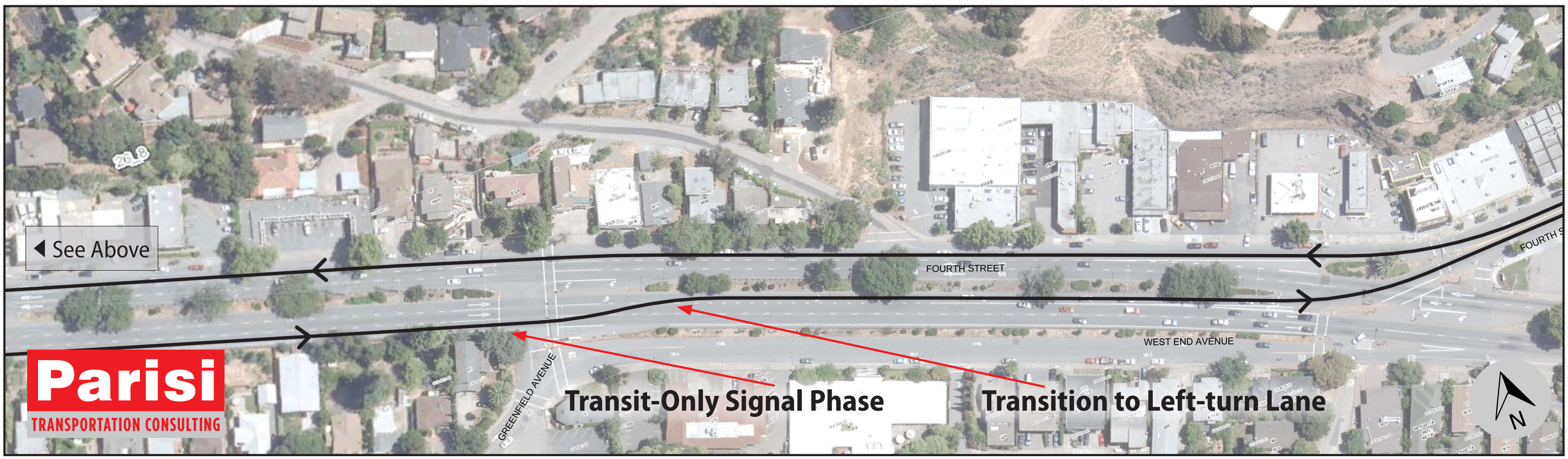
FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Bus or Streetcar Routing on Red Hill Avenue / Miracle Mile Median in San Anselmo



SEPTEMBER 2015

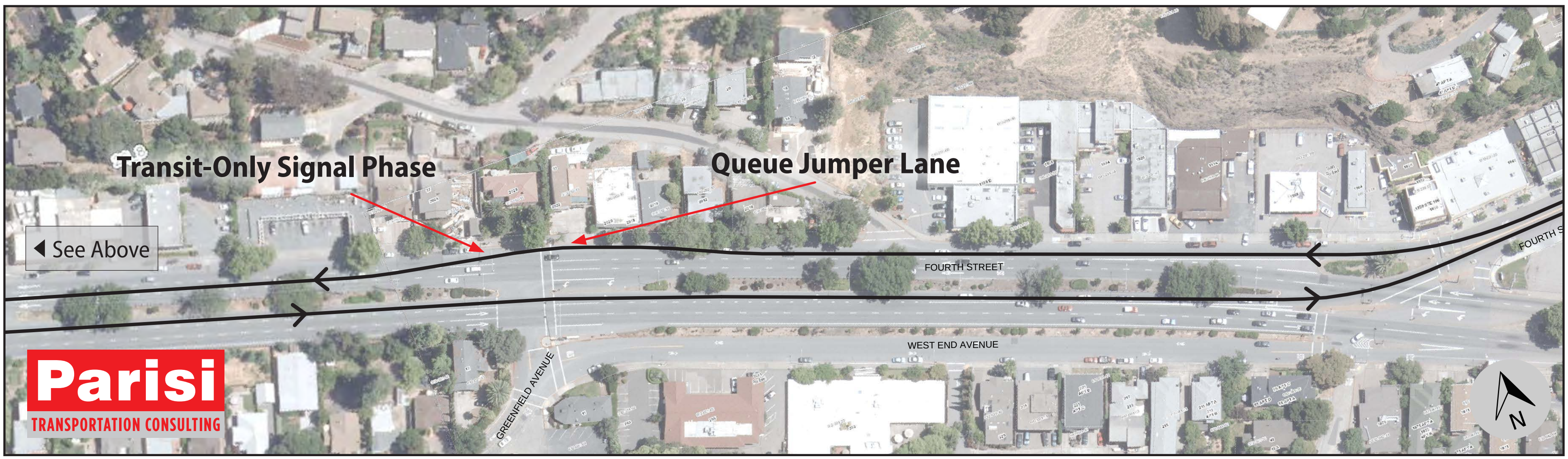
Potential Bus or Streetcar Routing in Outside Lane on Fourth Street / Miracle Mile in San Rafael



SEPTEMBER 2015

FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Bus or Streetcar Routing in Inside Lane on Fourth Street in San Rafael



SEPTEMBER 2015

Potential Bus or Streetcar Routing on Fourth Street in San Rafael

SEPTEMBER 2015

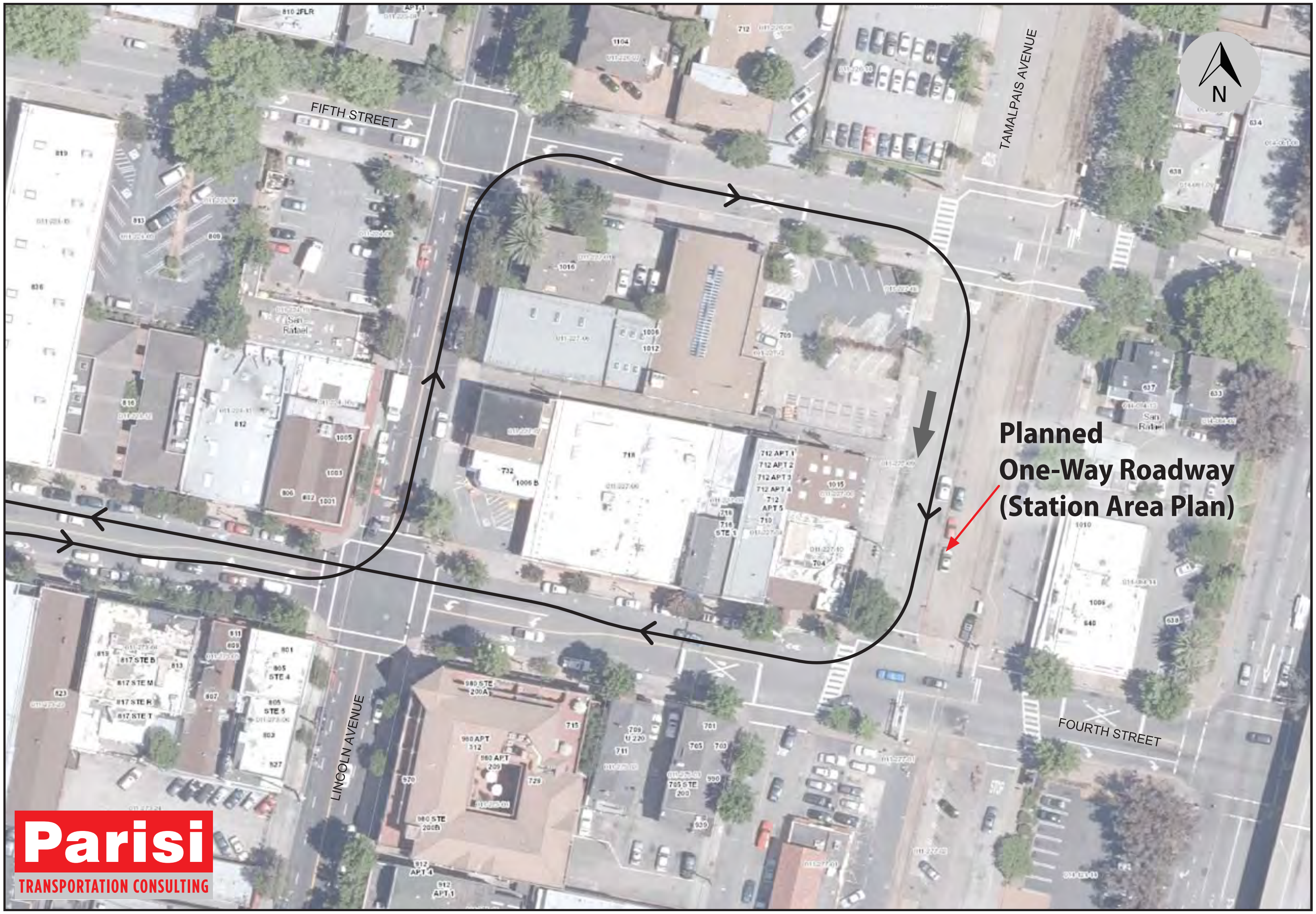
FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Bus or Streetcar Routing on Second Street and Third Street in San Rafael

SEPTEMBER 2015

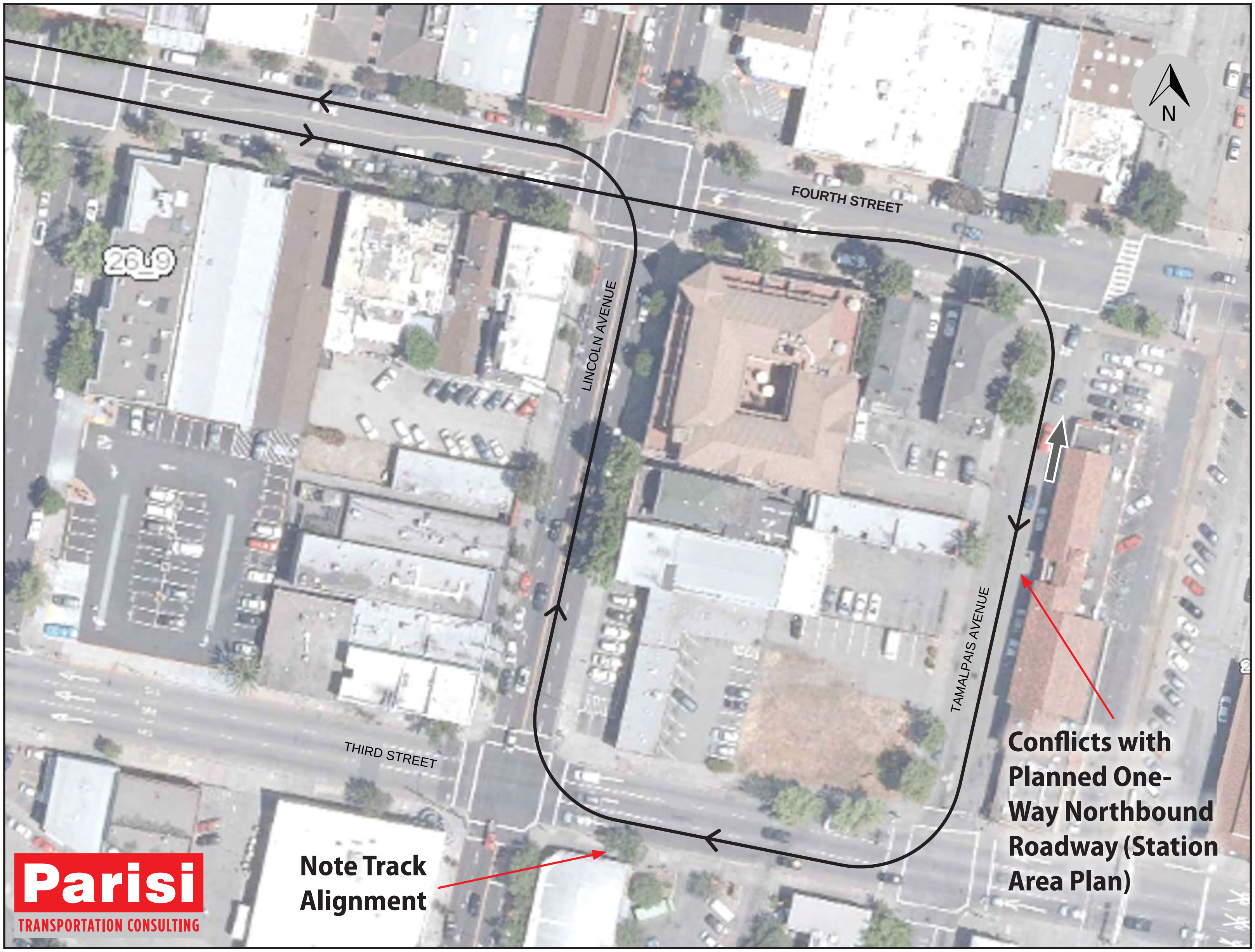
FAIRFAX - SAN RAFAEL CORRIDOR TRANSIT FEASIBILITY STUDY

Potential Streetcar Turn-Around at Tamalpais Avenue and Fifth Street in San Rafael



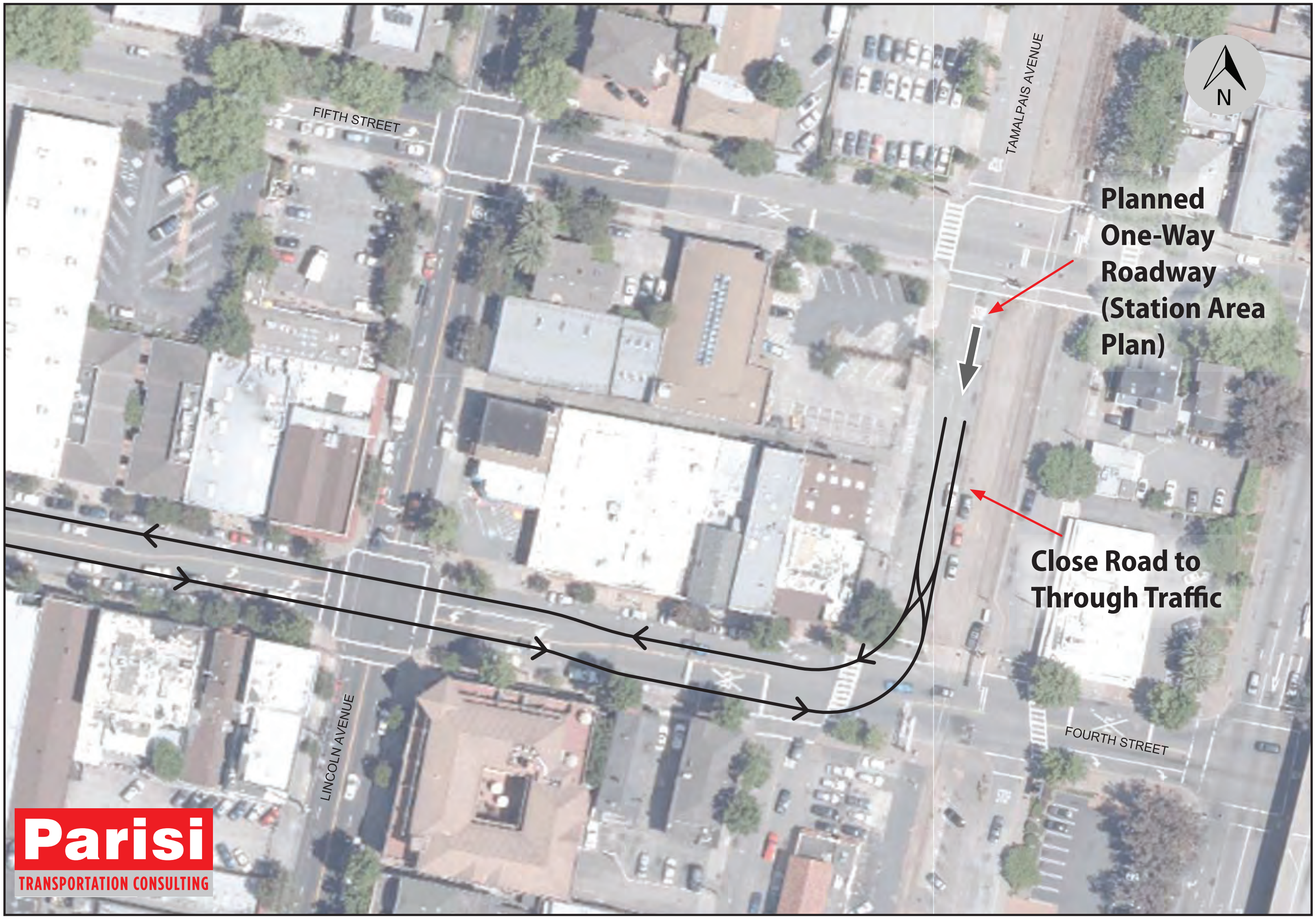
SEPTEMBER 2015

Potential Streetcar Turn-Around at Tamalpais Avenue and Third Street in San Rafael



SEPTEMBER 2015

Potential Streetcar Turnaround at Tamalpais Avenue in San Rafael



SEPTEMBER 2015

Table 1. Potential Impacts of High and Low Investment Alignments

Jurisdiction	Location/ Alternative	Considerations / Impacts for High Investment						Considerations / Impacts for Low Investment					
		Pedestrians	Bicyclists	Transit Interface	Motorists	Parking	Truck Loading	Pedestrians	Bicyclists	Transit Interface	Motorists	Parking	Truck Loading
Fairfax	**Bank Street Turnaround**	Low	Low	Low	Low	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A
Fairfax	**SFD Turnaround**	N/A	N/A	N/A	N/A	N/A	N/A	Low	Low	Low	Low	Low	Low
Fairfax	**Bolinas Road Turnaround**	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
Fairfax	**Merwin Ave Turnaround**	Low	Low	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
Fairfax	**East of Lumberyard Turnaround**	Low	Low	Low	Low	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A
San Anselmo	**Center Blvd. Queue Jump**	Medium	Low	Low	Low	Low	Low	Medium	Low	Low	Low	Low	Low
San Anselmo	**Center and San Anselmo**	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
San Anselmo	**Center/San Anselmo Roundabout**	Low	Medium	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
San Anselmo	**Hub**	Low	Low	Low	Medium	Medium	Low	Low	Low	Low	Medium	Medium	Low
San Anselmo	**Hub Roundabout**	Low	Medium	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low
San Anselmo	**Median Lane**	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
San Rafael	**Fourth/Miracle Mile Outside**	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
San Rafael	**Fourth/Miracle Mile Inside**	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
San Rafael	**Fourth Street**	Low	Low	Medium	Low	Medium	Medium	Low	Low	Low	Low	Medium	Medium
San Rafael	**Second and Third Street**	Low	Low	Low	Medium	Low	Low	Low	Low	Low	Medium	Low	Low
San Rafael	**Fifth Street Turnaround**	Low	Low	Low	Medium	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
San Rafael	**Third Street Turnaround**	Low	Low	Low	High	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
San Rafael	**Tamalpais Ave Turnaround**	Low	Low	Low	Medium	Medium	Low	N/A	N/A	N/A	N/A	N/A	N/A

Table 2. Potential Impacts of High and Low Investment Alignments - with Notes

		Considerations / Impacts for High Investment						Considerations / Impacts for Low Investment					
Jurisdiction	**Location/ Alternative**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**
Fairfax	**Bank Street Turnaround**	Low	Low	Low	Low (traffic stopped when transit leaves station)	Medium (remove parking lot)	Low	N/A	N/A	N/A	N/A	N/A	N/A
	SFD Turnaround	N/A	N/A	N/A	N/A	N/A	N/A	Low	Low	Low	Low	Low	Low
	Bolinas Road Turnaround	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Merwin Ave Turnaround	Low	Low	Low	Low	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	East of Lumberyard Turnaround	Low	Low	Low	Low (traffic stopped when transit leaves station)	Medium (remove some private parking)	Low	N/A	N/A	N/A	N/A	N/A	N/A
San Anselmo	**Center Blvd. Queue Jump**	Medium (longer crosswalk)	Low (consider rerouting bikes)	Low (may use queue jump lane)	Low	Low	Low	Medium (longer crosswalk)	Low	Low (may use queue jump lane)	Low	Low	Low

Table 2. Potential Impacts of High and Low Investment Alignments - with Notes

		Considerations / Impacts for High Investment						Considerations / Impacts for Low Investment					
Jurisdiction	**Location/ Alternative**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**
San Anselmo	**Center and San Anselmo**	Low	Low (consider rerouting bikes due to tracks)	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Center/San Anselmo Roundabout	Low	Medium (bikes on curved tracks)	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
	Hub	Low	Low	Low (no bus loading at streetcar platform, may use transit-only signal phase)	Medium (signal mod for transit)	Medium (replace parking with platform)	Low	Low	Low	Low (may use transit-only signal phase)	Medium (signal mod for transit)	Medium (replace parking with bus stop)	Low
	Hub Roundabout	Low	Medium (bikes on curved tracks)	Low (no bus loading at streetcar platform)	Low	Medium (replace parking with platform)	Low	Low	Low	Low	Low	Medium (replace parking with bus stop)	Low
	Median Lane	Low	Low	Low	Medium (signal mod for transit)	Low	Low	Low	Low	Low (may use exclusive lane)	Medium (signal mod for transit)	Low	Low

Table 2. Potential Impacts of High and Low Investment Alignments - with Notes

		Considerations / Impacts for High Investment						**Considerations / Impacts for Low Investment**					
Jurisdiction	**Location/ Alternative**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**
San Rafael	**Fourth/ Miracle Mile Outside**	Low	Low	Low (may use transit-only signal phase)	Medium (signal mod for transit)	Low	Low	Low	Low	Low (may use transit-only signal phase)	Medium (signal mod for transit)	Low	Low
	Fourth/ Miracle Mile Inside	Low	Low	Low (may use transit-only signal phase and queue jumper)	Medium (signal mod for queue jumper)	Low	Low	Low	Low	Low (may use transit-only signal phase and queue jumper)	Medium (signal mod for queue jumper)	Low	Low
	Fourth Street	Low	Low	Medium (if existing bus routes remain)	Low	Medium	Medium (would require parking removal for curbside loading zone)	Low	Low	Low	Low	Medium	Medium (would require parking removal for curbside loading zone)
	Second and Third Street	Low	Low	Low	Medium (delays on major roadway)	Low	Low	Low	Low	Low	Medium (delays on major roadway)	Low	Low

Table 2. Potential Impacts of High and Low Investment Alignments - with Notes

		Considerations / Impacts for High Investment						Considerations / Impacts for Low Investment					
Jurisdiction	**Location/ Alternative**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**	**Pedestrians**	**Bicyclists**	**Transit Interface**	**Motorists**	**Parking**	**Truck Loading**
San Rafael	**Fifth Street Turnaround**	Low	Low	Low (transfers to/from SMART and Transit Center)	Medium (eliminates left turn pocket at Lincoln/ 5th)	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	Third Street Turnaround	Low	Low (reroute bikes)	Low (transfers to/from SMART and Transit Center)	High (track alignment on left lane of major roadway on 3rd and conflicts with planned one-way)	Low	Low	N/A	N/A	N/A	N/A	N/A	N/A
	Tamalpais Turnaround	Low	Low	Low (transfers to/from SMART and Transit Center)	Medium (potential closure to through traffic)	Medium (parking removal for tail tracks)	Low	N/A	N/A	N/A	N/A	N/A	N/A

APPENDIX G

Streetcar Technology White Paper

TAM Fairfax-San Rafael Corridor Transit Feasibility Study
Streetcar Technology White Paper - August 3, 2015

Introduction

The Fairfax-San Rafael Corridor Transit Feasibility Study is examining transit mode and alignment options to serve a corridor connecting the downtowns of Fairfax, San Anselmo, and San Rafael. The Low-Investment Alternative would use enhanced bus technology, while the High Investment Alternative would use streetcar technology. The High Investment Alternative would be four miles long, running from approximately Bank Street in downtown Fairfax, through downtown San Anselmo, to a loop and terminus near the San Rafael Transit Center. The High Investment Alternative would be an investment in longer term infrastructure that would have higher up-front capital costs, but would be more permanent, with a 30-plus year life expectancy.

The High Investment Alternative would include vehicles, rails, a maintenance facility, and power-delivery systems. Rails and power-delivery systems would be constructed in the roadway along Center Boulevard from Fairfax to San Anselmo, along Red Hill Avenue and 4th Street from San Anselmo to San Rafael, and in downtown San Rafael along 4th Street to a loop just west of the SMART tracks. A maintenance facility would be located in close proximity to the alignment, preferably within three or four blocks to minimize the amount of rail and electrical infrastructure that is not part of the route.

Typically power-delivery systems would consist of overhead wires and substations along the full length of the alignment. However, there are a number of developing alternatives to overhead wires. Some of the newest US streetcar systems under-construction or in planning are moving towards technologies that include on-board energy storage to enable off-wire operation. Other new technologies, including underground charging and hydrogen fuel cell on-board generators, are in various stages of development.

This white paper describes the types of streetcar vehicles and power delivery technologies that are currently available, the trade-offs involved with different power systems, the requirements for maintenance facilities, and specific issues that should be considered for the Fairfax-San Rafael corridor.

Types of Streetcar Vehicles Available

There is a wide range of vehicle types available for US streetcar systems. Streetcars in the US are typically operated in mixed traffic environments and used for local circulation and short trips in downtown areas. US streetcars are generally not used for longer-distance regional travel, like light rail or commuter rail systems are. US streetcar systems are often used as feeder routes to larger regional routes.

Vintage Streetcar Vehicles

Several systems in the US utilize vintage streetcar vehicles, either restored heritage vehicles or newly manufactured replica vehicles. Most of these tend to be on tourist-oriented systems, such as the San Francisco F Line, the Little Rock River Rail Streetcar, the Memphis Trolley, or the TECO Line in Tampa. The San Francisco F Line utilizes a diverse range of restored historic streetcar vehicles from around the world (shown in Figure 1). The Tampa streetcar utilizes modern replica vehicles. A new streetcar line currently being designed for El Paso will utilize several of that city's historic PCC vehicles, which have been in storage for 40 years, since the historic streetcar system ceased operation. These vehicles will be restored and modernized.

Figure 1: PCC Streetcar on Historic F Line in San Francisco

Modern Streetcar Vehicles

Modern streetcar vehicles are similar to light rail vehicles (LRVs), but are generally shorter, lighter, and narrower. This gives them greater flexibility to maneuver in more constrained urban environments with mixed traffic. LRVs are typically 8 feet, 8 inches wide and 90 to 95 feet long. They are usually designed to be coupled together into multiple car trains. Typical light rail systems operate with train sets made up of two to four cars. Coupled together, light rail train sets can be 200 to 400 feet long.

Streetcar vehicles are typically narrower at 8 feet wide and in the range of 65 to 75 feet long. This makes them better suited to operation in narrow traffic lanes and navigation of tighter radius turns. They are typically not coupled together like LRVs. While LRVs can be used in streetcar applications, their use in mixed traffic is usually limited. Shorter streetcar vehicles are generally preferred for mixed traffic applications. Most manufacturers of light rail vehicles also produce streetcar vehicles.

Applicability to the Fairfax-San Rafael Corridor

Vintage streetcars are generally most applicable to transit corridors that are oriented toward tourist activity or to blend in with the vintage character of a historic district. Modern streetcars are more appropriate for serving mobility needs in a modern urban context. Modern streetcar vehicles have significantly larger passenger capacity than vintage streetcar vehicles. They also have low floors and rapidly deploying ramps, which speed boarding and alighting and accommodate wheelchairs and other mobility devices. The Fairfax-San Rafael corridor is a primary multi-modal travel corridor. A streetcar in this corridor would be serving a mobility function more than a tourism function. Therefore, a modern streetcar vehicle would be more applicable to the Fairfax-San Rafael corridor.

Streetcar Vehicle Manufacturers

There are several manufacturers that build streetcar vehicles for US markets. These include new modern streetcar vehicles, new replica heritage vehicles, and restoration or reconstruction of historic streetcar vehicles.

Inekon

The first modern streetcars introduced as part of the recent reemergence of streetcars in the US were implemented in Portland and Tacoma. These were built by a joint venture of Skoda-Inekon, which was based in the Czech Republic. At 66 feet long and eight feet wide, these vehicles were designed to fit more easily into a dense, mixed-traffic environment than a typical LRV, which are typically approximately eight feet, eight inches wide.

As Portland expanded its system and Seattle implemented its first line, additional vehicles were purchased for these systems from Inekon (shown in Figure 2), which was no longer partnered with Skoda. These Inekon vehicles were based on the same platform and were very similar to the original Skoda-Inekon partnership vehicles.

Figure 2: Inekon Streetcar in Seattle

The initial Portland, Tacoma, and Seattle systems did not include Federal funds and, as a result, were not constrained by Buy America standards, which require that at least 60 percent of the components of a streetcar vehicle purchased using a portion of federal funding, be manufactured in the US. Later extensions of the Portland and Seattle systems were constrained by these requirements. Generally, if vehicles are purchased from a foreign manufacturer, final assembly needs to occur in the US in order to meet Buy America requirements. Vehicles recently purchased from Inekon for Seattle's First Hill Streetcar project are having final assembly completed by Pacifica Marine in Seattle.

Brookville

Brookville is a US locomotive and streetcar manufacturing company located in Brookville, PA. It began building streetcars in 2002, specializing in replica heritage vehicles and remanufacturing historic streetcar vehicles. It has provided remanufactured historic vehicles for San Francisco and replica heritage vehicles for New Orleans. Brookville is also remanufacturing and modernizing the historic streetcar vehicles for the El Paso streetcar system.

Brookville recently began building modern low-floor streetcars. Brookville introduced the Liberty modern streetcar vehicle in 2012 (shown in Figure 3). It is 66 feet, 5 inches long and available in eight foot width or eight foot, eight inch width. The Oak Cliff Streetcar project in Dallas began operation in April 2015. It includes two Brookville Liberty vehicles serving a 1.6 mile initial route. Two additional vehicles have been ordered for an extension of the line, currently under construction. The Detroit M-1 Rail project has also selected Brookville to supply six Liberty vehicles.

Figure 3: Brookville Liberty Streetcar

CAF USA

CAF is based in Spain, but has an assembly facility in Elmira, New York. CAF USA has provided large fleets of LRVs for the light rail systems in Pittsburgh, Sacramento, and Houston since the early 2000s. They have a long history of streetcar building for European systems. Their first streetcar vehicles in the US will be for the systems currently under construction in Cincinnati and Kansas City. CAF USA will provide five Urbos LRVs (shown in Figure 4) for the Cincinnati system and four Urbos LRVs for the Kansas City system. The CAF USA Urbos LRV is 77.5 feet long and eight feet, eight inches wide.

Figure 4: CAF USA Urbos Streetcar

Siemens

Siemens is a German-based company with a long history of streetcar and light rail vehicle building. Siemens has production facilities in the US and has provided vehicles for several US light rail systems, including Houston, San Diego, Portland, Salt Lake City, and Minneapolis/Saint Paul.

Siemens' S70 vehicle is available in two general configurations. The standard LRV is 91 to 96 feet long. The streetcar version is approximately 80 feet long (shown in Figure 5). Both are the same width at eight feet, eight inches. Streetcar length S70s have recently been put into service on the Atlanta Streetcar and the Sugar House Streetcar in Salt Lake City.

Figure 5: Siemens S70 Streetcar in Atlanta

Bombardier

Bombardier is a global producer of trains and planes based in Montreal. They have a long history of providing vehicles for US light rail systems and streetcar vehicles around the world. They have manufacturing facilities in the US and are able to supply large fleets of light rail vehicles. There are no current US streetcar systems utilizing Bombardier streetcar vehicles. The largest North American fleet of Bombardier streetcar vehicles is currently being produced for the Toronto streetcar system.

TIG/m

TIG/m is a California-based firm, based in Los Angeles, which specializes in wireless, self-propelled streetcars. Their products utilize a range of innovative energy storage and generation systems. In addition to on-board battery systems, TIG/m streetcars can include on-board power generation utilizing diesel, Compressed Natural Gas (CNG), Liquid Natural Gas (LNG), and hydrogen fuel cell technology.

TIG/m built the first hydrogen fuel cell powered streetcar vehicles in use in the world for the Aruba streetcar system. Aruba ordered two hydrogen fuel cell powered streetcars from TIG/m for a route that connects cruise ship terminals with downtown Oranjestad. The vehicles are heritage replica style trolley vehicles (shown in Figure 6). The line began service in February 2013 with two vehicles built by TIG/m and two additional TIG/m vehicles are currently under construction. The streetcars are part of the country's effort to become the world's first 100 percent green economy.

Figure 6: TIG/m Self-Propelled Heritage Replica Streetcar

Similar heritage replica style hydrogen fuel cell powered vehicles were produced for the Downtown Dubai Trolley, which is currently undergoing testing on its initial one kilometer starter line.

TIG/m's US experience to date appears to be limited to short lines on private property. TIG/m has produced heritage replica style vehicles that are in service at two outdoor mixed-use "lifestyle" malls, including the Grove in Los Angeles and Eilan in San Antonio. Both utilize the heritage replica style vehicles. TIG/m is also developing a higher capacity modern low-floor streetcar vehicle.

Other Manufacturers

There are many other streetcar manufacturers that produce vehicles for markets in other parts of the world, but do not currently have experience building streetcars for the US market. These include the following companies:

- Alstom: A French manufacturer of rail vehicles and systems. Alstom is providing vehicles for the Ottawa light rail system.
- Ansaldo-Breda: An Italian manufacturer of streetcar, light rail, commuter rail, and heavy rail locomotive vehicles. Ansaldo-Breda has provided vehicles for the San Francisco and Los Angeles light rail systems and the Miami-Dade metro system.
- Stadler: A Swiss manufacturer that produces a wide range of streetcar, light rail, and bus transit vehicles.
- Vossloh: A German company that manufactures trains and train equipment throughout the world.
- Kinkisharyo: A Japanese company that provided light rail vehicles for Sound Transit in Seattle and is developing a streetcar vehicle for the US market.
- Kawasaki: Provided trolleys for SEPTA in Philadelphia in the 1990s.
- Mitsubishi

Applicability to the Fairfax-San Rafael Corridor

Any of the vehicles described in this section could be used on the Fairfax-San Rafael corridor. There are some locations at the ends of the corridor, in downtown Fairfax and downtown San Rafael, where the streetcar would need to be able to navigate tight corners and there are some locations along the alignment with relatively narrow lane widths.

All of the modern streetcar vehicles are articulated in order to navigate corners. The vintage vehicles are generally shorter (approximately 40 to 45 feet, more like a standard bus length) and non-articulated. While the size of the streetcar vehicle is an important factor in its ability to navigate tight turns, the type of rail and the type of wheels are more critical determinants of the minimum turning radius. The Inekon vehicles in use in Portland technically have a minimum turning radius of 59 feet. However, because of the specific rail and wheel types in use on the Portland system, the actual turning radius is 82 feet. This turning radius allows the Portland streetcars to navigate the tight corners and narrow streets in downtown Portland and would be adequate for the proposed terminus alignments in downtown Fairfax and downtown San Rafael.

Vehicle width is a critical factor if there are narrow lanes. Recommended absolute minimum lane widths for operation of the Inekon streetcar vehicles is ten feet. The absolute minimum for the wider Siemens S70 streetcar vehicle is 11 feet. The most constrained roadway segment along the proposed Fairfax-San Rafael corridor alignments is on Center Boulevard east of downtown Fairfax, which has two 10-foot lanes and bike lanes. A narrower eight-foot wide vehicle, such as the Inekon or the Brookville, would be the most flexible to use on these segments and accommodate the existing lane configuration.

Streetcar Power Sources

Streetcar systems have traditionally been powered by overhead wires, known as an Overhead Contact System (OCS), made up of overhead wires supported by poles located on the side of the roadway, and Traction Power Sub-Stations (TPSS) located approximately every mile. The streetcar vehicle connects to the OCS wires via a pantograph located on top of the vehicle and draws power.

Propulsion system technologies have improved in recent years, including improvements to energy storage technology enabling smaller lithium-ion battery packs to hold larger charges for longer periods as well as rapid charging systems. This section describes some of the available off-wire technology options and discusses the associated trade-offs.

Traditional OCS Systems

Traditional traction electrification systems utilizing OCS have been in use over the past 120 years. These systems are designed to maintain a consistent line voltage within a specified range over the length of a streetcar route. OCS has become the standard means of providing traction electrification for streetcar and light rail systems worldwide.

Capital costs for streetcar systems vary widely and every project is unique. OCS systems typically make up a significant portion of the total capital costs. In general, the largest cost items for a streetcar project are the construction of the embedded rail in the roadway, the OCS system, vehicles, utility relocation, and the maintenance facility.

Recent streetcar projects in the US have been constructed with costs for OCS power systems (including wires, poles, and substations) of between approximately $400 and $700 per track foot. This translates to rough typical OCS costs in the range of approximately $2 million to $3.6 million per mile of one-way track. The OCS poles, wires, and substations all require ongoing maintenance as well.

OCS with Partial Off-Wire Capability

Traditionally, one of the most significant ongoing operating expenses for streetcar and light rail systems is energy use. Modern vehicles with modern climate control systems utilize significantly more energy than older systems. The passenger rail industry has made significant advances in weight reduction and energy saving technologies in recent decades.

The most mature energy saving technology for rail vehicles is energy recovery through regenerative braking. This technology enables the wheels to act as electricity generators while the vehicle is braking. This electricity can be redistributed back through the OCS wires to be utilized by other streetcar vehicles on the system. This energy recovery system is particularly well suited for urban public transportation systems because they are continuously accelerating and decelerating as they serve stations and navigate urban traffic.

On-Board Energy Storage Systems (OESS), utilizing either batteries or capacitors, offer the ability for recovered energy to be stored on board the vehicle. They also offer the ability to travel off-wire for short segments of the route. As battery storage technology has improved, the ability to travel longer distances off-wire has increased.

The primary reasons for utilizing off-wire capable vehicles to date have been concerns about aesthetics of overhead wires and physical constraints due to low vertical clearance. Off-wire capable systems offer potential for capital and maintenance cost savings. However, because these systems are new and there is relatively limited experience using them, their potential to provide cost savings over the life of a streetcar project are not yet well understood. Currently, the potential savings in infrastructure costs are largely offset by ongoing vehicle maintenance costs related to regular battery replacement.

This section discusses the few examples of off-wire streetcar systems that are currently operating or in development in the US.

Dallas:

The Oak Cliff Streetcar in Dallas, Texas, began operation in April 2015 with an initial 1.6 mile route that will be part of a larger planned system (shown in Figure 7). The line crosses the historic Houston Street Bridge over the Trinity River (shown in Figure 8). The bridge is over 100 years old and there was a desire to maintain its historic appearance. The City of Dallas chose vehicles with off-wire capability in order to avoid installing OCS infrastructure on the historic bridge. The rest of the line operates with traditional OCS, but the vehicles run off-wire over the bridge. The Oak Cliff Streetcar is the first system in operation in the US to utilize off-wire running.

Figure 7: Dallas Streetcar Map[1]

Figure 8: Dallas Streetcar on the Houston Street Bridge[2]

[1] https://www.dart.org/riding/dallasstreetcar.asp
[2] Dallas Morning News: http://www.dallasnews.com/photos/20150416-dart-s-new-downtown-to-oak-cliff-streetcar-makes-it-s-public-debut.ece

The City purchased two vehicles from Brookville for the Oak Cliff Streetcar project. They operate one vehicle at a time on the 1.6 mile route and have one as a spare. They include OESS made up of two 550-volt batteries. The vehicles cost $4.5 million each.

Seattle:

Seattle opened its first streetcar line, the South Lake Union (SLU) line, in 2007. This line was a 1.3-mile initial route utilizing traditional OCS-powered vehicles from Inekon.

The second streetcar line in Seattle, the 2.5-mile First Hill Streetcar (FHS) line, was completed in 2014 and vehicle testing is currently under way. The FHS line (shown as the solid orange line in Figure 9) has OCS wires in one direction only (the uphill direction, from Pioneer Square to Capitol Hill). The return trip is all off-wire under battery power. The reason Seattle chose to operate with 50 percent off-wire is due to Seattle's dense network of trolley bus wires, which provide a unique challenge for the introduction of streetcar OCS wires (typical trolley bus wires along the streetcar route are shown in Figure 10). Seattle chose an off-wire system in order to minimize costs associated with relocating trolley bus wires.

Figure 9: First Hill Streetcar Map[3]

[3] From Seattle Streetcar website: http://www.seattlestreetcar.org/firsthill.htm

Figure 10: Typical Trolley Bus Wires Along First Hill Streetcar Route

Seattle purchased six vehicles with OESS from Inekon, the same company that had provided vehicles for the SLU line. These vehicles cost approximately $4.5 million each. Multiple supply chain issues delayed the delivery of all six vehicles, though these were not related to the off-wire technology.

<u>Oklahoma City</u>:

AECOM is currently designing the initial route of the Oklahoma City streetcar. The route will pass under two railroad overcrossings with limited vertical clearance. With vertical clearance of 13 feet, 7 inches at one and 13 feet, 9 inches at the other, there is not adequate room for OCS. Typically OCS wires need to be 19 feet above the street, which is high enough to conform to the 18-foot minimum clearance required by the National Electrical Safety Code with adequate room to allow for sagging of the wires. Accommodating these low clearance overcrossings will require vehicles with off-wire capability.

Because Oklahoma City will be utilizing vehicles with off-wire capability in order to operate in this small section of the route, the City determined that it would make sense to maximize use of the off-wire operation. AECOM is currently investigating which portions of the system would be the best candidate sections to operate off-wire. Because the vehicles with off-wire capability are more expensive to purchase and need the batteries replaced regularly, it is a goal of the design effort to be able to offset this cost by reducing the amount of OCS required and make the most use of the off-wire technology.

According to AECOM's current capital cost estimates for the Oklahoma City streetcar, a scenario with 16 percent off-wire (0.8 track miles of off wire out of a total of 5.1 track miles) would include approximately $15 million in OCS infrastructure, including wire, poles, and substations (plus contingencies). A second scenario with 35% off-wire (a total of 1.8 track miles of off wire out of a total of 5.1 track miles) would include approximately $13.5 million for OCS infrastructure, saving approximately $1.5 million.

The vehicles for the Oklahoma City streetcar are likely to be either the Brookville or Inekon vehicles with off-wire capability. The current cost estimate for these vehicles is approximately $6 million per vehicle.

<u>Detroit:</u>

The M-1 Rail project in Detroit, currently in design, will utilize six Brookville streetcar vehicles with off-wire capability, similar to the Dallas streetcar vehicles. The M-1 Rail project includes a 3.3-mile route, 60 percent of which will be off-wire. The reason was a desire to minimize aesthetic impacts in the historic downtown core. The M-1 Rail project will be the first system in the US to include an off-wire maintenance facility. The M-1 project purchased six vehicles, plus spare parts for a total of $32 million.

Ground-Level Power Systems

Ground-level power systems provide continuous power to the vehicle from infrastructure in the ground rather than overhead wires. A ground-level power system can eliminate OCS infrastructure completely. However, these systems are much newer, more specialized, and proprietary than OCS systems or even partial off-wire systems with batteries.

Systems utilizing in-ground power delivery systems are in various stages of development and testing in Europe. The TramWave system, developed by Ansaldo-Breda, and the Aesthetic Power Supply (APS) system, developed by Alstom, provide power to the vehicle via a central power rail that located in the street between the tracks (shown in Figure 11). The vehicle has a central pickup shoe that rides along the surface of the central power rail. These systems are designed in short segments (a vehicle length) that are only activated when the train is directly above. Pedestrians, bicyclists, automobiles, kids and animals would be able to safely interact with the street pavement when no train is present. This train-activated technology is referred to as a "conditioned contact line."

Figure 11: Bordeaux Streetcar with In-Ground Central Power Rail

The first modern ground-level power system in operation began service in Bordeaux, France in 2003 utilizing vehicles made by Alstom. The system utilizes traditional OCS in outlying areas, but ground-level power delivery was chosen in the historic city center for aesthetic reasons.

This central power rail technology remains somewhat controversial due to concerns about the possibility of a segment becoming activated when a streetcar is not present and posing a danger of electrocution to people on the street who may come in contact with it. This has not been an issue with any systems that have been implemented, but remains a concern.

The Primove system, developed by Bombardier, is similar to these in ground rail systems, except that it charges without making physical contact between the vehicle and the charging equipment. The system utilizes an inductive charger buried in the street at stations and in other locations where the vehicle needs extra power, such as on uphill segments. These systems are able to provide rapid recharging and can top off the vehicle charge while it is loading and unloading passengers at a station. These systems can be used for any type of transit vehicle. A prototype induction charging electric bus system is in operation in Berlin. Bombardier is also developing inductive ground charging prototypes for delivery van and taxi charging stations.

These central power rail and induction charging systems may be promising new technologies. However, they are in early testing phases, and have only been implemented in limited applications. The results of current testing and initial applications of these technologies will answer important question regarding this promising new technology. More information on the feasibility, safety and costs of induction technology will become available as testing is completed.

Because these systems are proprietary and only available from a limited number of vehicle and system suppliers, in the near term it is likely that costs would be relatively high and there would be a relatively high risk of supply chain issues.

Self-Propelled Operation

TIG/m is pioneering streetcar systems that require no power delivery systems along the route because the vehicles are equipped with on-board power generation. Utilizing on-board energy storage, regenerative braking, and a clean energy generator fueled by CNG, LNG, or hydrogen fuel cells, TIG/m vehicles only need to be refueled at the maintenance facility and can operate for a full service day, recharging on-board batteries with the generators. They can also be plugged in at night at the maintenance facility to recharge the batteries.

Hydrogen fuel cell generators work by utilizing hydrogen and oxygen to create a chemical reaction that generates electricity. This electricity is then stored in on-board batteries. TIG/m has experience working on advancing the use of hydrogen as an energy source for transportation systems. Interest in hydrogen fuel cell technology has grown nationally and in California in recent years. TIG/m has partnered with the California Fuel Cell Partnership, a consortium of vehicle manufacturers, energy providers, and government agencies working together to promote and establish hydrogen fuel delivery infrastructure and fuel cell vehicles.

Public transit vehicles are well suited to hydrogen fuel cell technology. Because they travel at low speeds and have a large amount of space for fuel tanks, they can be fueled up once and travel for an entire service day. Because they frequently start and stop, they are able to make extensive use of regenerative braking to keep the batteries charged. Hydrogen fuel cell buses are currently in operation in Contra-Costa County in the Bay Area and in Palm Springs as part of a pilot program.

This technology is very promising in the long term. However, as with the ground-level power systems, it is still in limited use with limited vehicle and system suppliers available. It is likely that costs would be relatively high early on and there would be a relatively high risk of supply chain issues.

Applicability to the Fairfax-San Rafael Corridor

The Fairfax-San Rafael corridor consists of a mix of environments, including three historic downtown centers, more auto-oriented commercial strips along arterials, and narrow tree lined residential streets. There may be some sensitivity to the visual environment in the town centers and in residential areas and a resulting desire to reduce the amount of overhead wiring and poles. However, there are currently overhead electrical wires throughout the corridor. The addition of streetcar wires would not represent a significant aesthetic change. There are ornamental light poles in downtown Fairfax and downtown San Rafael that could be utilized for OCS wires, which could reduce the number of new OCS poles.

There are no areas with a significant density of overhead wires, such as the trolley bus wires in Seattle, which would present a significant extra cost to accommodate streetcar OCS wires. There are some segments that are narrow and have trees located close to the roadway, such as along Center Boulevard and along the Miracle Mile. There may be some potential for impacts to trees in some of these areas, but these would likely be minor. There are no low clearance overcrossings, such as in Oklahoma City. Overall, there do not appear to be any significant physical obstacles to using traditional OCS for the entire corridor.

Off-Wire Technology Costs, Availability, and Trade-Offs

Costs

Off-wire technology for streetcars is a rapidly emerging market. Nearly all streetcar vehicle manufacturers are now offering some form of off-wire technology, mostly using on-board energy storage. Because the technology is so new and changing rapidly, the costs for these systems are challenging to nail down.

Companies like Inekon and Brookville have the most recent experience providing on-board energy storage systems for streetcars in the US. The up-front cost to purchase vehicles with off-wire capability appears not to be much higher than vehicles without. The cost difference is primarily for the batteries. Many manufacturers are also designing their vehicles to enable them to be retrofitted in the future to be off-wire capable. Recent off-wire capable vehicles from Inekon and Brookville have ranged in cost from $4.5 million to $6 million per vehicle.

The ongoing cost for battery replacement depends on many factors and remains difficult to estimate. Battery life depends on the amount of off-wire operation, the rate of recharging, and environmental conditions. If a system has an extensive amount of off-wire operation and each battery's charge is drawn down significantly as the vehicle serves this section, this will result in shorter battery life than a system with shorter off-wire sections. Faster recharge rates will also reduce battery life. If a system has extensive on-wire operation, it can recharge slowly as it operates in the on-wire sections. If a system has limited on-wire operation, recharging may need to be done rapidly during vehicle layover at the end of the route. Taking more time to recharge the battery during a layover may require operating more vehicles in order to maintain adequate service frequency.

Environmental conditions, including topography and climate, will have an impact on battery life. Significantly more energy is required for a streetcar to climb a hill than to descend. Energy recovery through regenerative braking is also more available as a vehicle descends a hill. The First Hill Streetcar in Seattle has significant grade change over its route. It will travel from a low point at its southern terminus up to the top of First Hill and Capitol Hill. For this reason, it will operate on-wire for the length of the uphill trip and off-wire for the length of the downhill trip. The Fairfax-San Rafael corridor traverses the bottom of the Ross Valley and is relatively flat with some gentle, rolling topography. As such, it does not have the same high power requirements for hill climbing that the First Hill Streetcar does.

Air conditioning systems require a significant amount of energy. Operating with air conditioning on takes nearly as much electricity as vehicle propulsion. Therefore, some systems are looking at operating with the air conditioning system switched off over off-wire segments. This may be feasible in the Bay Area's relatively mild climate. Other systems, such as Oklahoma City and Dallas, are opting for more robust battery systems to support continued air conditioning use while operating off-wire.

Each project would need to be evaluated on an individual basis to determine the optimum balance of off-wire operation and battery life depending on its unique operating environment.

Only one off-wire streetcar system is currently in operation in the US, the Oak Cliff streetcar in Dallas, and it has only been in operation for a few months. Therefore, it remains to be seen how long the batteries will last. Estimates for battery life in these vehicles range widely, from two years to eight years. Costs to replace batteries can vary significantly. Estimates for replacement batteries range from $125,000 to $400,000 per battery set (including two batteries). This could represent a significant ongoing maintenance expense, especially for a system with extensive route length and/or high frequency, requiring a large number of vehicles. It is likely, however, as energy storage technology continues to improve, that future batteries would last longer and become less expensive to replace.

In addition to Inekon and Brookville, Siemens and Bombardier have extensive experience providing LRVs in the US and both produce off-wire capable vehicles utilizing on-board energy storage systems. These four companies probably represent the most readily available sources for off-wire capable vehicles in the US currently.

Cost estimates for vehicles from TIG/m appear to be much lower than the current costs for other modern streetcar vehicles. Rough quoted cost estimates range from approximately $1.4 million for an open, single-level heritage vehicle to approximately $3.4 million for a modern, enclosed, articulated streetcar, including all on-board charging equipment. A hydrogen fuel cell vehicle would additionally require approximately $1 million for a hydrogen refueling station with the capacity to support up to four vehicles. It appears that TIG/m has not yet produced a modern streetcar vehicle and the prices described here should be considered very preliminary estimates. It is also unclear what ongoing maintenance costs would be like for the vehicles and the hydrogen refueling equipment.

Flexibility

Partial off-wire and other proprietary systems could pose constraints on system operations, making the system less flexible. The attractiveness of OCS is that it is standardized, non-proprietary, and provides continuous power to the vehicle at all times. Operating off-wire with on-board energy storage introduces operating constraints into the system. For example, if a vehicle needs to layover at the end of the line for a minimum length of time in order to fully charge and there are unusual traffic issues that result in the streetcar vehicles becoming very late, they may not have adequate time to recharge.

The proprietary nature of some of the off-wire technology would tend to reduce flexibility to purchase equipment and spare parts from various suppliers. Because OCS is well established as the standard system for supplying power to streetcar systems, there are multiple suppliers available from which to purchase equipment and the equipment is relatively standardized and interchangeable.

The battery systems are becoming more established and standardized. However, at this time the ground-level power systems and the on-board generator systems pose a particular risk of future supply chain issues. The battery based systems should be much more interchangeable and offer greater flexibility to obtain batteries and other spare parts in the future from multiple suppliers.

Risk

All of the available off-wire streetcar vehicles currently available in the US entail a certain amount of risk. Potential risks include capital and operating cost overruns and reliability issues due to how new the technology is, the limited number of systems currently using it, and the proprietary nature of some of the systems. As is the case with the growing market for hybrid and fully electric cars, the technology is rapidly improving, costs are coming down, and energy storage ability is going up.

Of all of the off-wire systems reviewed in this white paper, partial off-wire systems utilizing vehicles equipped with batteries offers the most promise for a system that has relatively low risk. The technology for this has reached a point in its evolution in which it is becoming relatively standardized. All of the major streetcar manufacturers are offering some form of this technology now and there is potential for interchangeability of batteries and related equipment as well as retrofitting vehicles to be off-wire capable in the future.

The ground-level power systems are promising technologies, but would likely come with a high degree of risk due to the degree of complication and the proprietary nature of the systems. The hydrogen fuel cell on-board generators offered by TIG/m are also a promising technology. However, because it is so new, it would come with a high degree of risk for cost overruns and reliability issues.

A decision to implement partial or total off-wire streetcar system at this time is very much dependent on how much risk a community is willing to accept to implement a streetcar system, the level of community concern regarding the aesthetics of OCS poles and wires, and how much a community is willing to be a pioneer in a relatively untested technology. The potential for cost savings from reduced OCS wires and poles could be largely offset by increased cost for battery replacement and moderate risk of cost overruns, supply issues, high ongoing operating costs, and future reliability issues. These risks are likely to come down in the near future and these systems hold significant promise in the long-term.

Table 1 summarizes the trade-offs of the various streetcar technologies.

Table 1: Summary of Cost and Risk Trade-Offs

Technology	Costs	Availability/ Flexibility	Risks	Applicability to Fairfax-San Rafael Corridor
Traditional OCS	Rough estimate: $2 million to $3.6 million per mile of one-way track for poles, wires, and substations. Actual cost varies significantly depending on local conditions.	Widely available from multiple suppliers.	Very low risk. Well known technology.	Very applicable.
Partial Off-Wire with On-Board Energy Storage	Somewhat higher costs for vehicles and ongoing costs for battery replacement. Cost savings due to less OCS infrastructure probably outweighed by ongoing battery replacement costs.	Somewhat limited availability, but increasing as technology becomes more standard. Potentially reduces operational flexibility.	Modest. Increasingly becoming a standardized technology.	Moderately applicable. Could be utilized if there is a community desire to reduce aesthetic impacts.
Ground-Level Power Systems	New technology. Likely not less expensive than OCS.	New and proprietary technology. Only available from certain suppliers. Good operational flexibility because vehicles would always be connected to a power source.	High risk because it is a new and proprietary technology. Controversial due to perceived potential for safety hazards.	Not applicable.
Self-Propelled Operation	New technology with potential for cost savings due to reduced power supply infrastructure. Actual costs not clear.	New and proprietary technology. Only available from one supplier. Good operational flexibility because vehicle does not need to be connected to a power source. California company.	High risk because it is a new and proprietary technology.	Potentially applicable if there is a community desire to be a pioneer in a new technology.

Table 2 summarizes vehicles available, US experiences of major vehicle manufacturers, the off-wire technologies available, costs, and potential risks.

Table 2: Summary of Available Streetcar Vehicles

Manufacturer	Vehicle Type	Current US Experience	Off-Wire Technology	Vehicle Cost	Risk Factors	Applicability to Fairfax-San Rafael Corridor
Inekon	Modern	Provided several vehicles for Portland and Seattle. Off-wire capable vehicles for Seattle currently in testing	Partial off-wire using batteries.	Recently purchased off-wire capable vehicles for Seattle approximately $4.5 million each.	Low to moderate risk. Foreign made. May be issues meeting Buy America standards. Potential for supply chain issues.	High
Brookville	Modern and heritage	Provided 2 off-wire capable vehicles for Dallas streetcar. Currently in operation	Partial off-wire using batteries.	$4.5 million each for Dallas. $5 million each for Detroit M-1. streetcar $6 million each for Oklahoma City.	Low risk. US company with experience providing off-wire vehicles.	High
CAF USA	Modern	Providing vehicles for Cincinnati and Kansas City streetcars.	Partial off-wire using batteries.	NA		Low. May be too wide.
Siemens	Modern	Provided streetcar vehicles for Atlanta and Salt Lake City streetcars. Extensive light rail experience.	Partial off-wire using batteries.	$3.6 to $4.2 million each for Salt Lake City.	Low risk. Well established company with extensive US experience.	Low. May be too wide.
Bombardier	Modern	Extensive light rail experience. No current streetcar experience.	Partial off-wire using batteries. PriMove inductive charging system.	NA	Low risk. Well established company with extensive US experience.	Low.
Alstom	Modern	No US streetcar experience. Providing LRVs for Ottawa.	In-ground power delivery via central power rail.	NA	High risk for in-ground power delivery system. May be issues meeting Buy America standards.	Low.

Manufacturer	Vehicle Type	Current US Experience	Off-Wire Technology	Vehicle Cost	Risk Factors	Applicability to Fairfax-San Rafael Corridor
Ansaldo-Breda	Modern	Light rail and heavy rail. No US streetcar experience.	In-ground power delivery via central power rail.	NA	High risk for in-ground power delivery system. May be issues meeting Buy America standards.	Low.
TIG/m	Heritage Replica. Modern vehicle in develop ment.	Limited. Current examples at malls on private property.	Full off-wire, self-propelled vehicles using batteries and on-board CNG, LNG, or hydrogen fuel cell generator.	Quoted price of $3.4 million for modern streetcar vehicle that has not yet been produced. Approximately $1 million per four vehicles for hydrogen refueling station.	High risk. Newest technology, not yet proven in long term use. Modern streetcar vehicle not yet produced.	Low to moderate if there is a community desire to be a pioneer in a new technology.

Maintenance Facility

A streetcar maintenance facility is similar to a light rail maintenance facility. The most pertinent differences are related to the dimensions of the vehicles and the size of the vehicle fleet. A streetcar maintenance facility is generally smaller than a light rail maintenance facility. This is largely because light rail systems typically include a much larger fleet of vehicles than streetcar systems and require much larger yards for storage. Current US streetcar systems have maintenance facilities that generally are of a scale that they fit on a typical city block and can be designed to fit in with the surrounding neighborhood.

A fleet of six to eight vehicles has been estimated for the four mile Fairfax-San Rafael corridor. A maintenance facility to accommodate this size of a fleet would need a building of approximately 15,000 to 20,000 square feet and a site of approximately one to two acres. It is also important to locate a facility that is close enough to the route to minimize the amount of non-revenue track that would need to be constructed to move streetcar vehicles between the route and the maintenance facility.

Staffing at a maintenance facility of this size would likely be approximately 20 to 25 employees, including drivers, mechanics, dispatchers, and supervisors.

Site selection for a maintenance facility needs to consider the size of the facility, the topography of the site, the distance from the route, and the zoning. Generally streetcar maintenance facilities need to be located in industrial or commercial zones and away from residential areas. Streetcar maintenance facilities are generally active through the night, as many daily vehicle maintenance activities occur after revenue service ends. Streetcar maintenance facilities are generally best suited to relatively flat sites, but can be designed with multiple levels to fit on steeply sloped sites.

It may be challenging to locate a streetcar maintenance facility in the Fairfax-San Rafael corridor. Much of the corridor is residential and the historic downtown centers of Fairfax, San Anselmo, and San Rafael would not likely be appropriate fits for a maintenance facility. However, a streetcar maintenance facility to support the Fairfax-San Rafael corridor would be relatively small and could be designed in a manner that fits in with the surrounding neighborhood. If carefully designed, a streetcar maintenance facility can blend in with the surrounding neighborhood in such a way that it is not a noticeable presence from the street or the surrounding neighborhood. It can be incorporated into the designs of other developments, placed behind other buildings, or otherwise screened off or tucked away.

It is also important to consider potential future phases when determining the size and location needs of a maintenance facility. Typically the building needs to accommodate two vehicles at a time while they're being serviced. The site needs to be large enough to accommodate storage and marshalling of the entire vehicle fleet. If there is a foreseeable extension of the streetcar system, it may make sense to select a site with room to expand.

The following provides some examples of streetcar maintenance facilities in other US cities:

- Seattle: Seattle has two maintenance facilities. The first was built with the initial 1.3-mile long South Lake Union line. The second was built to serve the recently completed 2.5-mile First Hill Streetcar line. The South Lake Union maintenance facility site is less than an acre and accommodates three vehicles. The First Hill Streetcar maintenance facility site is approximately one acre and accommodates six vehicles. All six of these vehicles are Inekon off-wire capable vehicles.
- Detroit: The Detroit maintenance facility will include an approximately 15,000 square foot building on an approximately one acre site and will accommodate six vehicles.
- Oklahoma City: The Oklahoma City maintenance facility will include an approximately 18,000 square foot building on an approximately 2.8 acre site. The facility will accommodate five vehicles for the initial streetcar line and the site will enable future expansion to accommodate up to 12 vehicles.

Relevant Regulations

In addition to California and local traffic codes and regulations that would apply to either a bus or a streetcar alternative, the streetcar would be subject to regulation by the California Public Utilities Commission (CPUC). The CPUC regulates safety issues related to railroads and has jurisdiction over railroad crossings. As an in-street railroad operating in mixed traffic, the CPUC would have an interest in several aspects of a streetcar project, including vehicle speeds, vehicle safety equipment, overhead or in-ground electrical supply equipment, etc.

CPUC General Order 143-B, Safety Rules and Regulations Governing Light-Rail Transit,[4] would apply to a streetcar project. General Order (GO) 143-B was originally adopted in 1991. The most recent amendment was in 2000. The GO was written to accommodate light rail vehicles traveling primarily in exclusive right-of-way. It defines streetcar as light rail transit operating in mixed traffic.

There are several light rail and heavy rail (commuter rail or metro system) systems in operation in California. All of these are regulated by GO 143-B. Several communities in California have plans to introduce new modern streetcar systems, but none have yet been implemented. These include Sacramento, Los Angeles, Santa Ana, and Irvine. It will be important for any new in-street streetcar systems to coordinate with CPUC on compliance with GO 143-B and coordination should begin early in the project design process. Because the GO was intended for light rail systems operating in primarily exclusive right-of-way, there may be issues with compliance with GO 143-B for a streetcar project. Coordination should also be started early on with other California streetcar project sponsors in order to have consistent conversations with CPUC. It may also make sense to coordinate with other California streetcar project sponsors on their vehicle procurement in case there are any specialized vehicle requirements for complying with GO 143-B.

Conclusion

The streetcar technology considerations detailed in this white paper should help inform a choice of vehicle type for the High Investment Alternative for the Fairfax-San Rafael corridor. Due to the existence of relatively narrow lanes in the corridor, the narrower Inekon and Brookville vehicles would likely be the most appropriate. Wider vehicles could be used, but would likely require elimination of the bike lanes on Center Boulevard.

Vintage streetcar vehicles could also be used if there is a desire for a vintage style system. However, if the primary purpose of the project is to provide improved mobility for multiple trip types, including commuter travel, then the modern, low-floor vehicles would offer the greatest capacity and comfort as well as efficient operation.

The lowest risk power delivery technology is a traditional OCS-powered system with overhead wires, poles, and substation equipment that are widely available from multiple suppliers. Partial off-wire with on-board energy storage is increasingly feasible with nearly every major streetcar manufacturer offering this equipment. This could be a good option for the Fairfax-San Rafael corridor if there is a community desire to minimize aesthetic impacts along sections of the route, such as in downtown Fairfax, downtown San Rafael, or along the tree lined residential streets between Fairfax and San Anselmo.

In-ground power delivery would likely not make sense for the Fairfax-San Rafael corridor. The technology is so new and not yet tested, that it would pose substantial risks of delays and cost overruns.

The self-propelled hydrogen powered vehicles made by TIG/m offer an intriguing option that would support a relatively local company. This option offers a high degree of operational flexibility because the

[4] http://docs.cpuc.ca.gov/PUBLISHED/Graphics/598.PDF

vehicles generate their own power and it may offer long-term cost savings. However, because the technology is so new and the company still has a limited record of success, the actual costs are unclear and it would represent a high risk for the Fairfax-San Rafael corridor.

A streetcar maintenance facility to support the Fairfax-San Rafael corridor would be relatively small. While locating an appropriate site and incorporating such a facility into the Fairfax-San Rafael corridor would be challenging, such a facility can be carefully designed to blend in with the surrounding area. Other planned developments in the corridor could present an opportunity to incorporate a maintenance facility as part of a larger development and design it in such a way as to be hidden behind other buildings.