

**Andersen Drive  
Report on Analysis of Alternatives to Accommodate Rail Service**

**Final Report**

**January 2015**



**Department of Public Works  
Engineering Division**

## **Purpose**

The purpose of this report is to identify, describe, analyze and compare conceptual alternatives for accommodating commuter rail service across Andersen Drive in the City of San Rafael.

## **Executive Summary**

In 1997, the City of San Rafael extended Andersen Drive from Francisco Boulevard West, paving over the existing railroad track and blockaded the track on either side of the roadway. The California Public Utilities Commission (CPUC) authorized the City to construct the roadway and blockade the track, but ruled that the authorization would expire once regular train service was scheduled through the crossing and that the City must apply for authorization to continue to utilize the crossing.

The Sonoma Marin Area Rail Transit District (SMART) is currently designing and reconstructing the portion of the tracks between downtown San Rafael and Windsor. In addition, SMART has sought both regional and federal funds for the completion of the Larkspur extension. Once funding is identified, SMART's proposed Larkspur Extension would bring thirty trains through Andersen Drive on a daily basis.

In preparation for rail service, the City of San Rafael identified and studied six alternatives to accommodate rail service through Andersen Drive:

1. Grade Separation
2. At-Grade Crossing with Chicane
3. Closure
4. One-Way Southbound Bypass via Woodland Avenue
5. Two-Way Bypass via Woodland Avenue
6. At-Grade Crossing with Additional Storage Capacity

Each alternative was evaluated in five categories:

1. Traffic Impacts
2. Cost
3. Feasibility
4. Safety
5. Schedule

The analysis concluded that the City should pursue alternative 6, At-Grade Crossing with additional Storage Capacity. This alternative will provide a safe, relatively low cost crossing while also providing minimal impact to the surrounding roadway network. This alternative also fits within the City's existing budget, is feasible, and can be constructed within the given timeline for rail service operations.

## **History of Andersen Drive**

In 1997, the City of San Rafael (City) extended Andersen Drive north from the intersection of Francisco Boulevard West through former mainline Northwestern & Pacific railroad tracks. The extension of Andersen Drive was intended to provide an improved connection from Downtown San Rafael to East San Rafael, I-580, the Richmond-San Rafael Bridge and US-101. As part of the extension, the City paved over the existing railroad track and blockaded the track on either side of the roadway. The California Public Utilities Commission (CPUC) authorized the City to construct the roadway and blockade the track, but ruled that the authorization would expire once regular train service was scheduled through the crossing. Additionally, the CPUC ruled that in order to accommodate rail service through Andersen Drive the City must apply for authorization to continue to utilize the crossing and the City would be financially responsible for making any future improvements that the Commission deemed necessary.

## **Status of Funding for Andersen Drive**

The City has set aside \$2 Million for improvements associated with the at-grade crossing.

## **Status of Andersen Drive**

Andersen Drive is a heavily traveled, two lane arterial, oriented in the general northbound/southbound direction. The roadway is skewed approximately eleven degrees in relation to the adjacent former Northwestern and Pacific railroad track, track which is now owned by Sonoma Marin Area Rail Transit (SMART). A southbound left turn pocket is located at the intersection of Andersen Drive and Francisco Boulevard West which serves as a feeder to a southbound US-101 on-ramp. Average Daily Traffic (ADT) volumes on Andersen Drive, which were collected in 2008, indicate over 15,000 vehicular trips north of Francisco Boulevard West, and over 24,000 trips south of Francisco Boulevard West.

Andersen Drive is also a major bicycle commute route featuring Class II bike lanes in both directions and a wide sidewalk on the west side of the road. The Class II bike lanes provide non-motorized access between Downtown San Rafael and the Larkspur Ferry Terminal via the recently constructed bridge over Auburn Street and the Cal Park Hill Tunnel.

## **Status of SMART Commuter Rail Service through Andersen Drive**

The Sonoma Marin Area Rail Transit District (SMART) is in the process of designing and constructing the 42.5 mile Initial Operating Segment of its commuter rail service, which features a northern terminal station at Airport Boulevard in Windsor, and a southern terminal station between 3rd and 4th Streets in Downtown San Rafael. The Downtown San Rafael Station will serve as a temporary terminal station until the agency implements the southern extension of its commuter rail service to Larkspur. Concurrent with these design and construction activities, SMART has sought both regional and federal funds for the completion of

the Larkspur extension. In response to SMART's pursuit of new funding sources, the Metropolitan Transportation Commission (MTC) has granted SMART \$20 million in Regional Measure 2 funds, and has endorsed SMART's pursuit of an additional \$20 million in federal funds with applications pending. With additional funds, SMART's plans to bring regularly scheduled rail service through Andersen Drive will occur soon after construction of the Initial Operating Segment, scheduled to open in late 2016. SMART's proposed Larkspur Extension would bring thirty trains through Andersen Drive on a daily basis, with the majority of the trips made during San Rafael's peak commute hours between 7 to 9 am and 4 to 6 pm.

## **Rail Crossing Alternatives**

In preparation for SMART's commuter rail service, and in response to the CPUC's 1997 ruling, the City of San Rafael has identified and studied six alternatives to accommodate rail service through Andersen Drive. These alternatives range from complete closure of the roadway at the crossing to grade separation of rail traffic from vehicular, pedestrian and bicycle traffic. A summary of each alternative is described below.

### Alternative 1 - Grade Separation

This alternative involves the construction of a grade separated structure to carry rail traffic over Andersen Drive. This alternative is depicted in Figure 1.



**Figure 1 - Alternative 1 Layout**

### Alternative 2 - At-Grade Crossing with Chicane

This alternative involves the construction of an at-grade crossing combined with a significant realignment of Andersen Drive. The realignment would improve the geometry of the crossing by bringing the roadway across the track at a 45 degree angle. This alternative is depicted in Figure 2.





Figure 2 - Alternative 2 Layout

Alternative 3 - Closure

This alternative involves the closure of Andersen Drive via the construction of a cul-de-sac north of the track and the construction of a permanent barrier (e.g. curb & gutter, fencing, etc.) south of the track at the intersection of Francisco Boulevard West and Andersen Drive. This alternative is depicted in Figure 3.



Figure 3 - Alternative 3 Layout

Alternative 4 - One-Way Southbound Bypass via Woodland Avenue

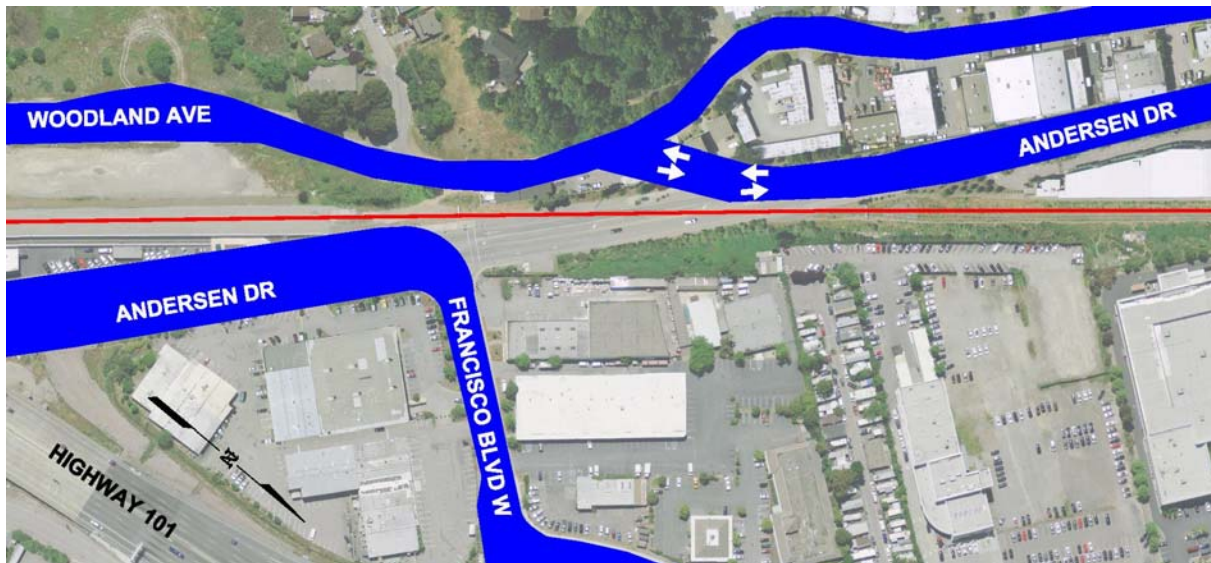
This alternative involves the closure of Andersen Drive north and south of the track and re-routing of vehicular, bicycle and pedestrian traffic via construction of a one-way southbound bypass to existing Woodland Avenue. This alternative is depicted in Figure 4.



**Figure 4 - Alternative 4 Layout**

*Alternative 5 - Two-Way Bypass via Woodland Avenue*

This alternative involves the closure of Andersen Drive north and south of the track and re-routing of vehicular, bicycle and pedestrian traffic via construction of a two-way bypass to existing Woodland Avenue. This alternative is depicted in Figure 5.



**Figure 5 - Alternative 5 Layout**

*Alternative 6 - At-Grade Crossing with Additional Storage Capacity*

This alternative involves the construction of an at-grade crossing of Anderson Drive with the existing roadway and track geometry and increasing the storage capacity for eastbound Francisco Boulevard West. This alternative is depicted in Figure 6.



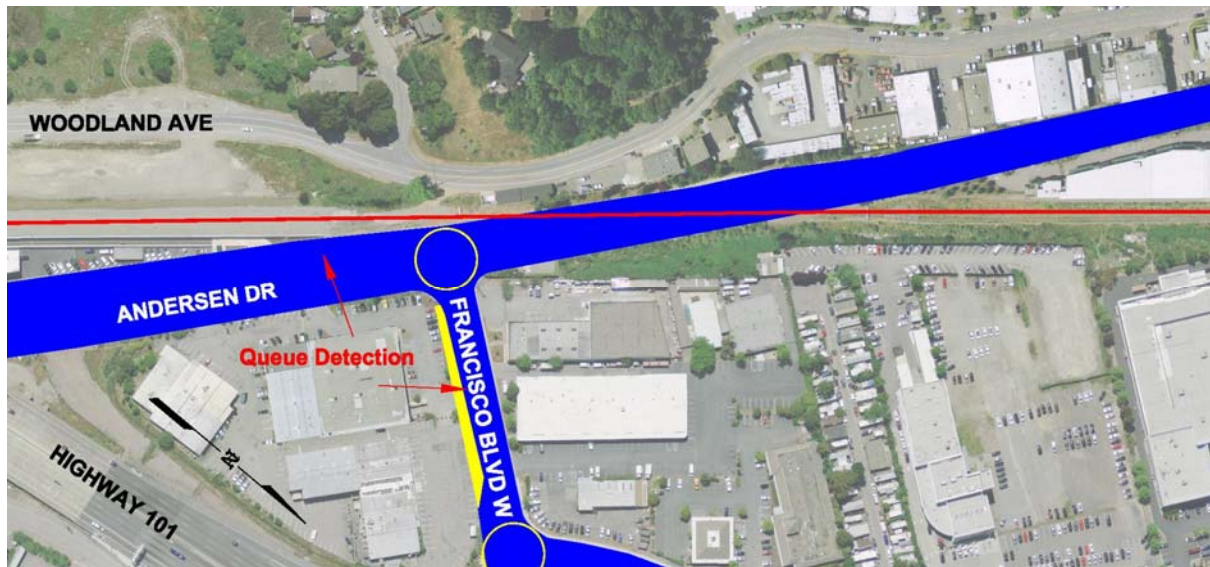


Figure 6 - Alternative 6 Layout

## Analysis of Alternatives

Each alternative was analyzed to determine relative cost, feasibility, and traffic impacts. In order to determine traffic impacts, traffic operations analyses were performed for each alternative utilizing the City's traffic modeling and simulation software packages. All traffic operations analyses involving alternatives featuring an at-grade crossing with SMART's tracks were performed in coordination with SMART's proposed timetable and associated schedule of train operations through Andersen Drive. For the alternatives in which detours or closures are proposed, existing traffic volumes were rerouted to the adjacent streets, and the net turning movement changes were applied to the City's traffic and simulation models which were then analyzed in order to determine the major impacts to ten intersections and multiple arterials located within the vicinity of the crossing.

### Alternative 1 - Grade Separation

This alternative involves construction of a raised double track rail structure over Andersen Drive to separate rail traffic from vehicular, pedestrian and bicycle traffic. The design of this structure would need to accommodate the capabilities of SMART's Diesel Multiple Units, which can negotiate a maximum ascending grade of 3%. In addition, the raised structure must maintain a fifteen foot vertical clearance over the vehicular travelled portion of Andersen Drive. Furthermore, high voltage Pacific Gas & Electric (60K VAC minimum) transmission lines are located within the median along this section of Andersen Drive and would require undergrounding or relocation in order to accommodate a raised structure.

### *Cost and Timeline*

A preliminary cost for this alternative is estimated to be \$30-50 Million and take approximately 10 years to design, permit and construct.

A summary of the advantages and disadvantages for this alternative are as follows:

*Advantages*

- Elimination of the potential for train/vehicle/bicycle/pedestrian collisions
- Elimination of train/vehicle/bicycle/pedestrian conflicts

*Disadvantages*

- High Cost
- Difficult and lengthy environmental permitting
- Costly, difficult and lengthy utility relocations
- 2 to 3 year long temporary closure of Andersen Drive required for construction

*Alternative 2 - At-Grade Crossing with Chicane*

This alternative involves significant realignment of Andersen Drive to increase the crossing angle and reduce the crossing length from over 450' to less than 60' by bringing the roadway across the track at an approximate 45 degree angle in lieu of the existing 11 degree angle.

*Roadway Impacts*

Construction of this alternative will require the acquisition of a portion of private property and the relocation and rebuilding of an existing sanitary sewer pump station as well as additional adjacent facilities.

*Cost and Timeline*

A preliminary cost for this alternative is estimated to be \$6 Million and take approximately 5 years to design, acquire the property and construct.

A summary of the advantages and disadvantages for this alternative are as follows:

*Advantages*

- Reduction in the at-grade crossing length
- Improves sight distance for drivers to oncoming train traffic

*Disadvantages*

- Cost
- Time
- Acquisition of adjacent private property
- Relocation of sanitary sewer pump station
- Chicane alignment may limit view of grade crossing warning devices
- Difficult environmental permitting



Alternative 3 – Andersen Drive Closure

This alternative involves the complete closure of Andersen Drive via the construction of a cul-de-sac north of the existing SMART railroad track, and the installation curb, gutter and fencing south of the track at the intersection of Andersen Drive and Francisco Boulevard West. A modification of the existing traffic signal system would be required to accommodate the revised roadway geometry. With the complete closure of the roadway, vehicles would be routed to nearby north/south arterials including Francisco Boulevard West, Woodland Avenue and US-101. Absent provisions for a stand-alone pedestrian and bicycle crossing, these facility users will also be routed to Francisco Boulevard West and Woodland Avenue. Impacts to each roadway user are expected and described below.

*Vehicular Impacts*

Vehicles would divert in the southbound direction from Andersen Drive to Francisco Boulevard West, Woodland Avenue and US-101 via Second Street, DuBois Street, Irwin Street and Rice Drive. In the northbound direction, vehicles would divert to Woodland Avenue, Francisco Boulevard West and Francisco Boulevard East/Grand Avenue via Bellam Boulevard and Third Street.

With the closure in place, queuing would extend in both the eastbound and westbound directions on Bellam Boulevard from Andersen Drive to their respective upstream intersections and a solid queue would form on Second Street (an arterial of regional significance) from A Street to Hetherton Street as eastbound vehicles would divert to the US-101 southbound on-ramps. Furthermore, the queuing on Bellam Boulevard would significantly limit access to and from East San Rafael, a secluded location of the City with only two access points in and out of the neighborhood. In general, closure of Andersen Drive would eliminate the improved access to surrounding communities, businesses and Downtown San Rafael and increase volume to nearby freeway on- and off-ramps.

The intersections of 2<sup>nd</sup> Street/Lincoln Avenue, Bellam Boulevard/Andersen Drive and Auburn Street/Woodland Avenue will fail as they will not be able to accommodate the additional vehicles. In addition, the intersections of 2<sup>nd</sup> Street/Hetherton Street, 2<sup>nd</sup> Street/Tamalpais Avenue and Francisco Boulevard West /101 southbound Ramps will experience major delays. The queuing on Bellam Boulevard will limit access to the driveways along this segment of the roadway, thereby reducing access to the adjacent businesses. A graphic depicting the queuing and intersection operational impacts is included in the appendix.

Table 1 – Alternative 3 Intersection Delay and Levels of Service

Intersection	Existing		Alternative 3	
	Delay (sec)	Level of Service	Delay (sec)	Level of Service
Andersen Dr & Rice Dr	0.2	A	2.0	A

Intersection	Existing		Alternative 3	
	Delay (sec)	Level of Service	Delay (sec)	Level of Service
Andersen Dr & Woodland Ave	-	-	-	-
Auburn St & Woodland Ave	12.6	B	<b>119.0</b>	<b>F</b>
Francisco Blvd W & Rice Dr	1.9	A	9.3	A
DuBois St & Rice Dr	2.8	A	5.7	A
Francisco Blvd W & 101 SB Ramps	30.8	C	<b>73.8</b>	<b>E</b>
Andersen Dr & Francisco Blvd W	29.6	C	-	-
Andersen Dr & Old 101 SB Ramps	0.9	A	0.9	A
Bellam Blvd & Andersen Dr	53.5	D	<b>94.4</b>	<b>F</b>
Andersen Dr & DuBois St	31.6	C	10.1	B
Second St & Hetherton St	30.6	C	<b>58.9</b>	<b>E</b>
Second St & Tamalpais Ave	35.1	D	<b>68.4</b>	<b>E</b>
Second St & Lincoln Ave	51.4	D	<b>124.0</b>	<b>F</b>

*Bicycle and Pedestrian Impacts*

Closure of Andersen Drive would result in the loss of direct bicycle and pedestrian connections between downtown San Rafael and the Cal Park Hill Tunnel, unless a pedestrian/bicycle at-grade crossing is provided. If such a crossing is not provided, bicyclists and pedestrians would be forced to utilize Woodland Avenue which currently has no bicycle facilities or sidewalks, or Francisco Boulevard West which is a narrow roadway with many driveways. Both of these alternate routes would increase the length of pedestrian and bicycle routes significantly, and may result in a reduction in the number of non-motorized users in this area.

*Cost and Timeline*

A preliminary cost for this alternative is estimated to be \$2 Million. This alternative would take approximately 2 years to design and construct.

A summary of the advantages and disadvantages for this alternative are as follows:

*Advantages*

- Low Cost
- Construction can occur relatively quickly
- Elimination of potential for train/vehicle collisions
- Elimination of potential for train/vehicle conflicts

*Disadvantages*

- Major traffic impacts
- Reduction to access
- Impacts to businesses due to vehicular queuing

- Increased pedestrian and bicycle route lengths and times
- No Pedestrian or Bicycle connection to Cal Park Hill Tunnel
- Possible reduction in the number of non-motorized users due to lack of connections
- Increased traffic volume on US-101.

#### Alternative 4 - One-Way Southbound Bypass via Woodland Avenue

This alternative involves the partial closure of Andersen Drive and the construction of a one-way, southbound bypass to existing Woodland Avenue. With the partial closure of the roadway, northbound vehicles, pedestrians and bicyclists would be routed to nearby arterials including Francisco Boulevard West, Woodland Avenue and US-101. All southbound vehicles bicycles, and pedestrians would connect to southbound Woodland Avenue. However, it is expected that some vehicles will divert to alternate roadways in the area, and therefore, the median on Andersen Drive will be removed at the intersection of Rice Drive in order to allow southbound left turns from Andersen Drive, onto Rice Drive, ultimately connecting to Francisco Boulevard West. Impacts to each roadway user are expected and are described below.

#### *Vehicular Impacts*

In the northbound direction, vehicles would be rerouted to northbound Francisco Boulevard West and northbound Woodland Avenue via westbound Bellam Boulevard. In the southbound direction, vehicles would continue from Andersen Drive and connect to Woodland Avenue. Woodland Avenue then connects to eastbound Bellam Boulevard and all southbound vehicles would then be arriving at the western leg of the intersection of Bellam Boulevard/Andersen Drive. It is expected that some vehicles will also divert to southbound Francisco Boulevard West and US-101 via DuBois Street, Rice Drive, Irwin Drive and Second Street as significant queuing is expected on southbound Woodland Avenue.

With the rerouting of vehicles as described above significant delay and queuing is expected as follows:

- Eastbound Bellam Boulevard at the intersection with Andersen Drive continuing on southbound Woodland until it reaches the merge point from the Andersen southbound bypass.
- Eastbound Rice Drive at Francisco Boulevard West and westbound Rice Drive at DuBois Street. These queues would extend over the existing at grade crossing on Rice Drive. Additional mitigations would therefore be required for this crossing (these mitigations were not studied).
- Southbound Francisco Boulevard West to the US-101 southbound ramps. Queue would extend onto northbound Andersen to the signal at the old US-101 southbound off ramp.

The intersections of Francisco Boulevard West/Rice Dr, Rice Drive/DuBois Street, Francisco Boulevard West/US 101 southbound Ramps, Bellam Boulevard/Andersen Drive, and Auburn Street/Woodland Avenue will fail as they will not be able to accommodate the additional vehicles. In addition, the intersection of 2<sup>nd</sup> Street/Lincoln Avenue will experience major delays. The queuing on southbound Francisco Boulevard West (approaching the US-101 southbound ramps) and northbound Andersen Drive will limit access to the driveways along these roadway segments, thereby reducing access to the adjacent businesses. A graphic depicting the queuing and intersection operational impacts is included in the appendix.

Table 2 – Alternative 4 Intersection Delay and Levels of Service

Intersection	Existing		Alternative 4	
	Delay (sec)	Level of Service	Delay (sec)	Level of Service
Andersen Dr & Rice Dr	0.2	A	6.0	A
Andersen Dr & Woodland Ave	-	-	20.2	C
Auburn St & Woodland Ave	12.6	B	<b>101.0</b>	<b>F</b>
Francisco Blvd W & Rice Dr	1.9	A	<b>51.5</b>	<b>F</b>
DuBois St & Rice Dr	2.8	A	<b>198.0</b>	<b>F</b>
Francisco Blvd W & 101 SB Ramps	30.8	C	<b>152.0</b>	<b>F</b>
Andersen Dr & Francisco Blvd W	29.6	C	-	-
Andersen Dr & Old 101 SB Ramps	0.9	A	0.9	A
Bellam Blvd & Andersen Dr	53.5	D	<b>167.0</b>	<b>F</b>
Andersen Dr & DuBois St	31.6	C	19.0	B
Second St & Hetherton St	30.6	C	30.8	C
Second St & Tamalpais Ave	35.1	D	35.1	D
Second St & Lincoln Ave	51.4	D	<b>63.1</b>	<b>E</b>

*Roadway Impacts*

To mitigate the expected queuing, this alternative would require widening Bellam Boulevard/Auburn Street beneath the US-101 overpass, SMART's railroad trestle and the recently constructed bike path bridge to accommodate a minimum of five vehicular travel lanes (two through lanes in each direction plus one left turn pocket). In addition, to provide a safe and accessible bypass for Andersen Drive, two bicycle lanes and an eight and a half foot wide sidewalk are also required, similar to the current configuration of Andersen Drive. This equates to a total of 80.5 feet of width needed for the connecting roadway ((5\*12)+(6\*2)+8.5)).

However, with the location of the existing columns and abutments of the three structures across this roadway it is not possible to increase the roadway width beyond its current capacity without reconstruction the US-101 overpass, the railroad trestle and the recently constructed bike path bridge.



Currently, Bellam Boulevard/Auburn Street travels under an existing SMART wood trestle which was built many years ago. This trestle has two abutments and three bents with two narrow vehicular lanes under the trestle. The current lane widths are approximately 10.5 feet each and have a height restriction of 14'-2" under the trestle.

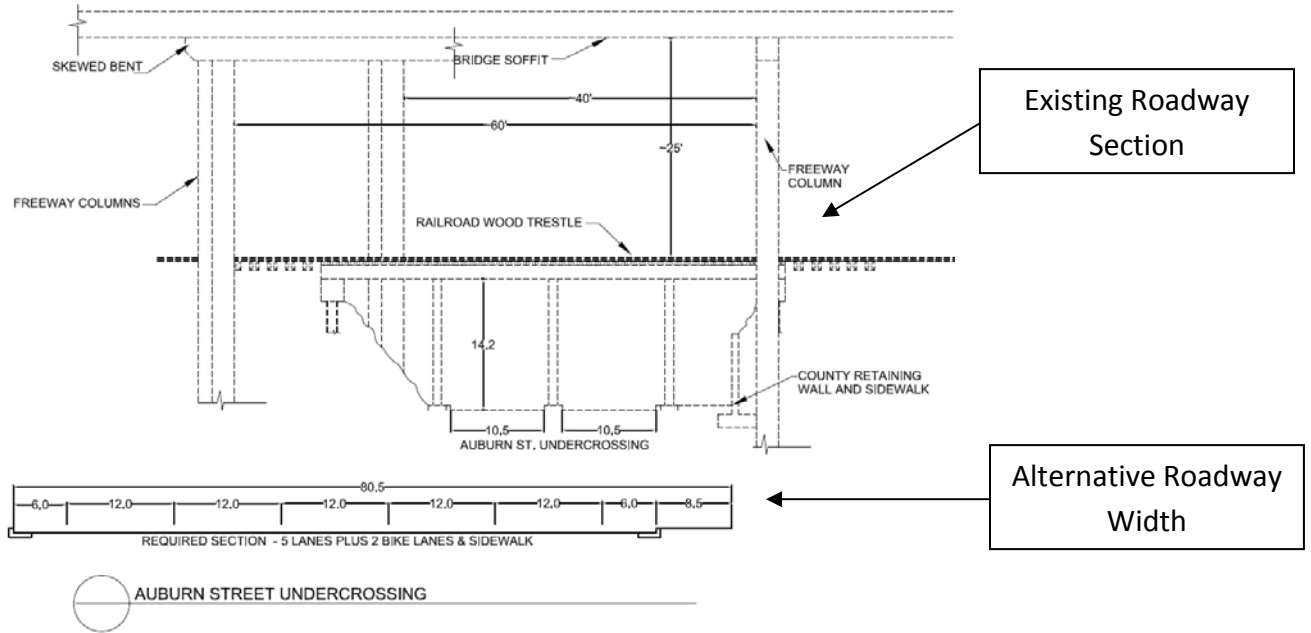


Figure 7 – Auburn Street Undercrossing

US-101 - California Park Overhead travels over the SMART trestle and over the top of Auburn Street. The supports for the US-101 Overhead are located in very close proximity to the existing Auburn Street traveled way. The US-101 Overhead was improved in the mid-1990's to

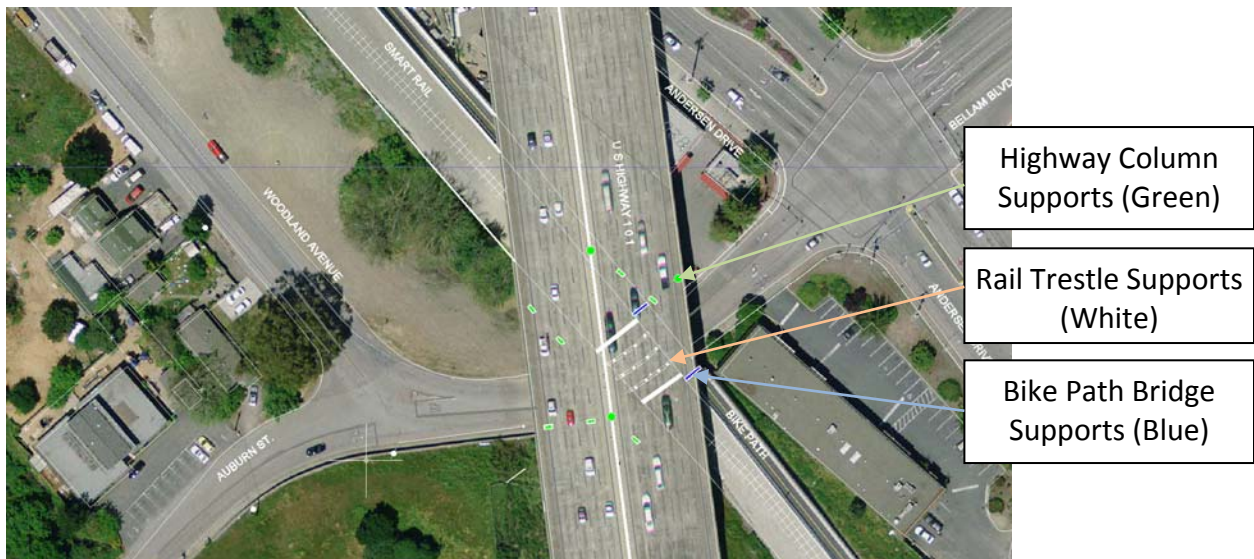


Figure 8 – Location of Existing Structural Supports

add additional supports and width to the freeway. The new supports are exceptionally close to the two vehicular lanes. In addition, the column supports are not perpendicular to the freeway lanes. A portion of the bents are parallel to the abutments while the remainder are skewed. There is 61 feet of clearance between the freeway columns supports on the west side of the rail crossing at Auburn Street and a narrower width for the columns supports on the east side of the rail crossing. The height between the trestle deck at the soffit of the overpass is approximately 25 feet.

The County of Marin installed a sidewalk on the south side of Auburn Street in the 1990's . This sidewalk is approximately six feet wide and involved the installation of a six to eight foot tall concrete retaining wall which travels between the abutment of the wood trestle and the first bent support of the trestle.



Figure 9 – Auburn Street Structural Photos



Figure 10 – More Auburn Street Structural Photos

In 2008, the County of Marin improved the CalPark Hill Tunnel to accommodate a bike path from Andersen Drive to Larkspur Landing. As part of that project, the County added a bike path

along the east side of the existing rail right-of-way. The project included adding abutments next to the existing trestle, adding a Keystone block wall on the east side of the rail right-of-way, adding retaining walls on the north side of Auburn Street, concrete barriers and a steel pedestrian bridge across Auburn Street which parallels the wood trestle. The pathway is constructed to wind around the existing freeway support columns.

The current alignment of Auburn Street is not directly in line with Bellam Boulevard and slight alignment modifications would be needed. In addition, there are significant challenges to providing a roadway that is 80.5 feet wide, travels under the existing train and bike path bridges and crosses under the US-101 Overhead. The following is a summary of these challenges:

### Highway Supports

The existing highway support columns on the west side of the rail line are 60 feet apart and less than 40 feet from the trestle and bike path bridge abutments on the east side of the rail crossing. The column supports change from being parallel with the abutments to being skewed at the Auburn Street crossing. In order to install a five lane roadway in this area the supports will need to be moved. This freeway was built in the 1950's and it is unlikely that the superstructure design can support a span width of 80 feet. Therefore, the relocation of the freeway columns supports is required, and possibly the raising of the freeway. Based on preliminary geometry shown on the following page at least two bents composed of two to four columns each will need relocation. The fact that the supports are skewed at the Auburn Street undercrossing also adds a level of complexity of the engineering involved with designing a new support system to accommodate the new Auburn Street Undercrossing.

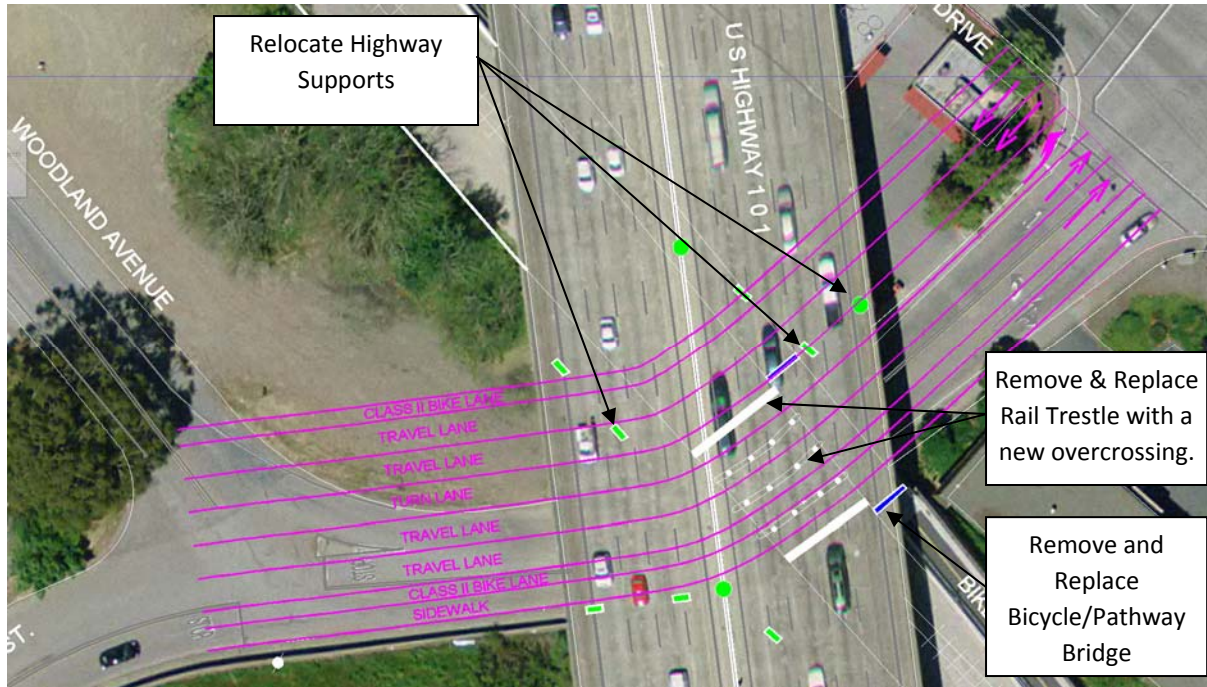


**Figure 11 – Highway Support Width**

### SMART Overcrossing

The current SMART wood trestle is obsolete and cannot remain in place with this alternative. Removal and replacement of the trestle will be required. When this occurs the length of the rail crossing will increase to a minimum of 80 feet. The depth of the new bridge to support the rail will increase significantly. We estimate a new section depth to be three feet minimum utilizing a U-Shaped structure for the rail with the structural girders on the side of the rail. In addition, a minimum of sixteen feet of vertical clearance is needed for vehicular travel on Auburn Street. Raising the rail line to accommodate the necessary clearance for vehicles on Auburn Street may conflict with any work necessary to relocate the freeway columns.





**Figure 12 – Existing Highway Support Width**

Right-of-Way

This alternative will require the acquisition of portions of several private property parcels. Currently there is less than 80 feet of public right-of-way through this area. If this alternative is pursued, acquisition of additional right-of-way will be required in order to accommodate the proposed roadway section on Auburn Street as well as make slight geometric changes to align with Bellam Blvd. and to provide a safe horizontal turning radius. Furthermore, acquisition of private property will be required in order to construct the bypass connector.

*Bicycle and Pedestrian Impacts*

Implementation of this alternative would result in the loss of direct bicycle or pedestrian connections between downtown San Rafael and the Cal Park Hill Tunnel, unless a pedestrian/bicycle at-grade crossing is provided. If such a crossing is not provided, bicycles and pedestrians would be forced to utilize Woodland Avenue, which currently has no bicycle facilities or sidewalks, or Francisco Boulevard West which is a narrow roadway with many driveways. Both of these alternate routes would increase the length of pedestrian and bicycle routes significantly, and may result in a reduction in the number of non-motorized users in this area.

*Cost and Timeline*

A preliminary cost for this alternative is estimated to be \$100 Million, which includes widening the road as well as relocating the US101 overhead support columns, replacing the existing bicycle path bridge and replacing the existing rail trestle. It is estimated that this alternative will take approximately 10-15 years to design, acquire right-of-way and construct.



Table 3 – Alternative 4 Cost Summary

	Estimated Cost (\$ Million)
Right of Way Purchase	5
California Park Overhead Reconstruction (Column Relocation)	80
Rail Trestle Reconstruction	10
Bicycle Path Bridge Reconstruction	2
Auburn Street Reconstruction to 5 lanes	3
<b>Total Estimated Cost</b>	<b>100</b>

A summary of the advantages and disadvantages for this alternative are as follows:

*Advantages*

- Elimination of potential for train/vehicle collisions
- Elimination of potential for train/vehicle conflicts

*Disadvantages*

- High Cost
- Major traffic impacts to existing roadway infrastructure
- Impacts to businesses due to vehicular queuing
- Impacts to businesses due to right-of-way acquisition
- Increased pedestrian and bicycle route lengths and times
- Requires reconstructing U.S. 101 overpass to relocate the support columns
- Requires reconstructing the rail trestle and bike path bridge
- Significant temporary traffic impacts during overpass reconstruction
- No Pedestrian or Bicycle connection to Cal Park Hill Tunnel
- Possible reduction in the number of non-motorized users due to lack of connections
- Difficult Permitting

*Alternative 5 - Two-Way Bypass via Woodland Avenue*

This alternative involves the partial closure of Andersen Drive and the construction of a two-way bypass to existing Woodland Avenue. This alternative is similar to Alternative 4 with the exception that instead of rerouting northbound traffic to alternate routes, the majority of northbound traffic will use the bypass route via westbound Bellam Boulevard, northbound Woodland Avenue and then the bypass to northbound Andersen Drive. However, it is expected that some vehicles will divert to alternate roadways in the area, and therefore, similar to Alternative 4, the median on Andersen Drive will be removed at the intersection of Rice Drive in order to allow southbound left turns from Andersen Drive. Impacts to each roadway user are expected and are described below.

### *Vehicular Impacts*

In both the northbound and southbound directions vehicles would continue from Andersen Drive and connect to Woodland Avenue. Woodland Avenue then connects to Bellam Boulevard just west of the intersection of Bellam Boulevard and Andersen Drive. All vehicles would then be traveling through the intersection of Bellam Boulevard/Andersen Drive in the eastbound/westbound directions. It is expected that some vehicles will also divert to Francisco Boulevard West and US 101 as significant queuing is expected on southbound Woodland Avenue.

With the rerouting of vehicles as described above significant delay and queuing is expected as follows:

- Eastbound Bellam Boulevard at the intersection with Andersen Drive continuing on southbound Woodland until it reaches the merge point from the Andersen southbound bypass.
- Westbound Bellam Boulevard/Auburn Street at Woodland Avenue extending to eastbound I-580 Ramps.
- Eastbound Rice Drive at Francisco Boulevard West and westbound Rice Drive at DuBois Street. These queues would extend over the existing at grade crossing on Rice Drive. Additional mitigations would therefore be required for this crossing (these mitigations were not studied).
- Eastbound Francisco Boulevard West to the US-101 southbound ramps.
- Southbound Andersen Drive at Rice Drive as people will wait to turn left onto Rice Drive to divert to Francisco Boulevard West.

The intersections of Bellam Boulevard/Andersen Drive and Auburn Street/Woodland Avenue will fail as they will not be able to accommodate the additional vehicles. In addition, the intersections of DuBois Street/Rice Drive and 2<sup>nd</sup> Street/Lincoln Avenue will experience major delays. The queuing on eastbound Francisco Boulevard West (approaching the US 101 southbound ramps) and westbound Bellam Boulevard will limit access to the driveways along these roadway segments, thereby reducing access to the adjacent businesses. A graphic depicting the queuing and intersection operational impacts is included in the appendix.

Table 4 – Alternative 5 Intersection Delay and Levels of Service

Intersection	Existing		Alternative 5	
	Delay (sec)	Level of Service	Delay (sec)	Level of Service
Andersen Dr & Rice Dr	0.2	A	16.7	C
Andersen Dr & Woodland Ave	-	-	32.3	D
Auburn St & Woodland Ave	12.6	B	<b>830.0</b>	<b>F</b>
Francisco Blvd W & Rice Dr	1.9	A	25.1	D
DuBois St & Rice Dr	2.8	A	<b>44.7</b>	<b>E</b>
Francisco Blvd W & 101 SB Ramps	30.8	C	52.3	D
Andersen Dr & Francisco Blvd W	29.6	C	-	-
Andersen Dr & Old 101 SB Ramps	0.9	A	0.9	A
Bellam Blvd & Andersen Dr	53.5	D	<b>137.0</b>	<b>F</b>
Andersen Dr & DuBois St	31.6	C	20.3	C
Second St & Hetherton St	30.6	C	30.8	C
Second St & Tamalpais Ave	35.1	D	35.1	D
Second St & Lincoln Ave	51.4	D	<b>63.1</b>	<b>E</b>

*Roadway Impacts*

Similar to Alternative 4, in order to mitigate the expected queuing, this alternative would require widening Bellam Boulevard beneath the US-101 overpass, SMART's railroad trestle and the recently constructed bicycle/pedestrian bridge, to accommodate a minimum of five vehicular travel lanes, two bike lanes and a wide sidewalk. Widening this roadway will require the reconstruction of the US-101 overpass to relocate the support columns as well as reconstruction of the rail trestle and bike path bridge.

This alternative will require the acquisition of portions of several private property parcels in order to accommodate the proposed roadway section on Auburn Street and to construct the bypass connector.

*Bicycle and Pedestrian Impacts*

Implementation of this alternative would result in the loss of direct bicycle or pedestrian connections between downtown San Rafael and the Cal Park Hill Tunnel, unless a pedestrian/bicycle at-grade crossing is provided. If no such crossing is provided, bicycles and pedestrians would be forced to utilize Woodland Avenue, which currently has no bicycle facilities or sidewalks, or Francisco Boulevard West which is a narrow roadway with many driveways. Both of these alternate routes would increase the length of pedestrian and bicycle routes significantly, and may result in a reduction in the number of non-motorized users in this area.

### *Cost and Timeline*

A preliminary cost for this alternative is estimated to be \$100 Million, which includes widening the road as well as replacing the existing freeway overpass, railroad trestle and bike path bridge. It is estimated that this alternative will take approximately 10-15 years to design, acquire right-of-way and construct.

A summary of the advantages and disadvantages for this alternative are as follows:

#### *Advantages*

- Elimination of potential train/vehicle collisions
- Elimination of potential for train/vehicle conflicts

#### *Disadvantages*

- High Cost
- Traffic impacts to existing roadway infrastructure
- Impacts to businesses due to vehicular queuing
- Impacts to businesses due to right-of-way acquisition
- Increased pedestrian and bicycle route lengths and times
- Requires reconstructing U.S. 101 overpass to relocate the support columns
- Requires reconstructing the rail trestle and bike path bridge
- Significant temporary traffic impacts during overpass reconstruction
- No Pedestrian or Bicycle connection to Cal Park Hill Tunnel
- Possible reduction in the number of non-motorized users due to lack of connections
- Difficult Permitting

### *Alternative 6 - At-Grade Crossing with Additional Storage Capacity*

This alternative involves the construction of an at-grade crossing of Andersen Drive and SMART's tracks in a configuration that retains the existing 11 degree roadway and track geometry. Commuter rail speeds will be restricted to 15 MPH through the Andersen Drive crossing, which is enforced by the railroad's Positive Train Control system. Active grade crossing warning devices will be installed as part of this alternative and include cantilevered flashing lights and automatic gates at both the northbound and southbound approaches to the crossing. Pedestrian and bicycle traffic will be separated from rail and vehicular traffic and channelized to at-grade crossings located north and south of the vehicular crossing. The pedestrian/bicycle crossings will be oriented 90 degrees to the track alignment and will be equipped with flashing lights, automatic gates and emergency egress swing gates. Grade crossing warning devices are controlled by a train-activated grade crossing predictor, which is interconnected with the City's traffic signal controller at the intersection of Andersen Drive and Francisco Boulevard West. This interconnection will be used to provide advance preemption notification of the approach of an oncoming train to the signal controller which allows the signal controller to route traffic away from the crossing. Additionally, during advance



preemption, a pre-signal governing traffic on the southbound leg of Andersen Drive will stop traffic from entering the crossing and prevent the development of any further queuing in the crossing.

With this alternative, presence detection cameras will be installed to continuously monitor vehicular queuing at key locations on several nearby arterials. The upstream intersection of Andersen Drive & DuBois Street will terminate southbound Andersen Drive movements if the queues exceed predetermined values to meter additional traffic approaching the rail crossing. For the majority of the time, there will be no impacts to vehicles, bicycles or pedestrians. However, in the instance when southbound vehicles are not permitted to continue on Andersen Drive due to the presence of the queuing, vehicles will be rerouted to adjacent roadways such as Francisco Boulevard West and Woodland Avenue. Because this temporary closure of southbound Andersen will be intermittent, occasional queues will form on southbound Andersen Drive at DuBois Street as vehicles will no longer be permitted to continue on this roadway. In addition, when queuing on eastbound Francisco Boulevard West is present, in order to provide an emergency refuge area for southbound left turning vehicles at the intersection of Andersen Drive & Francisco Boulevard West, the northbound right turn from Andersen Drive onto Francisco Boulevard West will be shut down, causing additional intermittent queuing on northbound Andersen Drive at this intersection.

In order to provide additional capacity downstream of the crossing, Francisco Boulevard West will be restriped from one to two lanes between Andersen Drive and the US-101 southbound ramps. Also, southbound Andersen Drive will be widened and striped to provide two lanes between Bellam Boulevard and Francisco Boulevard West. These additional lanes will provide emergency storage to assure vehicles can proceed forward and clear the railroad crossing and adjacent intersection.

A copy of the conceptual design is included in the appendix.

The traffic operation analysis indicated that the relevant intersections will continue to operate at acceptable levels of service. Although the level of service at the intersection of Bellam Boulevard/Andersen Drive will drop from a D to an E, there will only be a negligible increase in intersection delay of 1.5 seconds.

Table 5 – Alternative 6 Intersection Delay and Levels of Service

Intersection	Existing		Alternative 6	
	Delay (sec)	Level of Service	Delay (sec)	Level of Service
Francisco Blvd W & 101 SB Ramps	30.8	C	34.2	C
Andersen Dr & Francisco Blvd W	29.6	C	29.9	C
Andersen Dr & Old 101 SB Ramps	0.9	A	0.9	A
Bellam Blvd & Andersen Dr	53.5	D	<b>55.0</b>	<b>E</b>
Andersen Dr & DuBois St	31.6	C	40.1	D

*Bicycle and Pedestrian Impacts*

There will be no impacts to bicycles and pedestrians, as existing connections between downtown San Rafael and the Cal Park Hill Tunnel, ultimately leading to Larkspur and the Ferry Terminal, will be maintained.

*Cost and Timeline*

A preliminary estimate for the construction of this alternative is \$2 million, with an anticipated timeframe of 1-2 years for design and construction.

A summary of the advantages and disadvantages for this alternative are as follows:

*Advantages*

- Relatively low cost
- Relatively short construction period
- Minimal temporary traffic impacts
- Minimal long-term traffic impacts
- Maintained access for crossing users
- Maintain existing bicycle and pedestrian connections
- Separation of bicycle and pedestrian traffic from vehicular crossing

*Disadvantages*

- Lower commuter rail operational speed
- Potential for low-speed train/vehicle collisions
- Potential for low-speed train/vehicle conflict

**Comparison of Alternatives**

Based on the analysis, each alternative was scored on five categories and a total score was developed. The ratings are based on a scale of 0-5 with 0 representing little impact or change from existing and 5 representing significant impact or change from existing.

Alternative	Permanent Traffic Impacts	Cost	Feasibility	Safety	Schedule	Total
1. Grade Separation	0	4	4	0	4	12
2. At-Grade Crossing with Chicane	0	3	3	1	2	9
3. Closure	5	2	1	0	1	9
4. One-Way Southbound Bypass via Woodland Avenue	4	5	5	0	5	19
5. Two-Way Bypass via Woodland Avenue	3	5	5	0	5	18
6. At-Grade Crossing with Existing Geometry	1	1	1	2	1	6

## Conclusions

The City analyzed six alternatives to accommodate the at-grade crossing of Andersen Drive. The overall alternative for each is discussed below.

### Alternative 1 - Grade Separation

Grade separation appears to be an impracticable option due to its high cost and apparent conflicts with overhead electrical transmission facilities. Based on preliminary costs with PG&E undergrounding of the transmission lines may not be possible, and relocation and/or raising their height will be extremely costly and a lengthy process. Additionally, the long-term nature of a grade separation construction project appears to be directly at odds with SMART's schedule for scheduling train service through Andersen Drive.

### Alternative 2 - At-Grade Crossing with Chicane

Modifying the alignment of Andersen Drive to create improved crossing geometry appears to offer merit, but at a significant cost and time penalty due to the need to acquire private property and reconstruct a sanitary sewer pump station. In addition, the chicane of the roadway may limit visible of the rail signal equipment reducing the overall safety of this alternative.

### Alternative 3 - Closure

The traffic operations analysis indicates that closing Andersen Drive would have significant adverse impacts to the roadway traffic. The impacts would include significant queuing that would also adversely impact adjacent business owners as access to their properties would be blocked by queued vehicles. Furthermore, without the installation of an at-grade crossing exclusively for the use of bicycles and pedestrians, the impacts to non-motorized users will be

significant as closure of Andersen will eliminate direct access between the Larkspur Ferry Terminal and Downtown San Rafael.

*Alternative 4 – One-Way Southbound Bypass via Woodland Avenue*

The traffic operations analysis indicates that re-routing traffic via the construction of one-way southbound bypass would somewhat mitigate the adverse traffic impacts associated with closing Andersen Drive, but would require acquisition of a significant amount of right-of-way. Furthermore, this alternative will require the reconstruction of the US-101 overpass, the recently constructed bike path bridge and the railroad trestle; all of which are cost and schedule-prohibitive.

*Alternative 5 - Two-Way Bypass via Woodland Avenue*

The traffic operation analysis indicates that re-routing traffic via the construction of two-way bypass would further mitigate the adverse traffic impacts associated with closing Andersen Drive, but would also require acquisition of a significant amount of right-of-way. Furthermore, this alternative will require the reconstruction of the US-101 overpass, the recently constructed bike path bridge and the railroad trestle; all of which are cost and schedule-prohibitive.

*Alternative 6 - At-Grade Crossing with Additional Storage Capacity*

The Traffic operations analysis indicates that there will be minimal impact to the surrounding roadway network as a result of this alternative. Improvements will be installed to ensure safety of the crossing including a reduction in the operating speed of SMART trains to 15 mph. There will be no vehicular or pedestrian impacts as connections between Larkspur and Downtown San Rafael will be maintained. Lastly, this option fits within the City's existing budget and within the existing timeline for planned operation of SMART rail system.

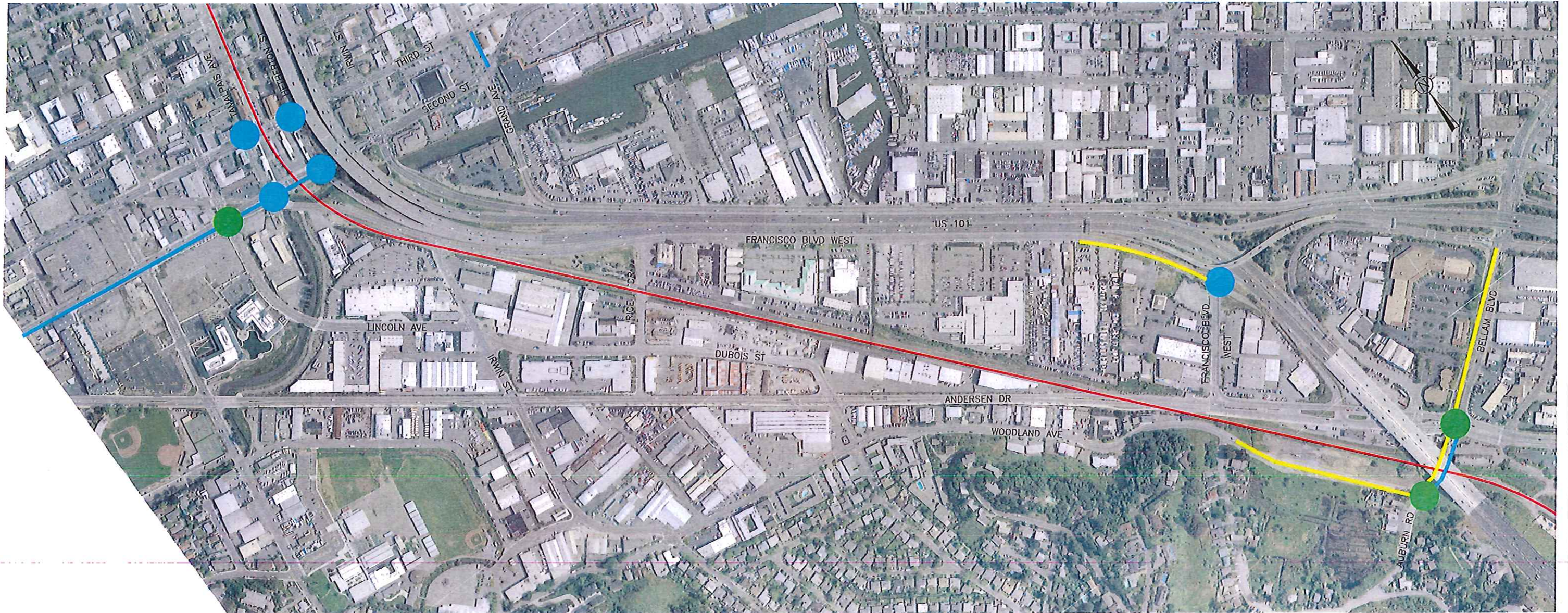
**Recommendations**

It is recommended that the City pursue construction of Alternative 6 and work with SMART to ensure pre-emption connection between the two signal systems. It is further recommended that the City work with Caltrans to interconnect the traffic signals at Andersen Drive/Francisco Boulevard West and Francisco Boulevard West/US-101 southbound ramps.







# ALTERNATIVE 3 - Closure

## QUEUE AND INTERSECTION IMPACT DIAGRAM



### LEGEND:

-  INTERSECTION FAILURE
-  SIGNIFICANT INTERSECTION DELAY
-  NORTHBOUND/EASTBOUND QUEUE
-  SOUTHBOUND/WESTBOUND QUEUE
-  SMART RAIL ALIGNMENT

NOT TO SCALE

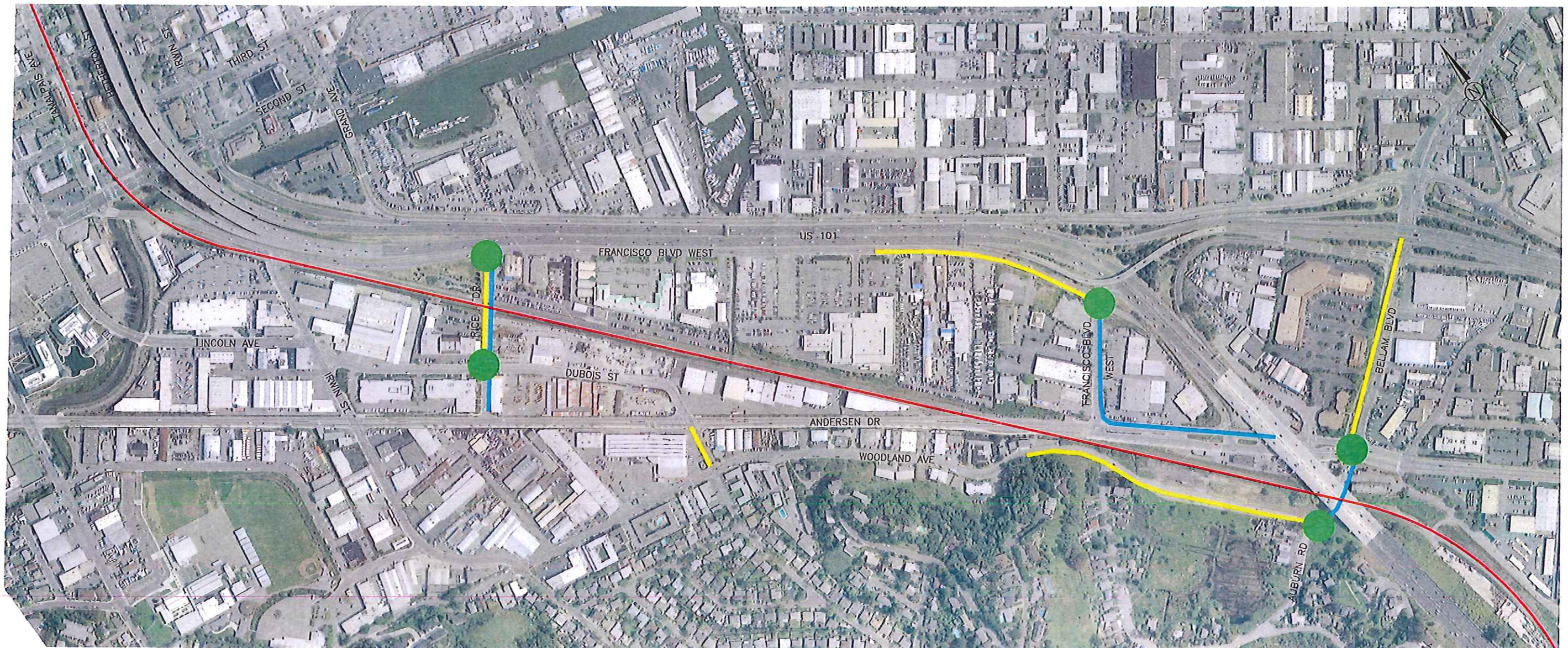


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# ALTERNATIVE 4 - One-Way Southbound Bypass via Woodland Avenue

## QUEUE AND INTERSECTION IMPACT DIAGRAM



### LEGEND:

-  INTERSECTION FAILURE
-  SIGNIFICANT INTERSECTION DELAY
-  NORTHBOUND/EASTBOUND QUEUE
-  SOUTHBOUND/WESTBOUND QUEUE
-  SMART RAIL ALIGNMENT

NOT TO SCALE

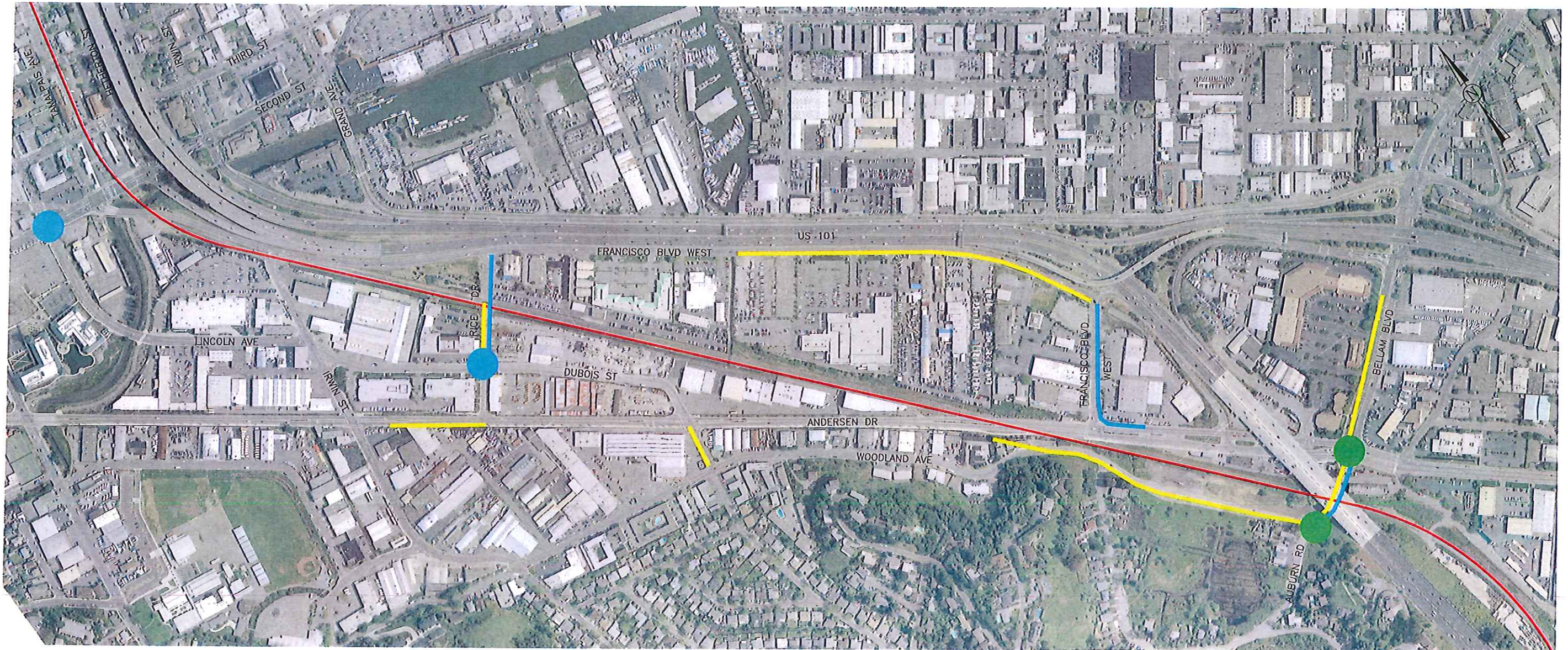


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PUBLIC WORKS








# ALTERNATIVE 5 - Two-Way Bypass via Woodland Avenue

## QUEUE AND INTERSECTION IMPACT DIAGRAM



### LEGEND:

-  INTERSECTION FAILURE
-  SIGNIFICANT INTERSECTION DELAY
-  NORTHBOUND/EASTBOUND QUEUE
-  SOUTHBOUND/WESTBOUND QUEUE
-  SMART RAIL ALIGNMENT

NOT TO SCALE

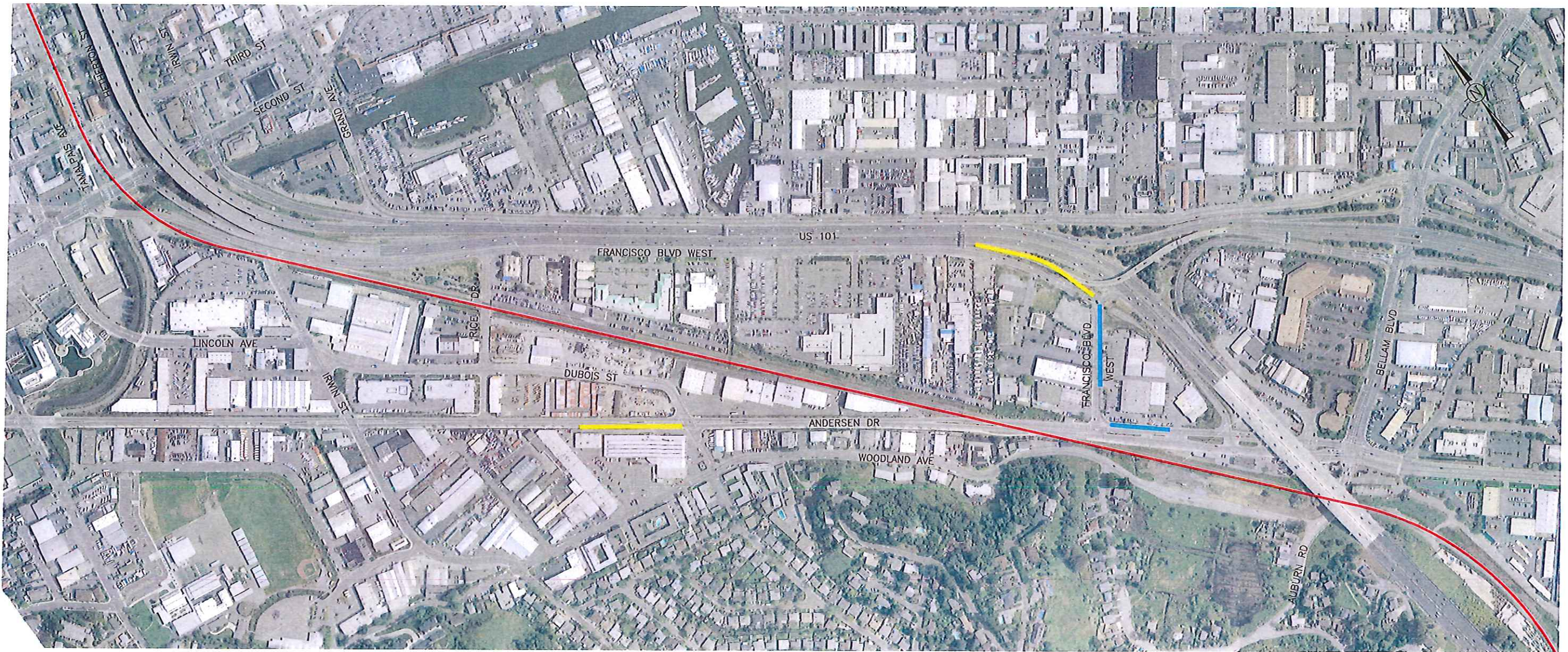


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# ALTERNATIVE 6 - At Grade Crossing

## QUEUE AND INTERSECTION IMPACT DIAGRAM



### LEGEND:

-  INTERSECTION FAILURE
-  SIGNIFICANT INTERSECTION DELAY
-  NORTHBOUND/EASTBOUND QUEUE
-  SOUTHBOUND/WESTBOUND QUEUE
-  SMART RAIL ALIGNMENT

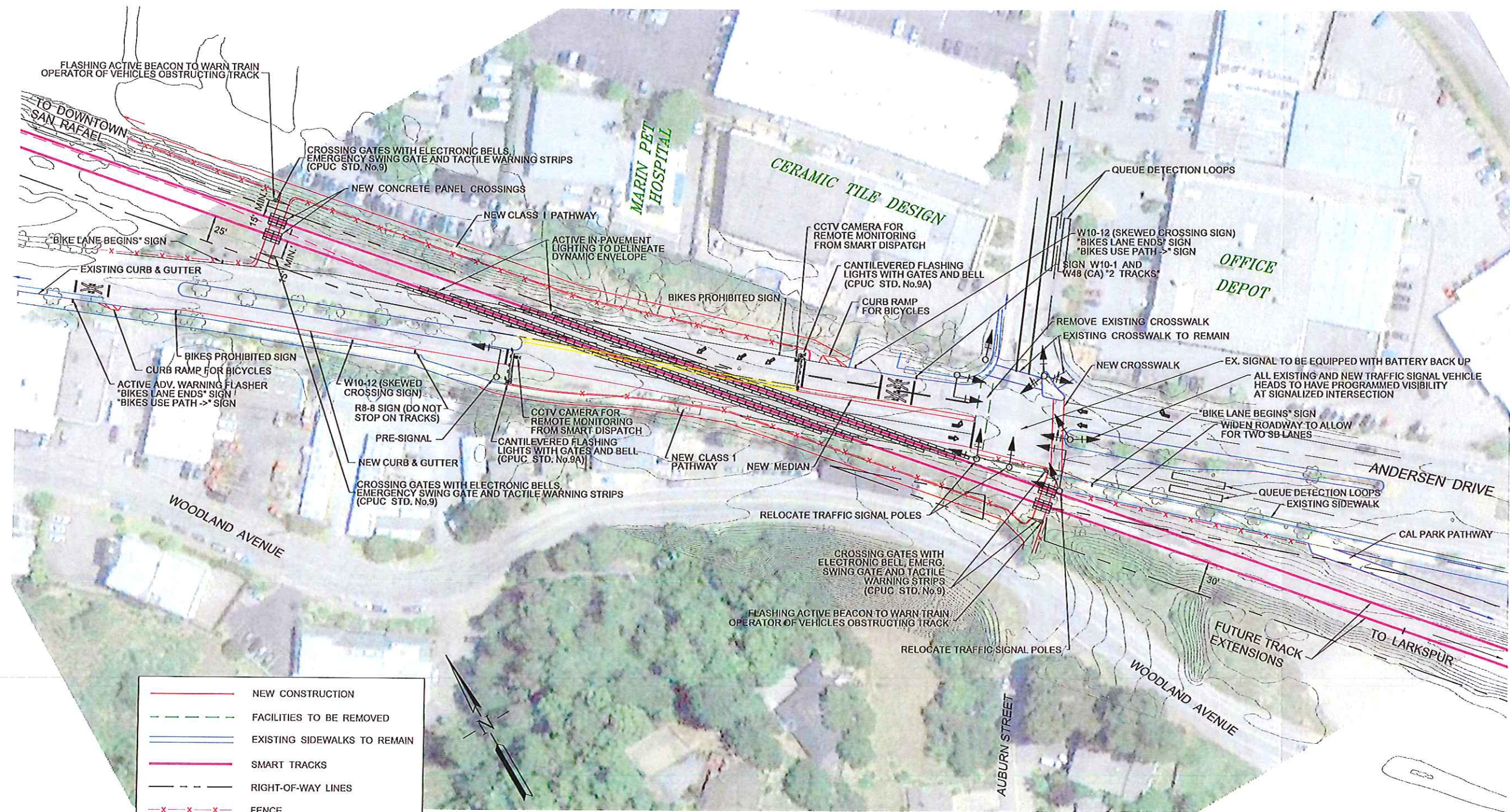
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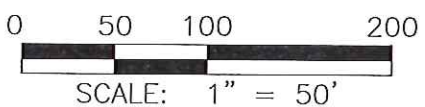
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Mar 05, 2014 - 4:37pm z:\18 Traffic\18.05 Studies and Reports\18.05.52 SMART Rail\Vendor\Drawings\ANDERSEN-FRANCISCO Detail Set - 2-27-14.dwg - OVERALL - Initial



- NEW CONSTRUCTION
- - - FACILITIES TO BE REMOVED
- EXISTING SIDEWALKS TO REMAIN
- SMART TRACKS
- - - RIGHT-OF-WAY LINES
- x x x x FENCE

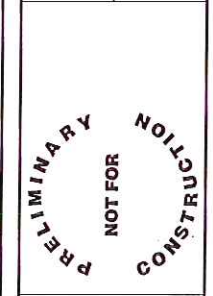


OTHER IMPROVEMENTS TO EVALUATE DURING DESIGN:  
 - KEEP CLEAR LEGENDS ON SB ANDERSEN  
 - PROGRAMMED VISIBILITY SIGNAL HEADS FOR SB ANDERSEN AT FRANCISCO BLVD WEST



DESIGNED	MRS/RAH	DATE
DRAWN <td>RAH <td></td> </td>	RAH <td></td>	
CHECKED		
APPROVED		

PROJECT NAME: ANDERSEN DRIVE AND SMART AT-GRADE CROSSING SIDEWALK AND PATHWAY  
 DRAWING NAME: EXHIBIT A  
 COUNTY OF MARIN CALIFORNIA  
 SAN RAFAEL



CITY OF SAN RAFAEL  
 DEPARTMENT OF PUBLIC WORKS

SCALE:	
DATE:	JULY 2013
CITY PROJECT NO.:	
SHEET NO.:	EXHIBIT A
DRAWING:	1 OF 1