Transportation Agency for Monterey County

REGIONAL ROUNDABOUT STUDY

Utilizing Caltrans' Intersection Control Evaluation

FINAL – March 2016

Prepared for:

Transportation Agency for Monterey County
55 B Plaza Circle
Salinas, CA 93901-2901
(831) 775-0903

Prepared by:

Kittelson & Associates, Inc.
428 J Street, Suite 500
Sacramento, CA 95814
(916) 266-2190
www.kittelson.com

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TRANSPORTATION ENGINEERING/PLANNING

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Regional Roundabout Study

Utilizing Caltrans' Intersection Control Evaluation

Transportation Agency for Monterey County
Monterey County, California

March 2016

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Prepared by Kittelson & Associates, Inc.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation

Monterey County, California

Prepared For:
Transportation Agency for Monterey County
55 B Plaza Circle
Salinas, CA 93901

Partner Agencies:
City of Greenfield
City of Gonzalez
City of King City
City of Marina
Monterey County
City of Monterey
City of Pacific Grove
City of Salinas
Sand City
City of Seaside
City of Soledad
California Department of Transportation
Monterey Bay Unified Air Pollution Control District

Prepared By:
Kittelson & Associates, Inc.
428 J Street, Suite 500
Sacramento, California 95814
(916) 226-2190

Project Manager: Sean Houck, P.E
Project Principal: Jim Damkowitch
Project Engineer: Neelam Dorman
Project Analyst: Sara Muse

Project No. 17974

March 2016

EXECUTIVE SUMMARY

The purpose of conducting an Intersection Control Evaluation (ICE) is to provide a holistic approach to the consideration and evaluation of intersection control alternatives. ICE is a decision-making process and framework to evaluate the control of intersections using a performance-based approach to engineering and investment decisions.

Effective August 30, 2013, Caltrans released Traffic Operations Policy Directive 13-02 (TOPD 13-02) describing guidance for completing an ICE on State highway facilities. TOPD 13-02 establishes procedures to evaluate impacts to all intersection users (e.g., pedestrian, bicycle, auto, transit) in order to identify the most effective and comprehensive access alternatives. Specifically, the evaluation is used to:

- Justify the installation of traffic signal systems, yield-control (roundabouts), and multi-way stop control at state highway intersections and interchanges.
- Identify effective intersection control strategies and alternative treatments, strategies and configurations for particular conditions.
- Estimate the relative effectiveness, impacts and utility of specific control strategies.

In addition to Caltrans, other State Departments of Transportation and local agencies have adopted similar policies in order to:

- Emphasize context, key performance outcomes, cost-effectiveness and sustainability instead of the historical reliance on intersection control warrants.
- Effect a cultural change and departure from the pre-selection or reliance on traffic signals and the widening they require along approach roadways.
- Promote and mainstream the consideration of innovative access strategies that are proven but under-utilized, such as a roundabout.

GOALS AND OBJECTIVES

The Transportation Agency for Monterey County (TAMC), through this study, has developed a Regional Intersection Control Evaluation of high priority intersections throughout Monterey County to evaluate the benefit of roundabouts or other alternative control devices to traditional signalized intersections. Overall, the purpose of the Regional Intersection Control Evaluation is to:

- Provide useful tools for jurisdictions to make investment decisions at the study intersections.
- Assess the benefit / cost of conceptual roundabouts and other intersection control measures to traditional signalized intersections at high priority intersections.
- Provide concept level intersection operations, intersection layouts, and initial capital costs.
- Identify cost effective improvements that may be eligible for grant funding.
- Prompt the ICE decision making process and framework to evaluate intersection control alternatives using a performance-based approach to engineering and investment decisions.

STUDY OVERVIEW

Within the TAMC region, 26 study area intersections were proposed by cities and the county to conduct an ICE. The study locations selected for evaluation are located in the following jurisdictions:

- City of Greenfield.
- City of Gonzalez.
- King City.
- City of Marina.
- Monterey County.
- City of Monterey.
- City of Pacific Grove.
- City of Salinas.
- Sand City.
- City of Seaside.
- City of Soledad.

KEY PERFORMANCE MEASURES

Five performance metrics were evaluated for proposed conceptual control types at each study location. The metrics include:

- Safety – measuring the societal cost associated with the predicted number and severity of collisions.
- Delay – measuring the societal cost associated with the number of person-hours of delay.
- Emissions – measuring the societal cost associated with the exposure to health based pollutants emitted by motor vehicles.
- Operations and Maintenance – measuring common annualized costs associated with operating and maintaining the intersection control.
- Initial Capital Costs – measuring the capital costs needed to plan, design, and construct the intersection improvement. The capital costs include construction, capital support, and right of way.

In addition to the key performance measures mentioned above, consideration is also given to pedestrian, bike, and transit facilities. The conceptual design accounts for pedestrian, bike, and transit access to ensure their sensible accommodation in the conceptual layout. As the project moves forward, a detailed design will need to be prepared accounting for each jurisdictions design standards as well as the best access and circulation for each transportation mode. Summary of Findings

Benefit cost (B/C) ratios were calculated for each study intersection to evaluate the return on investment of the existing control, proposed traditional signal control, or proposed roundabout control. Based on the initial layout and initial cost estimates, the conceptual roundabout control was identified as the highest scoring at the study locations shown in the table below:

B/C Rankings: Roundabout Control	
Jurisdiction	**Study Intersection**
City of Greenfield	Walnut Avenue at El Camino Real
City of Gonzalez	Fifth Street at US 101 Northbound and Southbound Ramp Terminals (2 intersections)
King City	Broadway Street at San Antonio Drive /US 101 Northbound Ramps
City of Marina	Reservation Road at Deforest Road
	Cardoza Avenue at Abdy Way
	8th Street at Inter-Garrison
Monterey County	San Miguel Canyon Road at Castroville Boulevard
	Laurles Grade at Carmel Valley Road
	Highway 68 at Corral de Tierra
City of Monterey	Pearl Street at Camino El Estero
	Del Monte Boulevard at English Avenue
	Munras Avenue / Abrego Street at El Dorado Street
	East Franklin Street at Camino El Estero
City of Salinas	West Alisal Street at Capitol Street
	East Laurel Drive at St Edwards Street
Sand City	Tioga Avenue at California Avenue
City of Seaside	Broadway Avenue at Alhambra Street
City of Soledad	Metz Road at Pinnacles Parkway
	Front Street at East Street

The conceptual signal control produced the best results at the following locations:

B/C Rankings: Signal Control	
Jurisdiction	**Study Intersection**
City of Marina	Reservation Road at Beach Road
City of Salinas	Sherwood Drive at Sherwood Place
Sand City	Tioga Avenue at Del Monte Boulevard
City of Seaside	Broadway Avenue & Contra Costa Street at Del Monte Boulevard (2 intersections)

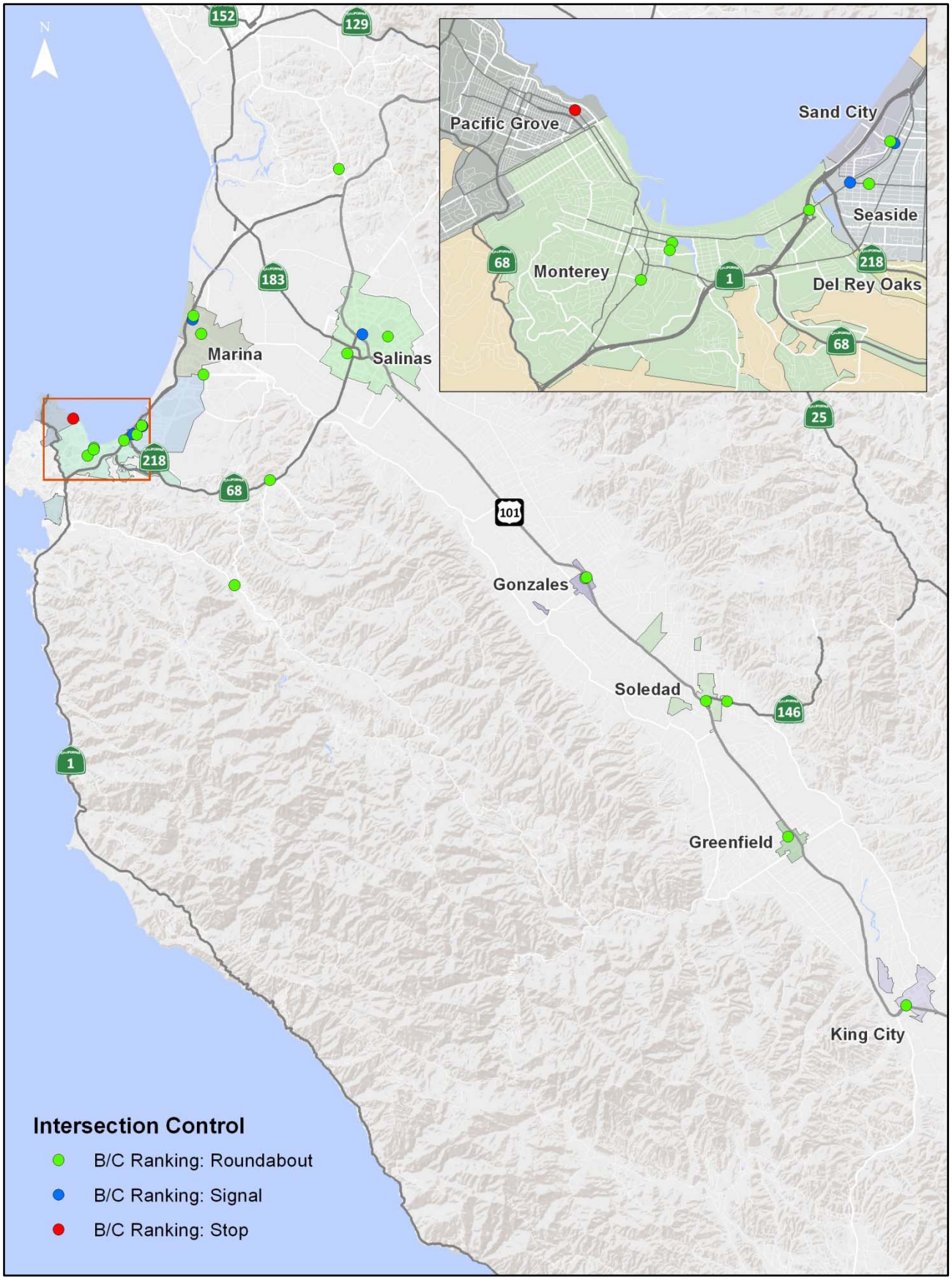
The conceptual stop control produced the best results at the following locations:

B/C Rankings: Stop Control	
Jurisdiction	**Study Intersection**
City of Pacific Grove	First Street at Central Avenue

RECOMMENDATIONS FOR FURTHER STUDY

The study uses performance measures to recommend the best intersection control at study locations throughout the TAMC region. These measures intend to identify potential fatal flaws in an alternative based on conceptual plans for each control type. The next step of preliminary engineering is required to fully investigate the option. Additional recommendations for further study include site investigations and traffic and collision data.

B/C Rankings Figure for all Study Locations



OVERVIEW OF STUDY AND FINDINGS

STUDY OVERVIEW

TAMC requested that interested jurisdictions submit a prioritized list of locations for which they would like to conduct an ICE. The following list of 26 study intersections was compiled by TAMC based on jurisdiction responses:

Jurisdiction	Study Intersection
City of Greenfield	Walnut Avenue at El Camino Real
City of Gonzalez	Fifth Street at US 101 Northbound and Southbound Ramp Terminals (2 intersections)
King City	Broadway Street at San Antonio Drive /US 101 Northbound Ramps
City of Marina	Reservation Road at Beach Road
	Reservation Road at Deforest Road
	Cardoza Avenue at Abdy Way
	8th Street at Inter-Garrison
Monterey County	San Miguel Canyon Road at Castroville Boulevard
	Laurles Grade at Carmel Valley Road
	Highway 68 at Corral de Tierra
City of Monterey	Pearl Street at Camino El Estero
	Del Monte Boulevard at English Avenue
	Munras Avenue / Abrego Street at El Dorado Street
	East Franklin Street at Camino El Estero
City of Pacific Grove	First Street at Central Avenue
City of Salinas	West Alisal Street at Capitol Street
	East Laurel Drive at St Edwards Street
	Sherwood Drive at Sherwood Place
Sand City	Tioga Avenue at California Avenue
	Tioga Avenue at Del Monte Boulevard
City of Seaside	Broadway Avenue & Contra Costa Street at Del Monte Boulevard (2 intersections)
	Broadway Avenue at Alhambra Street
City of Soledad	Metz Road at Pinnacles Parkway
	Front Street at East Street

Report Structure

The Regional ICE study is primarily intended to be used as a tool for each jurisdiction to make investment decisions for improvements at high priority intersections they submitted to TAMC. With this as the foundation of the study, the Regional ICE study is comprised of 11 standalone sections, one section for each jurisdiction. For each section, a screening summary is provided as an overview of the performance measures used to calculate the return on investment for the study intersections in the jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the types of intersection control evaluated in the study. For each type of control, whether existing or proposed, a corresponding icon is assigned and used throughout the report.

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

SUMMARY OF KEY PERFORMANCE MEASURES

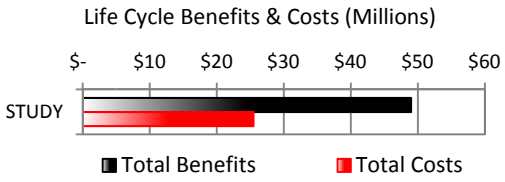
Five performance metrics were evaluated at each study intersection to calculate the B/C ratio which measures the expected return on investment for the various intersection controls. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the conceptual level ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The benefit cost ratios were calculated at each study location and an overall ratio is presented below for the TAMC region. The summation of the performance measure benefits and performance measure costs for all study intersections are illustrated below:



Life Cycle Benefit Cost Regional ICE Study	Discounted Life Cycle Costs
Total Benefits of a roundabout compared to a traditional intersection	$48,962,291
Total Costs of a roundabout compared to a traditional intersection	$25,484,189
B/C ratio based on study wide Benefits and Costs	**1.92**
Intersection control based on study wide B/C ratio	

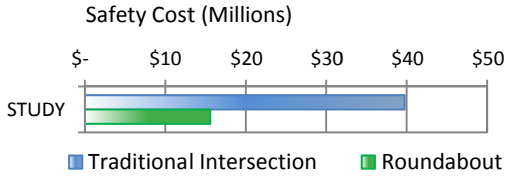
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Performance measure costs are a summation of the individual performance measures at each study location. Following the performance measure overview is a table summarizing the discounted life cycle costs for traditional and roundabout intersection control types. Traditional intersection control includes both stop and traffic signal control types.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout. The performance measures were calculated at each study location and overall summation data is presented below for the TAMC region.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 Statewide Integrated Traffic Records System (SWITRS) proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

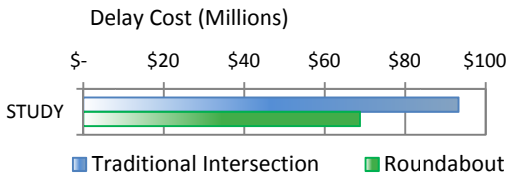


Based solely on the summation of the predicted discounted life-cycle cost for safety at all project study intersections, the intersection control type with the lowest predicted study wide safety costs is a ***roundabout***. The following table summarizes study wide safety costs:

Safety Regional ICE Study	**Discounted Life Cycle Costs**
Traditional Intersection	$39,735,189
Roundabout Intersection	$15,591,519
Intersection control type with the lowest safety cost	
Percent ***reduction*** in ***Safety Costs*** with **Roundabout Control**	**61%**
Estimated study wide savings with roundabout control	$24,143,670
Average savings per intersection	$928,603

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

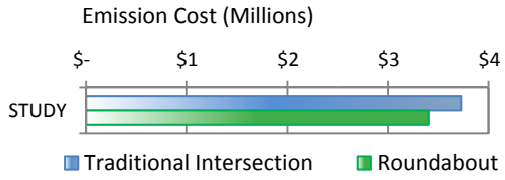


Based solely on the summation of the predicted discounted life-cycle cost for person hours of delay at all study intersections, the intersection control type with the lowest predicted study wide delay costs is a ***roundabout***. The following table summarizes study wide delay costs:

Delay Regional ICE Study	**Discounted Life Cycle Costs**
Traditional Intersection	$93,253,069
Roundabout Intersection	$68,757,635
Intersection control type with the lowest delay cost	
Percent ***reduction*** in ***Delay Costs*** with **Roundabout Control**	**26%**
Estimated study wide savings with roundabout control	$24,495,434
Average savings per intersection	$942,132

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on the summation of the predicted discounted life-cycle cost for tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the intersection control type with the lowest predicted study wide emission costs is a ***roundabout***. The following table summarizes study wide emission costs:

Emission Regional ICE Study	**Discounted Life Cycle Costs**
Traditional Intersection	$3,727,987
Roundabout Intersection	$3,404,800
Intersection control type with the lowest emission cost	
Percent ***reduction*** in ***Emission Costs*** with **Roundabout Control**	**9%**
Estimated study wide savings with roundabout control	$323,187
Average savings per intersection	$12,430

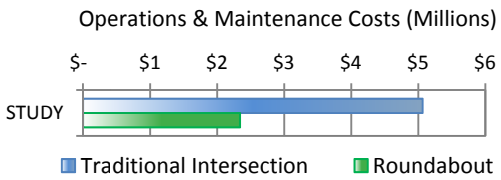
Operations and Maintenance Regional ICE Study	**Discounted Life Cycle Costs**
Traditional Intersection	$5,063,009
Roundabout Intersection	$2,339,743
Intersection control type with the lowest O&M cost	
Percent ***reduction*** in ***O&M Costs*** with **Roundabout Control**	**54%**
Estimated study wide savings with roundabout control	$2,723,266
Average savings per intersection	$104,741

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal. The performance measures were calculated at each study location and overall summation costs are presented below for the TAMC region.

Operations and Maintenance (O&M)

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

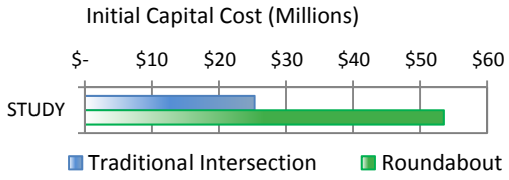


Based solely on the summation of the predicted discounted life-cycle cost for lowest expected annual operations and maintenance costs, the intersection control type with the lowest predicted study wide operations and maintenance costs is a ***roundabout***. The following table summarizes study wide operations and maintenance costs:

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.

Specific design requirements for each jurisdiction were not evaluated and any specific design standards or features required by a jurisdiction will be evaluated in future phases of the project. If the specific design standard or feature would impact the cost of the overall intersection, the guiding principle of this study is that design exemptions can be implemented.



Based solely on the summation of the predicted discounted life-cycle cost for the lowest estimated initial capital cost, the intersection control type with the lowest predicted study wide initial capital costs is a ***traditional intersection***. The following table summarizes study wide initial capital costs:

Initial Capital Cost Regional ICE Study	Discounted Life Cycle Costs
Traditional Intersection	$25,318,550
Roundabout Intersection	$53,526,005
Intersection control type with the lowest O&M cost	
Percent ***Increase*** in ***Initial Capital Costs*** with **Roundabout Control**	**111%**
Estimated study wide **added costs** with roundabout control	$28,207,455
Average **added cost** per intersection	$1,084,902

NOTE: The Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals study intersection does not include an initial capital cost for the traditional intersection. Refer to Section 3: King City for additional information.

OTHER PERFORMANCE MEASURES

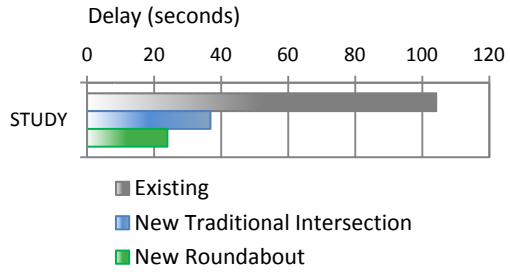
The following performance measures were evaluated at each study intersection:

- Intersection Delay
- Cost Effectiveness to Reduce Pollutant Emissions

The performance measures were calculated at each study location and overall summation data is presented below for the TAMC region.

Intersection Delay

Intersection delay was calculated using existing and design year peak hour traffic data provided by the jurisdictions. The following bar chart illustrates the average peak hour delay for design year traffic operations by intersection control form.



Significant reduction in delay can be made by improving the existing intersection with either traditional or roundabout control options. The following table summarizes the average peak hour delay:

Average Peak Hour Delay Regional ICE Study		% Reduction Compared to	
Control Type	Delay (s)	Existing	Traditional
Existing	104		
Traditional	37	65%	
Roundabout	24	77%	35%

Cost Effectiveness to Reduce Pollutant Emissions (AB 2766 Grant)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). The following table summarizes the number of intersections, by control type, that may be good candidates for AB 2766 grant funding:

AB 2766 Cost Effectiveness Regional ICE Study	No. of Locations
New Traditional Control	8
New Roundabout Control	15

Note: Study locations may include multiple intersections.

SUMMARY OF FINDINGS

The following section provides the project wide results of the Regional ICE as well as a brief overview of the benefit / cost methodologies used to determine the return on investment for improvements at the study intersections.

Benefit Cost Ratio Scoring

The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

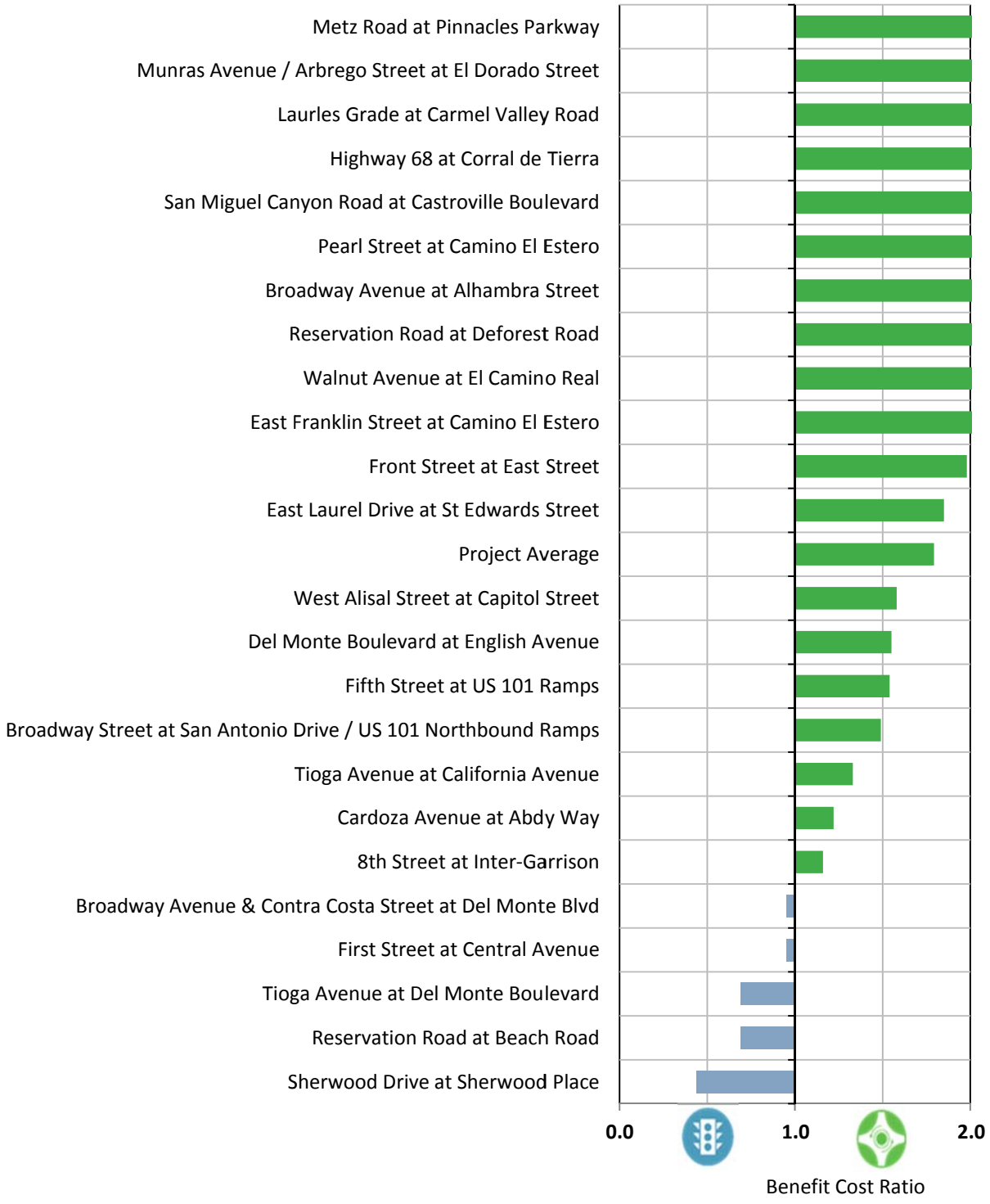
Benefit Cost Ratio Results

Based on data provided by each jurisdiction, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the associated intersection control type based on return on investment for each study intersection(s) is as follows:

Benefit Cost Ratio Results



Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 1:

City of Greenfield

Study Intersections:

- WALNUT AVENUE AT EL CAMINO REAL

CITY OF GREENFIELD SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Walnut Avenue at El Camino Real	GRF-01

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Greenfield jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Greenfield, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Walnut Avenue at El Camino Real	**2.95**	

SUMMARY OF KEY PERFORMANCE MEASURES

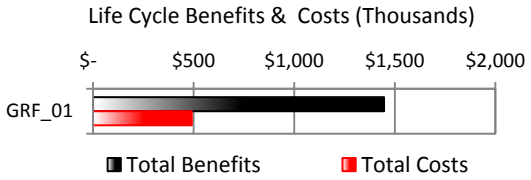
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



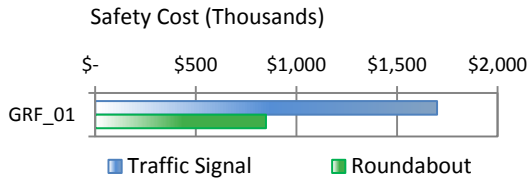
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

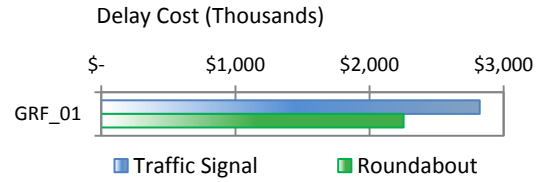


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety Study Intersection	**Preferred Control**
Walnut Avenue at El Camino Real	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.



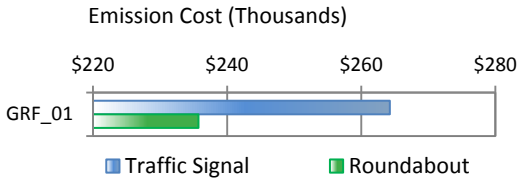
Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay Study Intersection	**Preferred Control**
Walnut Avenue at El Camino Real	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from

Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012 for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

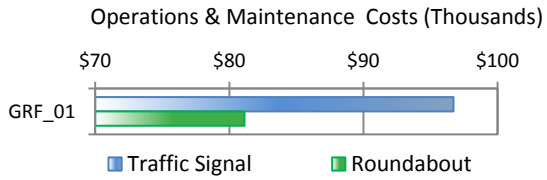
Emissions Study Intersection	Preferred Control
Walnut Avenue at El Camino Real	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

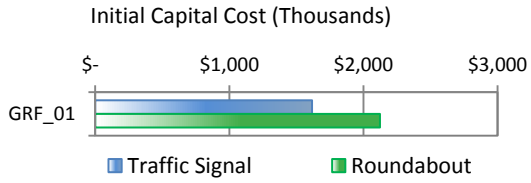


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Walnut Avenue at El Camino Real	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Walnut Avenue at El Camino Real	

Summary of B/C Performance Measures

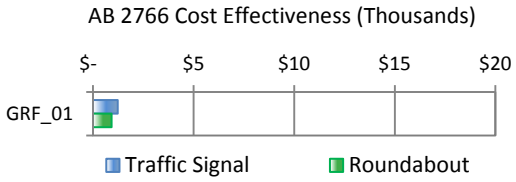
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Walnut Avenue at El Camino Real						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Greenfield.

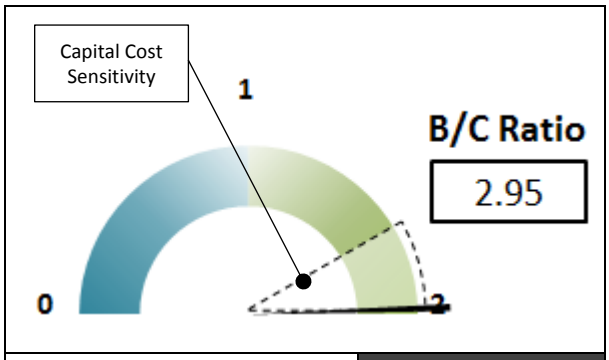


Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Walnut Avenue at El Camino Real	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

WALNUT AVENUE AT EL CAMINO REAL



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

The Benefit Cost (B/C) ratio for the intersection of Walnut Avenue at El Camino Real is 2.95. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control may change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $3.0M and all other performance measures remained unchanged.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 2 times higher than that of the roundabout. The costs to modify the retention pond and right of way acquisition are primary factors driving the cost sensitivity. The total life cycle benefits of the roundabout are estimated at $1,450,000 when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing signal control or, no project alternative, is at capacity and will continue to degrade over time with queues exceeding available storage capacity. Modifying the existing signal control may be a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number GRF-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
El Camino Real at Walnut Avenue	**El Camino Real**	2-lane Raised median north leg Two-Way-Left-Turn-Lane south leg	Local	25	Central Business District Serves residential, commercial/ retail, and institutional uses	Service provided by Monterey-Salinas Transit	Sidewalks Heavy east – west pedestrian volumes accessing Greenfield Elementary School	Class II bike lanes
	Walnut Avenue	2-lane Two-Way-Left-Turn-Lane east leg Undivided west leg	Local	25	Access to US 101 Serves residential, commercial/ retail, and institutional uses	Service provided by Monterey-Salinas Transit	Sidewalks Greenfield Elementary School	No bike lanes provided

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Walnut Avenue at El Camino Real is controlled by stop signs on the minor approach.

Parcels in the immediate vicinity of the project are developed. The existing intersection is within City of Greenfield right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Greenfield Elementary School
2. Retention Basin
3. McDonalds
4. Chase Bank
5. Garage / Auto Repair

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

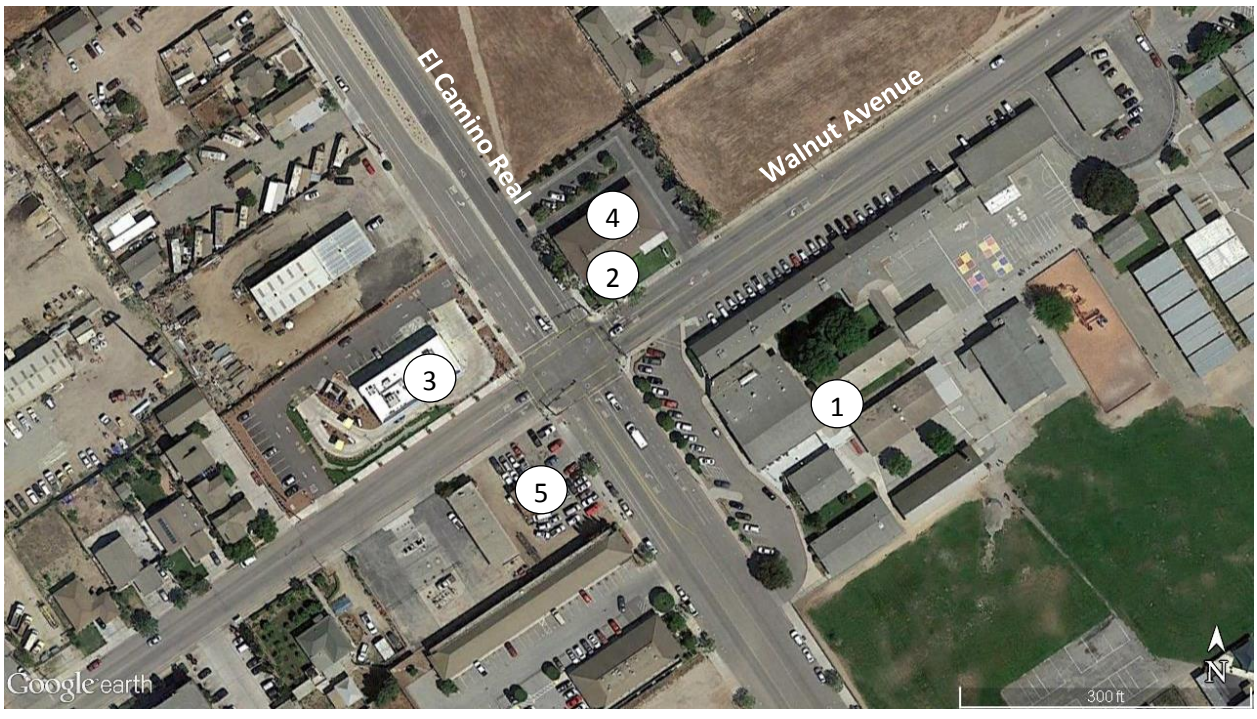
PLANNED IMPROVEMENTS

The study intersection is part of the Walnut Avenue Specific Plan. The Walnut Avenue Specific Plan identifies 335,000 square feet of commercial retail development and 220 high-density residential housing units. Full build-out of the Walnut Avenue Specific Plan is contingent on a number of significant infrastructure improvements being constructed before the final increment of approximately 250,000 square feet of commercial retail space can be developed. At this time it is anticipated that neither those infrastructure improvements nor development of the final increment of commercial retail space will occur by 2035. It is more likely that those improvements will not occur until the post-2040 timeframe.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Signal improvements	
Proposed Roundabout	



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Design Year Traffic

Base year and design year traffic data was provided by the City in the *"Walnut Avenue Specific Plan,"* dated 2012. Due to changes in the regional growth forecast for Greenfield and development contingencies, the City has requested the design year traffic data be shifted, at minimum, 5-years out.

Signal Control (Existing)

With signal control, demand exceeds capacity for both peak hours under existing conditions. Westbound Walnut Avenue left turning vehicles exceed available storage capacity. Heavy pedestrian movements further degrade vehicle operations. With buildout of the Walnut Avenue Specific Plan, operations are expected to degrade with demand exceeding available capacity.

Signal Control - Modification

With signal control modifications, additional westbound and southbound left turn lanes are required. Additional southbound and westbound lanes are needed to receive the dual left turns. The additional lanes needed for the signal modification will require right of way acquisition and modification to the retention pond. The proposed lane additions are expected to improve intersection performance to acceptable levels. However, vehicle queueing is expected to impact local access during the PM peak periods for all design years.

The additional lanes will also increase crossing distance as well as overall cycle length for protected phasing. Bike lanes along El Camino Real can be maintained with the necessary lane additions. Transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access.

Roundabout Control

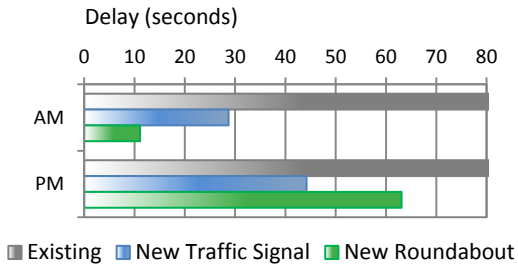
With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. A single right turn lane is needed for the westbound approach. The proposed roundabout is not expected to impact the retention basin and will likely require less right of way than the signal alternative. Intersection performance is expected to be well below capacity for the 2014 design year operations. The service life of the single lane roundabout is expected to be approximately 25 years based.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes along El Camino Real can be maintained with a one lane roundabout. Transit stops are not provided at the intersection therefore the roundabout alternative will not impact transit access.

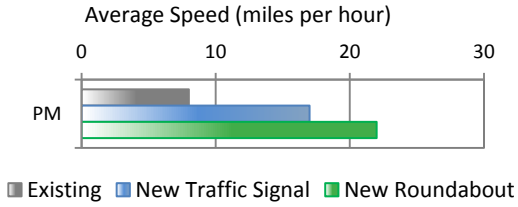
As full build out of the Walnut Avenue Specific Plan is achieved, additional approach and departure lanes will be required for the northbound, southbound, and eastbound directions. An additional westbound departure lane and conversion of the westbound right turn lane to a through-right lane will be required. The conversion of the roundabout to a dual lane roundabout will extend the design life of the intersection beyond forecast demand identified in the Walnut Avenue Specific Plan.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure

Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Cost to modify and/or relocate retention basin for Walnut Avenue widening.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **GRF-01**
01/16

Intersection Cost Comparison

Walnut Avenue at El Camino Real
Greenfield, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.30	$ 43,599	$ 681,107	0.66	$ 96,887	$ 1,513,571
Predicted PDO Crashes	1.05	$ 10,727	$ 167,583	1.16	$ 11,875	$ 185,513
Subtotal - Safety Costs	**-**	**$ 54,326**	**$ 848,690**	**-**	**$ 108,762**	**$ 1,699,084**
DELAY						
Delay to Persons in Vehicles (hours)	8926	$ 86,698	$ 2,254,150	10357	$ 108,528	$ 2,821,733
Subtotal - Delay Costs	-	**$ 86,698**	**$ 2,254,150**	-	**$ 108,528**	**$ 2,821,733**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 400	6,249
Cost of Illumination		$ 200	$ 3,124		$ 200	3,124
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 1,080	16,872
Cost of Pavement Rehabilitation			$ 46,758			$ 61,613
Subtotal - Operations and Maintenance Costs	-	**$ 2,200**	**$ 81,127**	-	**$ 2,247**	**$ 96,711**
EMISSIONS						
Tons of ROG	0.35	$ 331	$ 5,166	0.49	$ 463	$7,233
Tons of NOX	1.01	$ 13,023	$ 203,448	1.11	$ 14,370	$224,495
Tons of PM10	0.0174	$ 1,735	$ 27,110	0.0209	$ 2,082	$32,532
Subtotal - Emissions Costs		**$ 15,089**	**$ 235,725**		**$ 16,916**	**$ 264,260**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,522,025			$ 1,058,000
Construction Cost - Structures			$ -			$ 20,580
Capital Support			$ 518,000			$ 367,000
Right-of-Way			$ 83,000			$ 171,000
Subtotal - Initial Capital Costs			**$ 2,123,025**			**$ 1,616,580**
NET PRESENT VALUE			**$ 5,542,716**			**$ 6,498,367**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$850,394
Delay Reduction Benefit of Roundabout	$567,583
Emission Reduction Benefit of Roundabout	$28,535
Total Benefits	**$1,446,513**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$15,584
Added Capital Costs of a Roundabout	$506,445
Total Costs	**$490,861**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

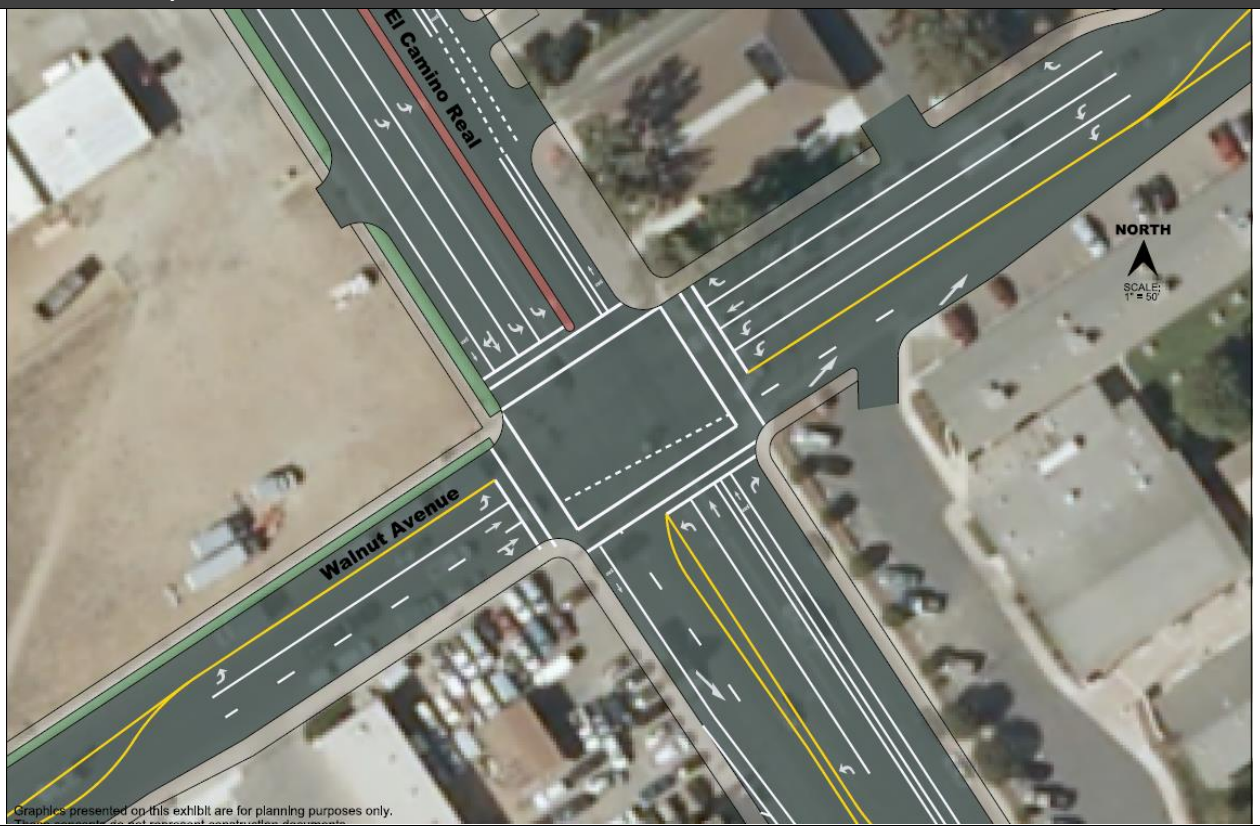
2.95

B/C Preferred: Roundabout Alternative

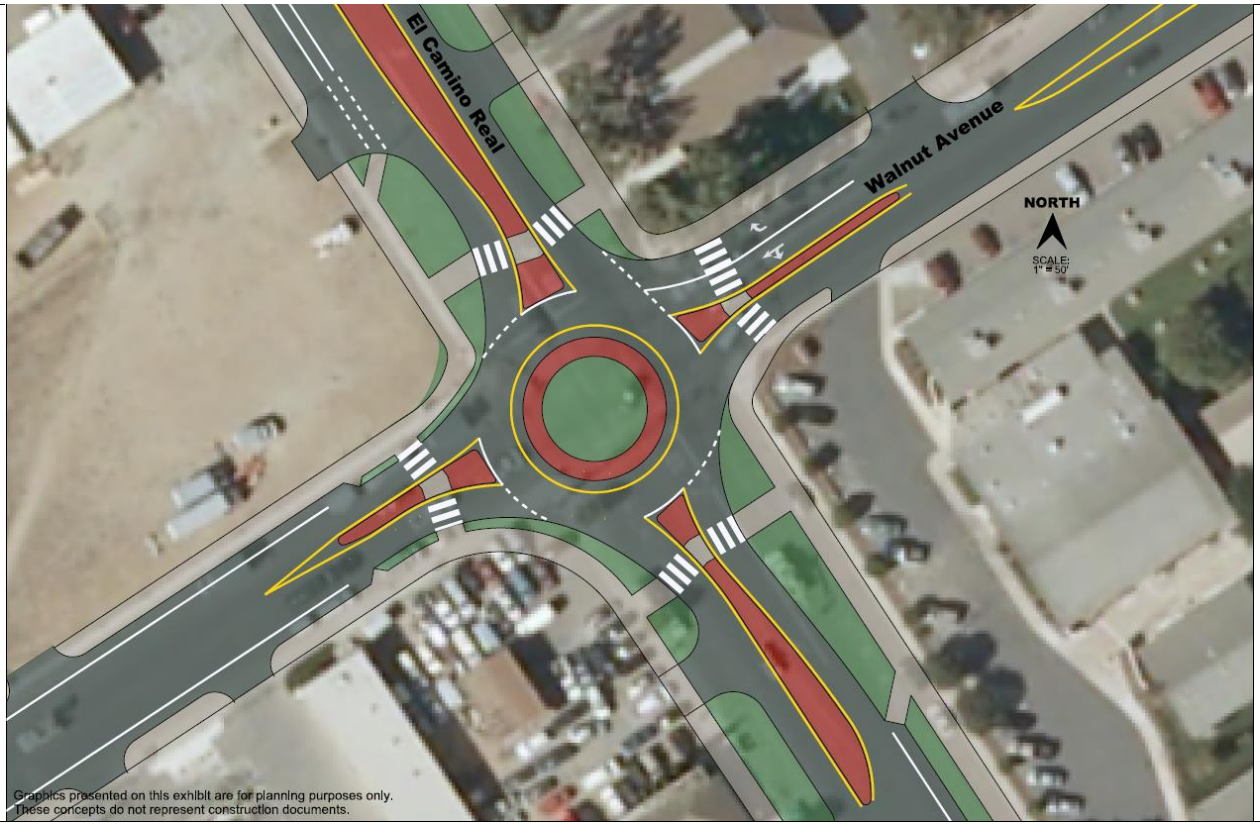
AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	1991	1497
Cost Per Pound Per Life	$11.54	$15.35
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$923**	**$1,228**

Intersection Improvement Alternatives



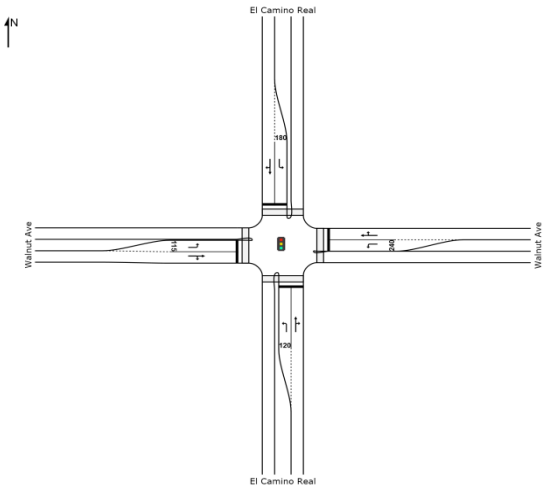
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

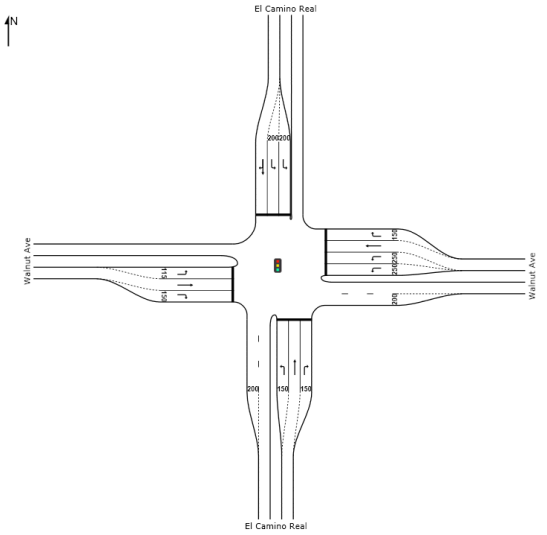


EXISTING INTERSECTION SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	E	60.3	#238 (WBL)	F	190.5	#434 (WBL)
2045	F	161.1	#375 (SBL)	F	372.6	#709 (WBT)

NOTES:

1. WBL and SBL queues exceed capacity during the 2014 p.m. peak hour
2. NBL, SBL, and WBL queues will exceed capacity during both 2045 peak hours.
3. EBL queues will exceed capacity during the 2045 p.m. peak hour

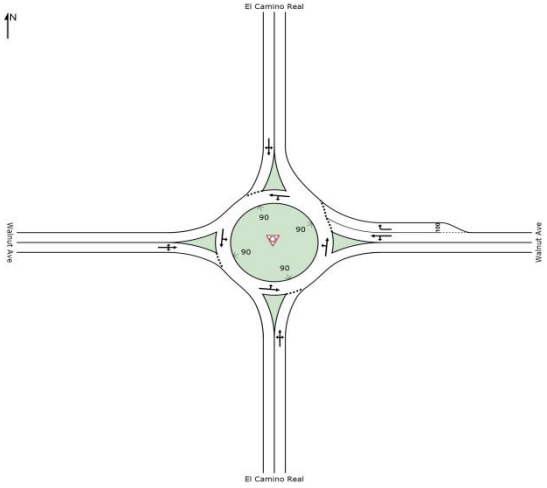


ALTERNATIVE 1 SIGNAL MODIFICATIONS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	C	23.9	85 (WBT)	C	32.3	235 (EBT)
2040	C	28.7	197 (EBT)	D	38.4	#335 (SBT)
2045	C	31.4	219 (EBT)	D	45.1	438 (WBT)

NOTES:

1. NBL queues exceed capacity during 2040 p.m. peak hour.
2. NBL and EBL queues exceed capacity during 2045 p.m. peak hour.



ALTERNATIVE 2 ROUNDABOUT

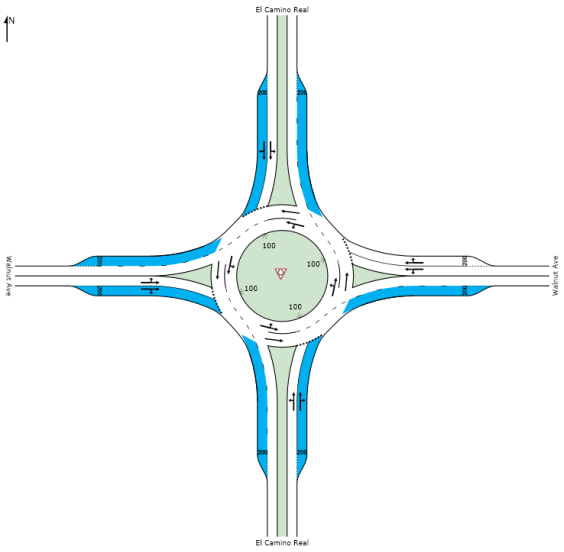
Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	6.0	37 (EB)	B	13.0	126 (WB)
2040	B	11.1	95 (SB)	F	63.1	867 (WB)

Improvements: Single lane roundabout with WB right turn lane

NOTES:

Roundabout has a service life of 2041 in the p.m. peak hour.

Intersection Control Alternative Summary



ALTERNATIVE 3

ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2040	A	6.0	42 (WB)	B	12.7	196 (WB)
2045	A	7.4	58 (SB)	C	18.1	319 (WB)

Improvements: Add approach and departure lanes to north, west, and south legs. Add departure lane on east leg. Add additional circulatory lane.

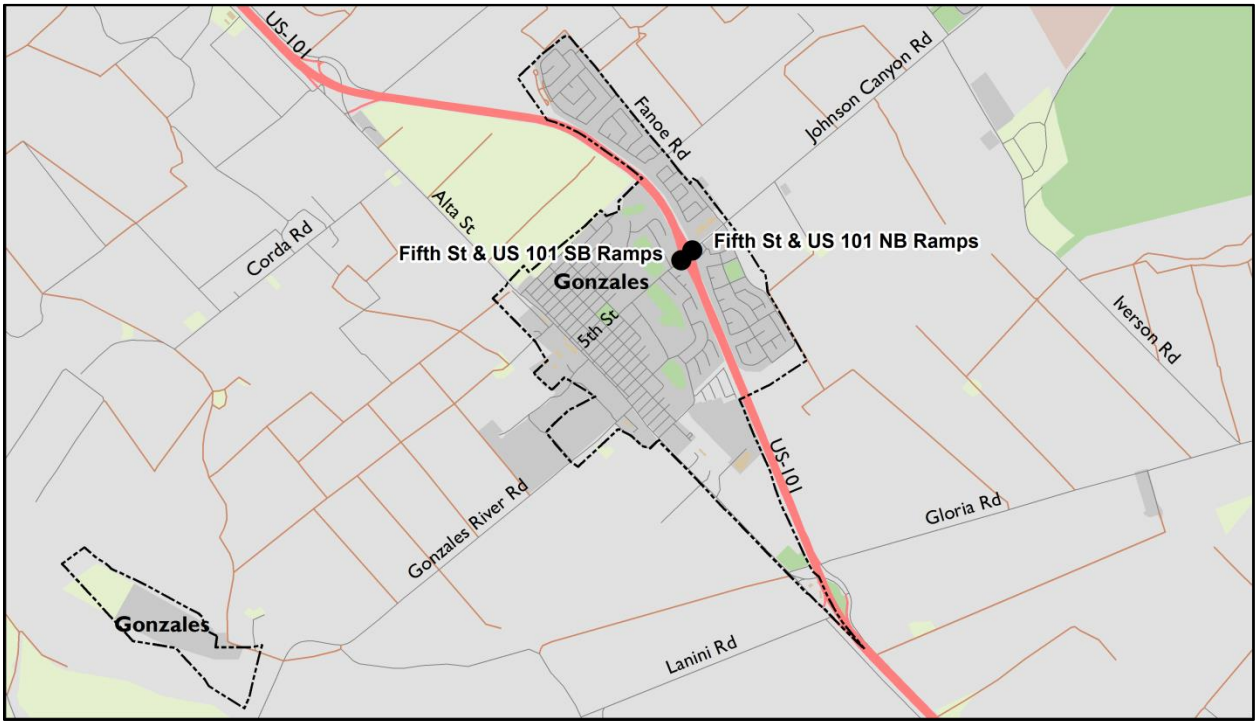
NOTES:

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 2:

City of Gonzales

Study Intersections:

- FIFTH STREET AT US 101 NORTHBOUND AND SOUTHBOUND RAMP TERMINALS



CITY OF GONZALES SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Fifth Street at US 101 Ramp Terminals	GZL-01

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Gonzales jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Gonzales, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Fifth Street at US 101 Ramp Terminals	**1.54**	

SUMMARY OF KEY PERFORMANCE MEASURES

As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

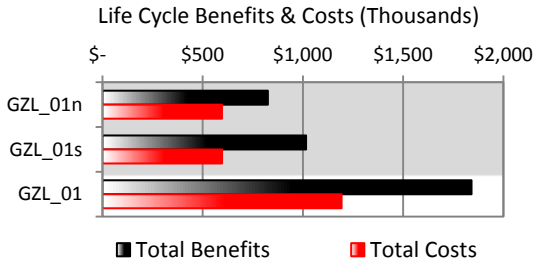
- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:

NOTE: Due to the close proximity of the US 101 northbound and southbound ramp terminal intersections with Fifth Street, the performance measures for the Fifth Street at US 101 ramp terminals study intersection, GZL-01, are a summation of performance measures at each of the intersections. As a reference, the performance measures for each intersection are reported in the following bar charts to illustrate the performance measure benefits and the performance measure costs that were used to calculate the "study intersection" performance measures. Fifth Street at US 101 northbound ramp terminal is assigned intersection number GZL-01n. Fifth Street at US 101 southbound ramp terminal is assigned intersection number GZL-01s. GZL-01n and GZL-01s are illustrated with a grey background in the following bar charts. Only the preferred control for the study intersection, GZL-01, is reported in the summary tables for each performance measure.



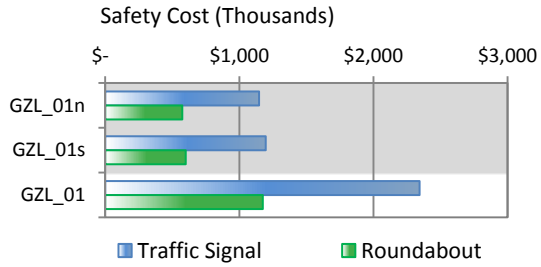
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

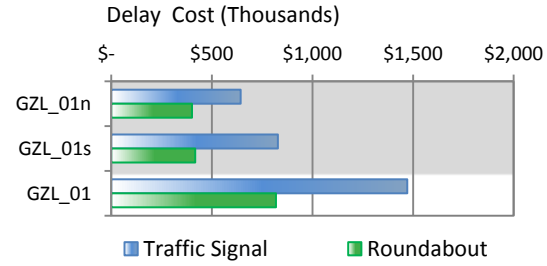


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Fifth Street at US 101 Ramp Terminals	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

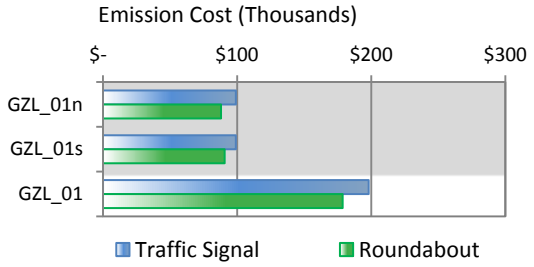


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay Study Intersection	Preferred Control
Fifth Street at US 101 Ramp Terminals	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

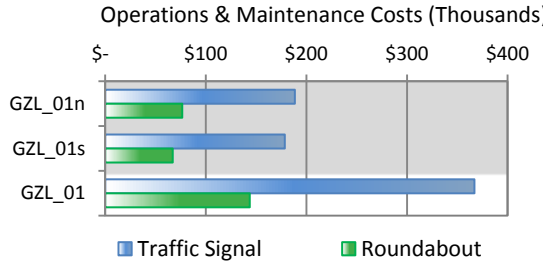
Emissions Study Intersection	Preferred Control
Fifth Street at US 101 Ramp Terminals	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

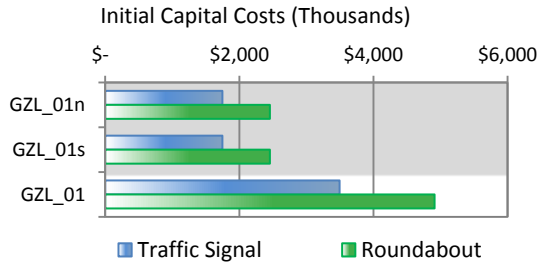


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Fifth Street at US 101 Ramp Terminals	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Fifth Street at US 101 Ramp Terminals	

Summary of B/C Performance Measures

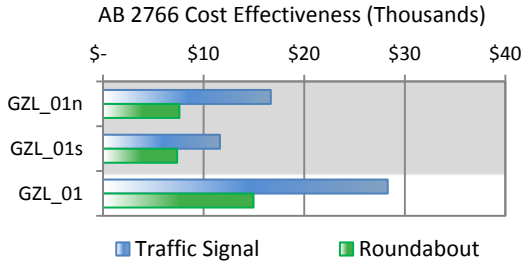
The following table summarizes the five performance measures evaluated at each project location.

Study Intersection	Preferred Intersection Control by Performance Measure					
	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Fifth Street at US 101 Ramp Terminals						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Gonzales.

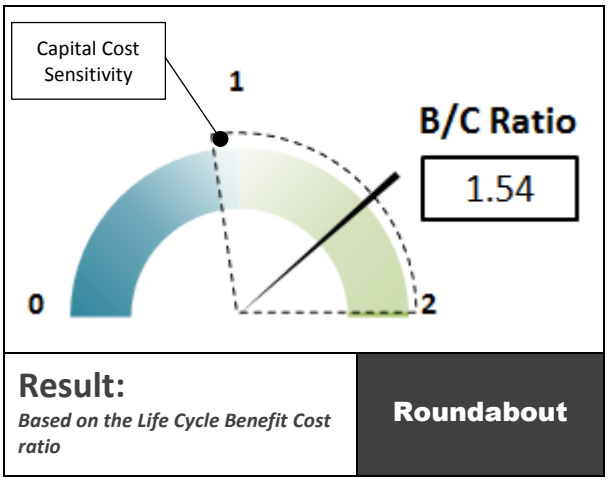


Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Fifth Street at US 101 Ramp Terminals	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

FIFTH STREET AT US 101 RAMP TERMINALS



The Benefit Cost (B/C) ratio for Fifth Street at US 101 ramp terminals is 1.54. The B/C ratio of 1.54 represents the combination of performance measures for the Fifth Street at US 101 Northbound (NB) Ramp terminal and the Fifth Street at US 101 Southbound (SB) Ramp terminal intersection. The intersections were combined into a single project due to the short distance between intersections and the need to widen the existing bridge on Fifth Street for the signal alternative. The individual B/C scores for each intersection are as follows:

Study Intersection	Intersection Number	B/C Ratio
Fifth Street at US 101 Northbound (NB) Ramp Terminals	GZL-01n	1.38
Fifth Street at US 101 Southbound (SB) Ramp Terminals	GZL-01s	1.70

Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety, *delay*, *structure costs*, and *right of way* are notable performance metrics driving the B/C ratio. The total life cycle benefits of the roundabout are estimated at $1,840,000 when compared to the traffic signal alternative. The total life cycle benefit includes an estimated $7,8-- reduction in annual operations and maintenance costs when compared to the traffic signal alternative.

Initial capital costs for the intersection were estimated as one project and evenly split for each intersection.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Fifth Street at US 101 Ramp Terminals	**Fifth Street (City of Gonzales)**	East: 4-lane divided West: 2-lane undivided	Local	25	Serves residential, commercial, institutional, recreational, and agricultural land uses	Service provided by Monterey Salinas Transit for Line 23 and 86	Sidewalks provided. East: X-walk on East leg West: X-walk on west leg Primary pedestrian route for schools with significant pedestrian volumes	Class II bike lanes
	US-101 (Caltrans)	4-lane Ramps: 1-lane + turn lanes	Highway	65	Regional highway Goods movement corridor	Service provided by Monterey Salinas Transit for Line 23 and 86	Restricted pedestrian access on ramps Crosswalks at all ramps	No bike lanes provided

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic while providing improved pedestrian and bicycle facilities. The existing all way stop control, or no project alternative, should provide adequate vehicle capacity to serve existing traffic. However, vehicle queues are expected to exceed available storage, impacting nearby intersection and driveway operations. The proposed signal alternative will provide pedestrian and bicycle improvements while adequately serving forecast traffic demand. The project assumes improvements are made at both US 101 NB and SB ramp terminal intersections with Fifth Street. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2035 design year. The year 2015 was assumed for the baseline "build" condition for a total 20 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Numbers GZL-01n and GZL-01s on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

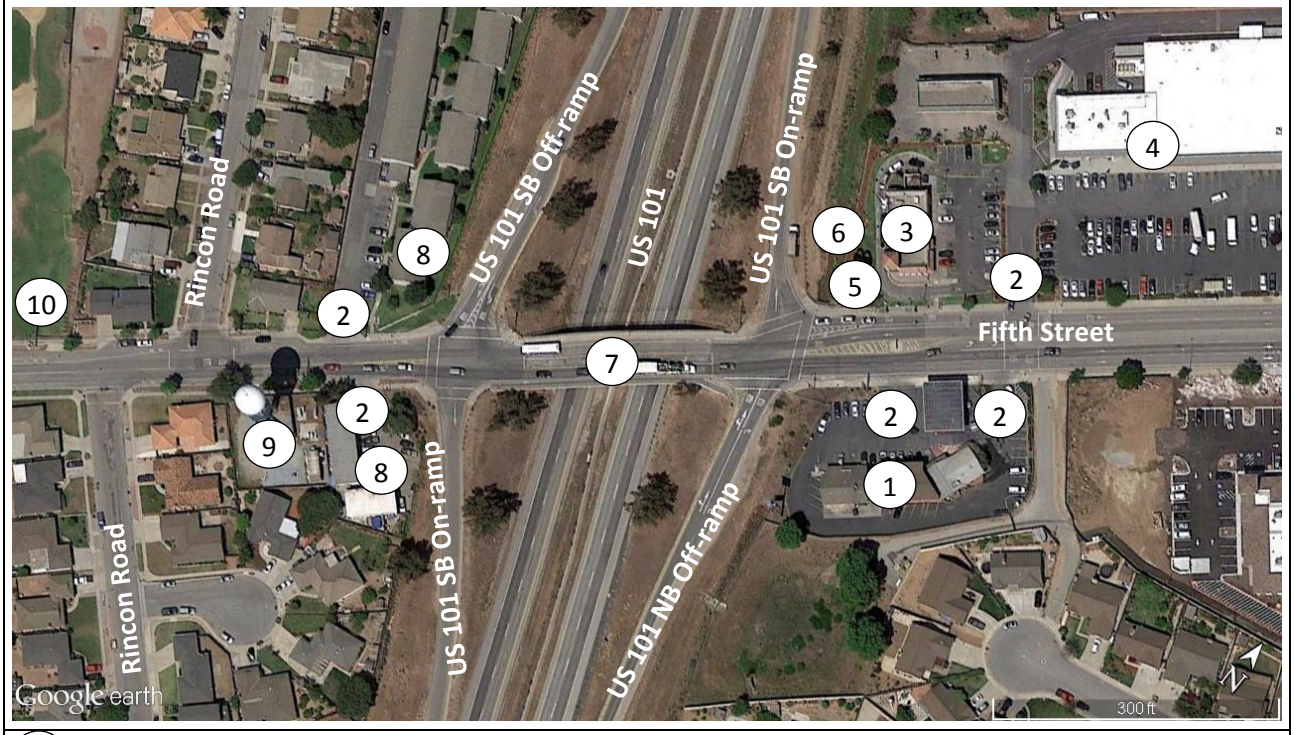
The existing Fifth Street at the US 101 NB and SB ramp terminals are controlled by all way stop signs.

Parcels adjacent to the intersections are developed. Parcels east of the interchange are commercial properties. Parcels west of the interchange are multi-family residences. Fifth Street is within the City of Gonzales right of way. US 101 ramps are within Caltrans right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Service station/commercial/food service
2. Driveway
3. McDonalds
4. Shopping center
5. Sign for shopping center
6. Ditch
7. Fifth Street Bridge
8. Multi-family residence
9. Water tower
10. Gonzales High School

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided on the previous page.



(1) Refer to the Existing Conditions section on the previous page for description of the design constraint.

PLANNED IMPROVEMENTS

No planned improvements have been identified.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for the 2013 AM /PM peak hour and the 2035 AM / PM peak hour traffic and pedestrian volumes were taken from the 2014 technical memorandum prepared by Fehr & Peers and provided by the City. At City direction, the 1.5% per year growth scenario was used. 2015 volumes were assumed to be equal to 2013 volumes.

Stop Control (Existing)

The existing stop control, or no project alternative, operates with all-way stop control at both ramp intersections. The critical queue under existing conditions is during the PM peak hour in the eastbound on the 5th Street Bridge. The is caused by operations at the northbound and impacts operations at the southbound ramps.

Signal Control

The US 101 Ramps at Fifth Street are proposed with protected left turns along Fifth Street with coordinated phasing on Fifth Street. The critical movement at both study locations is the left turn to the on-ramp as there is limited capacity on the bridge and any queue spillback will affect the other intersection operations. Coordination with emphasis on one left turn movement would increase queues for the other, therefore an east/west coordinated phasing is proposed to provide the best progression over the bridge.

With the signal control alternative, roadway improvements include the addition of one lane over the bridge. The additional lane will require the bridge to be widened and Fifth Street approaches adjusted.

The signal control alternative would provide pedestrian push button signal control for safer crossing as well as an additional crosswalk leg to either sides of the bridge. The lane addition on the 5th Street Bridge would not affect pedestrian access as sidewalks will be provided. Bike lanes along 5th Street can be maintained and also now provided over the bridge. Transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access.

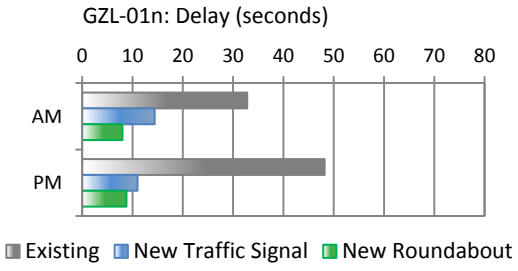
Roundabout Control

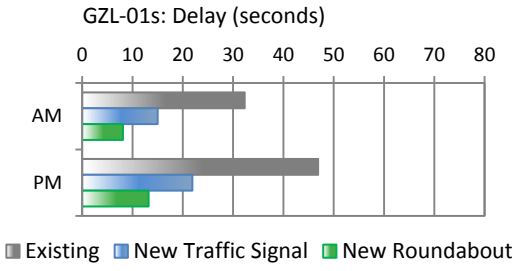
With roundabout control, two single lane roundabouts with single lane approaches and departures are proposed. A westbound Fifth Street right turn lane to the US 101 northbound on-ramp is provided. The westbound through traffic and right turn traffic are separated with a raised median and pedestrian refuge. The proposed roundabouts will improve performance at the study intersections for AM and PM peak hours under both existing and future design year conditions.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes along 5th Street can be maintained however are not considered over the bridge as they are not currently provided. Transit stops are not provided at the intersection therefore the roundabout alternative will not impact transit access.

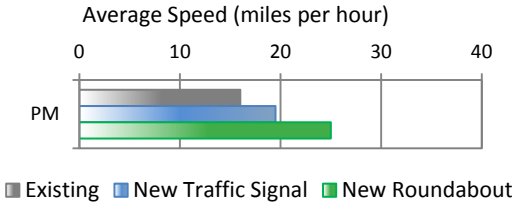
TRAFFIC OPERATIONS SUMMARY

The following bar charts illustrate the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.





The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



NOTE: The average speed identified in the bar chart above is the average of GZL-01n and GZL-01s.

PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table above. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- Preliminary engineering and additional site investigations.
- Topographic survey to better identify need for retaining structures.
- Refinement of right of way costs.
- Evaluation of Fifth Street Bridge, including existing and construction vertical clearances.
- Access for fuel tankers at service station facility.
- Access to multi-family units west of Fifth Street bridge.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **GZL-01n**
01/16

Intersection Cost Comparison

Fifth Street at US-101 Interchange (Northbound Ramp)
Gonzales, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.23	$ 33,623	$ 456,941	0.51	$ 74,717	$ 1,015,425
Predicted PDO Crashes	0.85	$ 8,662	$ 117,718	0.95	$ 9,684	$ 131,606
Subtotal - Safety Costs	**-**	**$ 42,284**	**$ 574,659**	**-**	**$ 84,401**	**$ 1,147,031**
DELAY						
Delay to Persons in Vehicles (hours)	1662	$ 19,113	$ 401,372	2637	$ 30,626	$ 643,154
Subtotal - Delay Costs	-	**$ 19,113**	**$ 401,372**	-	**$ 30,626**	**$ 643,154**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	7,701
Cost of Power for Signal				-	$ 4,255	57,827
Cost of Illumination	6	$ 873	$ 11,859	4	$ 582	7,906
Cost of Landscaping Maintenance	-	$ 2,000	$ 27,181			
Cost of Signal Maintenance				-	$ 4,660	63,331
Cost of Pavement Rehabilitation			$ 37,538			$ 51,754
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 76,578**	-	**$ 10,063**	**$ 188,520**
EMISSIONS						
Tons of ROG	0.14	$ 135	$ 1,836	0.19	$ 180	$2,448
Tons of NOX	0.44	$ 5,708	$ 77,577	0.49	$ 6,320	$85,889
Tons of PM10	0.0063	$ 630	$ 8,565	0.0079	$ 788	$10,707
Subtotal - Emissions Costs		**$ 6,474**	**$ 87,979**		**$ 7,288**	**$ 99,044**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,272,588			$ 614,400
Construction Cost - Structures			$ 250,460			$ 525,560
Capital Support			$ 762,000			$ 570,000
Right-of-Way			$ 170,500			$ 37,500
Subtotal - Initial Capital Costs			**$ 2,455,548**			**$ 1,747,460**
NET PRESENT VALUE			**$ 3,596,137**			**$ 3,825,208**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal

Safety Benefit of Roundabout	$572,372
Delay Reduction Benefit of Roundabout	$241,781
Emission Reduction Benefit of Roundabout	$11,065
Total Benefits	**$825,218**

COSTS - Roundabout compared to Traffic Signal

Added O&M Costs of a Roundabout	-$111,942
Added Capital Costs of a Roundabout	$708,088
Total Costs	**$596,146**

LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO

1.38

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	354	161
Cost Per Pound Per Life	$75.95	$166.79
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$7,595**	**$16,679**

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **GZL-01s**
01/16

Intersection Cost Comparison

Fifth Street at US-101 Interchange (Southbound Ramp)
Gonzales, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.24	$ 34,992	$ 475,554	0.53	$ 77,760	$ 1,056,787
Predicted PDO Crashes	0.90	$ 9,175	$ 124,698	1.01	$ 10,295	$ 139,919
Subtotal - Safety Costs	**-**	**$ 44,168**	**$ 600,252**	**-**	**$ 88,056**	**$ 1,196,706**
DELAY						
Delay to Persons in Vehicles (hours)	1743	$ 19,874	$ 417,347	3382	$ 39,440	$ 828,240
Subtotal - Delay Costs	-	**$ 19,874**	**$ 417,347**	-	**$ 39,440**	**$ 828,240**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	7,701
Cost of Power for Signal				-	$ 4,255	57,827
Cost of Illumination	6	$ 873	$ 11,859	4	$ 582	7,906
Cost of Landscaping Maintenance	-	$ 2,000	$ 27,181			
Cost of Signal Maintenance				-	$ 4,660	63,331
Cost of Pavement Rehabilitation			$ 28,068			$ 41,748
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 67,108**	-	**$ 10,063**	**$ 178,513**
EMISSIONS						
Tons of ROG	0.15	$ 139	$ 1,893	0.18	$ 170	$2,313
Tons of NOX	0.46	$ 5,884	$ 79,965	0.49	$ 6,304	$85,676
Tons of PM10	0.0065	$ 650	$ 8,829	0.0081	$ 812	$11,036
Subtotal - Emissions Costs		**$ 6,673**	**$ 90,686**		**$ 7,287**	**$ 99,026**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,272,588			$ 614,400
Construction Cost - Structures			$ 250,460			$ 525,560
Capital Support			$ 762,000			$ 570,000
Right-of-Way			$ 170,500			$ 37,500
Subtotal - Initial Capital Costs			**$ 2,455,548**			**$ 1,747,460**
NET PRESENT VALUE			**$ 3,630,941**			**$ 4,049,945**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$596,454
Delay Reduction Benefit of Roundabout	$410,893
Emission Reduction Benefit of Roundabout	$8,340
Total Benefits	**$1,015,686**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$111,405
Added Capital Costs of a Roundabout	$708,088
Total Costs	**$596,683**

LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO

1.70

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	365	231
Cost Per Pound Per Life	$73.68	$116.23
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$7,368**	**$11,623**

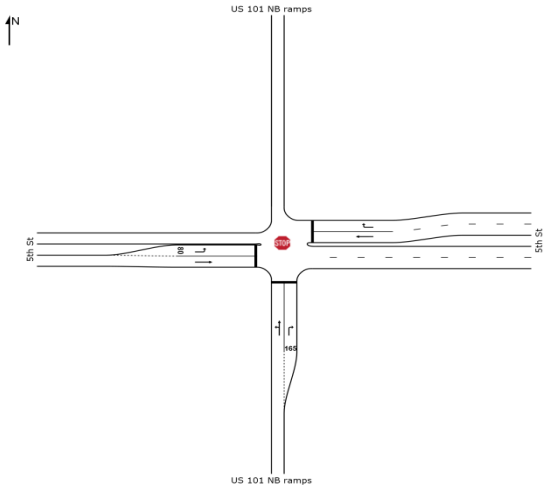
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

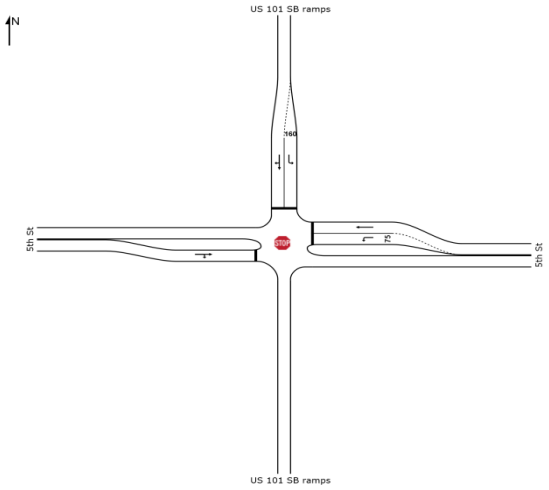


EXISTING INTERSECTION – NORTHBOUND RAMP STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	B	14.1	375 (WBT)	D	25.1	268 (EBT)
2035	D	32.8	375 (WBT)	E	48.2	358 (WBT)

NOTES:

1. EBT queues will exceed available storage during 2035 p.m. peak affecting operations at the SB Ramps.

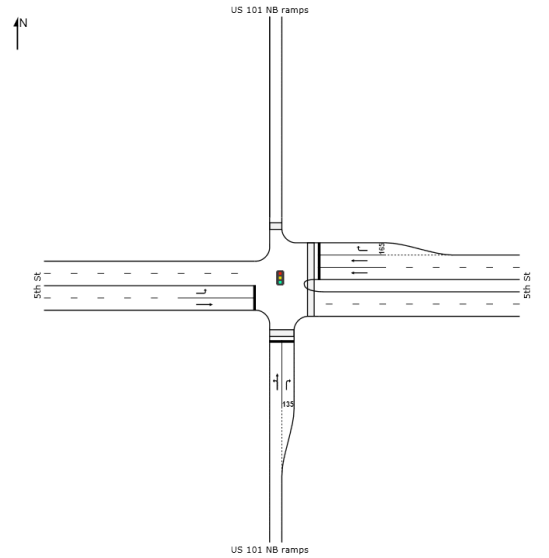


EXISTING INTERSECTION – SOUTHBOUND RAMP STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	B	14.2	83 (EBT)	C	18.1	128 (EBT)
2035	D	32.3	295 (EBT)	E	46.9	338(EBT)

NOTES:

1. EBT queues will affect operations at the adjacent intersection of Rincon Road during both 2035 peak hours.
2. WBT queues will exceed available storage during both 2035 peak hours affecting operations at the NB Ramps.



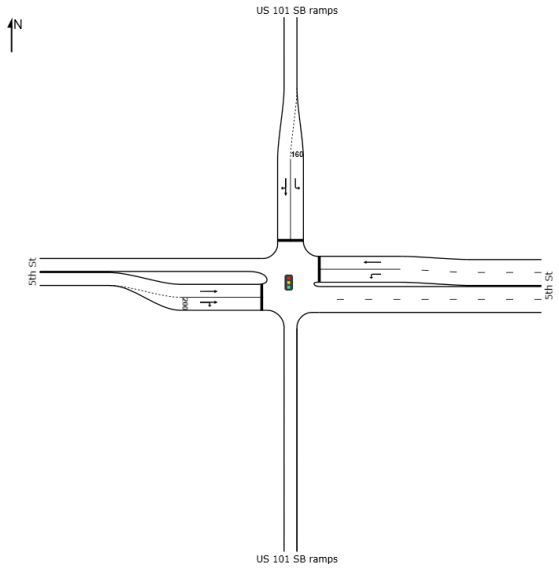
ALTERNATIVE 1– NORTHBOUND RAMP SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	B	11.2	106 (EBL)	A	9.7	66 (WBT)
2035	B	14.4	138 (EBL)	B	11.0	138 (WBT)

NOTES:

1. EBL queues will exceed available storage during weekday a.m. peak and cumulative a.m. peak.

Intersection Control Alternative Summary

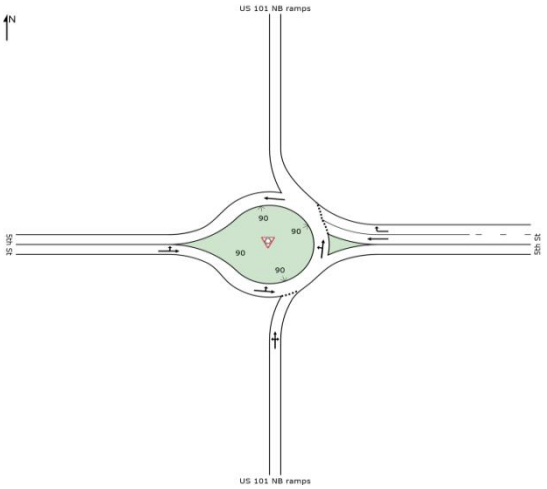


ALTERNATIVE 1 - SOUTHBOUND RAMP SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	B	13.4	96 (WBL)	B	18.9	163 (SBL)
2035	B	15.0	124 (WBL)	C	21.9	#292 (EBT)

NOTES:

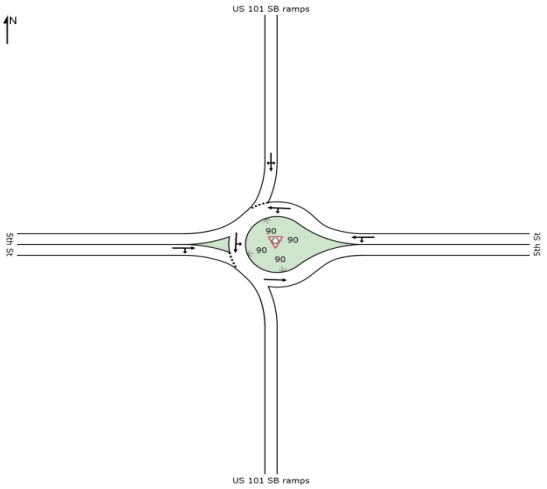
1. EBT queues will affect operations at the adjacent intersection of Rincon Road during both 2035 peak hours.
2. WBT queues will exceed available storage during both 2035 peak hours affecting operations at the NB Ramps.



ALTERNATIVE 2 – NORTHBOUND RAMP ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	A	5.8	60 (WB)	A	6.2	47 (WB)
2035	A	8.0	108 (WB)	A	8.8	80 (WB)

NOTES:



ALTERNATIVE 2 - SOUTHBOUND RAMP ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	A	5.9	51 (EB)	A	7.5	56 (WB)
2035	A	8.1	89 (EB)	B	13.2	140 (EB)

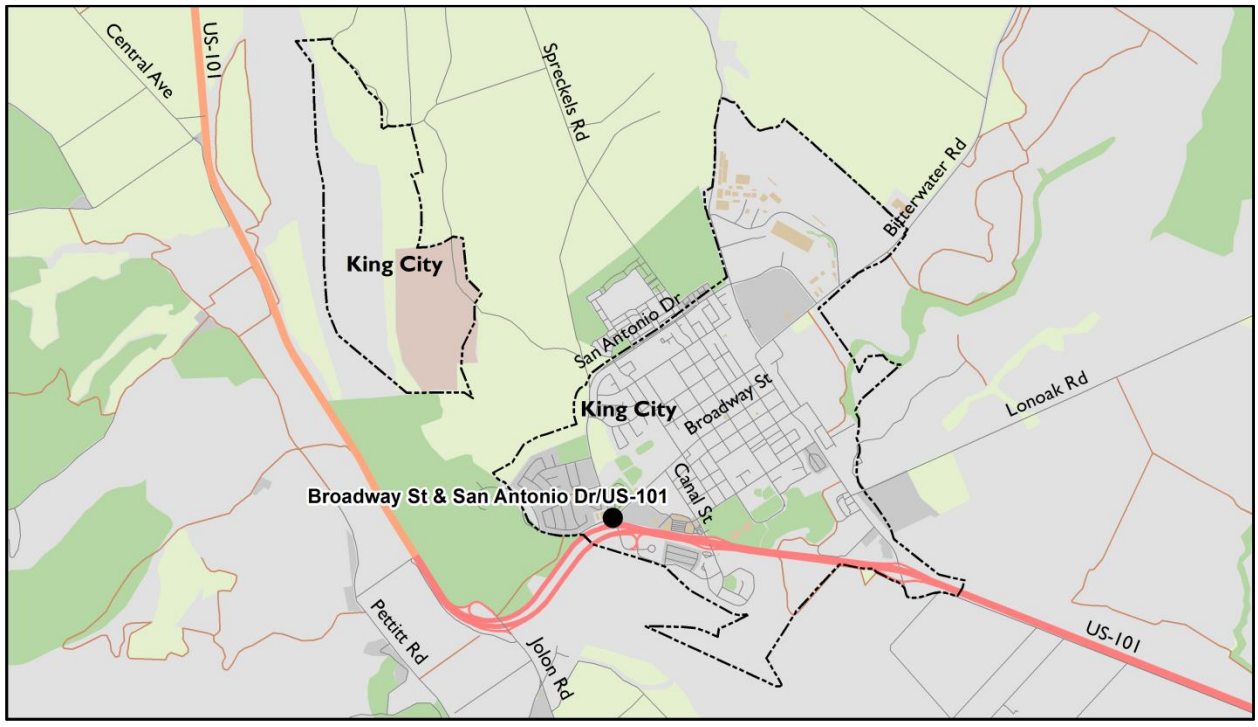
NOTES:

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 3:

King City

Study Intersections:

- BROADWAY STREET AT SAN ANTONIO DRIVE / US 101 NORTHBOUND RAMP TERMINALS



KING CITY SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	KGC-01

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under King City jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by King City, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	**1.49**	

SUMMARY OF KEY PERFORMANCE MEASURES

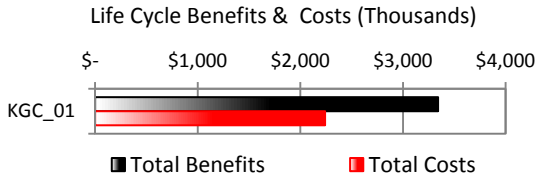
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



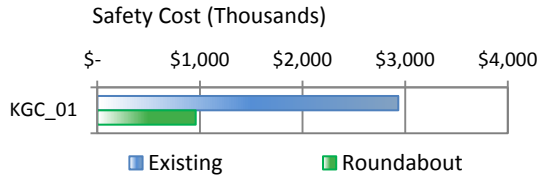
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

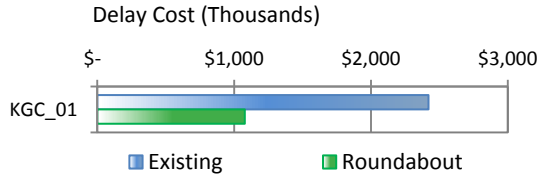


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.



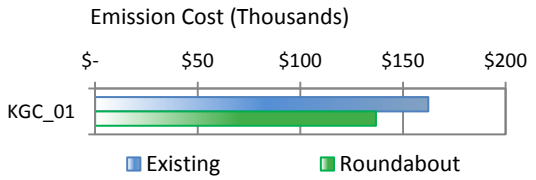
Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic*

Parameters 2012 for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

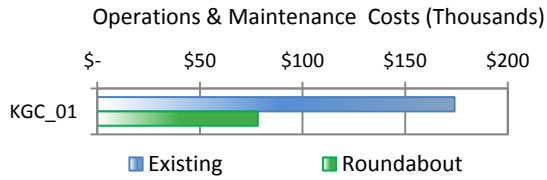
Emissions Study Intersection	Preferred Control
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

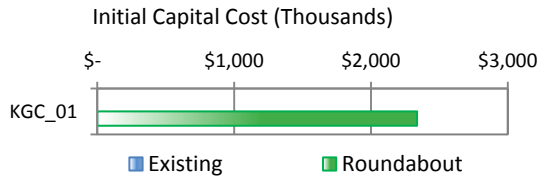


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	NO PROJECT

NOTE: The existing alternative has the lowest cost.

Summary of B/C Performance Measures

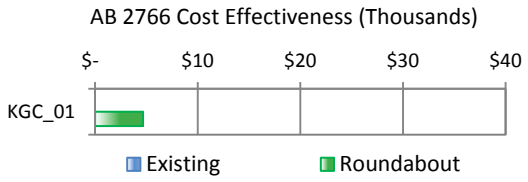
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals					NO PROJECT	

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and King City.

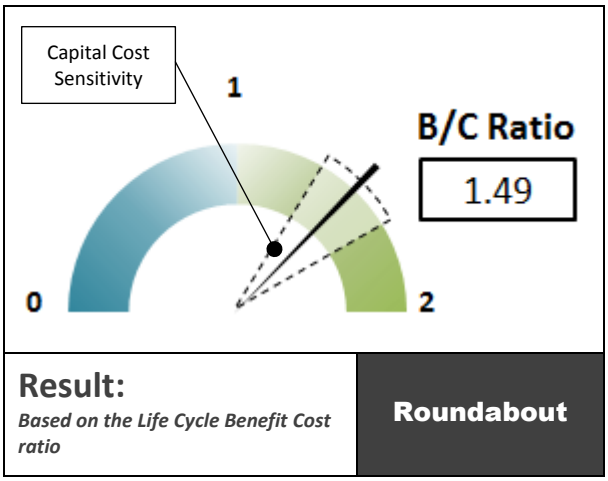


Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

BROADWAY STREET AT SAN ANTONIO DRIVE / US 101 NORTHBOUND RAMP TERMINALS



The Benefit Cost (B/C) ratio for the Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals intersection is 1.49. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $3.4M and all other performance measures remained unchanged.

Noteworthy performance measures driving the B/C ratio are *safety and delay*. The total life cycle benefits of the roundabout are estimated at $3,340,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $1,600 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a superior alternative to serve existing and forecast traffic. The existing signal control on Broadway Street at San Antonio Drive and the existing stop control on the US 101 northbound ramp terminal, or no project alternative, operates with acceptable delay for the existing traffic demand condition. Operations are expected to degrade to unacceptable levels as demand reaches forecast design year levels. In terms of vehicle queuing, vehicles queues are expected to exceed available storage for all movements on northbound Broadway Street and left turn movements on westbound Broadway Street. The proposed signal control alternative is not expected to improve overall operations at the intersection, but signal improvements are expected to improve ramp operations. There may be other considerations,

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals	**San Antonio Drive (north) / Broadway Street (south) (King City)**	North: 4-lane divided. South: 2-lane undivided south.	Local	35 north, 25 south	Serves residential, commercial business, and institutional uses. Provides circulation throughout King City.	Service provided by Monterey-Salinas Transit Line 23. (No service provided on San Lorenzo Park Road)	Sidewalks provided. Crosswalks are provided at signalized intersection.	No bike lanes provided.
	Broadway Street (east) / San Lorenzo Park Road (west) (King City)	East: 2-lane divided. West: 2-lane undivided. On-street parking.	Local	25	Serves residential, commercial business, and institutional uses. Provides circulation throughout King City.		Sidewalks provided. Crosswalks are provided at signalized intersection.	No bike lanes provided.
	US 101 Northbound Ramp Terminals (Caltrans)	1-lane.	Highway	60	Provides on/off access to/from northbound US 101.		No sidewalks. Crosswalks provided.	No bike lanes provided.

constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

For the purpose of this study, the B/C ratio was calculated for the roundabout vs. no project condition. The calculated B/C ratio assumes $0 in initial capital costs for improvements to the existing intersection. Operations for the proposed signal are expected to have greater delay than the no project alternative. Therefore, proposed signal improvements will likely increase the *delay reduction benefit* and decrease the *added capital cost of a roundabout*. The result would generate a B/C ratio greater than the no project alternative.

Refer to the Intersection Cost Comparison for intersection Number KGC-01E on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

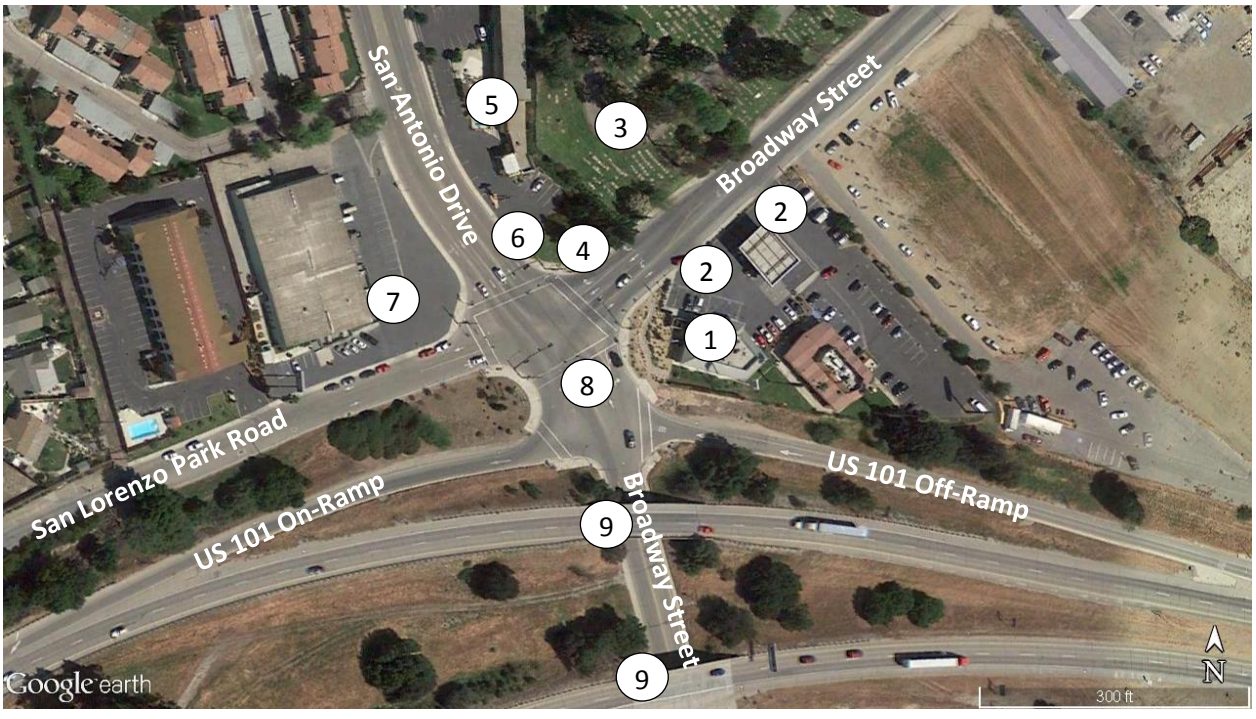
This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

The Broadway Street at San Antonio Drive / US 101 Northbound Ramp Terminals intersection is two closely spaced intersections with two types of traffic control. The Broadway Street at San Antonio Drive intersection is controlled by a traffic signal. The Broadway Street at US 101 Northbound Ramp Terminal intersection is controlled by a two-way stop on the minor approach, or off-ramp.

Parcels in the east, northeast, and northwest quadrants are developed. The easterly parcel is a service station with a structure close to the intersection and is considered a fatal flaw if disturbed. The existing signalized intersection is within City of Greenfield right of way and the existing stop control intersection is within Caltrans right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Service station (fatal flaw if disturbed)
2. Service station driveway
3. King City Cemetery
4. King City welcome sign / gateway feature
5. Days Inn King City
6. Days Inn driveway
7. Urgent care
8. Intersection spacing
9. US 101 overcrossing



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided on the previous page.

PLANNED IMPROVEMENTS

No planned improvements were identified.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal and Stop	
Proposed Signal improvements	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM and PM peak hour volumes was provided by the City. 2040 peak hour volumes were calculated using a 2.4% annual compound growth rate for all movements.

Signal Control (Existing)

With signal control, demand is adequately served for both peak hours under existing and design year conditions. Vehicle queuing for northbound Broadway Street extends beyond the existing two-way stop controlled intersection at the US 101 northbound ramp terminals. Queuing for the westbound Broadway Street left turn lane exceeds available storage under the existing condition. Vehicle queuing is expected to increase with travel demand, impacting ramp operations and driveway access on the easterly leg of Broadway Street.

Two-Way Stop Control (Existing)

Note: The two-way stop control intersection was evaluated using static, isolated intersection analysis. Microsimulation of the combined stop control and signal controlled intersections is recommended for further study.

Demand is adequately served for both peak hours under existing conditions. Beginning in design year 2030, off-ramp operations are expected to perform at unacceptable levels of delay. Under existing conditions, westbound vehicle movements are not coordinated with the signal at Broadway Street and San Antonio Drive. As a result, westbound vehicles turning left, or continuing through, are unable to distinguish southbound vehicles turning right on to the on-ramp, or continuing south. It is also difficult for stopped westbound vehicles to determine when westbound left turning Broadway Street vehicles are given a green arrow.

Signal Control - Modification

With signal control modifications, the existing two-way stop control intersection will be signalized and coordinated with the signal at Broadway Street and San Antonio Drive. The US 101 northbound off-ramp would operate with a dedicated phase creating 5-leg intersection operations. The signal would continue to operate with split phasing on all approaches.

For the signal control modification, additional lanes are required on the following approaches:

- US 101 Off-ramp: Add one lane
- Broadway Street (east leg): Add one left turn lane
- Broadway Street (south leg): Add one approach lane and one departure lane.

The signal modifications would require reconstruction of the US 101 overcrossing.

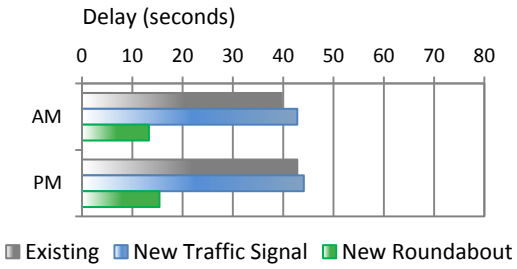
The additional lanes and reconfiguration of signal will also impact crossing distance as well as overall cycle length for protected phasing. Bike lanes and transit stops are not provided at the intersection therefore the reconfiguration of the intersection will not create an impact to these facilities.

Roundabout Control

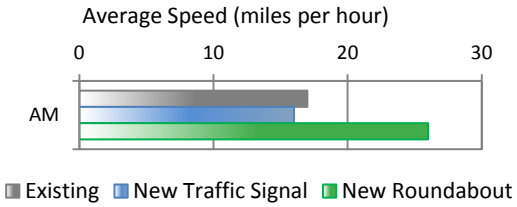
With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak hours through design year 2025 conditions. It is expected that between 2030 and 2040, a single westbound Broadway Street right turn lane will be needed. The roundabout is expected to provide superior operations compared to the existing conditions and proposed signal modification alternative.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	NO PROJECT
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Traffic microsimulation, such as VISSIM, of project area.
- Evaluation roundabout design checks, especially evaluation of roundabout intersection sight distances for vehicles on US 101 northbound off-ramp and entry speed of northbound Broadway Street vehicles.
- Project approval and coordination with Caltrans.
- Preliminary engineering, topographic survey of US 101 overcrossing and service station.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **KGC-01E**
01/16

Intersection Cost Comparison

Broadway Street/San Antonio Drive/US-101 Ramps (Existing Signal + Stop Condition)
King City, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal + Two-Way Stop		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.35	$ 51,880	$ 810,470	1.14	$ 168,878	$ 2,638,228
Predicted PDO Crashes	0.93	$ 9,488	$ 148,225	1.85	$ 18,850	$ 294,480
Subtotal - Safety Costs	**-**	**$ 61,368**	**$ 958,695**	**-**	**$ 187,728**	**$ 2,932,708**
DELAY						
Delay to Persons in Vehicles (hours)	3932	$ 41,456	$ 1,077,859	9295	$ 93,093	$ 2,420,430
Subtotal - Delay Costs	-	**$ 41,456**	**$ 1,077,859**	-	**$ 93,093**	**$ 2,420,430**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 333	5,207
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 1,200	18,746
Cost of Pavement Rehabilitation			$ 33,320			$ 74,554
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 78,196**	-	**$ 6,370**	**$ 174,069**
EMISSIONS						
Tons of ROG	0.19	$ 183	$ 2,856	0.30	$ 284	$4,443
Tons of NOX	0.60	$ 7,724	$ 120,664	0.68	$ 8,827	$137,901
Tons of PM10	0.0086	$ 853	$ 13,322	0.0128	$ 1,279	$19,984
Subtotal - Emissions Costs		**$ 8,760**	**$ 136,842**		**$ 10,391**	**$ 162,328**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,384,735			$ -
Construction Cost - Structures			$ -			$ -
Capital Support			$ 693,000			$ -
Right-of-Way			$ 259,000			$ -
Subtotal - Initial Capital Costs			**$ 2,336,735**			**$ -**
NET PRESENT VALUE			**$ 4,451,486**			**$ 5,527,207**

NOTE: Safety and Delay performance measures are the summation of the exsitng signal and stop controlled intersections.

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,974,013
Delay Reduction Benefit of Roundabout	$1,342,571
Emission Reduction Benefit of Roundabout	$25,486
Total Benefits	**$3,342,070**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$95,872
Added Capital Costs of a Roundabout	$2,336,735
Total Costs	**$2,240,863**

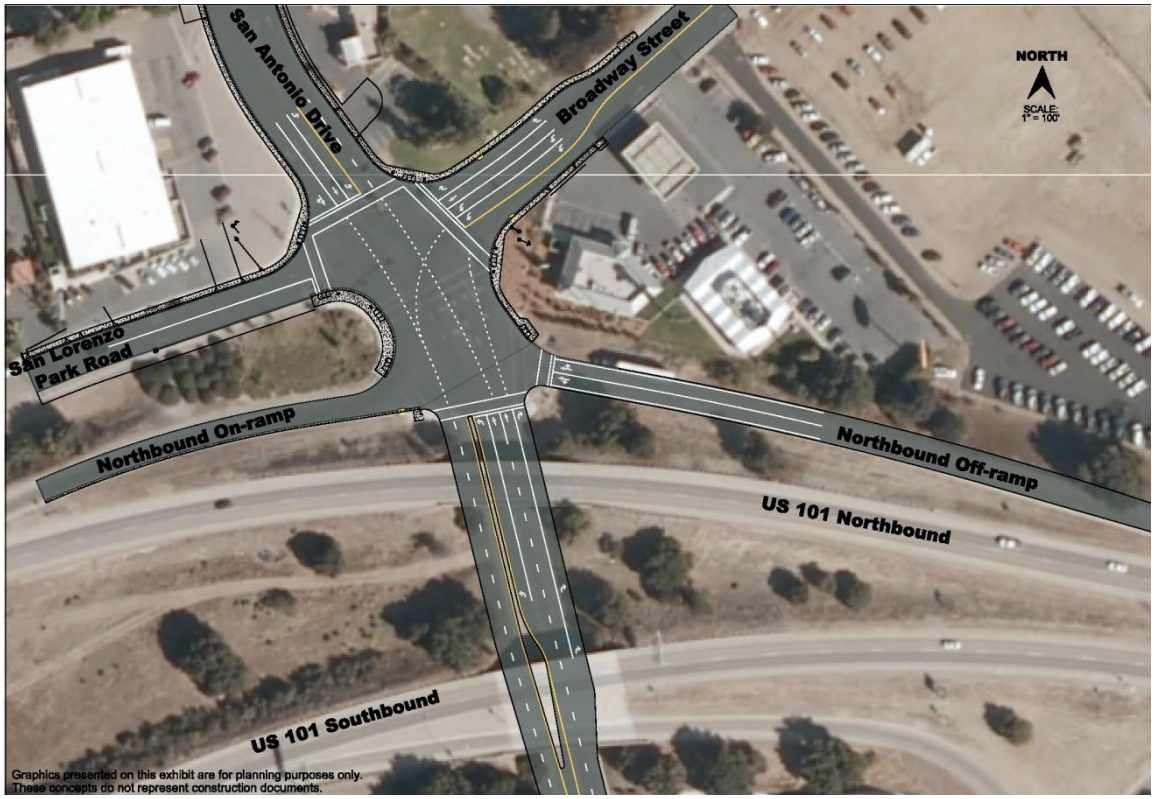
LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

1.49

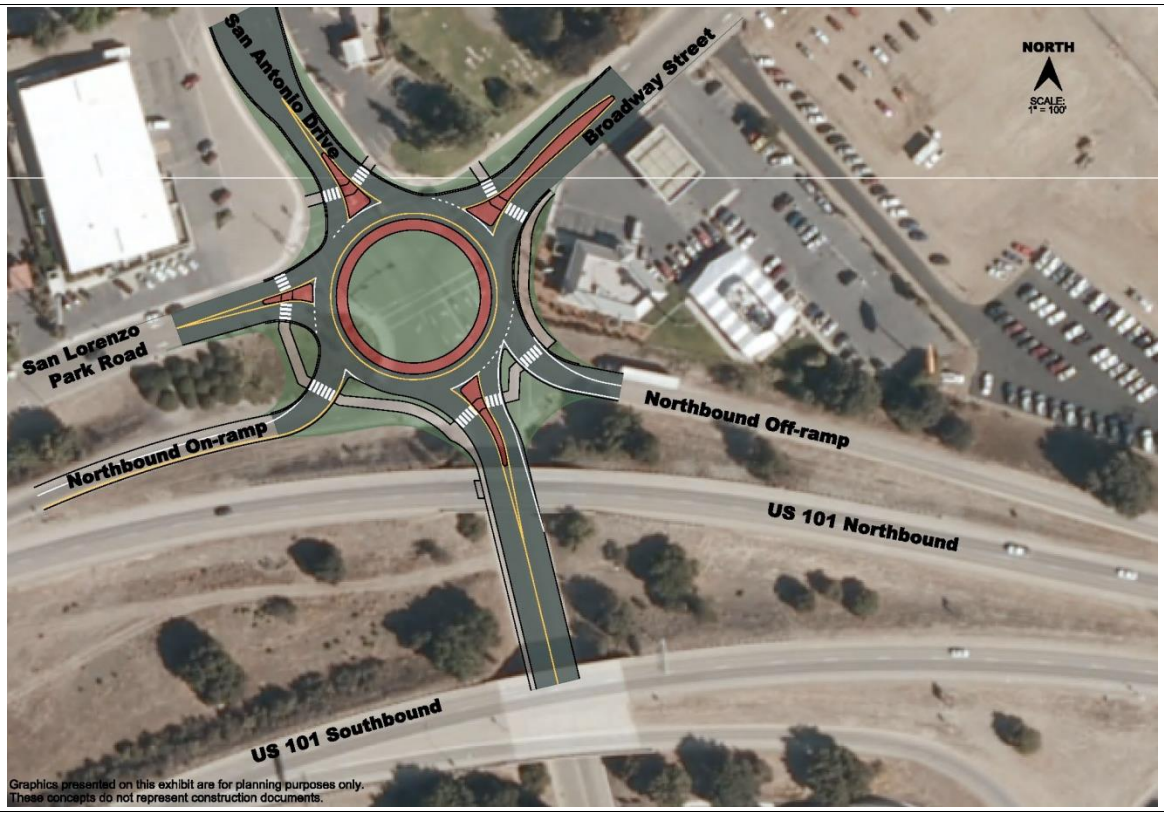
B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**ffic Signal + Two-Way Stop (vs. existi**
Annual Emission Reduction (lb/year)	393	N/A No Emission Change
Cost Per Pound Per Life	$58.38	N/A No Emission Change
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$4,671**	**N/A No Emission Change**

Intersection Improvement Alternatives



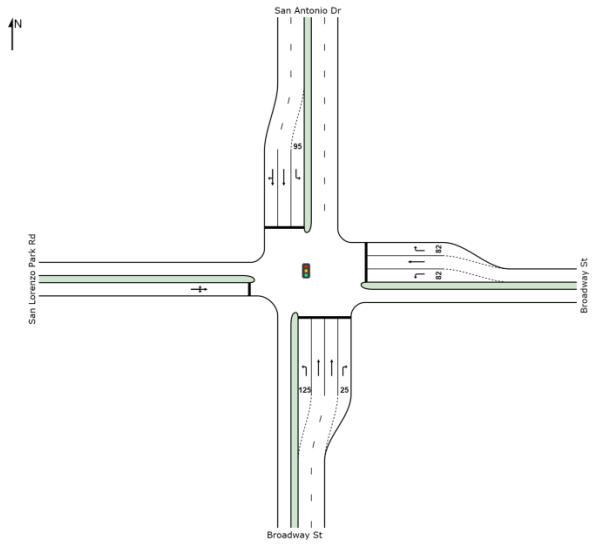
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

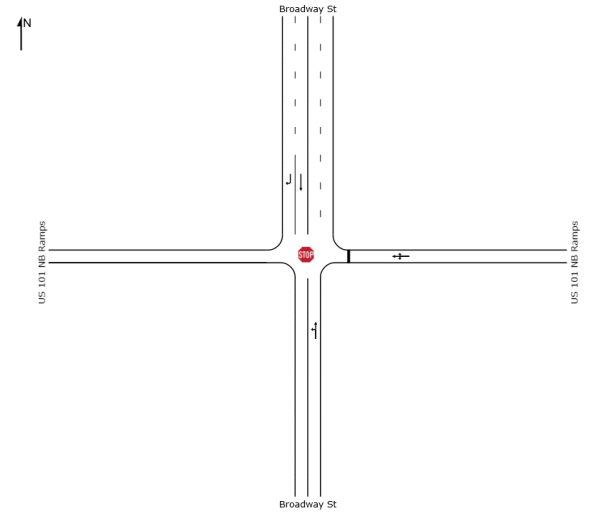


EXISTING INTERSECTION SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	B	18.6	107 (SBT)	B	19.0	160 (WBL)
2030	C	23.1	192 (SBT)	C	24.4	248 (WBL)
2040	D	36.2	334 (NBR)	C	31.0	367 (WBL)

NOTES:

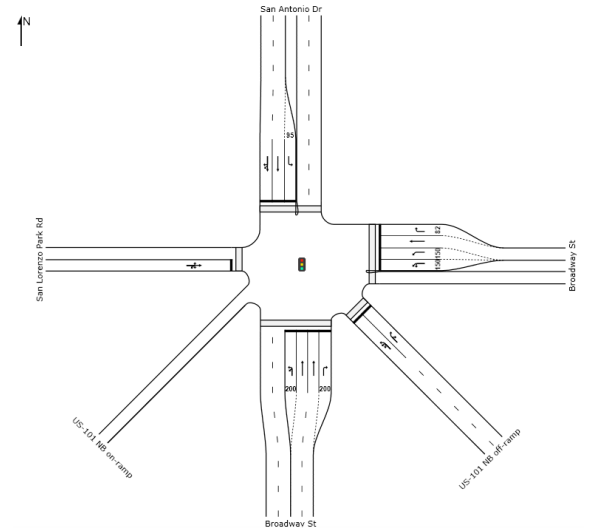
1. NB Broadway Street queues will exceed available storage affecting NB US-101 Ramps for all scenarios.
2. WBL Broadway Street will also exceed available storage for all scenarios.



EXISTING INTERSECTION STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	C	15.1	13 (WB)	C	16.5	25 (WB)
2030	C	23.6	30 (WB)	D	26.2	63 (WB)
2040	F	51.5	78 (WB)	F	106.7	210 (WB)

NOTES:



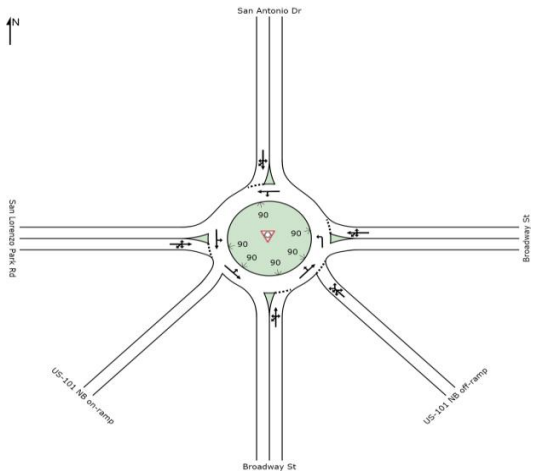
ALTERNATIVE 1 SIGNAL MODIFICATIONS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	C	25.5	222 (NBR)	C	26.5	194 (NBR)
2030	C	32.4	347 (NBR)	C	35.4	330 (NBR)
2040	D	42.8	550 (NBR)	D	44.1	515 (NBR)

NOTES:

1. WBL Broadway Street will exceed available storage for the 2030 p.m. peak hour

Intersection Control Alternative Summary

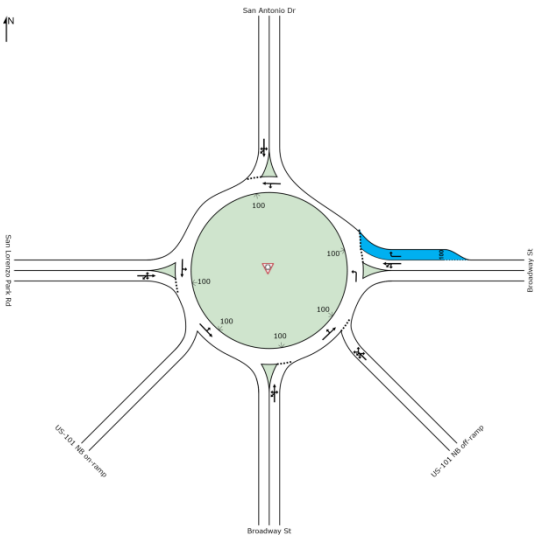


ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	6.2	66 (NB)	A	7.5	74 (NB)
2030	A	9.1	127 (NB)	B	15.0	235 (WB)

NOTES:

1. Significant queues are noted for WB Broadway Street during the 2015 and 2030 p.m. peak hour.



ALTERNATIVE 2a
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2040	B	13.3	235 (NB)	C	15.4	296 (NB)

NOTES:

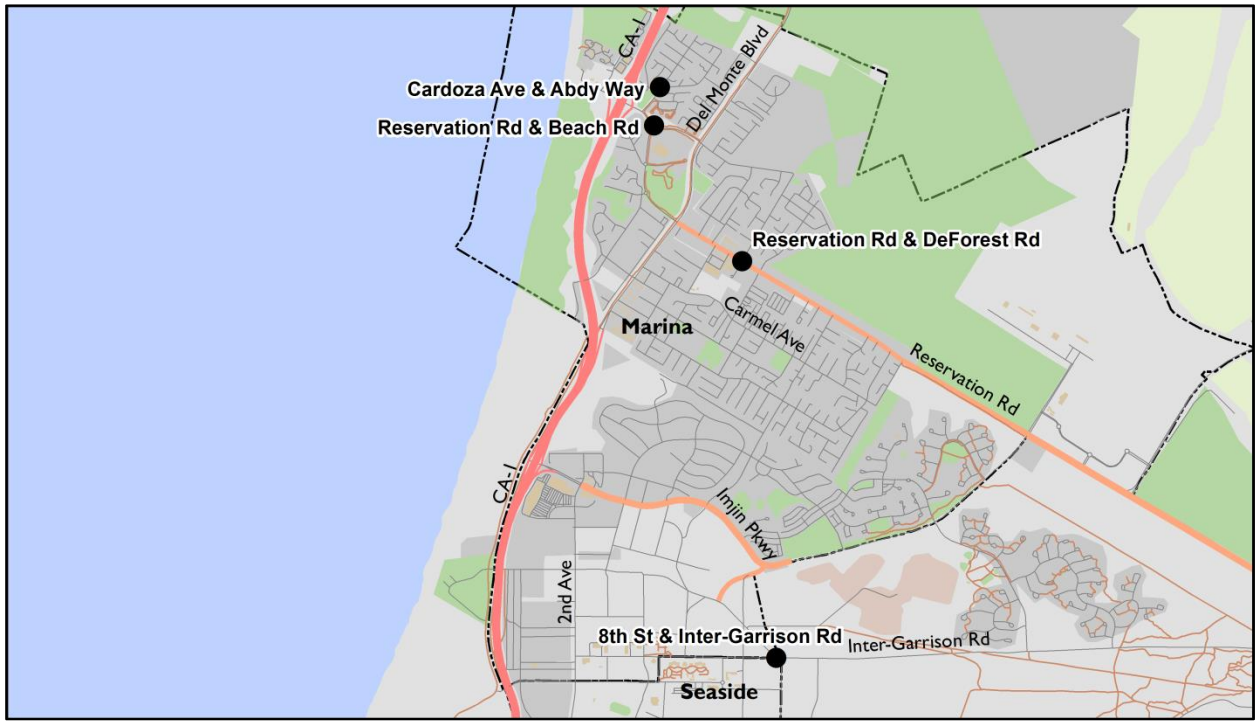
1. A 100 foot westbound right turn lane is added.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 4:

City of Marina

Study Intersections:

- RESERVATION ROAD AT BEACH ROAD
- RESERVATION ROAD AT DEFOREST ROAD
- CARDOZA AVENUE AT ABDY WAY
- 8TH STREET AT INTER-GARRISON



CITY OF MARINA SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Reservation Road at Beach Road	MAR-01
Reservation Road at DeForest Road	MAR-02
Cardoza Avenue at Abdy Way	MAR-03
8th Street at Inter-Garrison Road	MAR-04

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Marina jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Marina, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Reservation Road at Beach Road	**0.69**	
Reservation Road at DeForest Road	**3.92**	
Cardoza Avenue at Abdy Way	**1.22**	
8th Street at Inter-Garrison Road	**1.16**	

SUMMARY OF KEY PERFORMANCE MEASURES

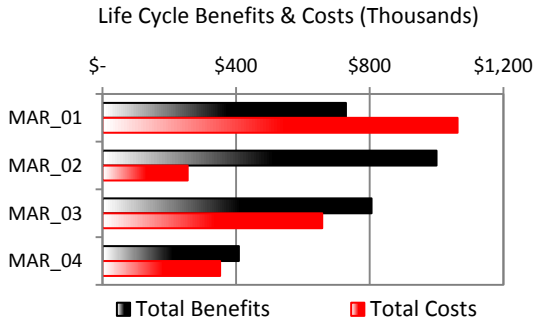
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



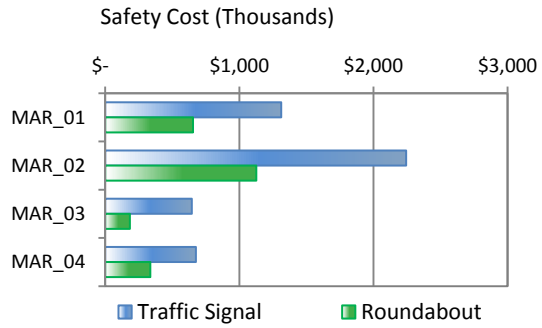
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

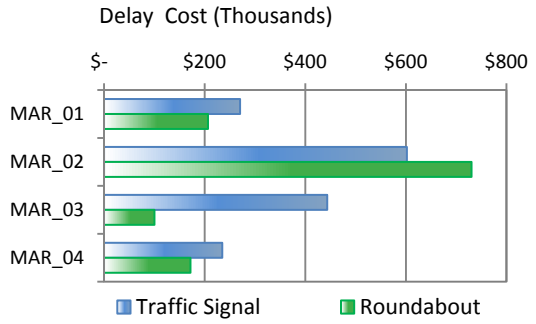


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	
8th Street at Inter-Garrison Road	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

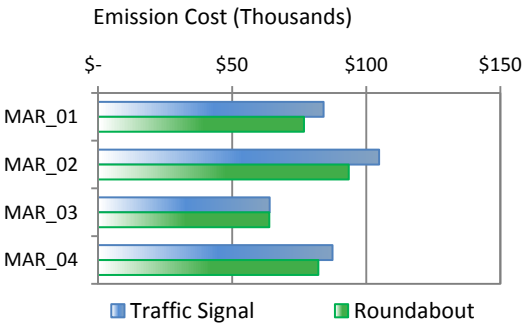


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay Study Intersection	Preferred Control
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	
8th Street at Inter-Garrison Road	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

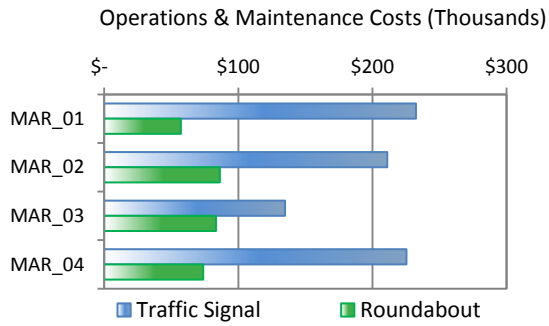
Emissions Study Intersection	Preferred Control
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	
8th Street at Inter-Garrison Road	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

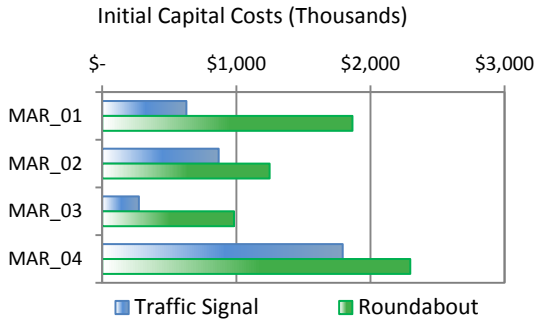


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	
8th Street at Inter-Garrison Road	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	
8th Street at Inter-Garrison Road	

Summary of B/C Performance Measures

The following table summarizes the five performance measures evaluated at each project location.

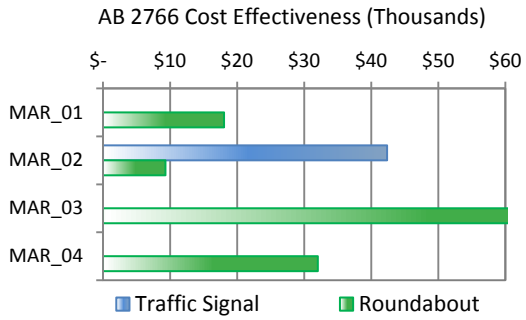
	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Reservation Road at Beach Road						
Reservation Road at DeForest Road						
Cardoza Avenue at Abdy Way						
8th Street at Inter-Garrison Road						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should

be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Marina.



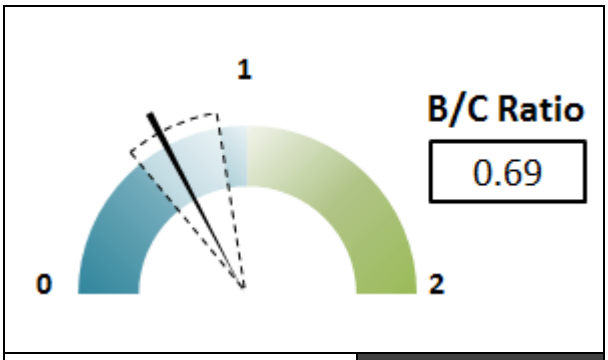
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness **Study Intersection**	**Preferred Control**
Reservation Road at Beach Road	
Reservation Road at DeForest Road	
Cardoza Avenue at Abdy Way	NONE
8th Street at Inter-Garrison Road	NONE

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

RESERVATION ROAD AT BEACH BOULEVARD



Result:
Based on the Life Cycle Benefit Cost ratio

Signal

The Benefit Cost (B/C) ratio for this intersection is 0.69. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a signal.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design. An initial capital cost budget of approximately $1.5 M would yeild a B/C ratio equal to 1.05 if all other performance measures remained equal.

Noteworthy performance measures driving the B/C ratio are *safety, operations and maintenance*, and *initial capital costs*. The estimated safety costs of the signal are 2 times higher than that of the roundabout. The estimated operations and maintenance costs of the signal are 3.5 times higher than that of the roundabout. The estimated initial capital costs are 2.5 higher for the roundabout than that of the signal. The total life cycle benefits of the roundabout are estimated at $730,000 when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing traffic signal control or, no project alternative, will continue to provide adequate capacity in terms of delay. However, queuing may exceed available storage capacity between Cardoza Avenue and Reservation Drive for westbound vehicles. Though not quantified in this evaluation, the roundabout will likely improve overall operations between the SR 1 northbound ramp terminals and Reservation Road by removing the dual northbound left turn lanes on Reservation Road and eliminating the westbound "weave" between Cardoza Avenue and Reservation Road. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Beach Boulevard at Reservation Road	**Beach Boulevard**	2-lane undivided	Urban	35	Serves residential and commercial land uses. Provides access to SR 1.	No transit services provided.	Some sidewalks provided	Partial Class II bike Lanes
	Reservation Road	2-lane undivided	Urban	35	Serves residential, commercial land uses, access to central Marina.	Service provided by Monterey-Salinas Transit. Stop located at intersection to remain.	Some sidewalks provided	Partial Class II bike Lanes

Refer to the Intersection Cost Comparison for intersection Number MAR-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Beach Boulevard at Reservation Road is controlled by a traffic signal.

Parcels in the immediate vicinity of the project are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement. The existing intersection is within Monterey County right of way.

Existing design constraints at the study intersection include (see map for locations):

1. Environmentally sensitive area
2. Right of way constraint – Gas Station
3. Transit access
4. Planned development

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

A hotel is planned for the vacant parcel in the southwest quadrant of the intersection. Future forecast assumes annual compound growth and does not account for specific projects.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Signal Modifications	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM peak hour volumes was provided by the City. 2040 AM peak hour volumes were calculated using a 2% annual compound growth rate for all movements. PM peak hour volumes were not provided.

Signal Control (Existing)

With signal control, demand is adequately served for the AM peak hour under existing conditions.

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Northbound left turning vehicles on Reservation Road are segregated between two left turn lanes to mitigate downstream weaving between Cardoza Avenue and Reservation Road. A bicycle lane is not provided at the eastbound approach between the through lane and the right turn lane.

Signal Control (Proposed)

With proposed signal control, the number of approach and departure lanes will remain the same as existing. Proposed improvements are limited to striping and pavement markings to improve safety and operations for cyclists and sidewalk improvements for pedestrians. Transit access will also not be affected by proposed improvements.

Roundabout Control

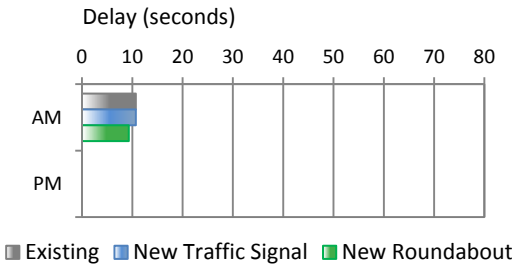
With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak hours under future design year conditions.

The single lane roundabout will eliminate the separation of left turning traffic and weave that currently exists for the signal alternative.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes can be maintained with a one lane roundabout. The nearest transit stop is over 100 feet south of the intersection and can be accommodated in the design of the roundabout.

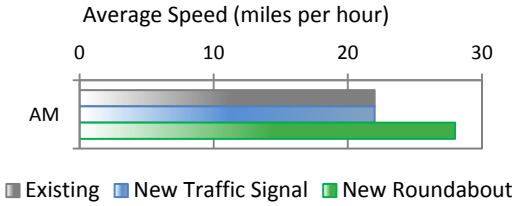
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: PM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- PM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MAR-01**

Intersection Cost Comparison

Beach Road at Reservation Road
Marina, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.23	$ 33,764	$ 527,459	0.51	$ 75,030	$ 1,172,131
Predicted PDO Crashes	0.80	$ 8,137	$ 127,115	0.88	$ 8,966	$ 140,065
Subtotal - Safety Costs	**-**	**$ 41,901**	**$ 654,574**	**-**	**$ 83,996**	**$ 1,312,197**
DELAY						
Delay to Persons in Vehicles (hours)	782	$ 7,949	$ 206,667	997	$ 10,403	$ 270,467
Subtotal - Delay Costs	-	**$ 7,949**	**$ 206,667**	-	**$ 10,403**	**$ 270,467**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 12,266			$ 75,211
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 57,143**	-	**$ 10,063**	**$ 232,423**
EMISSIONS						
Tons of ROG	0.10	$ 94	$ 1,474	0.12	$ 118	$1,843
Tons of NOX	0.34	$ 4,325	$ 67,567	0.36	$ 4,645	$72,572
Tons of PM10	0.0050	$ 495	$ 7,736	0.0062	$ 619	$9,670
Subtotal - Emissions Costs		**$ 4,915**	**$ 76,778**		**$ 5,382**	**$ 84,086**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,525,680			$ 526,600
Construction Cost - Structures			$ -			$ -
Capital Support			$ 290,000			$ 101,000
Right-of-Way			$ 50,000			$ -
Subtotal - Initial Capital Costs			**$ 1,865,680**			**$ 627,600**
NET PRESENT VALUE			**$ 2,860,843**			**$ 2,526,772**

LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$657,622	**LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	$63,800	
Emission Reduction Benefit of Roundabout	$7,308	
Total Benefits	**$728,730**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$175,280	**0.69**
Added Capital Costs of a Roundabout	$1,238,080	
Total Costs	**$1,062,800**	

B/C Preferred: Signal Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	102	N/A - same as existing
Cost Per Pound Per Life	$225.59	N/A - same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$18,047**	**N/A - same as existing**

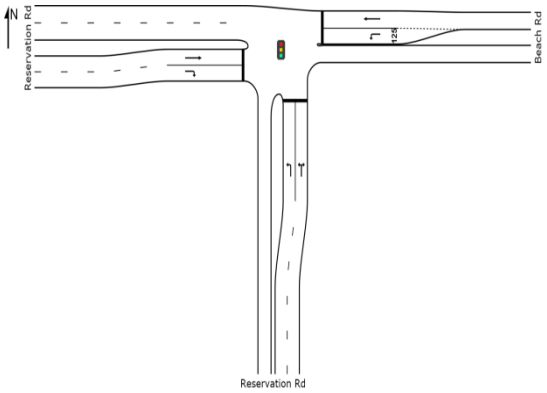
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

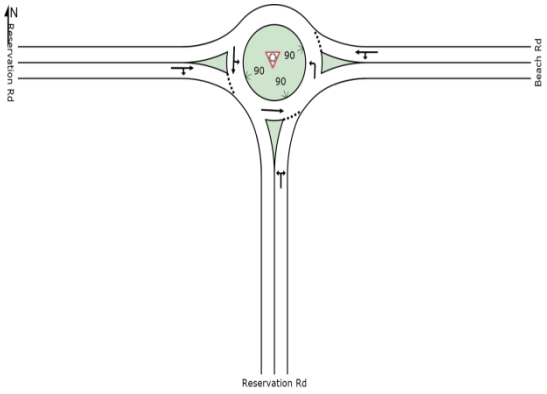


EXISTING INTERSECTION
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	8.8	75 (WBT)			
2040	B	10.7	175 (WBT)			

NOTES:

1. WBT queues will exceed available storage in 2040 a.m. peak.
2. PM data was not provided.



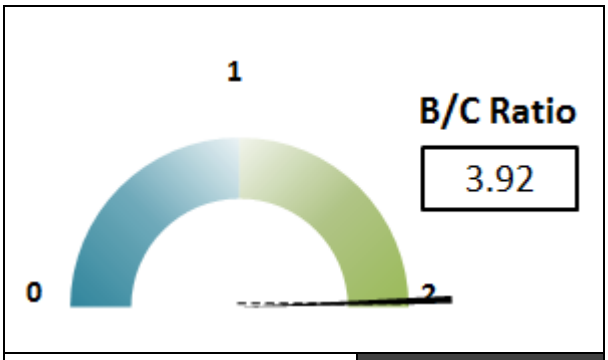
ALTERNATIVE 1
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	5.4	50 (EB)			
2040	A	9.3	125 (WB)			

NOTES:

1. PM data was not provided.

DEFOREST ROAD AT RESERVATION ROAD



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for this intersection is 3.92. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. However, an initial capital cost budget of approximately $2 M for the roudnabout alternative would yeild a B/C ratio equal to 1.0 if all other performance measures remained equal.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 2 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $1,000,000 when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing signal control or, no project alternative, is operating at an acceptable level under existing AM peak hour conditions but is expected to degrade over time to an LOS E. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2035 design year. The year 2015 was assumed for the baseline "build" condition for a total 20 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MAR-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

DeForest Road at Reservation Road is controlled by a traffic signal.

Parcels in the immediate vicinity of the project are developed. The existing intersection is within City of Marina right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
DeForest Road at Reservation Road	**DeForest Road**	2-lane undivided	Urban	25	Serves residential/ commercial land uses Regional transit center	Regional transit center on south leg, service provided by Monterey-Salinas Transit	Sidewalks with Crosswalks	No bike lanes provided
	Reservation Road	4-lane divided	Urban	35	Central business district	Primary access to transit center	Sidewalks with Crosswalks	Class II

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Marina Transit Exchange
3. Bus access
4. Closely spaced intersection
5. Shopping center access

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The DeForest Road intersection with Reservation Road is located within the City of Marina Downtown Specific Plan and may be impacted by planned improvements for the area as well as regulations for improvements.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Signal improvements	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM peak hour volumes was provided by the City. 2035 AM peak hour volumes were calculated using a 2% annual compound growth rate for all movements. PM peak hour volumes were not provided.

Signal Control (Existing)

With signal control, demand is adequately served for the AM peak hour under existing conditions. Eastbound left turn storage is forecast to be insufficient during peak periods.

Signal Control (Proposed)

With signal control, an additional eastbound left turn lane is proposed. The additional left turn lane will require an additional northbound lane on DeForest

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Road to receive left turning vehicles. Additional study is needed at the signalized intersection west of the study intersection. Study is needed to determine the full scope of improvements that may be needed to balance operation improvements with full access to the shopping center.

The proposed traffic signal is expected to improve intersection performance and provide sufficient capacity for the AM peak hour.

The PM peak hour was not evaluated at this intersection.

The additional lanes will increase crossing distance as well as overall cycle length for protected phasing. Bike lanes along Reservation Road can be maintained with the necessary lane additions. Transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access. Circulation to the transit center south of the intersection will be maintained.

Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform at capacity for the AM peak hour under future design year conditions. The need for additional lanes and improved vehicle operations should be balanced with road diet objectives and pedestrian safety.

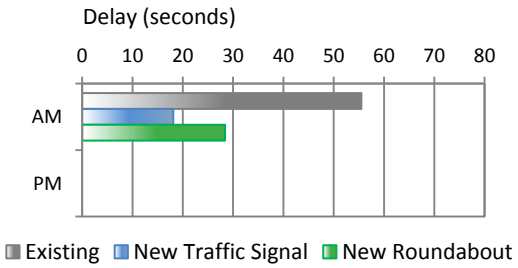
Future studies should consider the PM peak hour for design year conditions. Future PM peak hour demand may identify the need for additional through lanes in the roundabout.

Similar to the proposed traffic signal alternative, study is needed to determine the full scope of improvements that may be needed to balance operation improvements with full access to the shopping center.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes along Reservation Road can be maintained with a one lane roundabout. Transit stops are not provided at the intersection therefore the roundabout alternative will not impact transit access. Circulation to the transit center south of the intersection will be maintained.

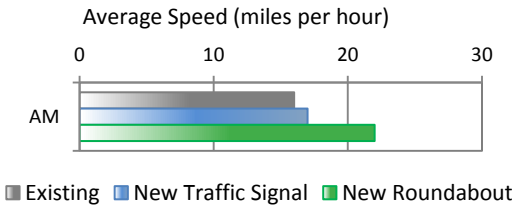
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: PM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- PM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Operations and access at intersection west of study intersection.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MAR-02**
01/2016

Intersection Cost Comparison

Deforest Road at Reservation Road
Marina, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.44	$ 65,462	$ 889,652	0.98	$ 145,471	$ 1,977,005
Predicted PDO Crashes	1.71	$ 17,431	$ 236,893	1.92	$ 19,620	$ 266,637
Subtotal - Safety Costs	**-**	**$ 82,893**	**$ 1,126,545**	**-**	**$ 165,091**	**$ 2,243,642**
DELAY						
Delay to Persons in Vehicles (hours)	3198	$ 34,793	$ 730,647	2510	$ 28,671	$ 602,094
Subtotal - Delay Costs	-	**$ 34,793**	**$ 730,647**	-	**$ 28,671**	**$ 602,094**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	7,701
Cost of Power for Signal				-	$ 4,255	57,827
Cost of Illumination	6	$ 873	$ 11,859	4	$ 582	7,906
Cost of Landscaping Maintenance	-	$ 2,000	$ 27,181			
Cost of Signal Maintenance				-	$ 4,660	63,331
Cost of Pavement Rehabilitation			$ 47,179			$ 74,277
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 86,219**	-	**$ 10,063**	**$ 211,042**
EMISSIONS						
Tons of ROG	0.16	$ 151	$ 2,049	0.22	$ 211	$2,868
Tons of NOX	0.46	$ 5,936	$ 80,675	0.51	$ 6,550	$89,021
Tons of PM10	0.0079	$ 791	$ 10,750	0.0095	$ 949	$12,900
Subtotal - Emissions Costs		**$ 6,878**	**$ 93,474**		**$ 7,711**	**$ 104,790**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,048,150			$ 729,200
Construction Cost - Structures			$ -			$ -
Capital Support			$ 200,000			$ 139,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,248,150**			**$ 868,200**
NET PRESENT VALUE			**$ 3,285,036**			**$ 4,029,768**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,117,097
Delay Reduction Benefit of Roundabout	-$128,553
Emission Reduction Benefit of Roundabout	$11,315
Total Benefits	**$999,860**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$124,823
Added Capital Costs of a Roundabout	$379,950
Total Costs	**$255,127**

LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO

3.92

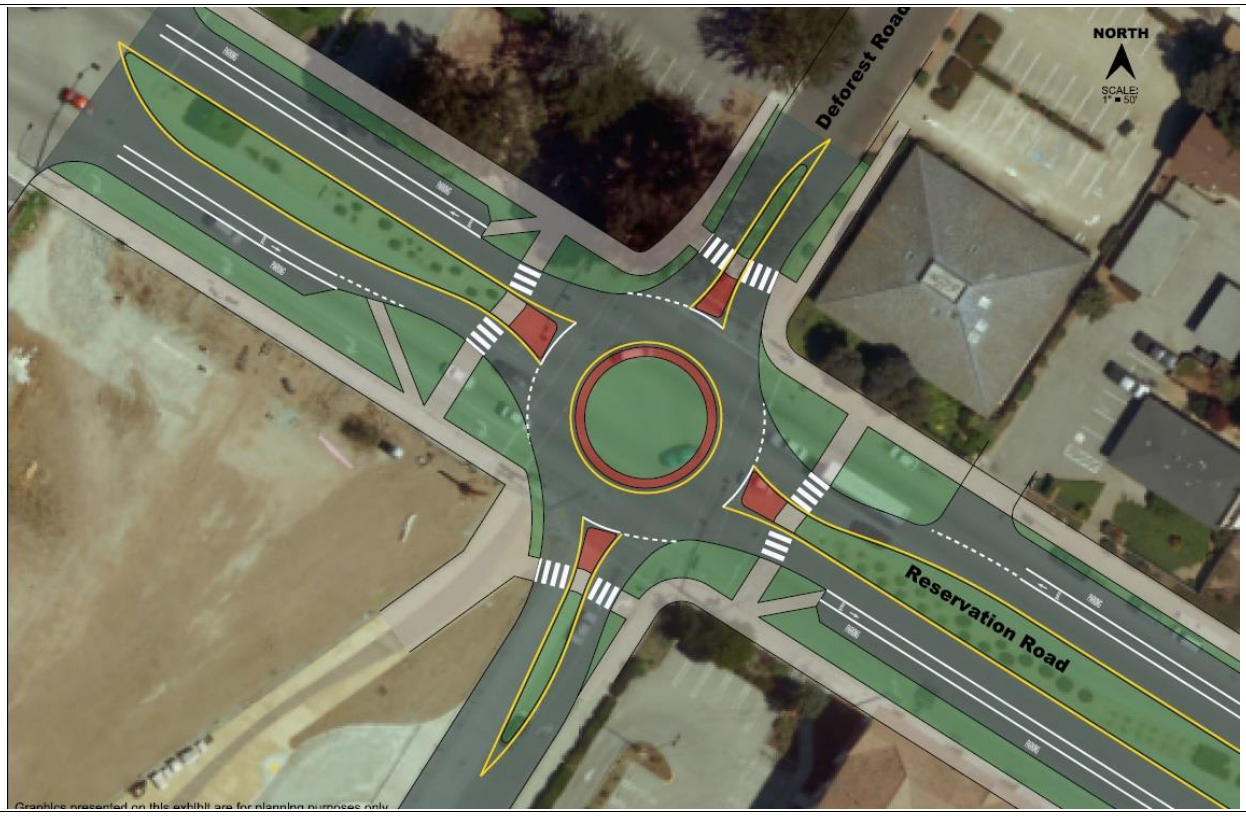
B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	289	63
Cost Per Pound Per Life	$93.10	$423.59
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$9,310**	**$42,359**

Intersection Improvement Alternatives

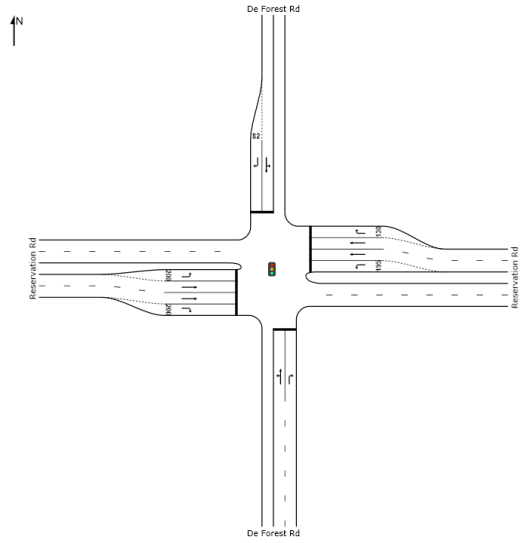
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

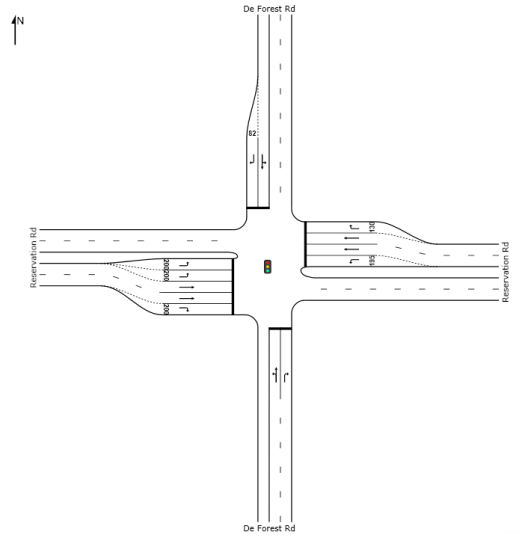


EXISTING INTERSECTION SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	C	30.6	#102 (EBL)			
2035	E	55.5	#170 (EBL)			

NOTES:

1. EBL queues will exceed available storage in 2040 a.m. peak.
2. PM data was not provided.

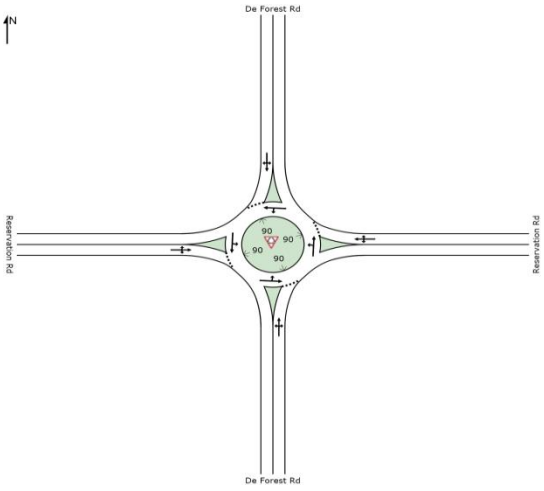


ALTERNATIVE 1 SIGNAL MODIFICATIONS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	B	14.0	137 (WBT)			
2035	B	18.1	#254 (WBT)			

NOTES:

1. Added additional eastbound left turn lane
2. PM data was not provided.



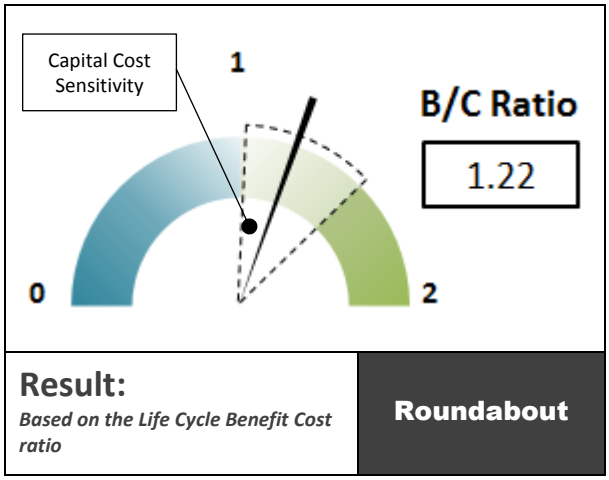
ALTERNATIVE 2 ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	8.9	100 (EB)			
2035	D	28.4	563 (WB)			

NOTES:

1. PM data was not provided.

CARDOZA AVENUE AT ABDY WAY



The Benefit Cost (B/C) ratio for Cardoza Avenue at Abdy Way is 1.22. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may to change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Noteworthy performance measures driving the B/C ratio are *safety* and *delay*. The estimated safety costs of the signal are 3 times higher than that of the roundabout. The estimated delay costs of the signal are 4 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $800,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $2,300 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic and is expected to have a traffic calming effect on Cardoza Avenue vehicles. The existing stop control will degrade over time with demand exceeding capacity on the westbound approach. Proposed stop control improvements are targeted to reduce vehicle speeds and reduce pedestrian crossing distances on Cardoza Avenue.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number MAR-03 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Cardoza Avenue at Abdy Way is controlled by a two-way stop sign. Vehicles are required to stop on Abdy Way.

All parcels are developed at the study intersection. The existing intersection is within City of Marina right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Cardoza Avenue at Abdy Way	**Cardoza Avenue**	2-lane undivided	Urban Residential	25	Serves residential land uses	No transit services provided	Sidewalks on south leg and northwest side Crosswalk on south leg	No bike lanes provided
	Abdy Way	2-lane undivided	Urban Residential	25	Serves residential land uses	No transit services provided	Sidewalks on west leg and southeast side	No bike lanes provided

Existing design constraints and considerations identified by the County at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Glorya Jean Tate Park (right of way constraint)
3. Vehicle Speeds
4. Residential driveways

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

No planned improvements were identified.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Traffic Signal	
Proposed Signal Modification	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM peak hour volumes was provided by the City. 2040 AM peak hour volumes were calculated using a 2% annual compound growth rate for all movements. PM peak hour volumes were not provided.

Two-Way Stop Control (Existing)

Demand is adequately served for the AM peak hour under existing conditions. Westbound vehicles on Abdy Way may experience significant delay based on 2040 AM design year conditions

Two-Way Stop Control with Traffic Calming

The proposed two-way stop control with traffic calming will provide the same capacity as the existing condition. Proposed improvements are targeted to reduce vehicle speeds on Cardoza Avenue and reduce pedestrian crossing lengths at the intersection.

Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak hours under future design year conditions.

The proposed single lane roundabout is expected to calm traffic and reduce pedestrian crossing lengths at the intersection.

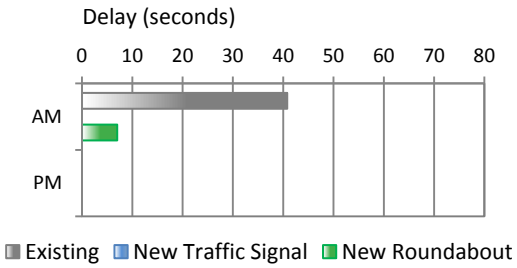
(1) Refer to the Existing Conditions section on the previous page for description of the design constraint.

The roundabout alternative provides access to the residential driveways in the northwest quadrant without direct access to the roundabout.

Crosswalks will be improved and provide midway refuge areas. Bike and transit stops are not provided at the intersection therefore the roundabout alternative will not impact bike or transit access.

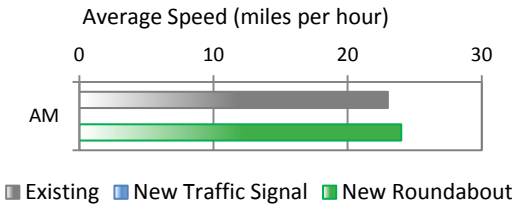
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is reported. The Intersection Control Alternative Summary reports maximum control delay for the worst approach of the two-way stop control intersection. PM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	NONE

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- PM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MAR-03**
01/16

Intersection Cost Comparison

Cardoza Avenue at Abdy Way
Marina, California

Cost Performance Measure	Intersection Type					
	Roundabout			Two-Way Stop Control		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.06	$ 8,143	$ 127,210	0.25	$ 37,013	$ 578,226
Predicted PDO Crashes	0.36	$ 3,629	$ 56,686	0.42	$ 4,315	$ 67,406
Subtotal - Safety Costs	**-**	**$ 11,772**	**$ 183,896**	**-**	**$ 41,328**	**$ 645,632**
DELAY						
Delay to Persons in Vehicles (hours)	376	$ 3,855	$ 100,227	1777	$ 17,067	$ 443,736
Subtotal - Delay Costs	-	**$ 3,855**	**$ 100,227**	-	**$ 17,067**	**$ 443,736**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ -	0
Cost of Power for Signal				-	$ -	0
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 34,229			$ 43,889
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 79,106**	-	**$ 5,242**	**$ 125,776**
EMISSIONS						
Tons of ROG	0.09	$ 83	$ 1,292	0.10	$ 92	$1,436
Tons of NOX	0.28	$ 3,619	$ 56,531	0.28	$ 3,619	$56,531
Tons of PM10	0.0039	$ 386	$ 6,026	0.0048	$ 482	$7,533
Subtotal - Emissions Costs		**$ 4,087**	**$ 63,850**		**$ 4,193**	**$ 65,500**
INITIAL CAPITAL COSTS						
Construction Cost			$ 825,675			$ 229,400
Construction Cost - Structures			$ -			$ -
Capital Support			$ 157,000			$ 44,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 982,675**			**$ 273,400**
NET PRESENT VALUE			**$ 1,409,753**			**$ 1,554,044**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Two-Way Stop Control	
Safety Benefit of Roundabout	$461,736
Delay Reduction Benefit of Roundabout	$343,509
Emission Reduction Benefit of Roundabout	$1,650
Total Benefits	**$806,896**
COSTS - Roundabout compared to Two-Way Stop Control	
Added O&M Costs of a Roundabout	-$46,670
Added Capital Costs of a Roundabout	$709,275
Total Costs	**$662,605**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

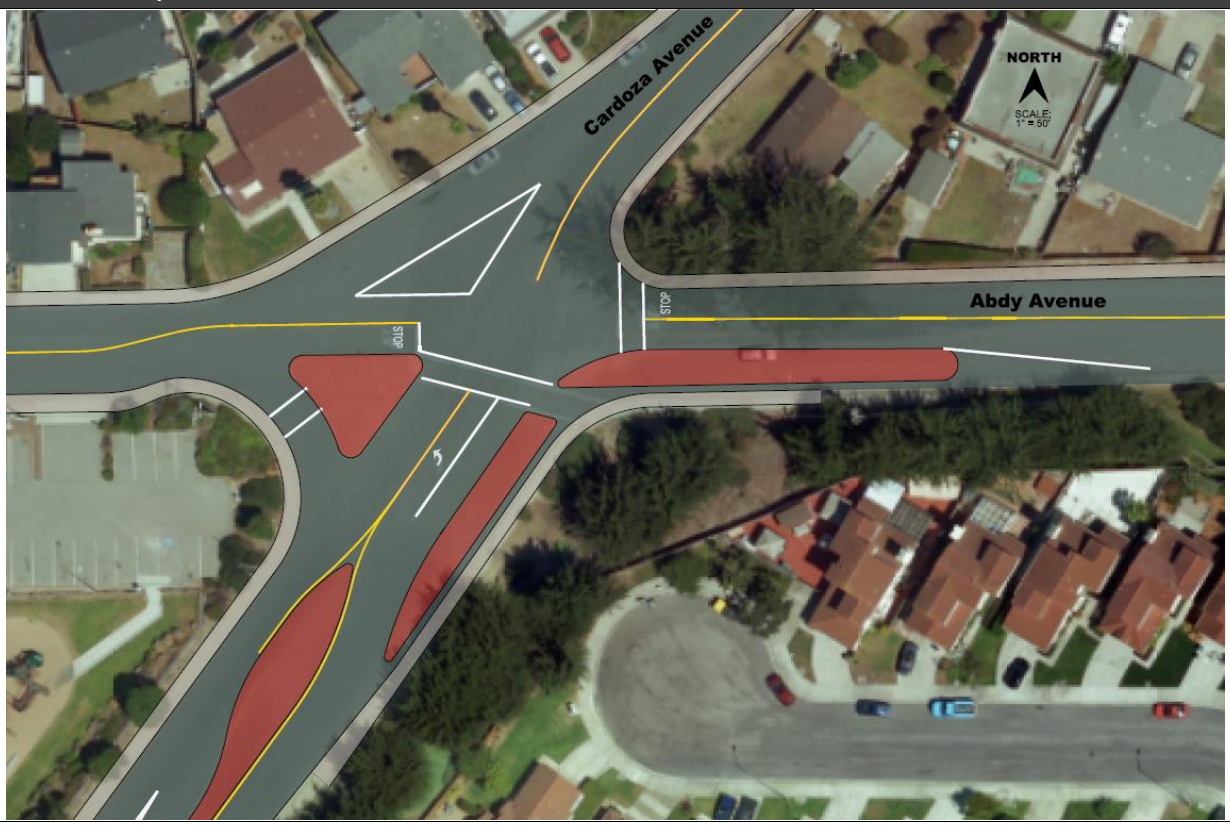
1.22

B/C Preferred: Roundabout Alternative

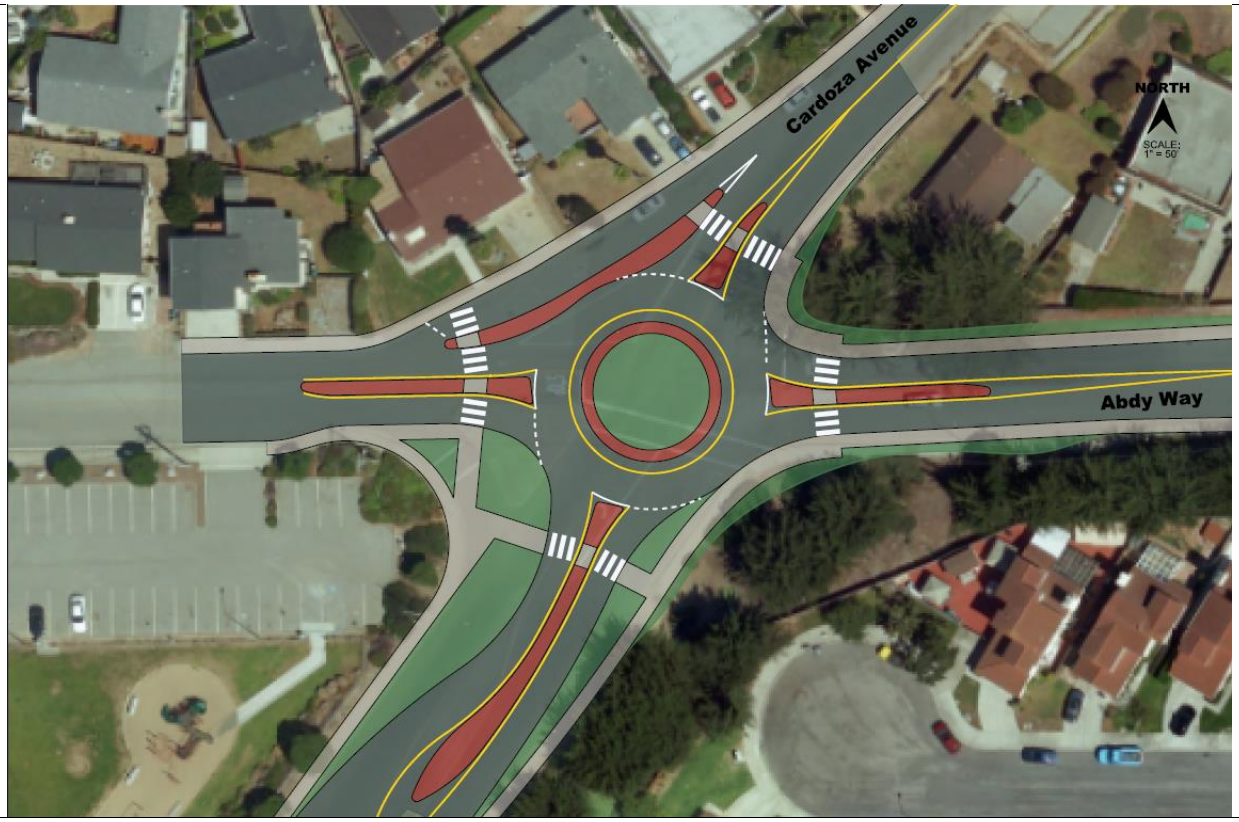
AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Two-Way Stop Control (vs. existing)**
Annual Emission Reduction (lb/year)	21	N/A - same as existing
Cost Per Pound Per Life	$1,079.44	N/A - same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$86,355**	**N/A - same as existing**

Intersection Improvement Alternatives



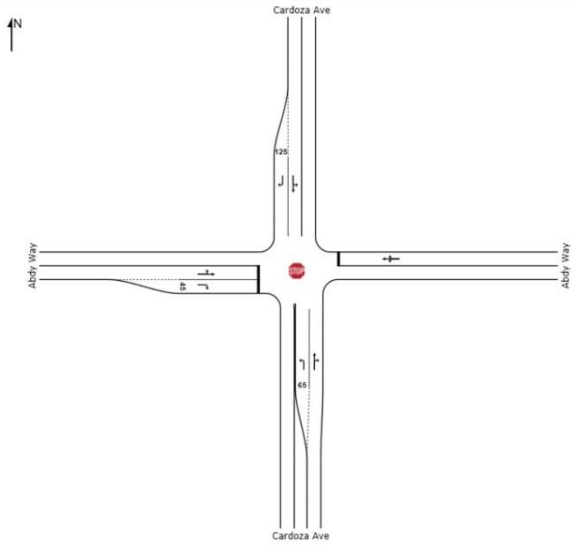
Signal Alternative *(Source: Monterey County)*



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

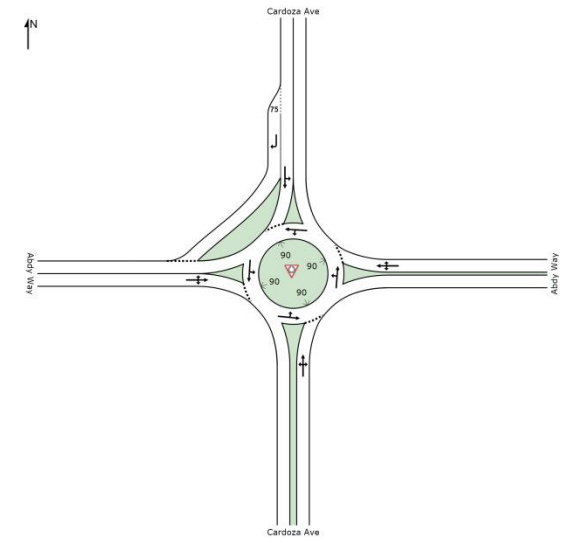


EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	C	17.2	43 (WB)			
2040	F	123.9	300 (WB)			

NOTES:

1. PM data was not provided.



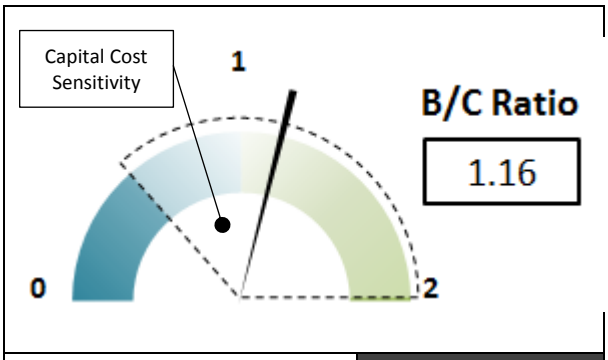
ALTERNATIVE 1
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	4.6	27 (SB)			
2040	A	7.0	59 (EB)			

NOTES:

1. PM data was not provided.
2. Southbound right turn lane is for illustrative purposes only.

8TH STREET AT INTER-GARRISON ROAD



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

The Benefit Cost (B/C) ratio for this intersection is 1.16. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Noteworthy performance measures driving the B/C ratio are *safety, delay,* and *operations & maintenance.* However, initial capital cost is the primary performance measure effecting the B/C ratio. The estimated initial capital cost of both alternatives are high with the roundabout costing approximately 25 percent more than the signal. The total life cycle benefits of the roundabout are estimated at $410,000 when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, operates at acceptable levels during the AM peak hour but is forecast to degrade over time to unacceptable levels. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MAR-04 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

8th Street at Inter-Garrison Road is controlled by stop signs on all approaches.

Parcels in the immediate vicinity of the project are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement in the northeast and southerly quadrants. A structure is located within 100 feet of the intersection in the northwest quadrant.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
8th Street at Inter-Garrison Road	**8th Street**	2-lane undivided	Urban	35	Serves local, institutional access	No transit services provided	Sidewalk on west side. No crosswalk	No bike lanes provided
	Inter-Garrison Road	2-lane undivided	Urban	35	Serves residential, open space, & institutional land uses	Routes 16, 19, 25, 26, and 74 with service by Monterey-Salinas Transit	Sidewalks on west leg and south side of east leg No crosswalks	Sharrow pavement markings

The existing approach alignment for 8th Street is at a 42 degree skew relative to Inter-Garrison Road. The skew angle at the intersection longer crossing distances for pedestrian and bicycles, may encourage high speed turns and/or restrict certain turning movements.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Potential right of way constraint (structure)
2. Closely spaced intersection (100 feet center to center)
3. Skew angle at intersection

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The project location is within the California State University, Monterey Bay Master Plan. 8th Street is part of the planned 8th Street Reconstruction Project for the City of Marina.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

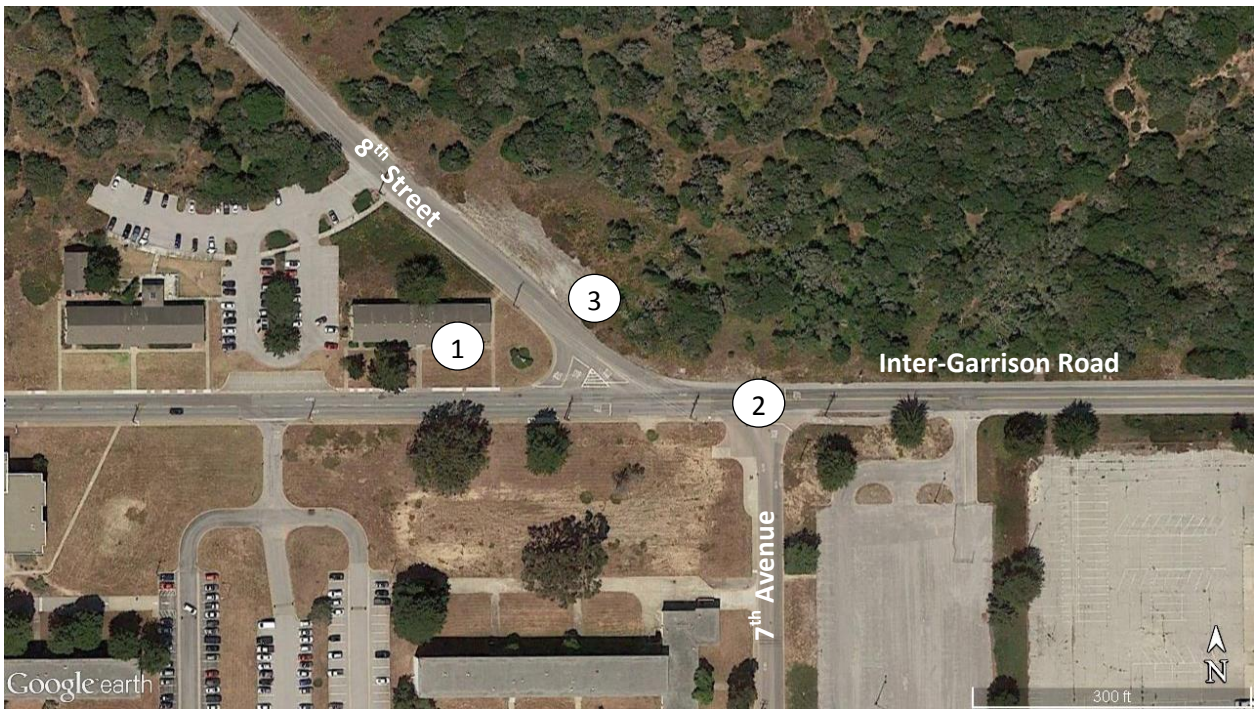
Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM peak hour volumes was provided by the City. 2040 AM peak hour volumes were calculated using a 2% annual compound growth rate for all movements. PM peak hour volumes were not provided.

Stop Control (Existing)

Demand is adequately served for the AM peak hour under existing conditions. Eastbound vehicles on Inter-Garrison Road may experience significant delay based on 2040 AM design year conditions.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With signal control, the intersection skew angle should be corrected to measure not less than 75 degrees. An additional eastbound left turn lane is needed to accommodate future demand.

The proposed traffic signal is expected to improve intersection performance and provide sufficient capacity for the AM peak hour under future design year conditions.

The reduced skew of the intersection will provide better visibility of crosswalks for drivers and on-coming traffic for pedestrians. Crosswalks are currently not stripped at the intersection. The additional lanes will increase crossing distance as well as overall cycle length for protected phasing. Currently sharrows are provided along Inter-Garison Road and be maintained with the necessary lane additions. Transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access.

Roundabout Control

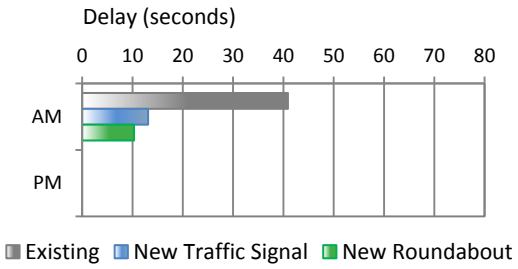
With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for the AM peak hour under future design year conditions.

Future studies will need to carefully consider the alignment of 8th Street. The right turn speeds from westbound Inter-Garrison Road will need to balance with other project constraints, right of way, and construction costs.

The reduced skew of the intersection will provide better visibility of crosswalks for drivers and on-coming traffic for pedestrians. Crosswalks are currently not stripped at the intersection. Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Currently sharrows are provided along Inter-Garison Road and be maintained with a one lane roundabout. Transit stops are not provided at the intersection therefore the roundabout alternative will not impact transit access.

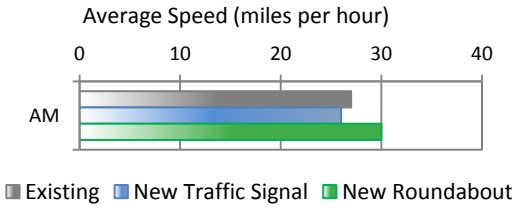
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: PM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	None

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- PM peak hour traffic data.
- Further evaluation of the 8th Street approach to mitigate the skew angle for all project alternatives.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MAR-04**
01/16

Intersection Cost Comparison

8th Street at Inter-Garrison
Marina, California

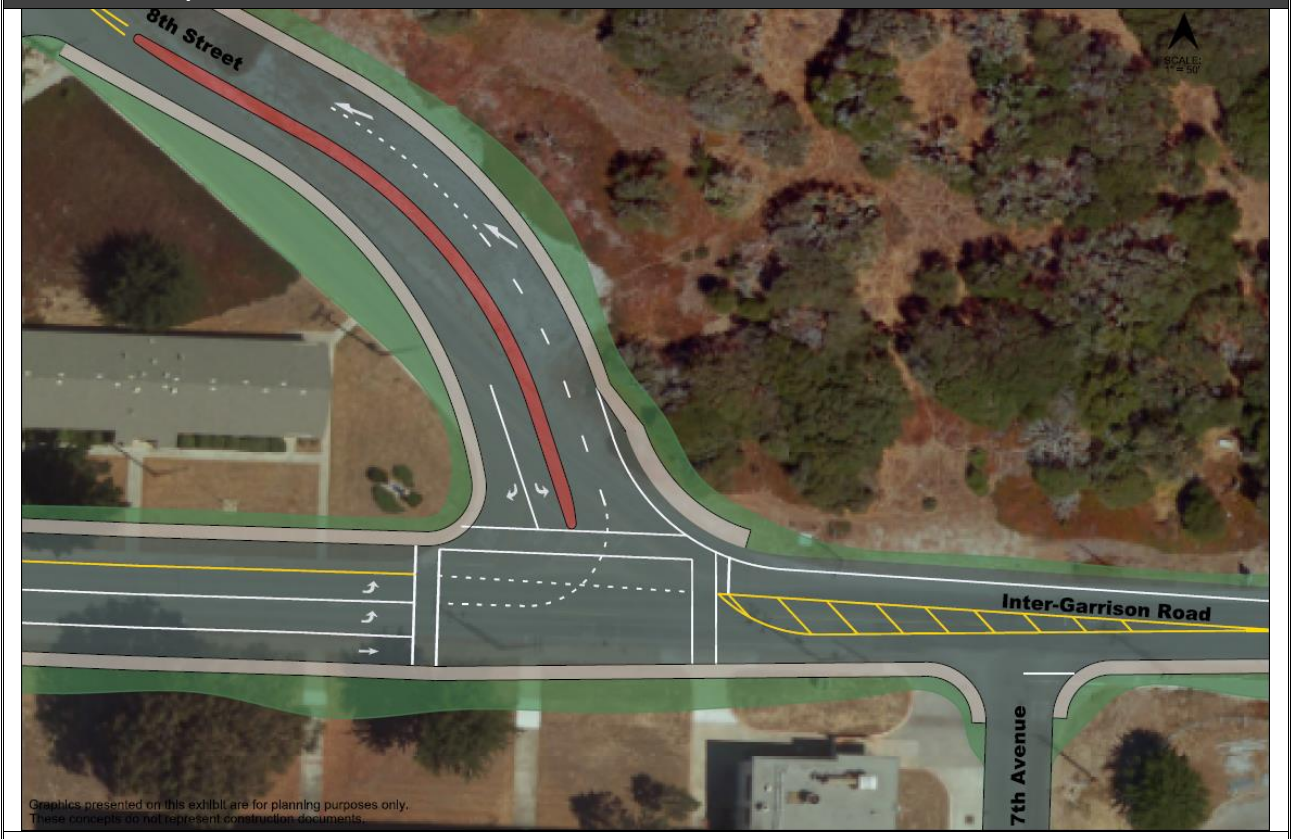
Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.12	$ 17,504	$ 273,451	0.26	$ 38,898	$ 607,670
Predicted PDO Crashes	0.39	$ 4,021	$ 62,816	0.43	$ 4,381	$ 68,446
Subtotal - Safety Costs	**-**	**$ 21,525**	**$ 336,267**	**-**	**$ 43,279**	**$ 676,115**
DELAY						
Delay to Persons in Vehicles (hours)	652	$ 6,609	$ 171,837	878	$ 9,041	$ 235,062
Subtotal - Delay Costs	-	**$ 6,609**	**$ 171,837**	-	**$ 9,041**	**$ 235,062**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 28,931			$ 68,121
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 73,807**	-	**$ 10,063**	**$ 225,333**
EMISSIONS						
Tons of ROG	0.10	$ 91	$ 1,419	0.12	$ 117	$1,825
Tons of NOX	0.37	$ 4,758	$ 74,328	0.38	$ 4,934	$77,081
Tons of PM10	0.0041	$ 409	$ 6,383	0.0055	$ 545	$8,510
Subtotal - Emissions Costs		**$ 5,257**	**$ 82,130**		**$ 5,596**	**$ 87,416**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,555,715			$ 1,208,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 296,000			$ 230,000
Right-of-Way			$ 445,000			$ 355,000
Subtotal - Initial Capital Costs			**$ 2,296,715**			**$ 1,793,000**
NET PRESENT VALUE			**$ 2,960,757**			**$ 3,016,925**

LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$339,848	**LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	$63,224	
Emission Reduction Benefit of Roundabout	$5,286	
Total Benefits	**$408,358**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$151,525	**1.16**
Added Capital Costs of a Roundabout	$503,715	
Total Costs	**$352,190**	

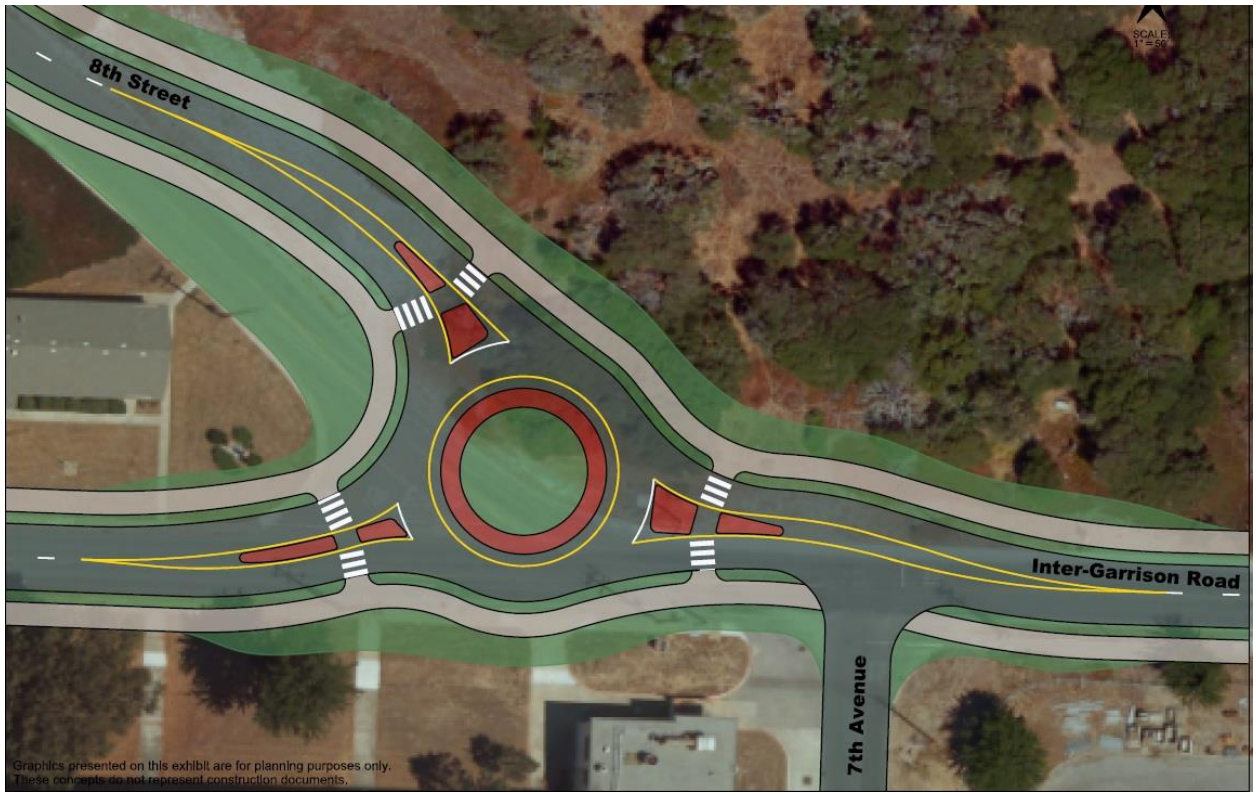
B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	57	emissions increase
Cost Per Pound Per Life	$400.38	emissions increase
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$32,031**	**emissions increase**

Intersection Improvement Alternatives



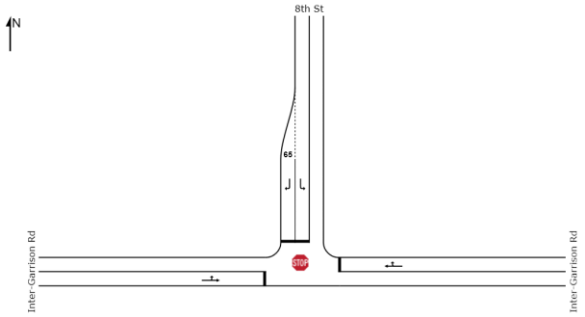
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

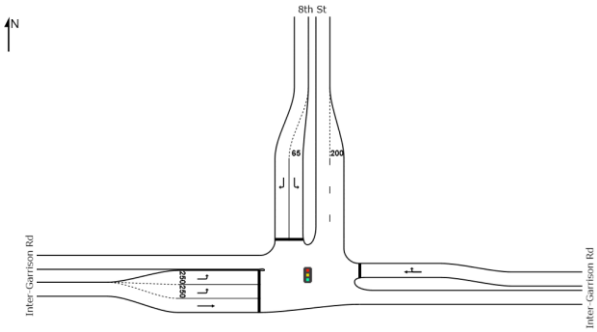


EXISTING INTERSECTION
ALL WAY STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	B	13.6	125 (EB)			
2040	E	40.9	415 (EB)			

NOTES:

1. PM data was not provided.

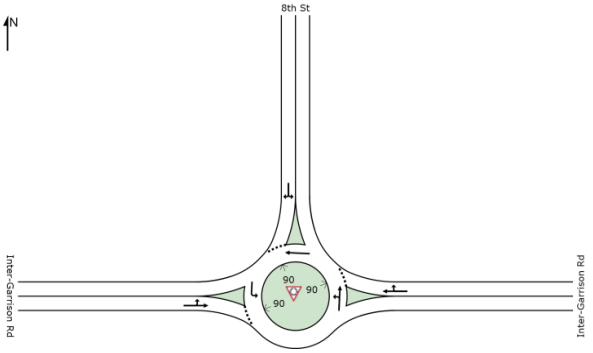


ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	9.1	86 (EBL)			
2040	B	13.1	#221 (EBL)			

NOTES:

1. PM data was not provided.



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	5.8	63 (EB)			
2040	B	10.3	171 (EB)			

NOTES:

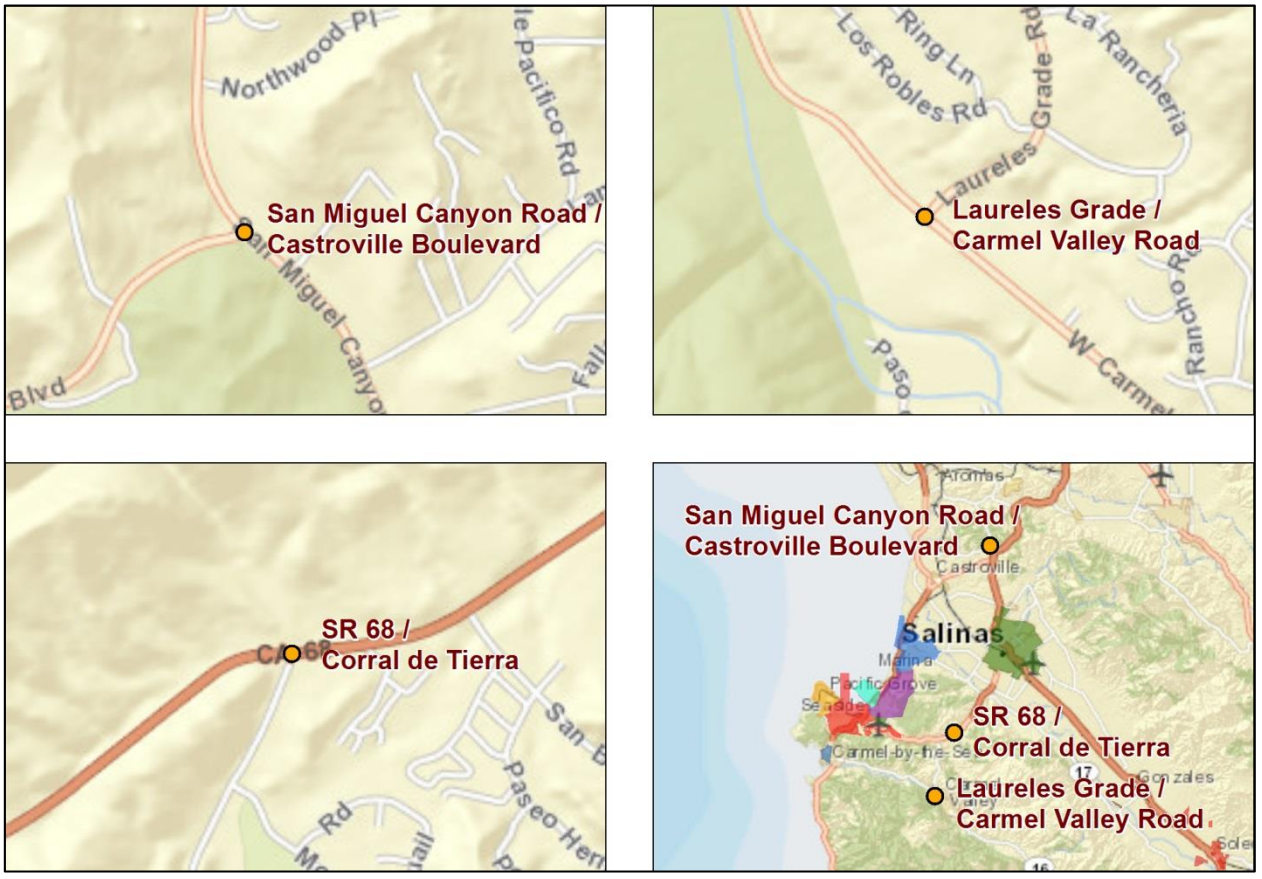
1. PM data was not provided.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 5:

Monterey County

Study Intersections:

- SAN MIGUEL CANYON ROAD AT CASTROVILLE BOULEVARD
- LAURELES GRADE AT CARMEL VALLEY ROAD
- HIGHWAY 68 AT CORRAL DE TIERRA



MONTEREY COUNTY SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
San Miguel Canyon Road at Castroville Boulevard	MCO-01
Laureles Grade at Carmel Valley Road	MCO-02
Highway 68 at Corral de Tierra	MCO-03

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under Monterey County jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the County of Monterey, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
San Miguel Canyon Road at Castroville Boulevard	**7.74**	
Laureles Grade at Carmel Valley Road	**NA-R**	
Highway 68 at Corral de Tierra	**8.08**	

SUMMARY OF KEY PERFORMANCE MEASURES

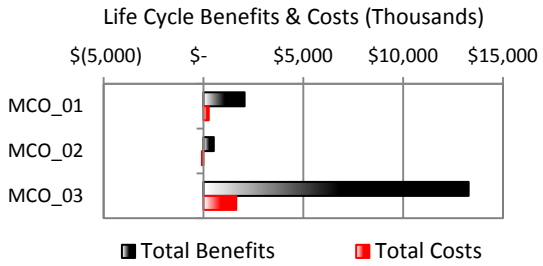
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



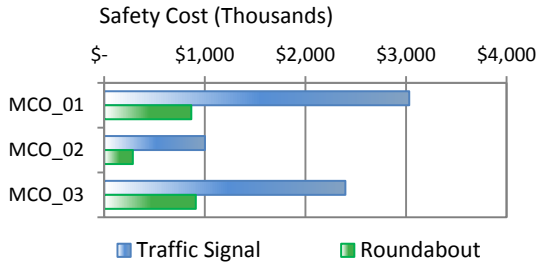
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

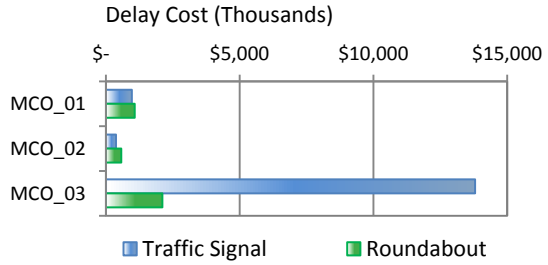


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	
Highway 68 at Corral de Tierra	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

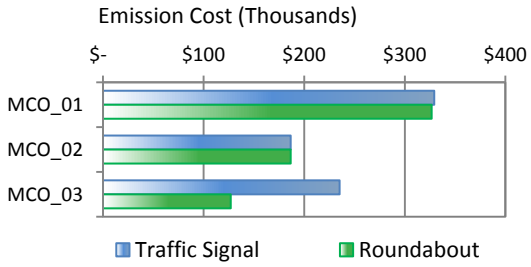


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	
Highway 68 at Corral de Tierra	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

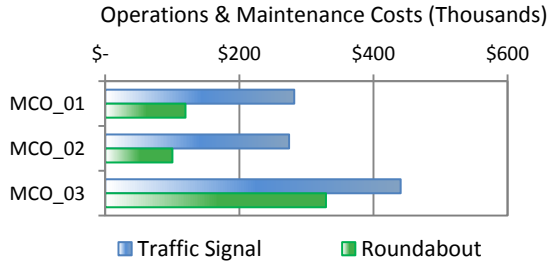
Emissions **Study Intersection**	**Preferred Control**
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	EQUAL
Highway 68 at Corral de Tierra	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

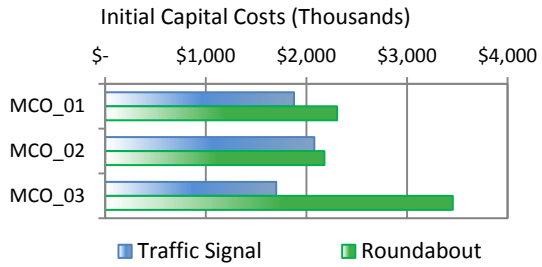


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	
Highway 68 at Corral de Tierra	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	
Highway 68 at Corral de Tierra	

Summary of B/C Performance Measures

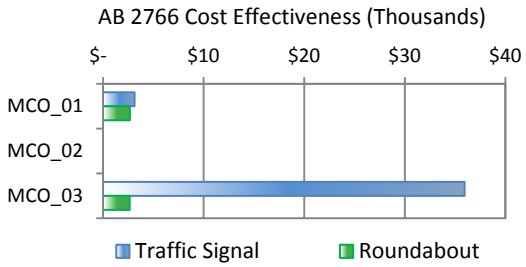
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
San Miguel Canyon Road at Castroville Boulevard						
Laureles Grade at Carmel Valley Road				EQUAL		
Highway 68 at Corral de Tierra						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and Monterey County.



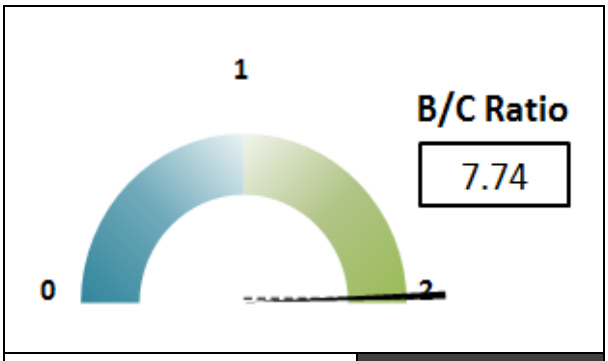
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness **Study Intersection**	**Preferred Control**
San Miguel Canyon Road at Castroville Boulevard	
Laureles Grade at Carmel Valley Road	NONE
Highway 68 at Corral de Tierra	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

SAN MIGUEL CANYON AT CASTROVILLE BOULEVARD



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) Ratio for this intersection is 7.74. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C Ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C Ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 3 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $2,060,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,200 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, is at capacity and will continue to degrade over time with queues exceeding available storage capacity. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MCO-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

San Miguel Canyon Road at Castroville Boulevard is controlled by stop signs on the minor approach.

Parcels in the immediate vicinity of the project are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement. The existing intersection is within Monterey County right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
San Miguel Canyon Road at Castroville Boulevard	**San Miguel Canyon Road**	2-lane undivided	Rural	55	Serves residential & agricultural land uses Provides regional access via US-101	Service provided by Monterey-Salinas Transit Stop located at intersection	No sidewalks provided	Class II bike Lanes
	Castroville Boulevard	2-lane undivided	Rural	55	Serves residential, recreational, & agricultural land uses.	No transit services provided.	No sidewalks provided	No bike lanes provided

Existing design constraints at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Roadside grade differentiation on all legs
3. Approach grade on Castroville Boulevard
4. Transit access
5. Manzanita County Park

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Draft 2014 Monterey County Regional Transportation Plan prepared by TAMC identifies the widening of San Miguel Canyon Road to four lanes, including Class II bike lanes, through the project area.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop (Castroville Boulevard)	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2014 AM and PM peak hour volumes was provided by the County. Design year 2040 peak hour volumes were calculated with an assumed annual growth rate of 1%.

Stop Control (Existing)

With stop control, demand exceeds capacity for both peak hours under existing conditions. Eastbound Castroville Boulevard vehicles experience significant delay while trying to enter San Miguel Canyon Road. Additional capacity required to improve stop control operations is not feasible based on forecast demand.

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With signal control, an additional northbound through lane, northbound left turn lane, southbound through lane, and a westbound lane would be needed to achieve a level of service D or better. The westbound lane on Castroville Boulevard can be dropped after safe merge and taper lengths are achieved. The proposed lane additions are consistent with the improvement plans for San Miguel Canyon Road and would improve intersection performance to well below capacity for both peak hours under future design year conditions.

The PM peak hour at this intersection meets peak hour signal warrants under existing conditions.

The additional lanes will increase crossing distance as well as overall cycle length. Crosswalks are currently not stripped at the intersection. Bike lanes along San Miguel Canyon Road can be maintained with the necessary lane additions. Access to transit stops can be maintained with the necessary lane additions.

Roundabout Control

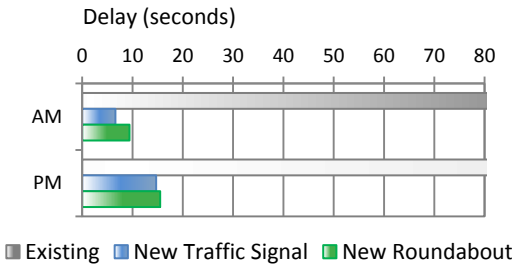
With roundabout control, two approach and departure lanes are required for the northbound and southbound directions. The proposed lane additions are consistent with the improvement plans for San Miguel Canyon Road and would improve intersection performance to well below capacity for both peak hours under future design year conditions.

Planned construction of additional lanes on San Miguel Canyon Road will increase intersection capacity based on the roundabout operations capacity model. The capacity model used in the ICE assigns 50% lane underutilization for the downstream, outside lane-drop. Extending the lane-drop beyond 650 feet or widening San Miguel Canyon Road to 4 lanes will provide full lane utilization and increase overall intersection capacity.

Crosswalks will be stripped as none are currently provided and provide midway refuge areas. Bike lanes along San Miguel Canyon Road can be maintained with the proposed roundabout. Access to transit stops can be maintained with the proposed roundabout.

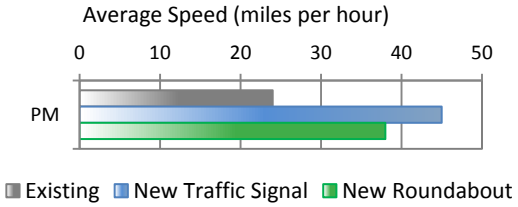
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Castroville Boulevard approach vertical/profile design through roundabout based on topographic data.
- Approach geometry of roundabout on San Miguel Canyon Road to reinforce reduced vehicle speeds at entry.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCO-01**

Intersection Cost Comparison

San Miguel Canyon Road at Castroville Boulevard
Monterey County, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.27	$ 39,356	$ 614,824	1.15	$ 169,534	$ 2,648,471
Predicted PDO Crashes	1.57	$ 16,062	$ 250,928	2.41	$ 24,560	$ 383,672
Subtotal - Safety Costs	**-**	**$ 55,418**	**$ 865,752**	**-**	**$ 194,093**	**$ 3,032,143**
DELAY						
Delay to Persons in Vehicles (hours)	3981	$ 41,529	$ 1,079,751	3558	$ 37,413	$ 972,735
Subtotal - Delay Costs	-	**$ 41,529**	**$ 1,079,751**	-	**$ 37,413**	**$ 972,735**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 74,826			$ 124,651
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 119,703**	-	**$ 10,063**	**$ 281,863**
EMISSIONS						
Tons of ROG	0.34	$ 321	$ 5,019	0.34	$ 321	$5,019
Tons of NOX	1.47	$ 18,905	$ 295,341	1.52	$ 19,632	$306,700
Tons of PM10	0.0169	$ 1,686	$ 26,338	0.0113	$ 1,124	$17,558
Subtotal - Emissions Costs		**$ 20,913**	**$ 326,697**		**$ 21,078**	**$ 329,277**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,918,250			$ 1,569,600
Construction Cost - Structures			$ -			$ -
Capital Support			$ 365,000			$ 299,000
Right-of-Way			$ 22,000			$ 8,000
Subtotal - Initial Capital Costs			**$ 2,305,250**			**$ 1,876,600**
NET PRESENT VALUE			**$ 4,697,153**			**$ 6,492,618**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$2,166,391
Delay Reduction Benefit of Roundabout	-$107,016
Emission Reduction Benefit of Roundabout	$2,580
Total Benefits	**$2,061,955**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$162,160
Added Capital Costs of a Roundabout	$428,650
Total Costs	**$266,490**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

7.74

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	688	586
Cost Per Pound Per Life	$33.40	$39.19
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$2,672**	**$3,135**

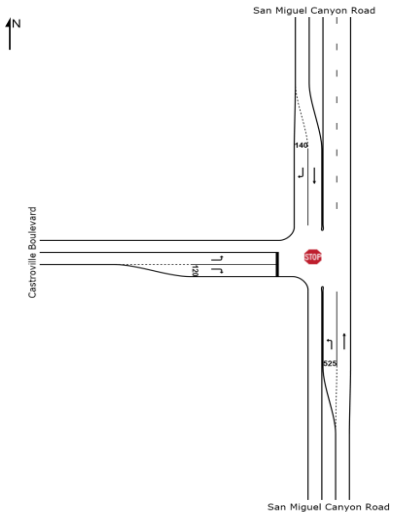
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

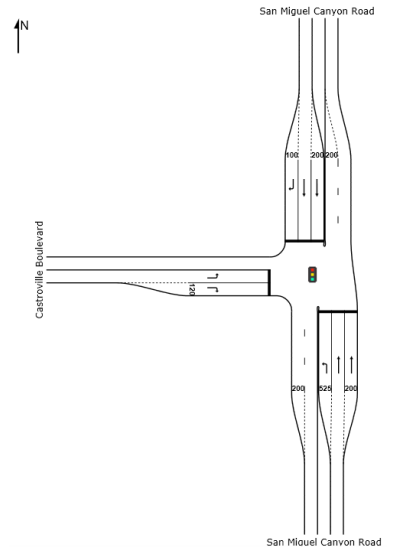


EXISTING INTERSECTION
ALL WAY STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	E	42.1	68 (EBL)	F	187.8	243 (EBL)
2040	F	194.0	160 (EBL)	F	1116.0	305 (EBL)

NOTES:

1. EBR queues on Castroville Boulevard will exceed available storage during the 2015 PM peak hour and both peak hours for 2040.

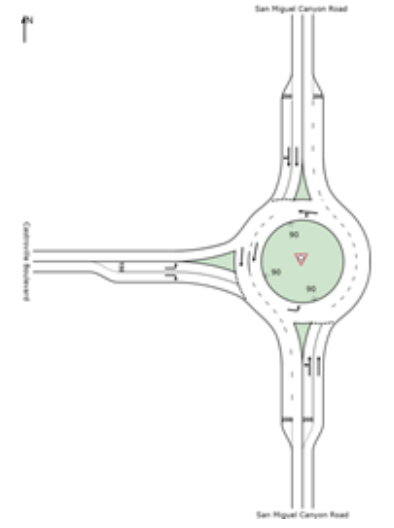


ALTERNATIVE 1
SIGNAL WITH IMPROVEMENTS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	5.7	132 (SBT)	A	9.2	133 (SBT)
2040	A	6.6	163 (SBT)	B	14.7	224 (SBT)

NOTES:

1. EBR queues on Castroville Boulevard will exceed available storage during the 2040 PM peak hour.



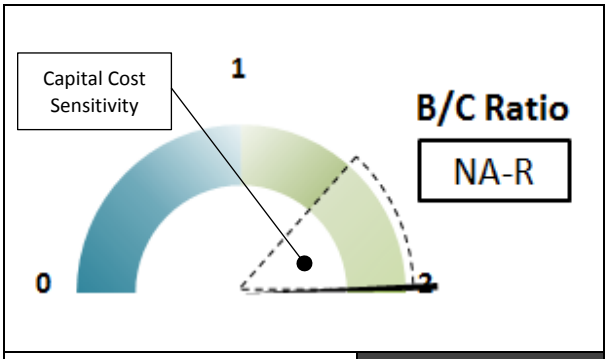
ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	6.9	92 (NB)	A	8.9	128 (NB)
2040	A	9.4	164 (SB)	C	15.5	293 (SB)

NOTES:

1. Results reflect NB and SB through lane underutilization due to the short merging distance of the outside receiving lanes.

LAURELES GRADE AT CARMEL VALLEY ROAD



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for this intersection is NA-R. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 3 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $520,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,200 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, is at capacity in the PM peak hour and will continue to degrade over time. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MCO-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Laureles Grade at Carmel Valley Road is controlled by stop signs on the minor approach, Laureles Grade.

Parcels in the immediate vicinity of the project are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement. The existing intersection is within Monterey County right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Laureles Grade at Carmel Valley Road	**Laureles Road (County of Monterey)**	2-lane undivided	Rural	45	Serves residential, recreational, & agricultural land uses	No transit services provided	No sidewalks provided	No bike lanes provided
	Carmel Valley Road (County of Monterey)	2-lane undivided	Rural	50	Serves residential, recreational, & agricultural land uses	Service provided by Monterey-Salinas Transit Stop located at intersection	No sidewalks provided	No bike lanes provided

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Roadside grade differentiation on all legs
3. Approach grade on Laureles Grade
4. Transit stop
5. Crest vertical curve

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Laureles Grade intersection with Carmel Valley Road is located within the Carmel Valley Master Plan – Traffic Improvement Plan and may be impacted by planned improvements for the area as well as regulations for improvements. Additionally, a roundabout was identified as the preferred improvement in the *Carmel Valley Road Corridor Study, Draft report, January 2014.*

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop (Laureles Grade)	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2014 AM and PM peak hour volumes was provided by the County. Design year 2040 peak hour volumes were calculated with an assumed annual growth rate of 1%.

Stop Control (Existing)

With stop control, demand exceeds capacity for the PM peak hour under existing conditions. Southbound Laureles Grade vehicles experience significant delay while trying to turn left onto Carmel Valley Road. Additional capacity required to improve and maintain stop control operations is not feasible based on forecast demand.

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With signal control, additional lanes are not required to achieve design year operations. However, roadway widening is needed for turn-lane channelization improvements. The widening for turn-lane channelization is required to achieve an acceptable approach taper, storage length, and deceleration length on all approaches. Additionally, the County has identified the need to lower the profile of Carmel Valley Road, west of Laureles Grade, to achieve acceptable sight lines for eastbound vehicles approaching the signal.

The proposed traffic signal is expected to improve intersection performance and provide sufficient capacity for both peak hours under future design year conditions.

The PM peak hour at this intersection meets peak hour signal warrants under existing conditions.

The reconfiguration of the intersection will provide shorter crossing distance and better visibility for pedestrians. Crosswalks are currently not stripped at the intersection. Bike lanes are currently not provided along either roadway and therefore will not be impacted by the intersection reconfiguration. Access to transit stops can be maintained with the intersection reconfiguration.

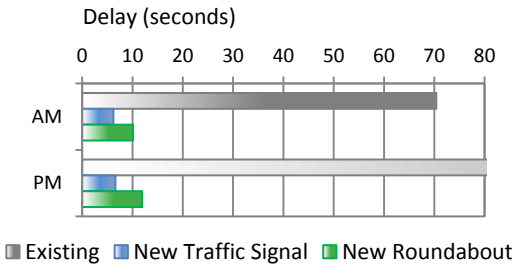
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak hours under future design year conditions.

Crosswalks will be stripped as none are currently provided and provide midway refuge areas. Bike lanes are currently not provided along either roadway and therefore will not be impacted by a one lane roundabout. Access to transit stops can be maintained with a one roundabout.

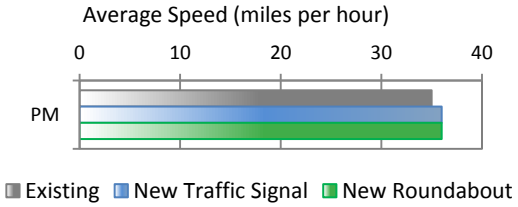
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	None

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Vertical/profile design on Laureles Grade approach to the roundabout based on topographic data.
- Evaluation of sight lines on eastbound Carmel Valley Road with traffic signal improvements.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCO-02**

Intersection Cost Comparison

Laureles Grade at Carmel Valley Road
Monterey County, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.09	$ 13,068	$ 204,142	0.38	$ 56,291	$ 879,380
Predicted PDO Crashes	0.50	$ 5,148	$ 80,429	0.76	$ 7,798	$ 121,816
Subtotal - Safety Costs	**-**	**$ 18,216**	**$ 284,571**	**-**	**$ 64,088**	**$ 1,001,195**
DELAY						
Delay to Persons in Vehicles (hours)	2118	$ 22,209	$ 577,429	1361	$ 14,607	$ 379,794
Subtotal - Delay Costs	-	**$ 22,209**	**$ 577,429**	-	**$ 14,607**	**$ 379,794**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 55,330			$ 116,961
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 100,206**	-	**$ 10,063**	**$ 274,173**
EMISSIONS						
Tons of ROG	0.19	$ 183	$ 2,866	0.19	$ 183	$2,866
Tons of NOX	0.84	$ 10,796	$ 168,651	0.84	$ 10,796	$168,651
Tons of PM10	0.0097	$ 963	$ 15,040	0.0097	$ 963	$15,040
Subtotal - Emissions Costs		**$ 11,942**	**$ 186,557**		**$ 11,942**	**$ 186,557**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,453,995			$ 1,644,700
Construction Cost - Structures			$ -			$ -
Capital Support			$ 277,000			$ 313,000
Right-of-Way			$ 448,000			$ 121,000
Subtotal - Initial Capital Costs			**$ 2,178,995**			**$ 2,078,700**
NET PRESENT VALUE			**$ 3,327,758**			**$ 3,920,419**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$716,625
Delay Reduction Benefit of Roundabout	-$197,635
Emission Reduction Benefit of Roundabout	$0
Total Benefits	**$518,989**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$173,967
Added Capital Costs of a Roundabout	$100,295
Total Costs	**-$73,672**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

N/A

B/C Preferred: Roundabout Alternative

Roundabout Preferred
Cost of Roundabout is less than cost of Traffic Signal, and Roundabout offers benefits compared to Traffic Signal.

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	0	0
Cost Per Pound Per Life	N/A - No emissions change	N/A - No emissions change
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**N/A - No emissions change**	**N/A - No emissions change**

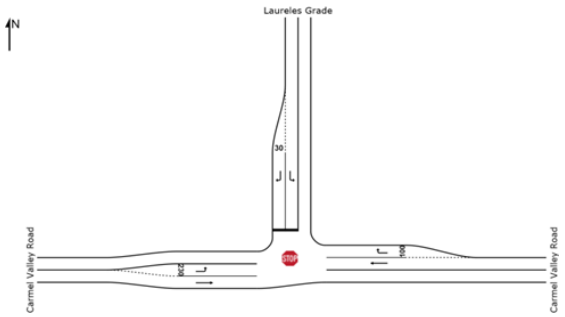
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

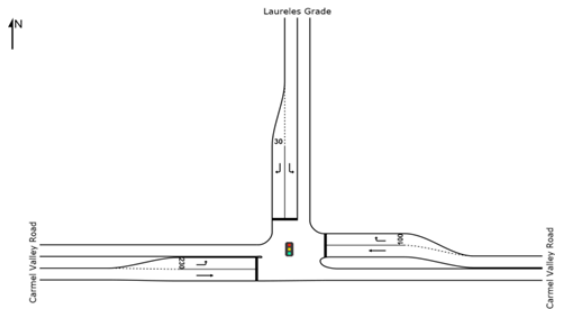
Intersection Control Alternative Summary



EXISTING INTERSECTION
ALL WAY STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	D	34.2	132.5 (SBL)	F	70.5	195 (SBL)
2040	F	70.4	225 (SBL)	F	379.6	495 (SBL)

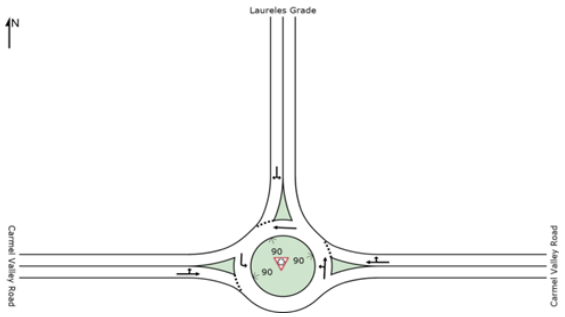
NOTES: N/A



ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	A	5.9	114 (WBT)	A	5.5	130 (EBT)
2040	A	6.2	170 (WBT)	A	6.6	211 (EBT)

NOTES: N/A

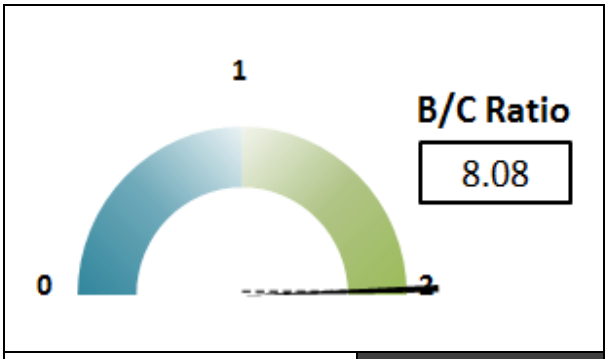


ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	A	7.1	96 (WB)	A	7.8	108 (EB)
2040	B	10.1	167 (WB)	B	11.9	250 (EB)

NOTES: N/A

HIGHWAY 68 AT CORRAL DE TIERRA



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for Highway 68 at Corral de Tierra is 8.08. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $15,000,000.

Noteworthy performance measures driving the B/C ratio are *safety* and *delay*. The estimated safety costs of the signal are 2.5 times higher than that of the roundabout. The estimated delay costs of the signal are 6times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $13,280,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,200 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing signal-control or, no project alternative, is at capacity during the AM and PM peak hour and will continue to degrade over time. Signal control improvements are currently under design and are summarized in this study. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2025 design year. The year 2015 was assumed for the baseline "build" condition for a total 10 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number MCO-03 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Highway 68 at Corral de Tierra is controlled by a traffic signal.

Parcels north of Highway 68 are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement. Developed parcels in the southwest quadrant are a constraint. Right of way in the southeast quadrant is reserved for potential development and is a constraint. The existing intersection is within Caltrans right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Highway 68 at Corral de Tierra	**Coral de Tierra (County of Monterey)**	2-lane undivided	Rural	35	Serves residential & recreational agricultural land uses	No transit services provided	No sidewalks provided	No bike lanes provided
	Highway 68 (Caltrans)	2-lane undivided	Conventional highway	55	Regional facility serving residential, recreational, & commercial land uses	Service provided by Monterey-Salinas Transit Stop located at intersection	No sidewalks provided	No bike lanes provided

Existing design constraints and considerations identified by the County at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Property acquisition considered a fatal Flaw
3. Environmentally sensitive area
4. Transit stop

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

Consistent with the Draft *2014 Monterey County Regional Transportation Plan* prepared by TAMC, Monterey County is leading the design of traffic signal and intersection improvements at this location.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

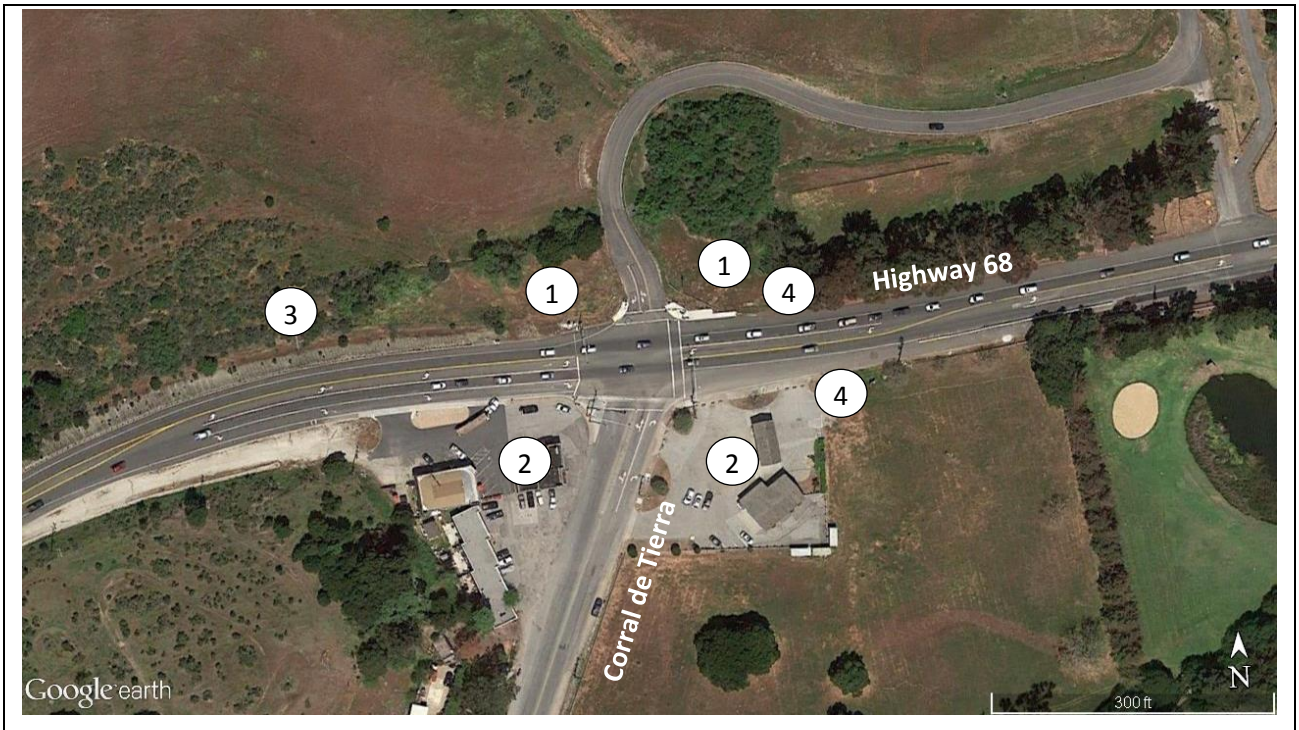
Control Type	Legend
Existing Traffic Signal	
Proposed Signal Modification	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 and 2025 AM and PM peak hour volumes was provided by the County in the *Traffic Operations Analysis Addendum for the SR 68/ Corral de Tierra Intersection Operational Improvements*, dated August 20, 2012.

Signal Control (Existing)

Demand exceeds capacity for the AM and PM peak hour under existing conditions. Eastbound and westbound Highway 68 traffic experience significant delay and extensive vehicle queueing.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

The proposed signal control project is sponsored by the County and will construct an additional westbound left turn lane; a southbound receiving lane merging into Corral de Tierra; a northbound right turn lane. Intersection operations and improvements for the proposed signal control alternative have been provided by the County.

The proposed traffic signal is expected to improve intersection performance compared to the existing condition.

The additional lanes will also increase crossing distance as well as overall cycle length for protected phasing. . Bike lanes are currently not provided along either roadway and therefore will not be impacted by the necessary lane additions. Access to transit stops can be maintained with the necessary lane additions.

Roundabout Control

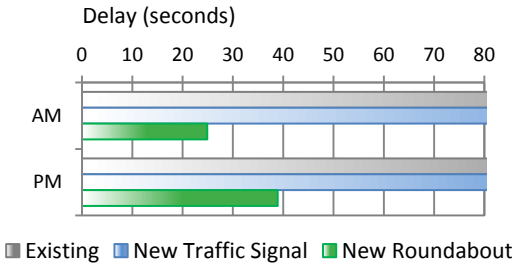
With roundabout control, two approach and departure lanes are required for the westbound and eastbound directions. The proposed lane additions are consistent with the improvement plans for the traffic signal alternative.

Compared to the proposed signal alternative, the roundabout improvements will require less roadway widening and reduce the overall project footprint. However, there will be greater impact to parcels in the northeast and northwest quadrants, at the intersection. It is not anticipated that right of way will be required at the southeast or southwest quadrant.

Crosswalks will be improved and provide midway refuge areas. Bike lanes are not provided at the intersection therefore the roundabout alternative will not impact bike access. Access to transit stops can be maintained with the proposed roundabout.

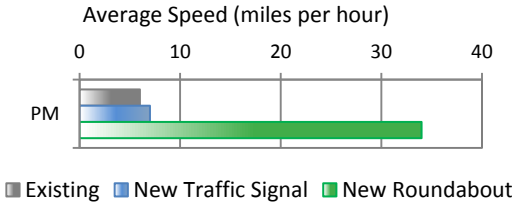
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCO-03**

Intersection Cost Comparison

Highway 68 at Corral De Tierra
Monterey County, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.52	$ 76,176	$ 617,855	1.78	$ 262,676	$ 2,130,535
Predicted PDO Crashes	3.54	$ 36,079	$ 292,632	3.23	$ 32,900	$ 266,848
Subtotal - Safety Costs	**-**	**$ 112,255**	**$ 910,487**	**-**	**$ 295,576**	**$ 2,397,384**
DELAY						
Delay to Persons in Vehicles (hours)	13904	$ 192,154	$ 2,113,693	91675	$1,254,447	$13,798,913
Subtotal - Delay Costs	-	**$ 192,154**	**$ 2,113,693**	-	**$1,254,447**	**$13,798,913**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	4,596
Cost of Power for Signal				-	$ 4,255	34,512
Cost of Illumination	6	$ 873	$ 7,078	4	$ 582	4,719
Cost of Landscaping Maintenance	-	$ 2,000	$ 16,222			
Cost of Signal Maintenance				-	$ 4,660	37,797
Cost of Pavement Rehabilitation			$ 305,862			$ 358,893
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 329,161**	-	**$ 10,063**	**$ 440,517**
EMISSIONS						
Tons of ROG	0.29	$ 280	$ 2,270	1.22	$ 1,159	$9,404
Tons of NOX	1.09	$ 14,116	$ 114,491	1.77	$ 22,802	$184,946
Tons of PM10	0.0126	$ 1,259	$ 10,210	0.0505	$ 5,035	$40,840
Subtotal - Emissions Costs		**$ 15,654**	**$ 126,971**		**$ 28,997**	**$ 235,191**
INITIAL CAPITAL COSTS						
Construction Cost			$ 2,319,240			$ 1,700,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 812,000			$ -
Right-of-Way			$ 324,000			$ -
Subtotal - Initial Capital Costs			**$ 3,455,240**			**$ 1,700,000**
NET PRESENT VALUE			**$ 6,935,552**			**$18,572,004**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,486,896
Delay Reduction Benefit of Roundabout	$11,685,221
Emission Reduction Benefit of Roundabout	$108,220
Total Benefits	**$13,280,337**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$111,356
Added Capital Costs of a Roundabout	$1,755,240
Total Costs	**$1,643,884**

LIFE CYCLE (10 YEAR) BENEFIT/COST RATIO

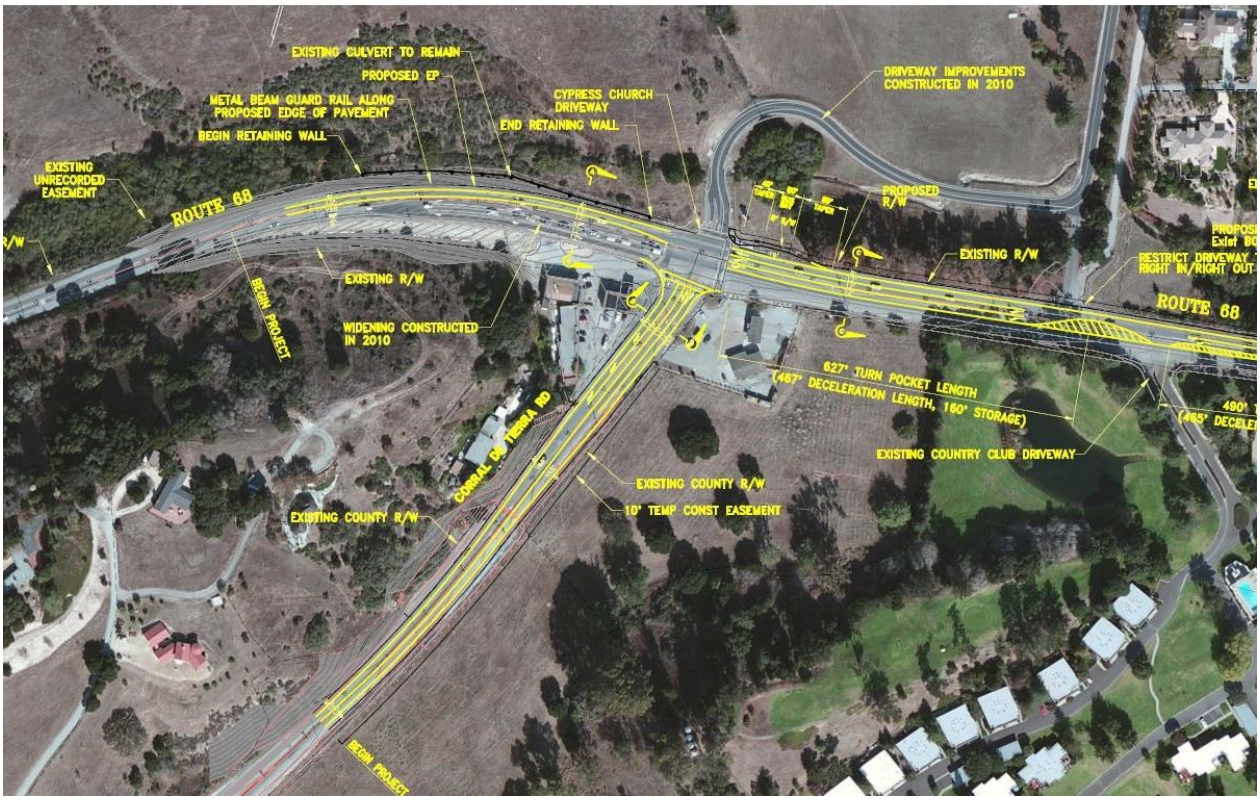
8.08

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	3535	261
Cost Per Pound Per Life	$13.26	$179.71
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$2,653**	**$35,942**

Intersection Improvement Alternatives

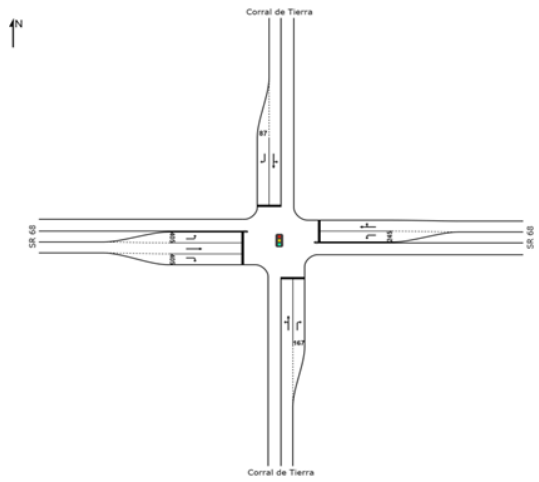


Signal Alternative *(Source: Monterey County)*

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary



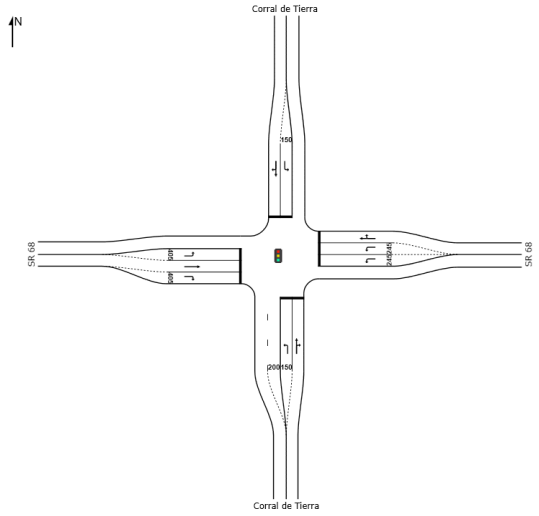
EXISTING INTERSECTION SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	E	75.3	#1266 (EBT)	F	90.4	#1545 (EBT)
2025	F	258.1	#2499 (WBT)	F	240.7	#2705 (EBT)

2015 LOS and Delay results sourced from Wood Rodger's technical memorandum.

NOTES:

WBL and NBL queues exceed available storage for both 2025 peak hours.



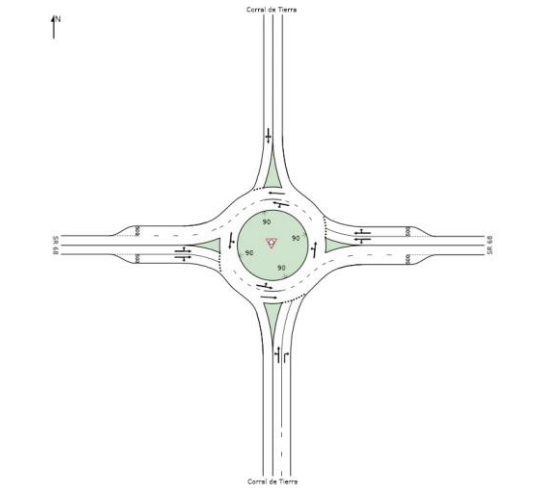
ALTERNATIVE 1 SIGNAL MODIFICATION PER COUNTY PLAN

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	E	68.6	#1267 (EBT)	E	70.1	#1508 (EBT)
2025	F	242.4	#2499 (WBT)	F	217.3	#2667 (EBT)

2015 LOS and Delay results sourced from Wood Rodger's technical memorandum.

NOTES:

NBL queues exceed available storage for both 2025 peak hours.



ALTERNATIVE 2 ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	B	13.6	230 (WB)	B	14.0	265 (EB)
2025	C	24.9	656 (WB)	E	38.9	1249 (EB)

NOTES:

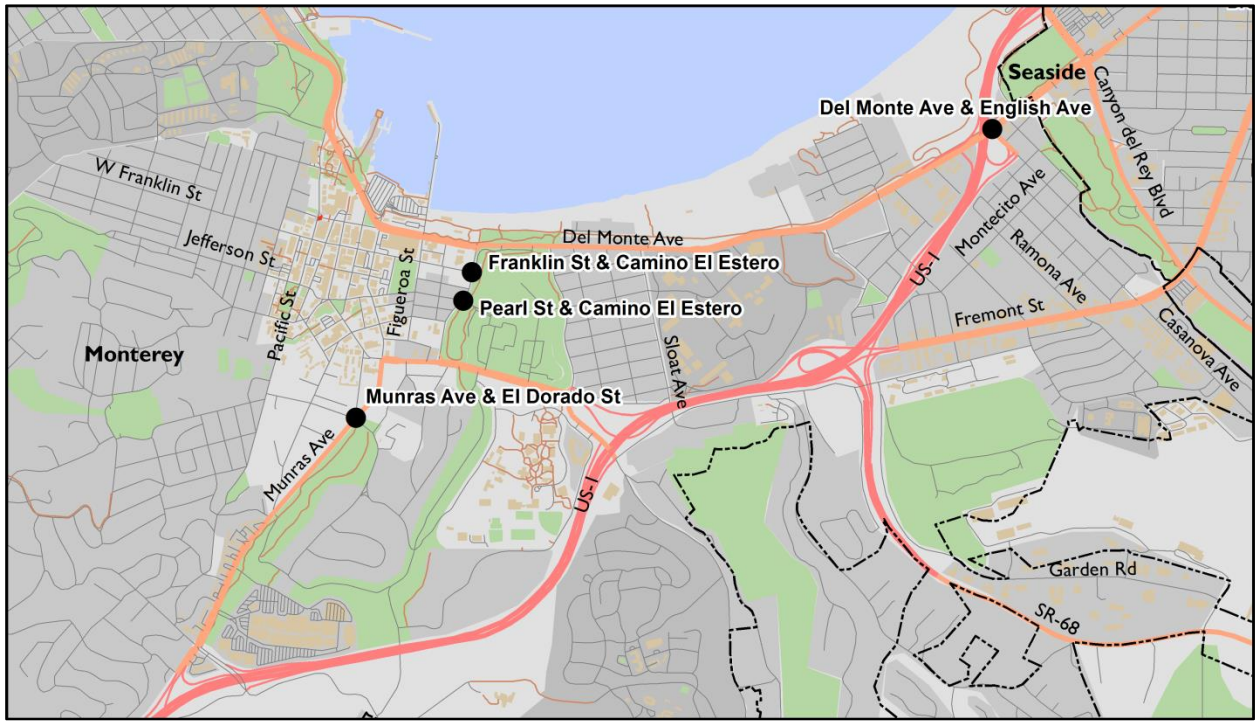
Significant queuing is noted eastbound along SR-68.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 6:

City of Monterey

Study Intersections:

- PEARL STREET AT CAMINO EL ESTERO
- DEL MONTE BOULEVARD AT ENGLISH AVENUE
- MUNRAS AVENUE / ARBREGO STREET AT EL DORADO STREET
- EAST FRANKLIN STREET AT CAMINO EL ESTERO



CITY OF MONTEREY SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Pearl Street at Camino El Estero	MCY-01
Del Monte Boulevard at English Avenue	MCY-02
Munras Avenue / Abrego Street at El Dorado Street	MCY-03
East Franklin Street at Camino El Estero	MCY-04

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Monterey jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Monterey, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Pearl Street at Camino El Estero	**5.78**	
Del Monte Boulevard at English Avenue	**1.55**	
Munras Ave./Abrego St. at El Dorado Street	**NA-R**	
East Franklin Street at Camino El Estero	**2.19**	

SUMMARY OF KEY PERFORMANCE MEASURES

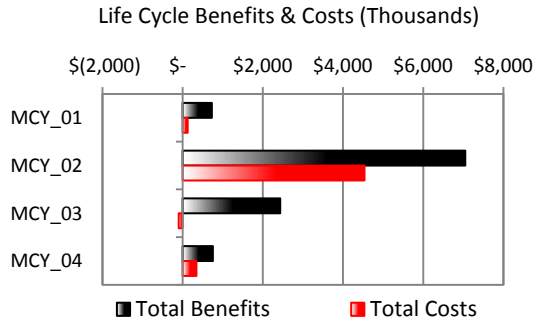
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

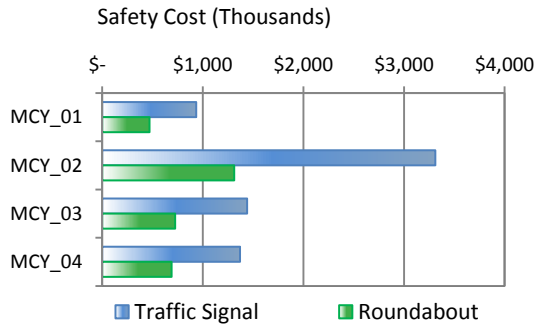
NOTE: Traffic demand for the Del Monte Boulevard at English Avenue intersection significantly exceeds capacity for both signal and roundabout alternatives during the existing and future PM peak design year periods. The operational effects of such over-saturated traffic flow conditions cannot be confidently forecast without the application of micro-simulation. Hence, all results for the Del Monte Boulevard at English Avenue intersection should be viewed as "hypothetical" pending a more robust analysis that is beyond the scope of this study.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.



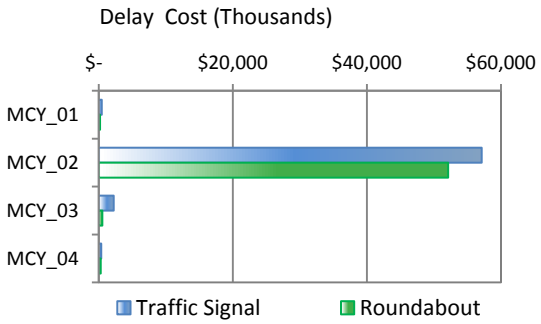
Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

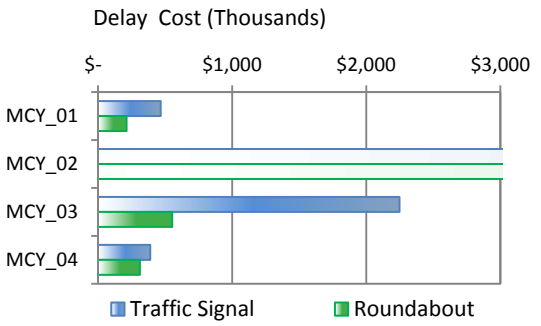
Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection

during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.



The magnitude of delay cost for MCY_02 in the above bar chart is disproportionate to the other three intersections in the study. The bar chart below sets the maximum delay cost to $3,000,000 to better illustrate the relationship of delay costs for intersections MCY_01, MCY_03, and MCY_04.

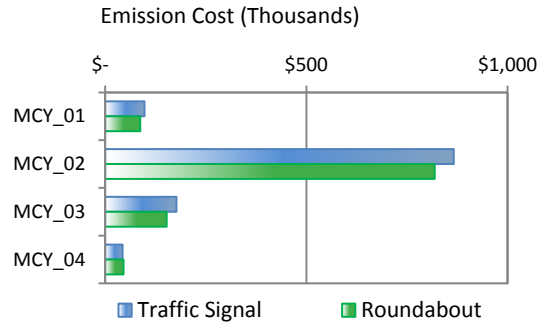


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

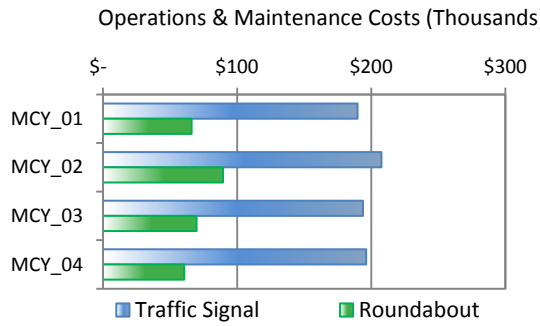
Emissions **Study Intersection**	**Preferred Control**
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

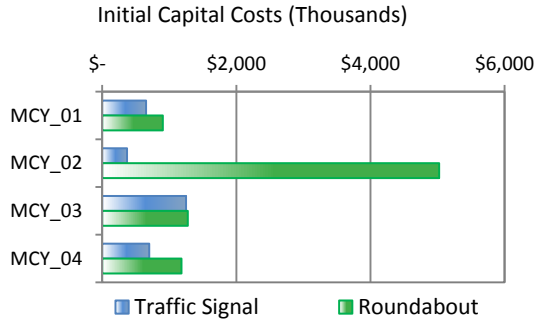


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

Summary of B/C Performance Measures

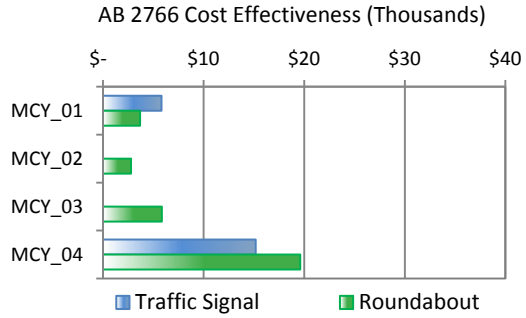
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Pearl Street at Camino El Estero						
Del Monte Boulevard at English Avenue						
Munras Avenue / Abrego Street at El Dorado Street						
East Franklin Street at Camino El Estero						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Monterey.

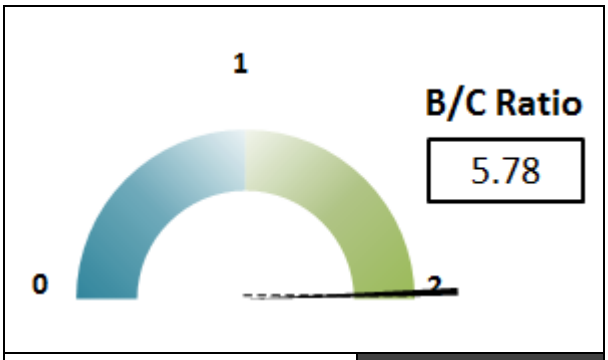


Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Pearl Street at Camino El Estero	
Del Monte Boulevard at English Avenue	
Munras Avenue / Abrego Street at El Dorado Street	
East Franklin Street at Camino El Estero	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

PEARL STREET AT CAMINO EL ESTERO



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for Pearl Street at Camino El Estero is 5.78. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $1,500,000.

Noteworthy performance measures driving the B/C ratio are *safety* and *operations and maintenance.* The estimated safety costs of the signal are 2 times higher than that of the roundabout. The estimated operations and maintenance costs of the signal are 2.5 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $729,000 when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic and will provide superior operations compared to the existing stop control or signal control alternative. The existing stop control, or no project alternative, will continue to provide adequate capacity in terms of delay. The signal control alternative will provide similar operations as the existing stop control alternative. However, vehicle queuing may affect operations at Anthony Street as travel demand increases. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MCY-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Pearl Street at Camino El Estero	**Pearl Street (City of Monterey)**	2-lane undivided with on street parking	Local	25	Serves residential, commercial/ business, institutional, & recreational land uses	Service provided by Monterey-Salinas Transit Lines 14 & 56	Sidewalks and crosswalks provided	Class II bike Lanes
	Camino El Estero (City of Monterey)	2-lane undivided with on street parking	Local	25	Serves residential, commercial/ business, institutional, tourism, & recreational land uses	Service provided by Monterey-Salinas Transit Line 56	Sidewalks and crosswalks provided	Class II bike Lanes

identified at the study location.

Pearl Street at Camino El Estero is an all-way stop controlled intersection.

Parcels west of Camino El Estero are developed with structures located at or near the existing back of sidewalk. Parcels east of Camino El Estero are open space and part of El Estero Park. The existing intersection is within City of Monterey right of way.

Existing design constraints at the study intersection include (see map for locations):

1. El Estero Presbyterian Church – fatal flaw
2. El Estero water basin
3. Pearl Street Bridge – fatal flaw
4. Office complex
5. Driveways

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Pearl Street at Camino El Estero intersection is located within the City of Monterey Downtown Specific Plan.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

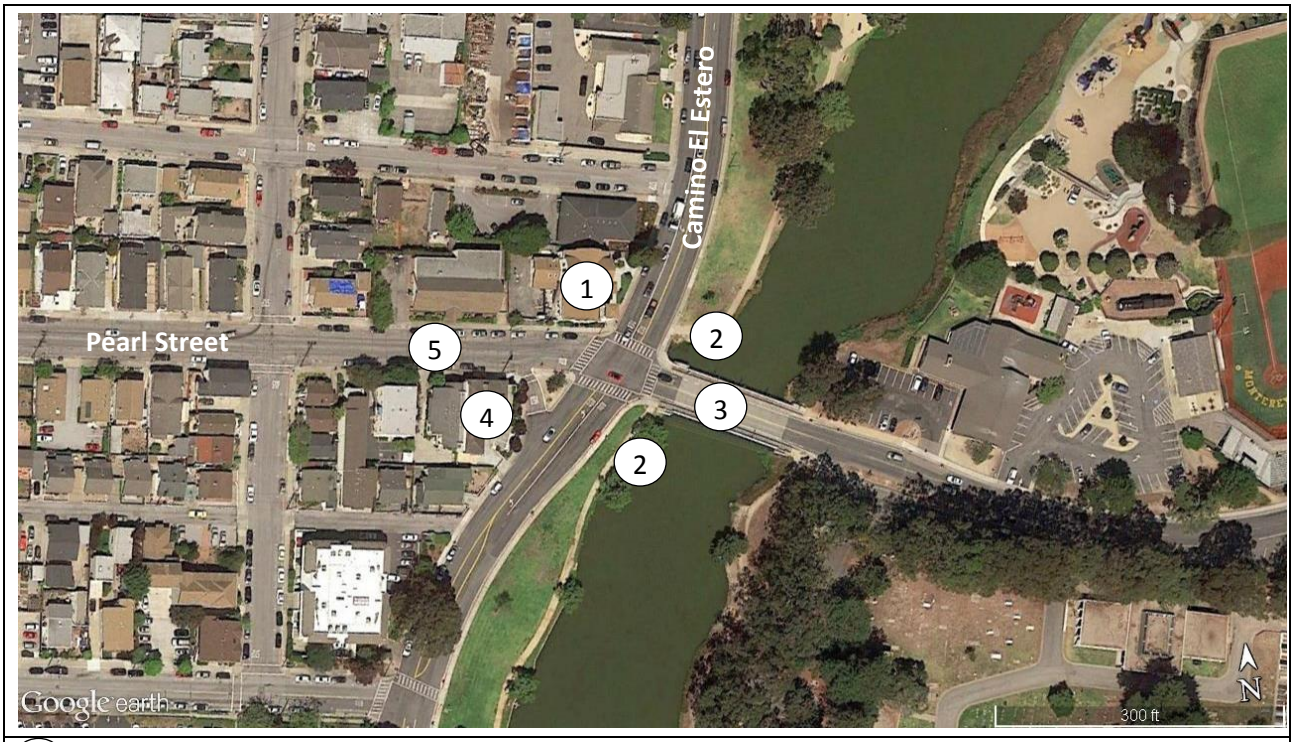
Traffic data for 2015 PM peak hour volumes was provided by the City. 2040 PM peak hour volumes were calculated for a total growth of 5% for all movements. AM peak hour volumes were not provided.

Stop Control (Existing)

With stop control, demand is adequately served for the PM peak period under existing and future design years.

Signal Control

With proposed signal control, the number of approach and departure lanes will remain the same as existing. Vehicle demand will be adequately served for the PM peak period under existing and future design years.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

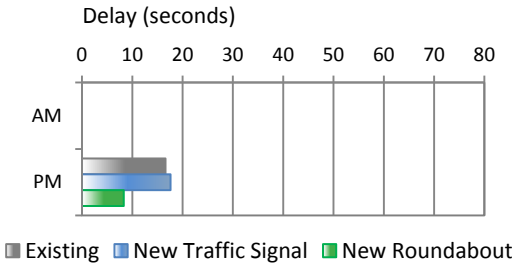
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve existing intersection operations and provide superior operations compared to the proposed signal alternative. Vehicle demand will be adequately served for the PM peak period under existing and future design years.

The proposed single lane roundabout may require a mountable central island and splitter islands to accommodate design vehicles given the design constraints at the intersection.

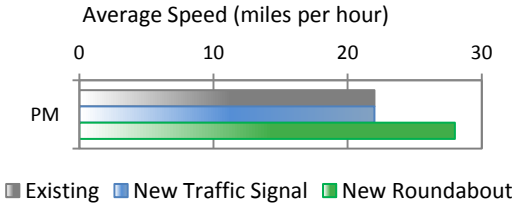
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: AM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- AM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering, topographic survey of bridge and northwest quadrant, and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCY-01**
01/16

Intersection Cost Comparison

Pearl Street at Camino El Estero
Monterey, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.16	$ 23,612	$ 368,871	0.36	$ 52,472	$ 819,714
Predicted PDO Crashes	0.64	$ 6,486	$ 101,319	0.72	$ 7,345	$ 114,740
Subtotal - Safety Costs	**-**	**$ 30,098**	**$ 470,191**	**-**	**$ 59,816**	**$ 934,454**
DELAY						
Delay to Persons in Vehicles (hours)	745	$ 8,183	$ 212,747	1628	$ 17,973	$ 467,288
Subtotal - Delay Costs	-	**$ 8,183**	**$ 212,747**	-	**$ 17,973**	**$ 467,288**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 1,333	20,829
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,000	62,488
Cost of Pavement Rehabilitation			$ 21,166			$ 30,900
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 66,043**	-	**$ 10,170**	**$ 189,778**
EMISSIONS						
Tons of ROG	0.13	$ 122	$ 1,907	0.18	$ 171	$2,670
Tons of NOX	0.37	$ 4,807	$ 75,100	0.41	$ 5,305	$82,869
Tons of PM10	0.0064	$ 641	$ 10,007	0.0077	$ 769	$12,009
Subtotal - Emissions Costs		**$ 5,570**	**$ 87,014**		**$ 6,244**	**$ 97,548**
INITIAL CAPITAL COSTS						
Construction Cost			$ 758,775			$ 548,800
Construction Cost - Structures			$ -			$ -
Capital Support			$ 145,000			$ 105,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 903,775**			**$ 653,800**
NET PRESENT VALUE			**$ 1,739,770**			**$ 2,342,869**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$464,264
Delay Reduction Benefit of Roundabout	$254,541
Emission Reduction Benefit of Roundabout	$10,533
Total Benefits	**$729,338**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$123,736
Added Capital Costs of a Roundabout	$249,975
Total Costs	**$126,239**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

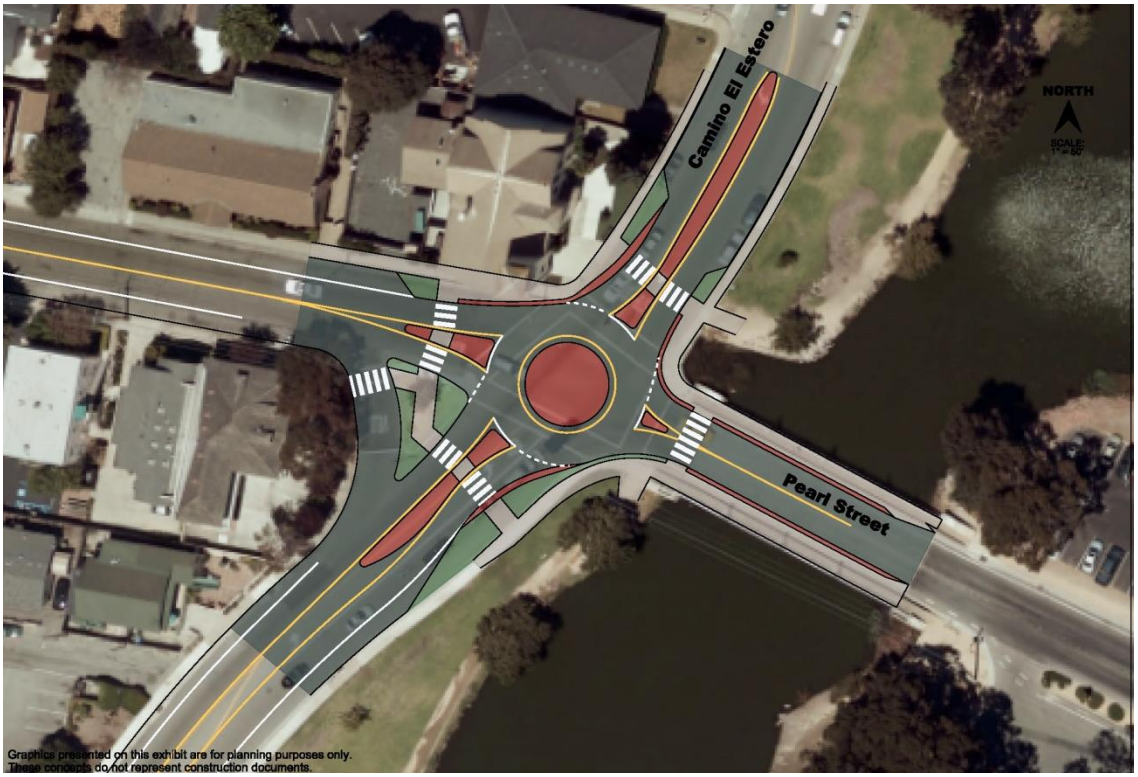
5.78

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	499	316
Cost Per Pound Per Life	$46.07	$72.67
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$3,686**	**$5,813**

Intersection Improvement Alternatives

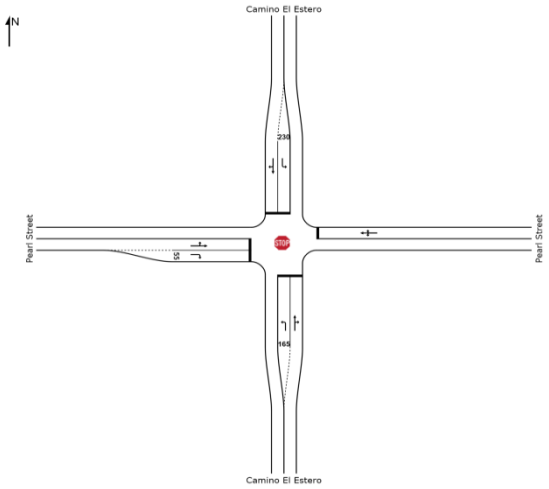
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

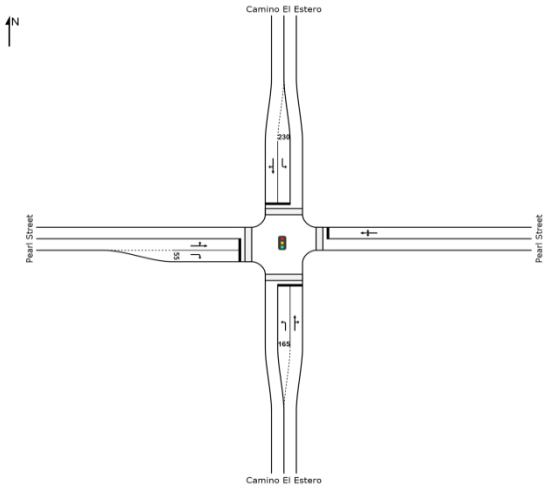


EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	C	15.2	108 (SBT)
2040	-	-	-	C	16.6	128 (SBT)

NOTES:

1. AM data was not provided.

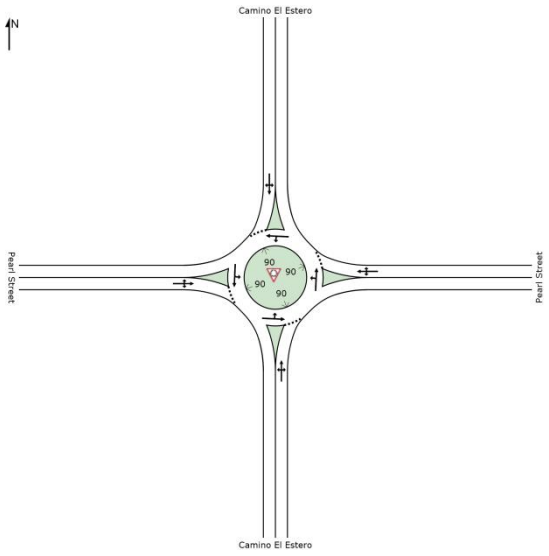


ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	B	17.6	141 (SBT)
2040	-	-	-	B	17.6	169 (SBT)

NOTES:

1. AM data was not provided.



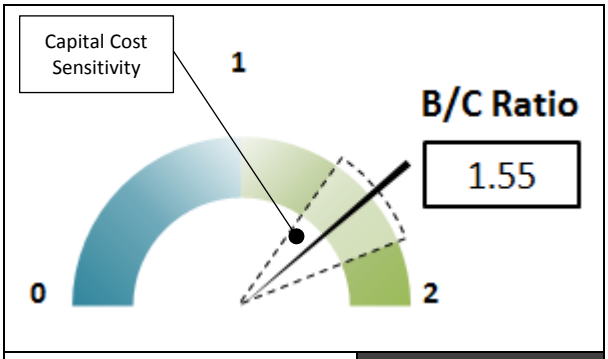
ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	A	7.8	89 (SB)
2040	-	-	-	A	8.3	101 (SB)

NOTES:

1. AM data was not provided.

DEL MONTE BOULEVARD AT ENGLISH AVENUE



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

NOTE: Traffic demand for the Del Monte Boulevard at English Avenue intersection significantly exceeds capacity for both signal and roundabout alternatives during the existing and future PM peak design year periods. The operational effects of such over-saturated traffic flow conditions cannot be confidently forecast without the application of micro-simulation. Hence, all results for the Del Monte Boulevard at English Avenue intersection should be viewed as "hypothetical" pending a more robust analysis that is beyond the scope of this study.

The Benefit Cost (B/C) ratio for Del Monte Boulevard at English Avenue is 1.55. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection may be sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control may change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $7,000,000.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 2.5 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $7,050,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,300 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, neither the roundabout nor the signal is a viable alternative to serve traffic demand during the PM peak design year periods given the project constraints. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MCY-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Del Monte Boulevard at English Avenue	**Del Monte Boulevard (City of Monterey)**	4-lane divided	Regional	40	Serves commercial/ business, tourism, & recreational land uses Provides on/off access to southbound SR 1	Service provided by Monterey-Salinas Transit Lines 10, 12, 20, 55, 56, 74, 75, 76, and 78 Stops at intersection	Sidewalk along south side and multiuse path on north side of street Crosswalk on east leg	Multiuse path on north side of street
	English Avenue (City of Monterey)	2-lane undivided	Regional	30	Serves commercial/ business, tourism, & recreational land uses Provides on/off access to northbound SR 1	No transit services provided	Sidewalks No crosswalk. No pedestrian crossing permitted	Class II

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Del Monte Boulevard at English Avenue is controlled by a traffic signal.

The southeast parcel is developed with a commercial structure located at or near the back of existing sidewalk. Parcels north of Del Monte Boulevard are used for Caltrans/freeway overhead structures and a multi-use path. The southwest parcel is undeveloped.

Freeway bridge columns are located just north of the northerly Del Monte Boulevard curb line. Freeway abutments and retaining structure are located just south of the southerly Del Monte Boulevard sidewalk. The combination of freeway bridge columns, abutments, and retaining walls Constrain the number of lanes and geometry of Del Monte Boulevard at the project intersection.

The existing intersection is within City of Monterey and Caltrans right of way.

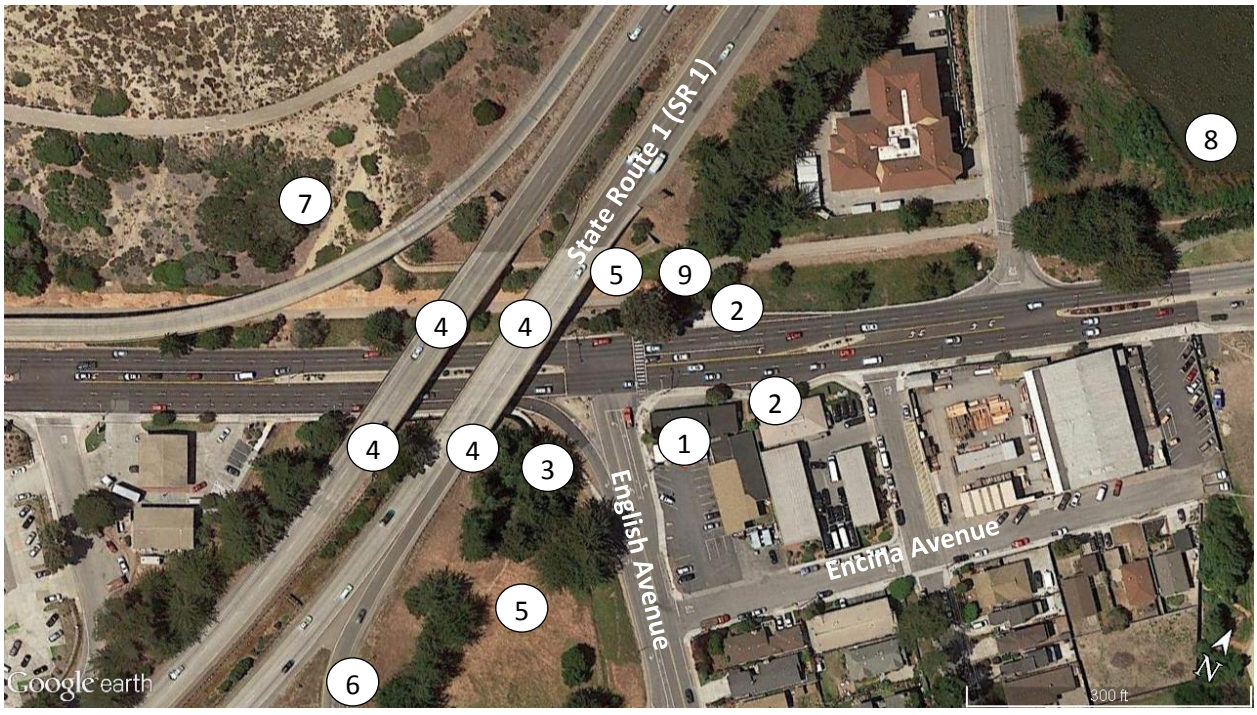
Existing design constraints and considerations at the study intersection include (see map for locations):

1. Peninsula Produce (building and parking lot)
2. Transit stop
3. Pedestrian bridge
4. Freeway column/abutment
5. Caltrans right of way
6. SR 1 on-ramp
7. Monterey State Beach
8. Laguna Del Rey
9. Monterey Peninsula Recreational Trail

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The 2012 Monterey Peninsula Fixed Guideway Study prepared by TAMC identifies the trail corridor north of the intersection as the preferred alignment for a future light rail or bus rapid transit corridor.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Road Improvements	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2007 AM and PM peak hour volumes was provided by the City. 2015 volumes were assumed to be the same as 2007 peak hour volumes. 2040 AM and PM peak hour volumes were calculated using a 1% annual compound growth rate for all movements.

Signal Control (Existing)

The existing signal control, or no project alternative, operates as a 3 phase signal with protected left turn phasing and a free right turn along Del Monte Boulevard. Heavy through volumes along with heavy right turns onto English Avenue cause significant delay along Del Monte Boulevard.

Additional lanes on Del Monte Boulevard are required to increase intersection capacity. The existing freeway columns and abutments were considered a fatal flaw constraint for this study. Therefore, a proposed signal alternative to increase intersection capacity was not evaluated.

Roundabout Control

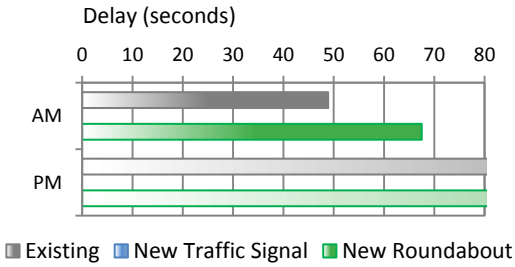
With roundabout control, a multi lane roundabout with two approach and departure lanes on Del Monte Boulevard was evaluated. In coordination with the City of Monterey, the preferred treatment for English Avenue was to provide pedestrian access with single lane crossings between pedestrian refuges.

Similar to the signal control alternative, additional lanes on Del Monte Boulevard are required to increase intersection capacity. The existing freeway columns and abutments were considered a fatal flaw constraint for this study. Therefore, a proposed roundabout alternative with additional lanes was not evaluated.

Crossings will be improved and midway refuge areas can also be provided. Bike lanes and multipurpose paths at the intersections can be maintained with a two lane roundabout. Transit stops at the intersection including the transit pay can be maintained with a two lane roundabout.

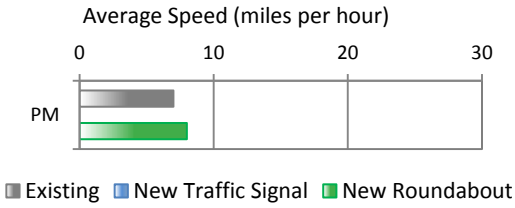
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Current intersection traffic counts.
- Forecast design year traffic volumes at the study intersection.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCY-02**
01/16

Intersection Cost Comparison

Del Monte Boulevard at English Avenue
Monterey, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.36	$ 52,540	$ 820,781	1.23	$ 181,172	$ 2,830,279
Predicted PDO Crashes	3.08	$ 31,453	$ 491,362	3.02	$ 30,801	$ 481,180
Subtotal - Safety Costs	**-**	**$ 83,993**	**$ 1,312,143**	**-**	**$ 211,973**	**$ 3,311,459**
DELAY						
Delay to Persons in Vehicles (hours)	195555	$2,004,489	$ 52,116,703	201437	$ 2,196,893	$ 57,119,227
Subtotal - Delay Costs	-	**$2,004,489**	**$ 52,116,703**	-	**$ 2,196,893**	**$ 57,119,227**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 1,333	20,829
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,000	62,488
Cost of Pavement Rehabilitation			$ 44,611			$ 48,700
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 89,487**	-	**$ 10,170**	**$ 207,578**
EMISSIONS						
Tons of ROG	2.17	$ 2,064	$ 32,246	2.33	$ 2,217	$34,635
Tons of NOX	3.22	$ 41,525	$ 648,700	3.38	$ 43,601	$681,135
Tons of PM10	0.0885	$ 8,826	$ 137,874	0.0966	$ 9,628	$150,408
Subtotal - Emissions Costs		**$ 52,414**	**$ 818,820**		**$ 55,446**	**$ 866,177**
INITIAL CAPITAL COSTS						
Construction Cost			$ 2,099,125			$ 300,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 1,050,000			$ 70,000
Right-of-Way			$ 1,875,000			$ -
Subtotal - Initial Capital Costs			**$ 5,024,125**			**$ 370,000**
NET PRESENT VALUE			**$ 59,361,278**			**$ 61,874,441**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,999,317
Delay Reduction Benefit of Roundabout	$5,002,524
Emission Reduction Benefit of Roundabout	$47,358
Total Benefits	**$7,049,198**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$118,090
Added Capital Costs of a Roundabout	$4,654,125
Total Costs	**$4,536,035**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

1.55

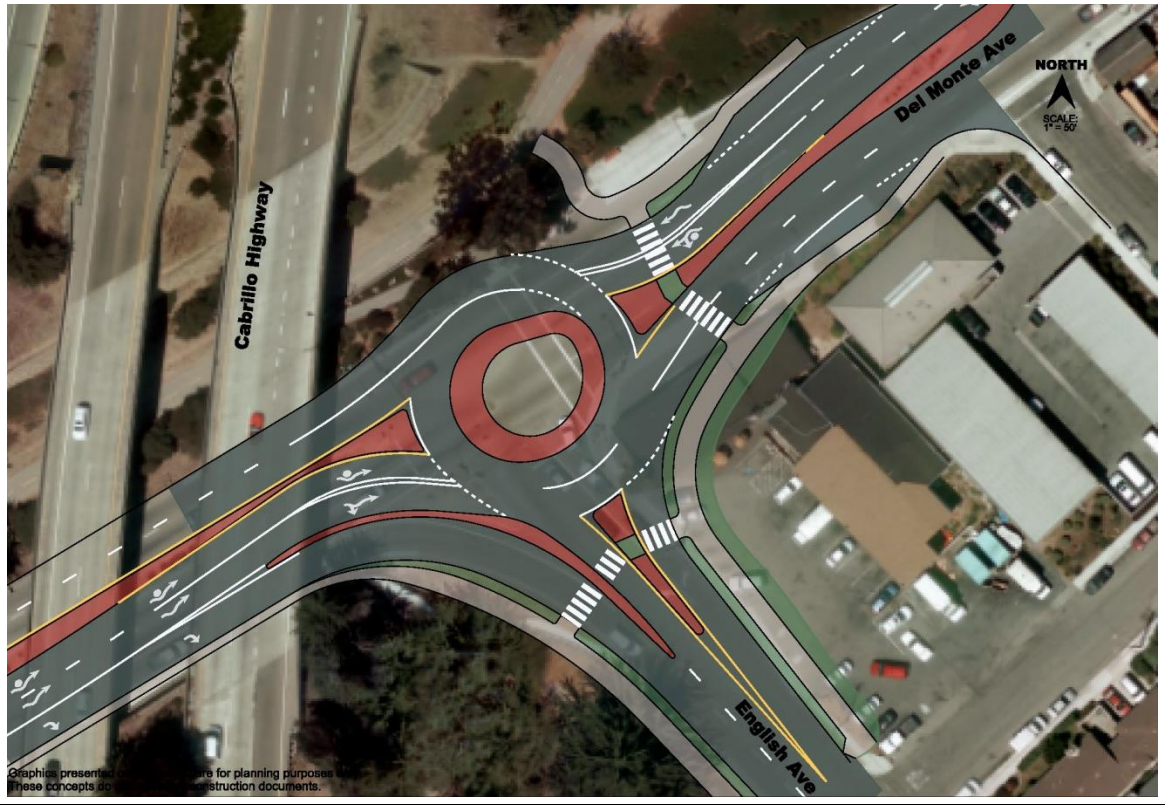
B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	660	N/A - Same as existing
Cost Per Pound Per Life	$34.81	N/A - Same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$2,785**	**N/A - Same as existing**

Intersection Improvement Alternatives

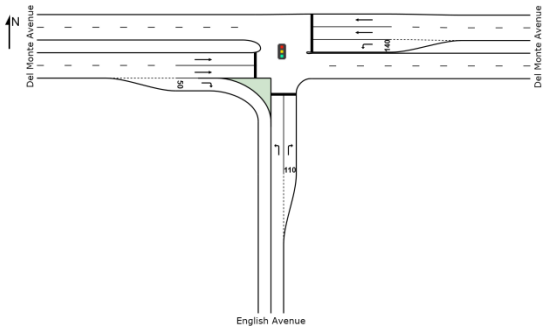
Existing Signal



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

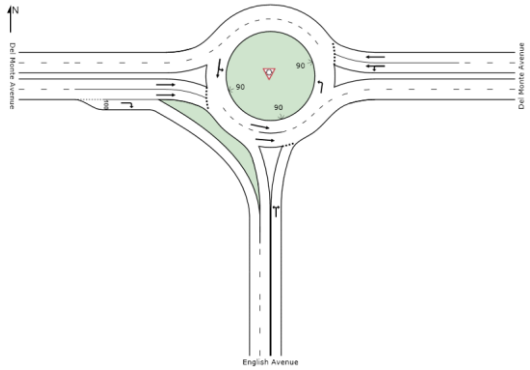


EXISTING INTERSECTION SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2007	D	37.8	#862 (WBT)	F	359.6	#1688 (EBT)
2040	D	48.9	#1534 (WBT)	F	304.2	#2651 (EBT)

NOTES:

1. WB queues on Del Monte Avenue will exceed available storage during all scenarios and affect operations at Roberts Avenue.
2. EB queues on Del Monte Avenue will exceed available storage during all scenarios and affect operations at Hannon Avenue.
3. NB queues on English Avenue will exceed available storage during both 2040 peak hour and affect operations at Encina Avenue



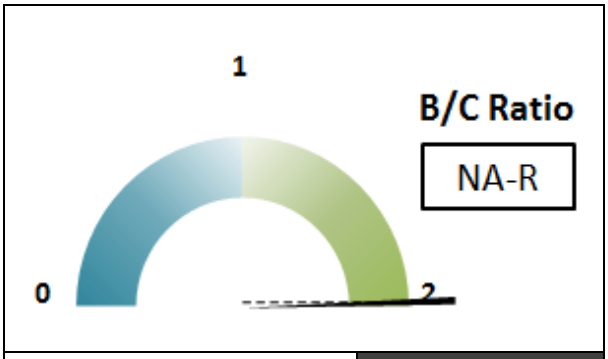
ALTERNATIVE 1 ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2007	B	12.9	341 (WB)	F	223.8	5110 (NB)
2040	F	67.5	2621.3 (WB)	F	383.7	7402 (NB)

NOTES:

1. WB queues on Del Monte Avenue will exceed available storage during all scenarios and affect operations at Roberts Avenue.
2. EB queues on Del Monte Avenue will exceed available storage during all scenarios and affect operations at Hannon Avenue.
3. NB queues on English Avenue will exceed available storage during 2015 p.m. peak hour and both 2040 peak hours and affect operations at Encina Avenue

MUNRAS AVENUE / ABREGO STREET AT EL DORADO STREET



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for Munras Avenue / Abrego Street at El Dorado Street is NA-R. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $3,800,000.

Noteworthy performance measures driving the B/C ratio are *safety* and *delay*. The estimated safety costs of the signal are 2 times higher than the estimated safety costs of the roundabout. The estimated delay costs of the signal are 3 times higher than the estimated safety costs of the roundabout.The total life cycle benefits of the roundabout are estimated at $2,430,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,200 in reduced operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a superior alternative to serve forecast traffic. The proposed traffic signal improvements will improve pedestrian access at the intersection and reduce crosswalk lengths. Traffic signal operations will perform at a similar level as the existing intersection.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number MCY-03 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
							Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context	Transit Service	Pedestrian Considerations	Bicycle Routes
Munras Avenue / Abrego Street at El Dorado Street	**Munras Avenue/ Abrego Street (City of Monterey)**	4-lane undivided with-on street parking (west side)	Local	40	Serves commercial/ business & recreational land uses	Service provided by Monterey-Salinas Transit Lines 2, 18, 19, 22, 24, 69, 91, & 94 Stop at intersection	Sidewalk on westerly side Crosswalk on all legs	No bike lanes provided Trail through park
	Munras Avenue (City of Monterey)	2-lane undivided with on-street parking	Local	25	Serves commercial/ business land uses	No transit services provided	Sidewalks and crosswalks provided	No bike lanes provided
	El Dorado Street (City of Monterey)	2-lane undivided with on street parking	Local	25	Serves residential, commercial/ business, institutional, & recreational land uses	No transit services provided	Sidewalks and crosswalks provided	No bike lanes provided

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Munras Avenue / Abrego Street at El Dorado Street intersection is controlled by a traffic signal.

All parcels, except along the easterly leg of El Dorado Street, are developed at the study intersection. The two northwesterly parcels have a commercial structure at the back of the existing sidewalk. The existing intersection is within City of Monterey right of way.

Existing design constraints and considerations identified by the City at the study intersection include (see map for locations):

1. Intersection with five legs
2. Vertical profile of easterly leg (El Dorado Street)
3. Monterey State Historic Park
4. Multi-use path
5. Restricted open space
6. Jack in the Box (two driveways)
7. Transit stop
8. Monterey Cork 'n' Bottle Liquors (fatal flaw is disturbed)
9. Office Complex (fatal flaw is disturbed)
10. The El Dorado Inn (two driveways)

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

No planned improvements were identified.

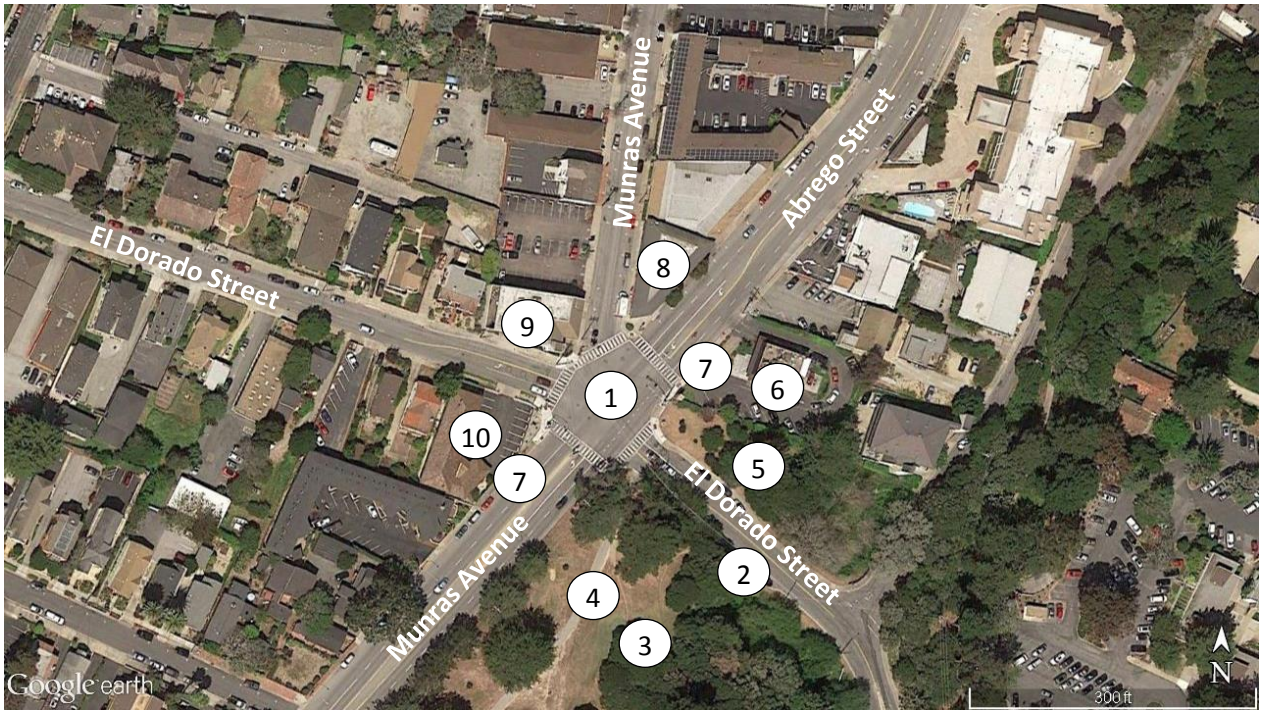
INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Traffic Signal	
Proposed Signal Modification	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM / PM peak hour volumes was provided by the City. 2040 peak hour volumes were calculated using a 1% annual compound growth rate for all movements.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With signal control, demand is adequately served for AM and PM peak hours under existing and future design year conditions. However, PM peak hour is estimated to be near capacity for existing and future design year conditions.

Proposed modifications to the intersection will require relocation, and likely new, signal equipment to construct improved pedestrian facilities. Proposed pedestrian improvements will reduce pedestrian crossing lengths and shift the northerly crosswalk closer to El Dorado Street and away from the Jack in the Box driveway.

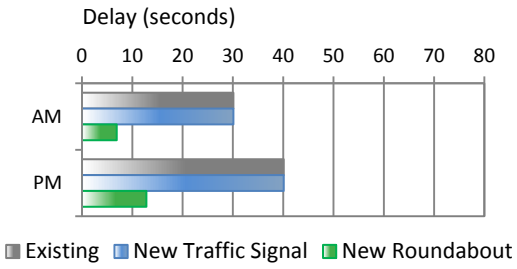
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak hours under future design year conditions.

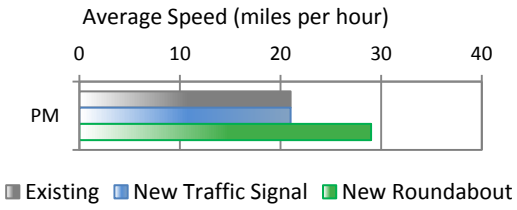
The proposed single lane roundabout is expected to calm traffic and reduce pedestrian crossing lengths at the intersection.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Lane reductions on Munras Avenue / Abrego Street.
- Access to Jack in the Box.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCY-03**
01/16

Intersection Cost Comparison

Munras Avenue / Abrego Street at El Dorado Street
Monterey, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.25	$ 36,372	$ 568,212	0.55	$ 80,827	$ 1,262,693
Predicted PDO Crashes	0.98	$ 10,038	$ 156,822	1.12	$ 11,379	$ 177,759
Subtotal - Safety Costs	**-**	**$ 46,411**	**$ 725,033**	**-**	**$ 92,206**	**$ 1,440,452**
DELAY						
Delay to Persons in Vehicles (hours)	2051	$ 21,282	$ 553,332	8098	$ 86,455	$ 2,247,830
Subtotal - Delay Costs	-	**$ 21,282**	**$ 553,332**	-	**$ 86,455**	**$ 2,247,830**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 1,333	20,829
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,000	62,488
Cost of Pavement Rehabilitation			$ 24,889			$ 34,933
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 69,766**	-	**$ 10,170**	**$ 193,811**
EMISSIONS						
Tons of ROG	0.20	$ 193	$ 3,008	0.28	$ 265	$4,136
Tons of NOX	0.68	$ 8,824	$ 137,848	0.76	$ 9,804	$153,165
Tons of PM10	0.0076	$ 758	$ 11,838	0.0127	$ 1,263	$19,729
Subtotal - Emissions Costs		**$ 9,774**	**$ 152,694**		**$ 11,332**	**$ 177,030**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,065,155			$ 1,000,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 203,000			$ 250,000
Right-of-Way			$ 8,000			$ -
Subtotal - Initial Capital Costs			**$ 1,276,155**			**$ 1,250,000**
NET PRESENT VALUE			**$ 2,776,980**			**$ 5,309,123**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$715,418
Delay Reduction Benefit of Roundabout	$1,694,498
Emission Reduction Benefit of Roundabout	$24,336
Total Benefits	**$2,434,252**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$124,045
Added Capital Costs of a Roundabout	$26,155
Total Costs	**-$97,890**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

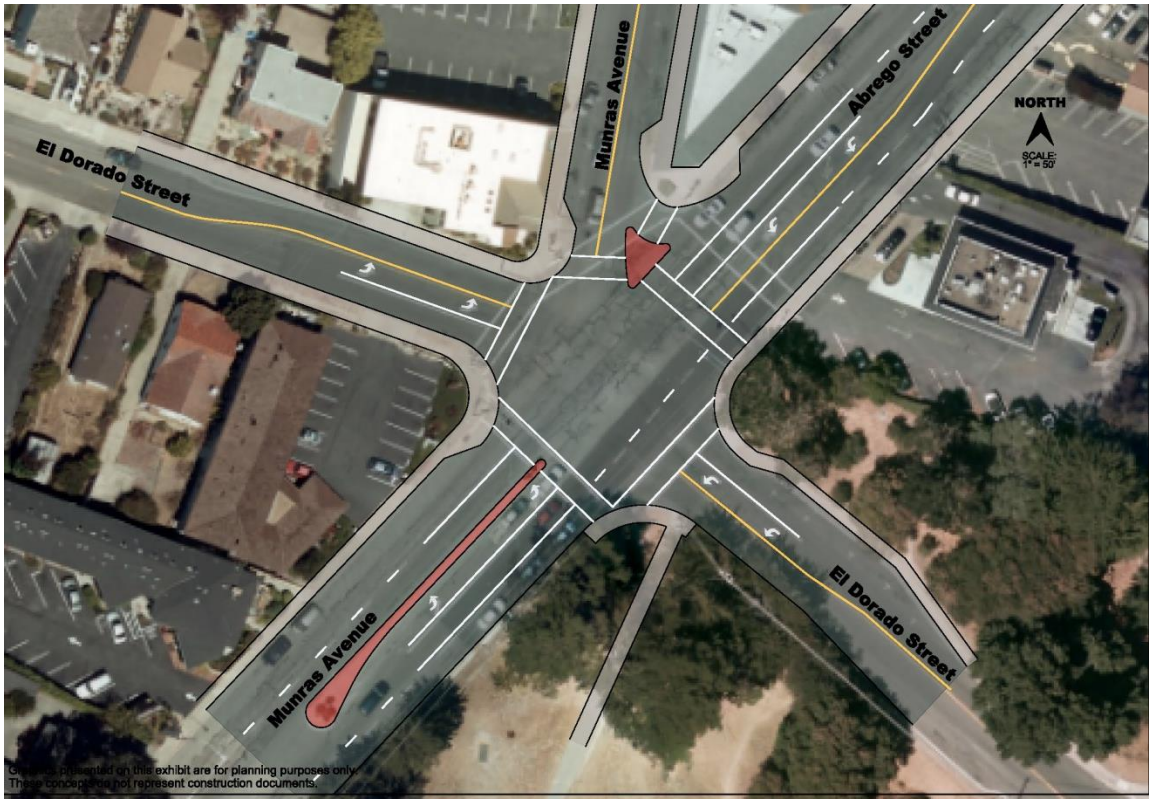
N/A

B/C Preferred: Roundabout Alternative

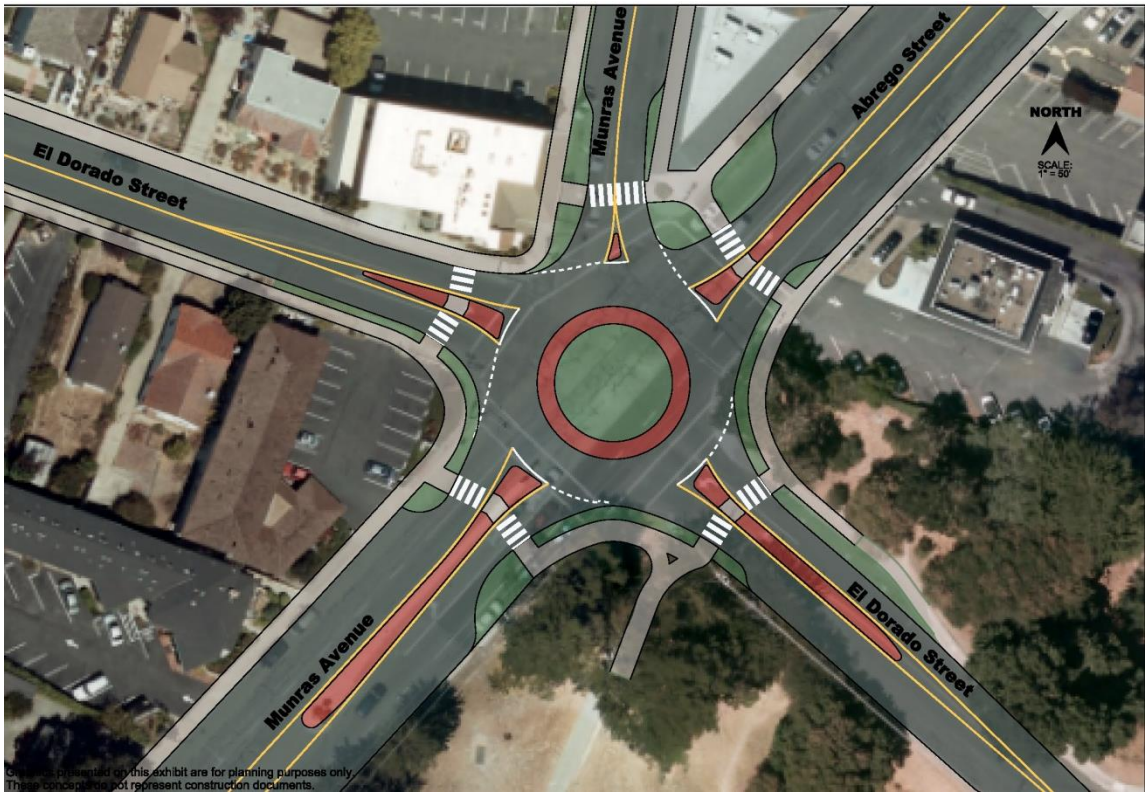
Roundabout Preferred
Cost of Roundabout is less than cost of Traffic Signal, and Roundabout offers benefits compared to Traffic Signal.

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	314	N/A - same as existing
Cost Per Pound Per Life	$73.12	N/A - same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$5,850**	**N/A - same as existing**

Intersection Improvement Alternatives



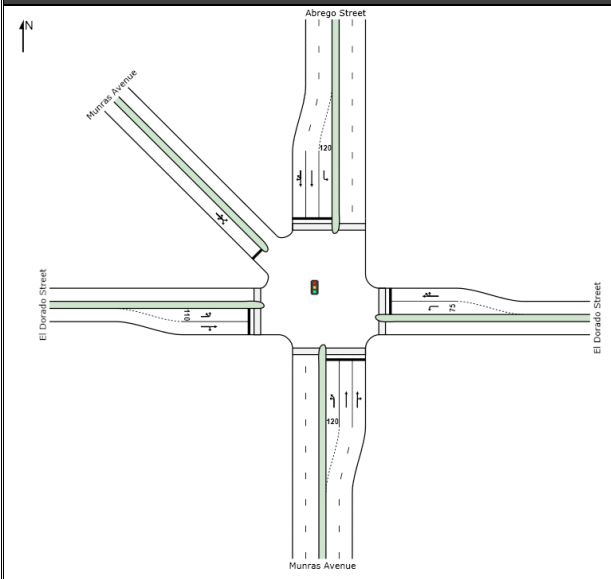
Signal Alternative *(Source: Monterey County)*



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

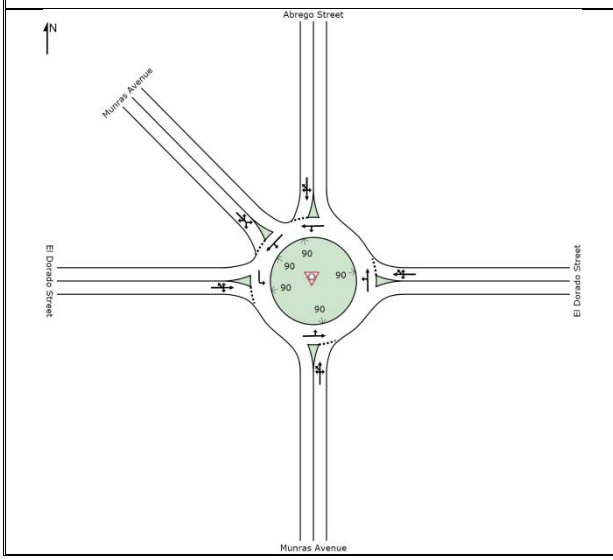


EXISTING INTERSECTION
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	C	33.1	134 (EBL)	D	36.2	211 (NBT)
2040	C	30.1	148 (EBL)	D	40.1	#248 (SEL)

NOTES:

1. EBL queues will exceed capacity during all scenarios.
2. WBL queues will exceed capacity during the 2015 and 2040 p.m. peak hours.

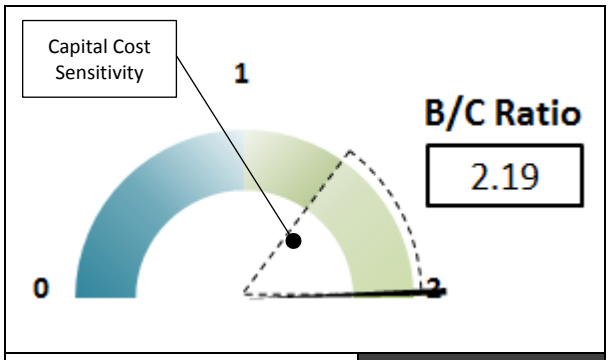


ALTERNATIVE 1
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	5.6	40 (SB)	A	8.2	91 (NB)
2040	A	6.9	59 (SB)	C	12.8	207 (NB)

NOTES:

EAST FRANKLIN STREET AT CAMINO EL ESTERO



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

The Benefit Cost (B/C) ratio for East Franklin Street at Camino El Estero is 2.19. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

The estimated safety costs of the signal are 2 times higher than that of the roundabout.The total life cycle benefits of the roundabout are estimated at $891,000. The total life cycle benefit includes an estimated $7,200 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic and will provide improved operations compared to the existing stop control or signal control alternative. The existing stop control, or no project alternative, will continue to provide adequate capacity in terms of delay. The signal control alternative will provide improved operations compared to the existing stop control alternative. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number MCY-04 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
East Franklin Road at Camino El Estero	**East Franklin Road (City of Monterey)**	One way east leg with on street parking West Leg: Driveway	Local	25	Serves residential, commercial/ business, institutional, tourism, & recreational land uses	Service provided by Monterey-Salinas Transit Line 10, 20, 55, 56, 74, 75, 76, & 78	Sidewalks provided Crosswalks (safe routes to schools)	No bike lanes provided
	Camino El Estero (City of Monterey)	South Leg: 3-lane undivided with on street parking North Leg: 4-lane undivided	Local	25	Serves residential, commercial/ business, institutional, tourism, & recreational land uses	Service provided by Monterey-Salinas Transit Line 10, 20, 55, 56, 74, 75, 76, & 78	Sidewalks provided Crosswalks (safe routes to schools)	No bike lanes provided

East Franklin Street at Camino El Estero is controlled by stop signs on all approaches.

Parcels in the immediate vicinity of the project are developed. A structure is located within 100 feet of the intersection in the northeast, southeast, and southwest quadrants.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Potential right of way constraint (structure)
2. Monterey County Visitors Center and El Estero Park
3. Trinity Christian High School
4. Utility pole (potential fatal flaw if disturbed)

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Pearl Street at Camino El Estero intersection is located within the City of Monterey Downtown Specific Plan.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

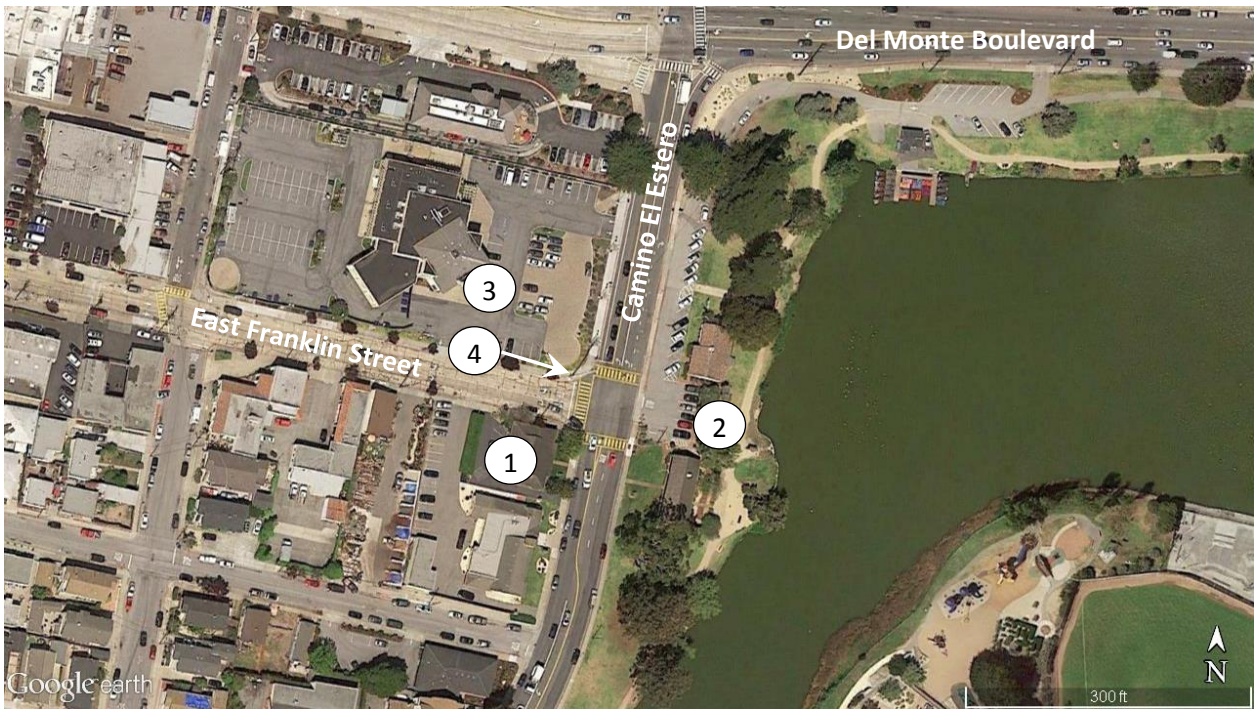
Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 PM peak hour volumes was provided by the City. 2040 AM peak hour volumes were calculated for a total growth of 5% for all movements. AM peak hour volumes were not provided.

Stop Control (Existing)

With stop control, demand is adequately served for the PM peak period under existing and future design years.



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With proposed signal control, the number of approach and departure lanes will remain the same as existing. Vehicle demand will be adequately served for the PM peak period under existing and future design years.

Crossing at the intersection can be maintained and pedestrian phasing will be provided. Bike lanes and transit stops are not provided at the intersection therefore a signal alternative will not impact either facility.

Roundabout Control

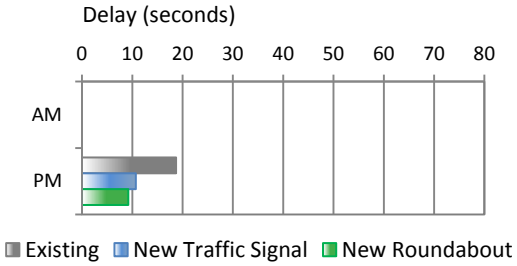
With roundabout control, a single lane roundabout with single lane approaches and departures will provide less delay than the signal alternative and will improve existing intersection operations. Vehicle demand will be adequately served for the PM peak period under existing and future design years.

The proposed single lane roundabout may require a mountable central island and splitter islands to accommodate design vehicles given the design constraints at the intersection.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes and transit stops are not provided at the intersection therefore a one lane roundabout will not impact either facility.

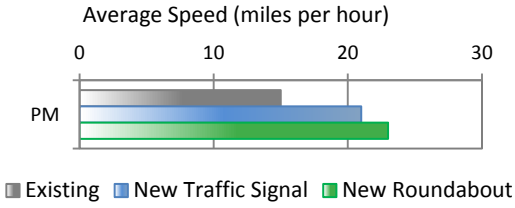
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: AM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- AM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering, topographic survey of bridge and northwest quadrant, and additional site investigations.
- Evaluation of protecting utility pole in place at northwest corner.
- Driveway access and parking circulation for Monterey County Visitors Center and El Estero Park.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **MCY-04**
01/16

Intersection Cost Comparison

E Franklin Street at Camino El Estero
Monterey, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.23	$ 34,567	$ 540,011	0.52	$ 76,816	$ 1,200,025
Predicted PDO Crashes	0.94	$ 9,583	$ 149,703	1.07	$ 10,871	$ 169,835
Subtotal - Safety Costs	**-**	**$ 44,150**	**$ 689,714**	**-**	**$ 87,687**	**$ 1,369,860**
DELAY						
Delay to Persons in Vehicles (hours)	1104	$ 12,009	$ 312,227	1384	$ 14,978	$ 389,415
Subtotal - Delay Costs	-	**$ 12,009**	**$ 312,227**	-	**$ 14,978**	**$ 389,415**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 15,652			$ 38,984
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 60,528**	-	**$ 10,063**	**$ 196,196**
EMISSIONS						
Tons of ROG	0.07	$ 68	$ 1,063	0.07	$ 62	$966
Tons of NOX	0.20	$ 2,519	$ 39,354	0.19	$ 2,435	$38,043
Tons of PM10	0.0033	$ 324	$ 5,069	0.0026	$ 260	$4,055
Subtotal - Emissions Costs		**$ 2,912**	**$ 45,486**		**$ 2,757**	**$ 43,064**
INITIAL CAPITAL COSTS						
Construction Cost			$ 875,925			$ 599,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 167,000			$ 102,000
Right-of-Way			$ 139,000			$ -
Subtotal - Initial Capital Costs			**$ 1,181,925**			**$ 701,000**
NET PRESENT VALUE			**$ 2,289,881**			**$ 2,699,534**

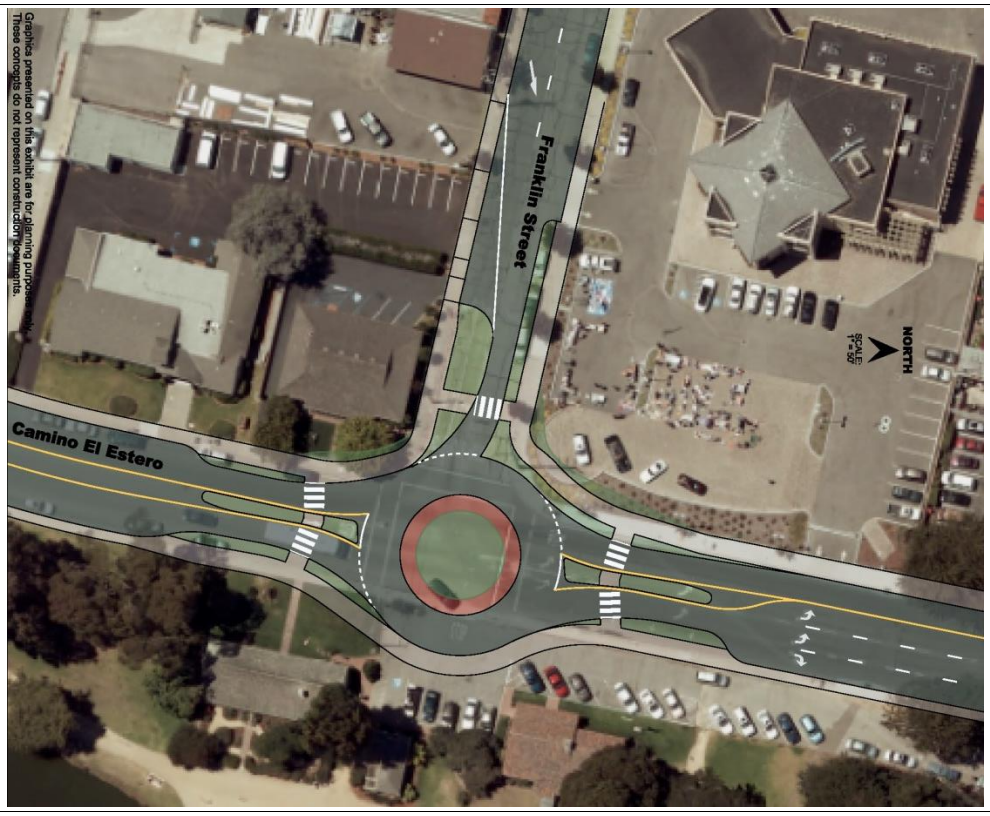
LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$680,145	**LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	$77,188	
Emission Reduction Benefit of Roundabout	-$2,422	
Total Benefits	**$754,911**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$135,667	**2.19**
Added Capital Costs of a Roundabout	$480,925	
Total Costs	**$345,258**	

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	94	121
Cost Per Pound Per Life	$245.06	$189.73
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$19,605**	**$15,178**

Intersection Improvement Alternatives

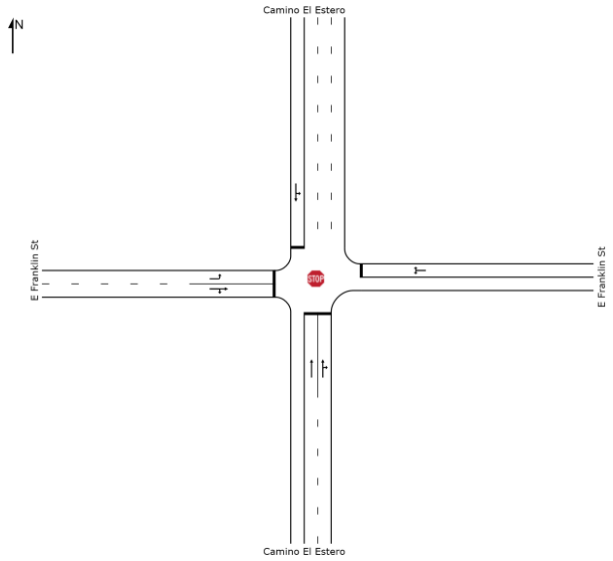
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

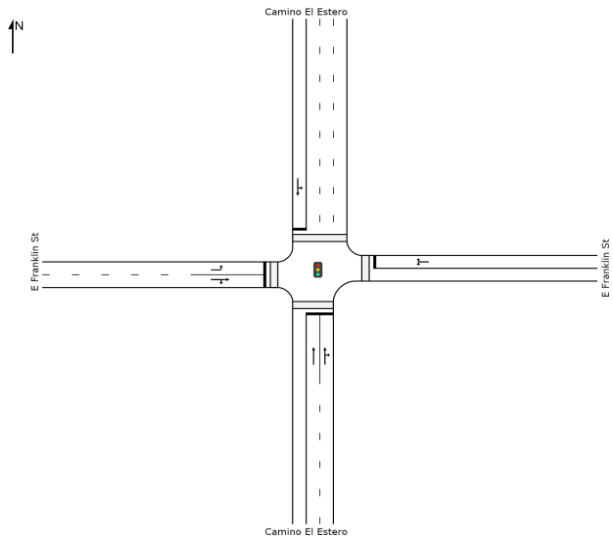


EXISTING INTERSECTION
ALL WAY STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	C	17.0	80 (EBL)
2040	-	-	-	C	18.7	148 (SBT)

NOTES:

1. AM data was not provided.

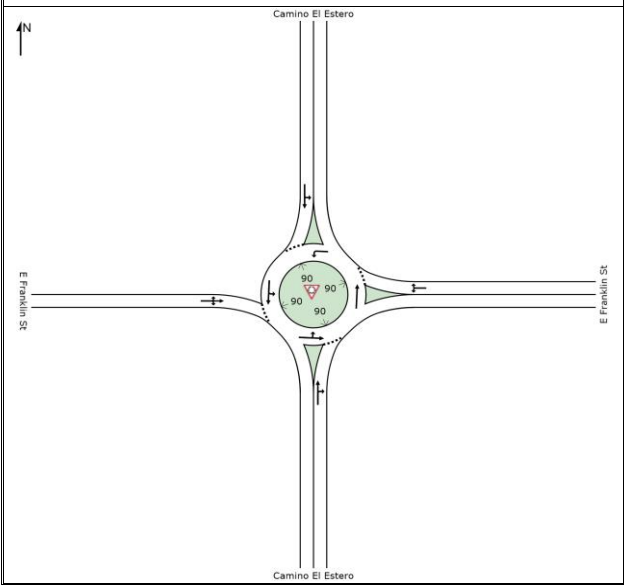


ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	B	10.3	164 (SB)
2040	-	-	-	B	10.7	174 (SBT)

NOTES:

1. AM data was not provided.



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	A	8.4	118 (EB)
2040	-	-	-	A	9.2	138 (EB)

NOTES:

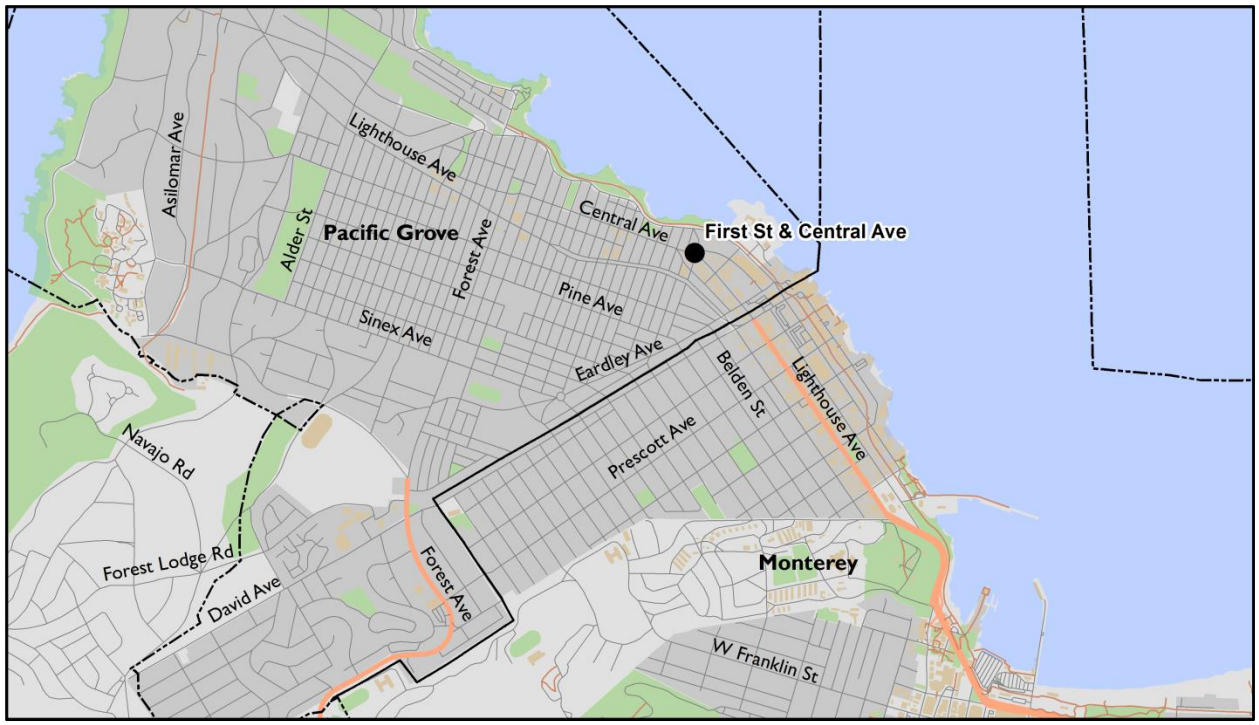
1. AM data was not provided.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 7:

City of Pacific Grove

Study Intersections:

- FIRST STREET AT CENTRAL AVENUE



CITY OF PACIFIC GROVE SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
First Street at Central Avenue	PCG-01

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Pacific Grove jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Pacific Grove, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
First Street at Central Avenue	**0.95**	

SUMMARY OF KEY PERFORMANCE MEASURES

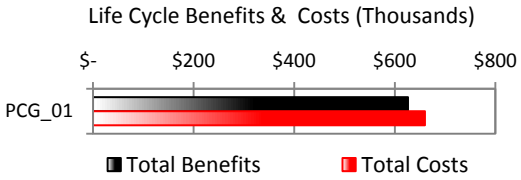
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



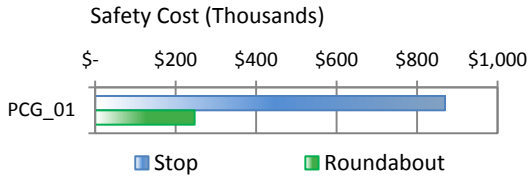
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

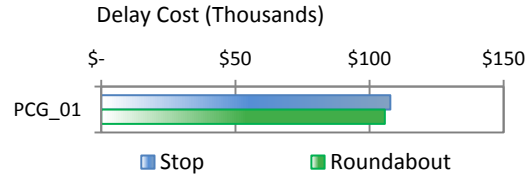


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety Study Intersection	**Preferred Control**
First Street at Central Avenue	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

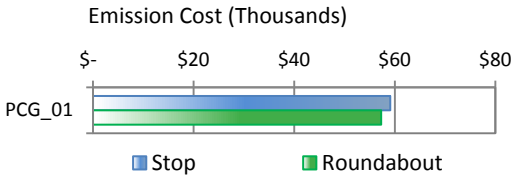


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay Study Intersection	**Preferred Control**
First Street at Central Avenue	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

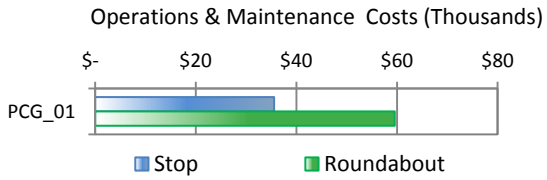
Emissions Study Intersection	Preferred Control
First Street at Central Avenue	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

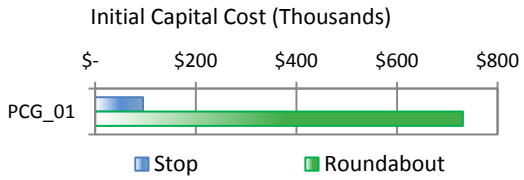


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
First Street at Central Avenue	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
First Street at Central Avenue	

Summary of B/C Performance Measures

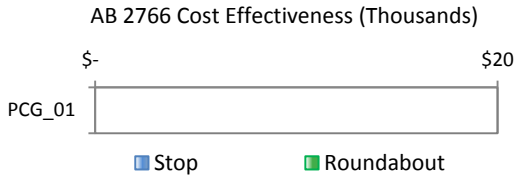
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
First Street at Central Avenue						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Pacific Grove.



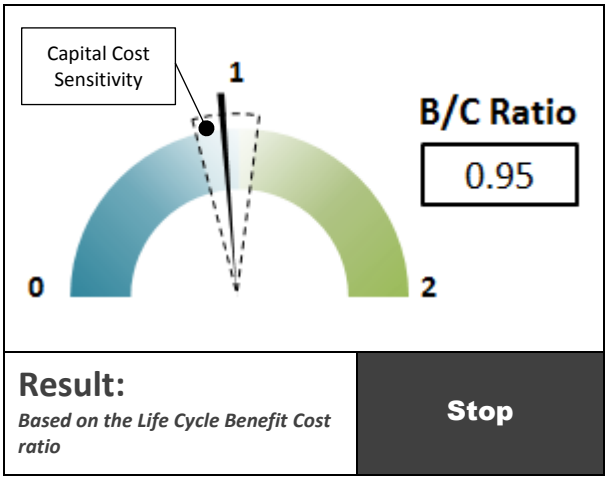
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
First Street at Central Avenue	NONE

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

FIRST STREET AT CENTRAL AVENUE



The Benefit Cost (B/C) ratio for this intersection is 0.95. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a stop.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 3.5 times higher than that of the roundabout. The cost of landscape maintenance was not included in the *Operations & Maintenance* calculation for the stop alternative. The total life cycle benefits of the roundabout are estimated at $630,000 when compared to a stop control.

Operationally, the roundabout and two-way stop control configurations are equally viable alternatives to serve forecast traffic. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number PCG-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

First Street at Central Avenue is controlled by stop signs on the minor approach.

Parcels in the immediate vicinity of the project are developed. The existing intersection is within City of Pacific Grove right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Right of Way constraint (all quadrants)
2. Intersection alignment / large open space
3. On-street parking (all legs)

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
First Street at Central Avenue	**First Street**	2 lane undivided with on street parking	Local	25	Serves residential uses Provides access to coastal recreation	No transit services provided	Sidewalk No crosswalk	No bike lanes provided
	Central Avenue	2 lane undivided with on street parking	Local	25	Serves residential, commercial/ retail uses	No transit services provided	Sidewalk No crosswalk	No bike lanes provided

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The study intersection is part of planned improvements on Central Avenue. The improvements at Central Avenue and First Street have been adopted as the stop control alternative for the intersection control evaluation.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Stop improvements	
Proposed Roundabout	

Design Year Traffic

Base year and design year traffic data was provided by the City. 2040 peak hour volumes were calculated using a 1% annual compound growth rate for all movements.

Two-Way Stop Control (Existing)

Demand is adequately served for the AM and PM peak hours under existing conditions.

Two-Way Stop Control with Traffic Calming

The proposed two-way stop control with traffic calming will provide the same capacity as the existing condition. Proposed improvements are targeted to reduce vehicle speeds on Central Avenue, improve intersection geometry, add pedestrian crosswalks, and reduce pedestrian crossing lengths at the intersection. Bike lanes and transit stops are not provided at this location therefore would not be impacted by the proposed traffic calming.

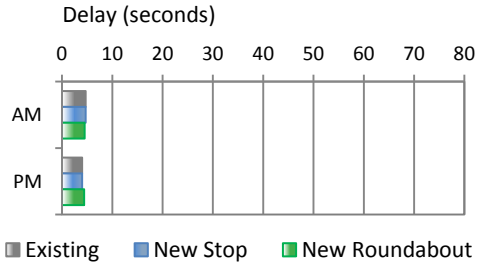
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures is forecast to operate with a similar amount of intersection delay as the two-way stop control alternative. The roundabout will provide pedestrian crossings on all legs and will have a traffic calming effect on all directions of travel. Bike lanes and transit stops are not provided at this location therefore would not be impacted by a one lane roundabout.

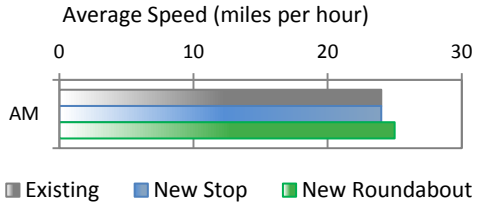
1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	STOP
Initial Capital Cost	STOP
Return on Investment	
Life Cycle B/C Ratio	STOP
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	NONE

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Preliminary engineering and additional site investigations.
-

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **PCG-01**
01/16

Intersection Cost Comparison

First Street at Central Avenue
Pacific Grove, California

Cost Performance Measure	Intersection Type					
	Roundabout			Two-Way Stop Control		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.07	$ 10,988	$ 171,651	0.34	$ 49,944	$ 780,234
Predicted PDO Crashes	0.47	$ 4,827	$ 75,405	0.56	$ 5,708	$ 89,176
Subtotal - Safety Costs	**-**	**$ 15,815**	**$ 247,056**	**-**	**$ 55,653**	**$ 869,409**
DELAY						
Delay to Persons in Vehicles (hours)	379	$ 4,066	$ 105,720	383	$ 4,145	$ 107,767
Subtotal - Delay Costs	-	**$ 4,066**	**$ 105,720**	-	**$ 4,145**	**$ 107,767**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ -	0
Cost of Power for Signal				-	$ -	0
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ -	0
Cost of Pavement Rehabilitation			$ 14,676			$ 26,483
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 59,553**	-	**$ 582**	**$ 35,572**
EMISSIONS						
Tons of ROG	0.08	$ 77	$ 1,196	0.08	$ 77	$1,196
Tons of NOX	0.25	$ 3,234	$ 50,519	0.26	$ 3,349	$52,323
Tons of PM10	0.0036	$ 357	$ 5,578	0.0036	$ 357	$5,578
Subtotal - Emissions Costs		**$ 3,667**	**$ 57,293**		**$ 3,783**	**$ 59,097**
INITIAL CAPITAL COSTS						
Construction Cost			$ 613,925			$ 75,000
Construction Cost - Structures			$ -			$ -
Capital Support			$ 117,000			$ 20,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 730,925**			**$ 95,000**
NET PRESENT VALUE			**$ 1,200,547**			**$ 1,166,845**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Two-Way Stop Control	
Safety Benefit of Roundabout	$622,353
Delay Reduction Benefit of Roundabout	$2,047
Emission Reduction Benefit of Roundabout	$1,804
Total Benefits	**$626,205**
COSTS - Roundabout compared to Two-Way Stop Control	
Added O&M Costs of a Roundabout	$23,982
Added Capital Costs of a Roundabout	$635,925
Total Costs	**$659,907**

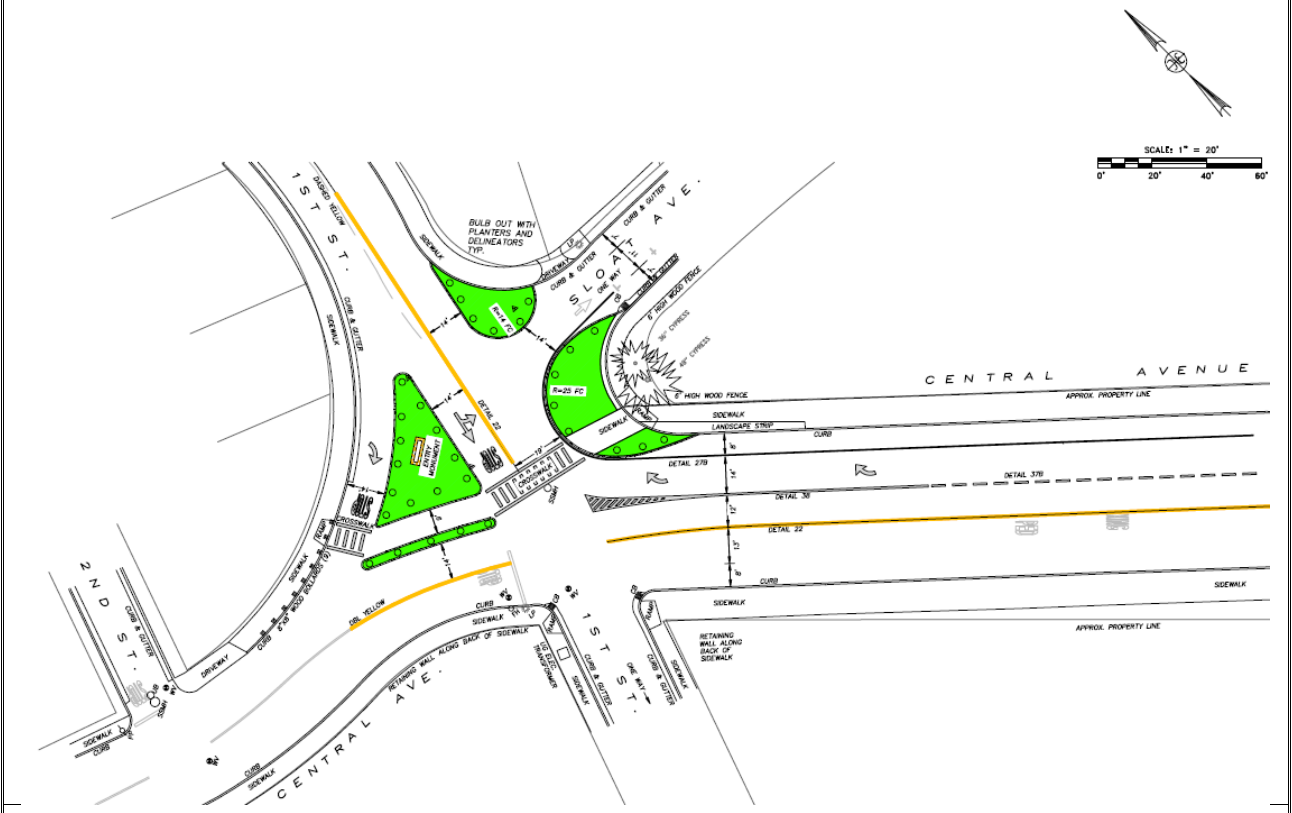
LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

0.95

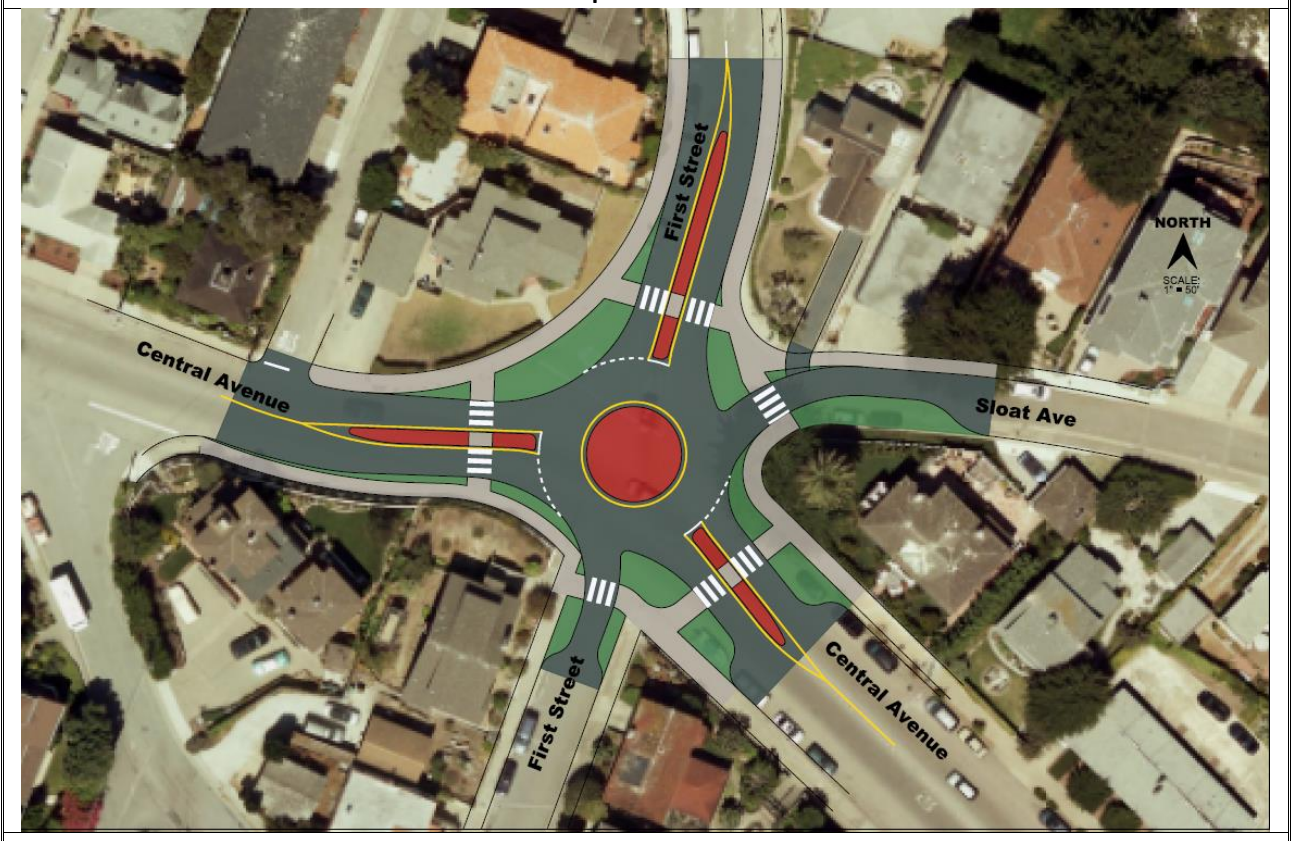
B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Two-Way Stop Control (vs. existing)**
Annual Emission Reduction (lb/year)	18	0
Cost Per Pound Per Life	$1,282.87	N/A - no emissions change
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$102,630**	**N/A - no emissions change**

Intersection Improvement Alternatives



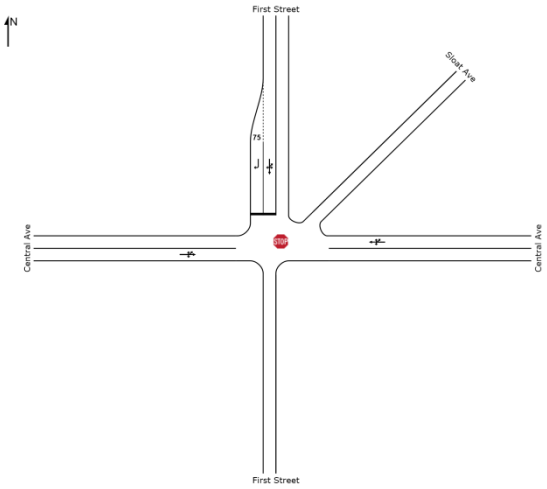
Stop Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

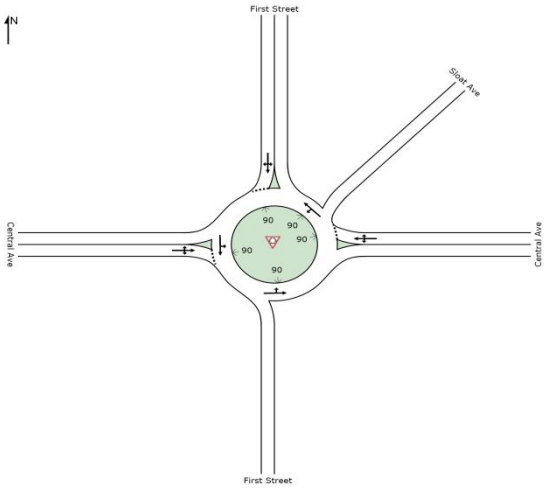


EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	9.3	0	A	9.4	25 (SBT)
2040	A	9.7	50 (EB)	A	9.8	50 (WB)

NOTES:

1. Intersection delay is reported for the worst movement.



ALTERNATIVE 1
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	4	25 (EB)	A	3.9	25 (WB)
2040	A	4.5	50 (EB)	A	4.4	50 (WB)

NOTES:

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 8:

City of Salinas

Study Intersections:

- WEST ALISAL STREET AT CAPITOL STREET
- EAST LAUREL DRIVE AT ST. EDWARDS STREET
- SHERWOOD DRIVE AT SHERWOOD PLACE

CITY OF SALINAS SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
East Alisal Street at Capitol Street	SAL-01
East Laurel Drive at St. Edwards Street	SAL-02
Sherwood Drive at Sherwood Place	SAL-03

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Salinas jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Salinas, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
East Alisal Street at Capitol Street	**1.58**	
East Laurel Drive at St. Edwards Street	**1.85**	
Sherwood Drive at Sherwood Place	**0.44**	

SUMMARY OF KEY PERFORMANCE MEASURES

As stated above, five performance metrics were evaluated at each study intersection to calculate the

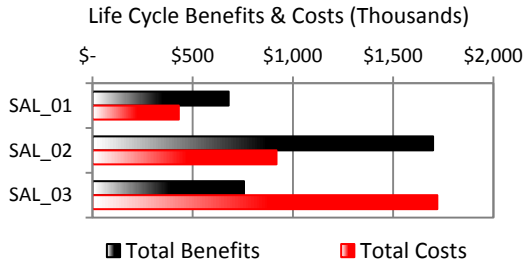
B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



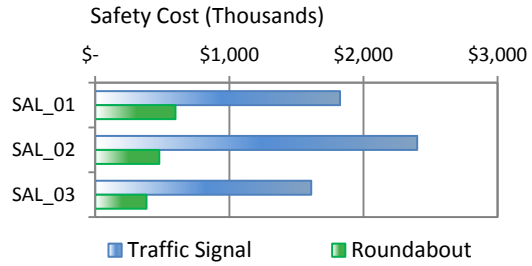
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

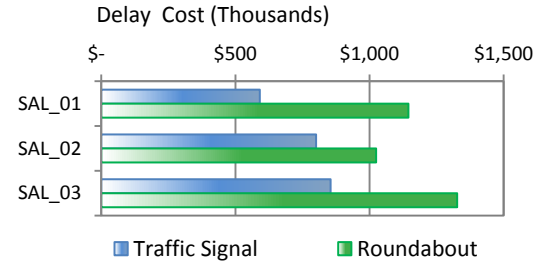


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
East Alisal Street at Capitol Street	
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

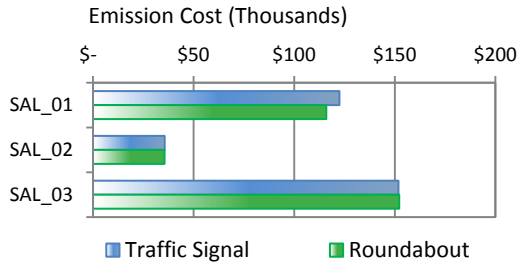


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay Study Intersection	Preferred Control
East Alisal Street at Capitol Street	
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

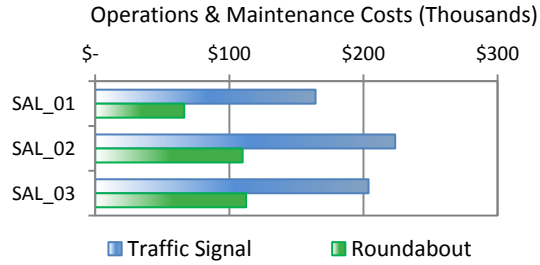
Emissions Study Intersection	Preferred Control
East Alisal Street at Capitol Street	
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

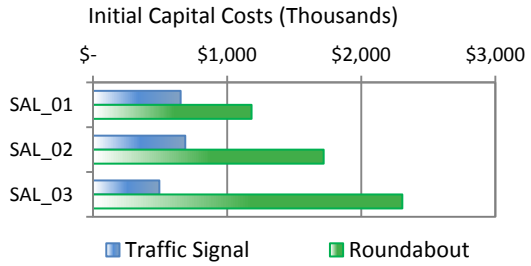


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
East Alisal Street at Capitol Street	
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
East Alisal Street at Capitol Street	
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	

Summary of B/C Performance Measures

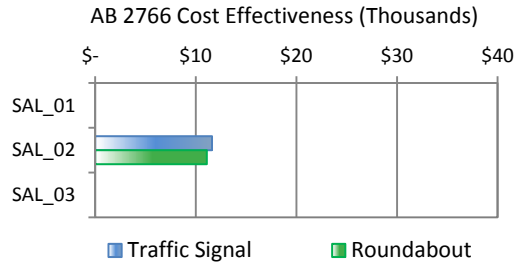
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	**Safety**	**Delay**	**Ops. & Maint.**	**Emission**	**Capital Cost**	**B/C**
East Alisal Street at Capitol Street						
East Laurel Drive at St. Edwards Street						
Sherwood Drive at Sherwood Place						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Salinas.



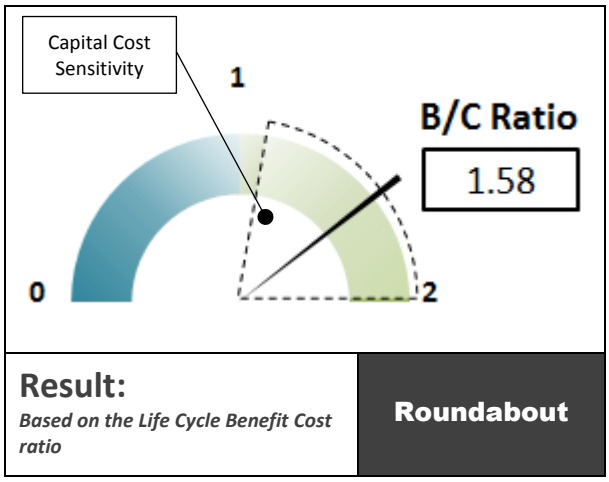
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness **Study Intersection**	**Preferred Control**
East Alisal Street at Capitol Street	NONE
East Laurel Drive at St. Edwards Street	
Sherwood Drive at Sherwood Place	NONE

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are equal to or greater than existing and do not provide a benefit.

WEST ALISAL STREET AT CAPITOL STREET



The Benefit Cost (B/C) ratio for West Alisal Street at Capitol Street is 1.58. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $1,400,000.

Noteworthy performance measures driving the B/C ratio are *safety and delay.* The estimated safety costs of the signal are 3 times higher than that of the roundabout. The estimated delay costs of the signal are 3 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $680,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $6,500 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic and will provide improved operations compared to the existing stop control. The existing stop control, or no project alternative, experiences significant delay on the minor street approaches and will continue to degrade as forecast demand exceeds capacity. The signal control alternative will provide improved operations compared to the existing stop control and the proposed roundabout control. However, as travel demand increases, vehicle queuing may affect operations at Riker Street to the west and Cayuga Street to the east for the signal and roundabout alternatives. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2035 design year. The year 2015 was assumed for the baseline "build" condition for a total 20 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number SAL-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
West Alisal Street at Capitol Street	**West Alisal Street (City of Salinas)**	4 lane undivided with on street parking	Local	25	Serves residential, business, institutional & commercial land uses	Service provided by Monterey-Salinas Transit lines 23, 25, & 82	Sidewalks Crosswalk on westerly leg (school crossing)	No bike lanes provided
	Capitol Street (City of Salinas)	2 lane undivided with on street parking	Local	25	Serves residential, business, institutional & commercial land uses	No transit services provided	Sidewalks Crosswalk on northerly leg (school crossing)	No bike lanes provided

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

West Alisal Street at Capitol Street is controlled by stop signs on the minor approach.

Parcels west of Capitol Street are developed with structures located near the existing back of sidewalk. Parcels east of Capitol Street are developed as surface parking lots. The existing intersection is within the City of Salinas right of way.

Existing design constraints at the study intersection include (see map for locations):

1. Single family residential
2. Multi-family residential
3. Visitor parking lot (Monterey County)
4. County permitted parking lot
5. Salinas Fire Department Station 1

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The West Alisal Street at Capital Street intersection is located within the Salinas Downtown Vibrancy Plan and the Marina-Salinas Multimodal Corridor Conceptual Plan.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop (Capitol Street)	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for the 2013 AM/PM peak hour and the 2035 AM/PM peak hour volumes were provided by the City of Salinas. 2015 volumes were assumed to be equal to 2013 peak hour volumes.

Stop Control (Existing)

With stop control, demand exceeds capacity for the AM peak hour under existing conditions. Northbound Capitol Street vehicles experience significant delay

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

while trying to cross or turn onto West Alisal Street. As demand increases to forecast 2035 peak hour volumes, southbound and northbound Capitol Street delay will continue to increase, resulting in failing operations. Additional capacity required to improve and maintain stop control operations is not feasible based on forecast demand.

Signal Control

With proposed signal control, West Alisal Street will be reduced to a single through, left-turn, and right-turn lane in each direction. Capitol Street approach and departure lanes will remain the same as existing. Vehicle demand will be adequately served for both peak periods under existing and future design years. However, vehicle queues on West Alisal Street are expected to extend beyond Riker Street and Cayuga Street.

The reduction in lanes will decrease crossing distance and reduce overall cycle length for the intersection. Bike lanes and transit stops are not provided at the intersection therefore signalization will not impact either facility.

Roundabout Control

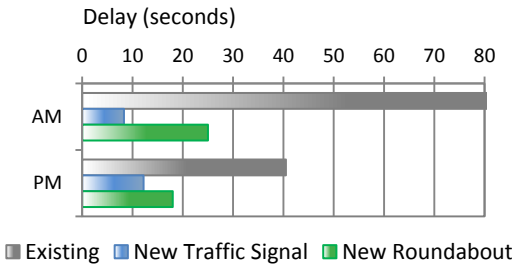
With roundabout control, a single lane roundabout with single lane approaches and departures will provide adequate capacity for both peak periods under existing and future design years. However, vehicle queues on West Alisal Street are expected to extend beyond Riker Street and Cayuga Street.

The proposed single lane roundabout will reduce the number of lanes pedestrians will cross at the intersection.

Crossing distances will be significantly reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes and transit stops are not provided at the intersection therefore the roundabout alternative will not impact either facility.

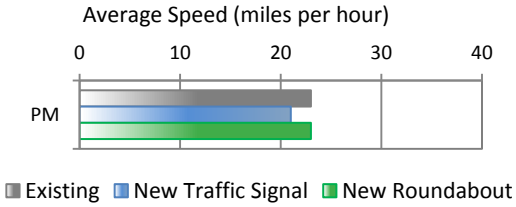
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	NONE

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- AM peak hour traffic data.
- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering, topographic survey of bridge and northwest quadrant, and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SAL-01**
01/16

Intersection Cost Comparison

West Alisal Street at Capitol Street
Salinas, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.21	$ 31,479	$ 427,811	0.80	$ 118,482	$ 1,610,206
Predicted PDO Crashes	1.23	$ 12,548	$ 170,532	1.55	$ 15,825	$ 215,067
Subtotal - Safety Costs	**-**	**$ 44,027**	**$ 598,343**	**-**	**$ 134,307**	**$ 1,825,273**
DELAY						
Delay to Persons in Vehicles (hours)	4919	$ 54,527	$ 1,145,077	2503	$ 28,149	$ 591,124
Subtotal - Delay Costs	-	**$ 54,527**	**$ 1,145,077**	-	**$ 28,149**	**$ 591,124**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 100	1,359
Cost of Power for Signal				-	$ 720	9,785
Cost of Illumination	6	$ 873	$ 11,859	4	$ 582	7,906
Cost of Landscaping Maintenance	-	$ 2,000	$ 27,181			
Cost of Signal Maintenance				-	$ 8,000	108,723
Cost of Pavement Rehabilitation			$ 27,349			$ 36,511
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 66,389**	-	**$ 9,402**	**$ 164,284**
EMISSIONS						
Tons of ROG	0.20	$ 191	$ 2,601	0.22	$ 211	$2,861
Tons of NOX	0.58	$ 7,537	$ 102,435	0.60	$ 7,797	$105,967
Tons of PM10	0.0081	$ 804	$ 10,920	0.0101	$ 1,004	$13,650
Subtotal - Emissions Costs		**$ 8,532**	**$ 115,956**		**$ 9,012**	**$ 122,478**
INITIAL CAPITAL COSTS						
Construction Cost			$ 992,975			$ 548,200
Construction Cost - Structures			$ -			$ -
Capital Support			$ 189,000			$ 105,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,181,975**			**$ 653,200**
NET PRESENT VALUE			**$ 3,107,740**			**$ 3,356,359**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,226,930
Delay Reduction Benefit of Roundabout	-$553,953
Emission Reduction Benefit of Roundabout	$6,522
Total Benefits	**$679,499**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$97,895
Added Capital Costs of a Roundabout	$528,775
Total Costs	**$430,880**

LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO

1.58

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	0	Emissions increase
Cost Per Pound Per Life	N/A - No emissions change	Emissions increase
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**N/A - No emissions change**	**Emissions increase**

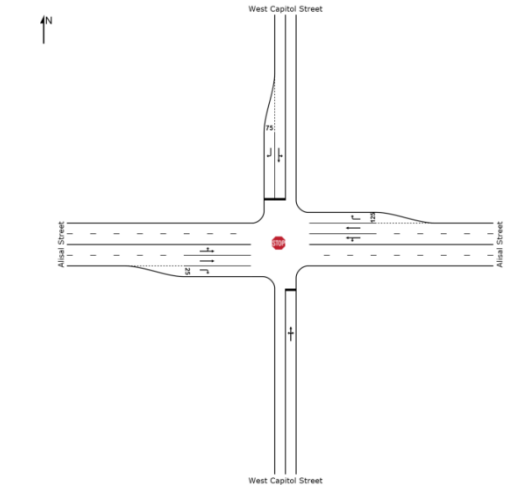
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

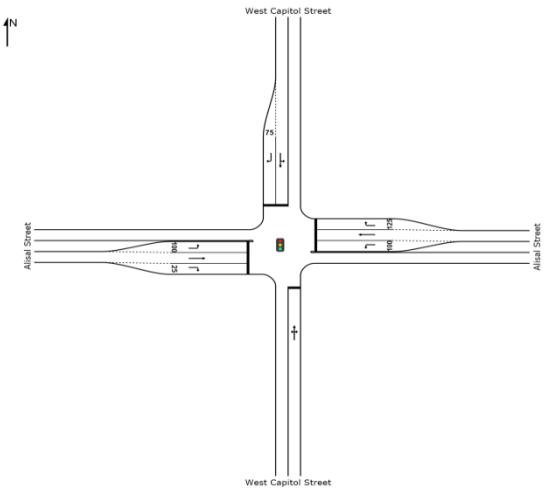


EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	E	40.2	53 (SBT)	C	24.8	58 (SBT)
2035	F	1147	243 (SBT)	F	350	255 (SBT)

NOTES:

1. AM data was not provided.

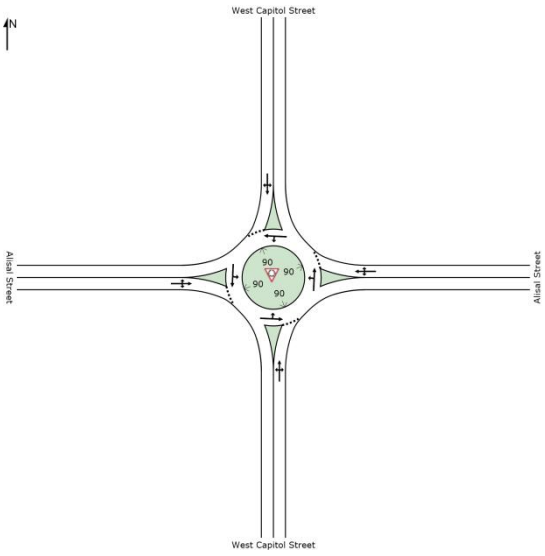


ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	A	5.0	121 (EBT)	A	5.9	144 (EBT)
2035	A	8.3	302 (EBT)	B	12.2	#464 (WBT)

NOTES:

1. EBL queue exceed available storage during 2035 AM peak.
2. EBT and WBT queues will exceed available storage during 2035 PM peak.



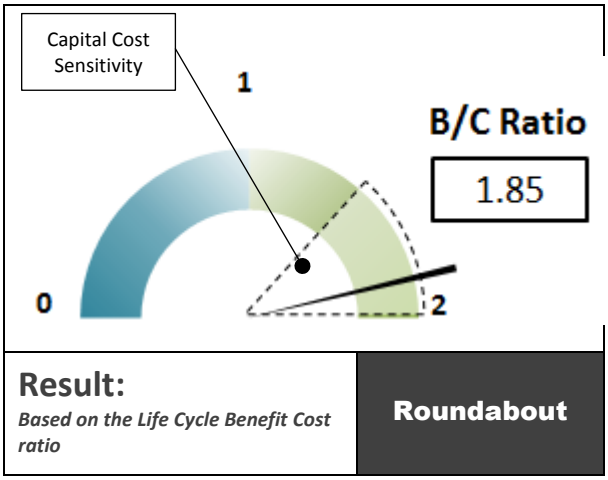
ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2013	A	9.2	144 (EB)	A	8.4	120 (EB)
2035	C	25.0	558 (EB)	C	18.0	354 (EB)

NOTES:

1. EB and WB queues will exceed available storage during 2035 AM and PM peak.

EAST LAUREL DRIVE AT ST. EDWARDS STREET



The Benefit Cost (B/C) ratio for East Laurel Drive at St. Edwards Street is 1.85. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection may be sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control may change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would reduce to 1.00 if initial capital costs for the construction of the roundabout exceed $2,500,000.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are 5 times higher than the estimated safety costs of the roundabout.

The total life cycle benefits of the roundabout are estimated at $1,700,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $6,500 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, both the roundabout and the signal alternatives are expected to improve intersection performance for existing and forecast traffic demand during peak AM and PM design year conditions. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number SAL-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

East Laurel Drive at St. Edwards Street is controlled by a side-stop on St. Edwards Street.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
East Laurel Drive at St. Edwards Street	**East Laurel Drive (City of Salinas)**	4-lane divided	Local	45	Serves residential, recreational, and agricultural land uses.	Service provided by Monterey-Salinas Transit Line 42. Stops located at intersection.	Sidewalk along west side, south of St. Edwards Street. No crosswalks.	Class II lanes north of St Edwards Street.
	St. Edwards Street (City of Salinas)	2-lane undivided	Local	25	Serves residential land uses.	No transit services provided.	Sidewalks are provided. No crosswalk.	None.

The southwest and southeast parcels are developed with residential structures. The easterly parcel is undeveloped, wooded, and provides an approximate 50 foot buffer to multi-unit residential structures that are accessible via North Sanborn Road.

The intersection is located in a cut-slope with westerly parcels approximately 10 feet above East Laurel Drive. Easterly parcels are approximately eight feet below East Laurel Drive.

The existing intersection is within the City of Salinas right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Single family residential
2. Undeveloped parcel (City of Salinas – to be verified)
3. Embankment
4. Transit stop

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

No planned improvements were identified.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop (St. Edwards Street)	
Proposed Road Improvements	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 AM and PM peak hour volumes was provided by the City. 2040 AM and PM peak hour volumes were calculated using a 2% annual compound growth rate for all movements.

Stop Control (Existing)

With stop control, demand exceeds capacity for both peak hours under existing conditions. Eastbound St. Edwards Street vehicles experience significant delay while trying to turn left onto East Laurel Drive. Additional capacity required to improve and maintain stop control operations is not feasible.

Signal Control

With proposed signal control, additional lanes are not required to achieve acceptable design year operations.

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

The existing northbound acceleration lane on East Laurel Drive would be removed and replaced with raised median and a pedestrian refuge.

The proposed signal is expected to improve intersection performance and provide sufficient capacity for both peak hours under future design year conditions.

Crosswalks are currently not stripped at the intersection. Crosswalks with the signal will provide safer movement for pedestrians. Bike lanes along East Laurel Drive will not be affected by signalization. Access to transit stops can be maintained with signalization.

Roundabout Control

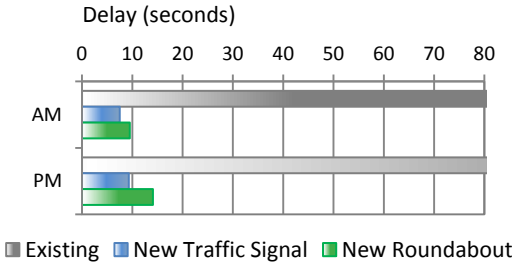
With roundabout control, a multi lane roundabout with two approach and departure lanes on East Laurel Drive, and a single approach and departure lane on St. Edwards Street will be required to serve forecast traffic. Pedestrian crossings with refuges are provided on each leg. Transit stops are improved, but shifted away from the intersection.

The proposed roundabout is expected to improve intersection performance and provide sufficient capacity for both peak hours under future design year conditions.

Crosswalks will be stripped as none are currently provided and provide midway refuge areas. Bike lanes along East Laurel Drive can be maintained with the proposed roundabout. Access to transit stops can be maintained with the proposed roundabout.

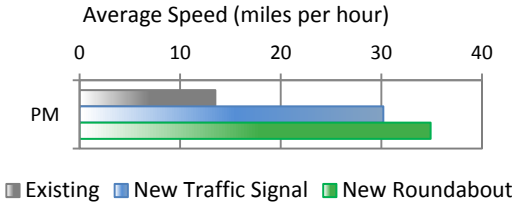
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Preliminary engineering with topographic and boundary surveys.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SAL-02**
01/16

Intersection Cost Comparison

East Laurel Drive at St. Edwards Street
Salinas, CA

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.12	$ 17,813	$ 278,276	0.92	$ 136,062	$ 2,125,570
Predicted PDO Crashes	1.25	$ 12,766	$ 199,434	1.73	$ 17,600	$ 274,943
Subtotal - Safety Costs	**-**	**$ 30,579**	**$ 477,710**	**-**	**$ 153,662**	**$ 2,400,514**
DELAY						
Delay to Persons in Vehicles (hours)	3905	$ 39,410	$ 1,024,664	2985	$ 30,804	$ 800,891
Subtotal - Delay Costs	-	**$ 39,410**	**$ 1,024,664**	-	**$ 30,804**	**$ 800,891**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 100	1,562
Cost of Power for Signal				-	$ 720	11,248
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 8,000	124,977
Cost of Pavement Rehabilitation			$ 65,036			$ 76,777
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 109,912**	-	**$ 9,402**	**$ 223,652**
EMISSIONS						
Tons of ROG	0.05	$ 46	$ 719	0.05	$ 51	$799
Tons of NOX	0.16	$ 2,015	$ 31,473	0.16	$ 2,015	$31,473
Tons of PM10	0.0022	$ 215	$ 3,355	0.0022	$ 215	$3,355
Subtotal - Emissions Costs		**$ 2,275**	**$ 35,548**		**$ 2,281**	**$ 35,628**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,318,620			$ 577,755
Construction Cost - Structures			$ 126,000			$ -
Capital Support			$ 275,000			$ 110,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,719,620**			**$ 687,755**
NET PRESENT VALUE			**$ 3,367,454**			**$ 4,148,439**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,922,804
Delay Reduction Benefit of Roundabout	-$223,773
Emission Reduction Benefit of Roundabout	$80
Total Benefits	**$1,699,111**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$113,740
Added Capital Costs of a Roundabout	$1,031,865
Total Costs	**$918,125**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

1.85

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	242	232
Cost Per Pound Per Life	$110.94	$116.10
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$11,094**	**$11,610**

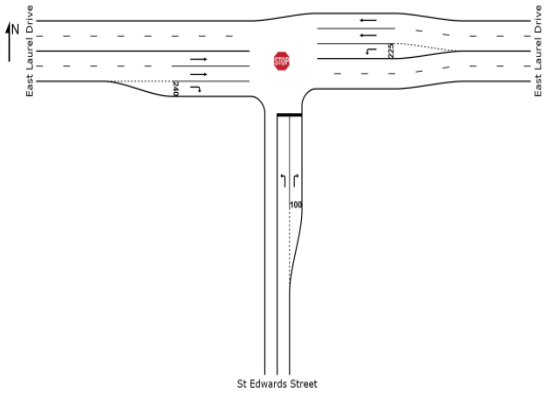
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

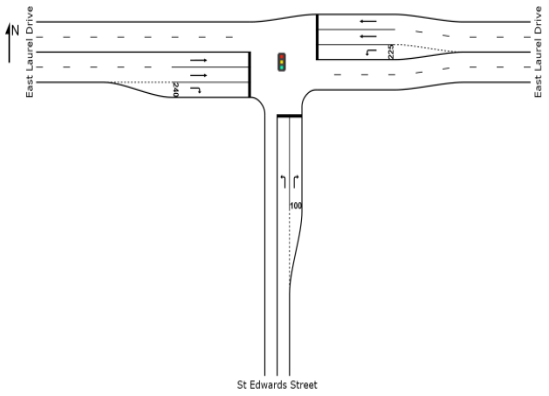
Intersection Control Alternative Summary



EXISTING INTERSECTION
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	E	45.9	88 (NBL)	F	168.9	188 (NBL)
2040	F	1014.9	460 (NBL)	F	3510.0	598 (NBL)

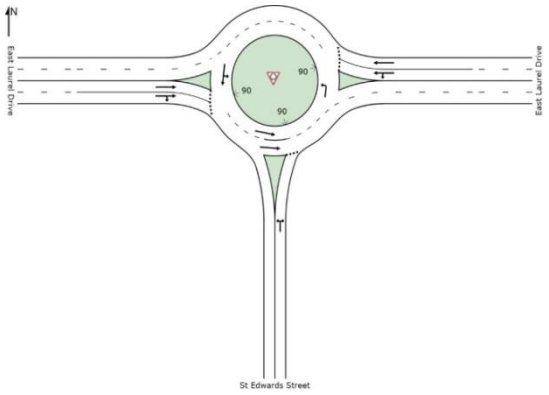
NOTES:



ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	5.8	127 (EBT)	A	6.1	168 (EBT)
2040	A	7.5	280 (EBT)	A	9.3	#470 (EBT)

NOTES:

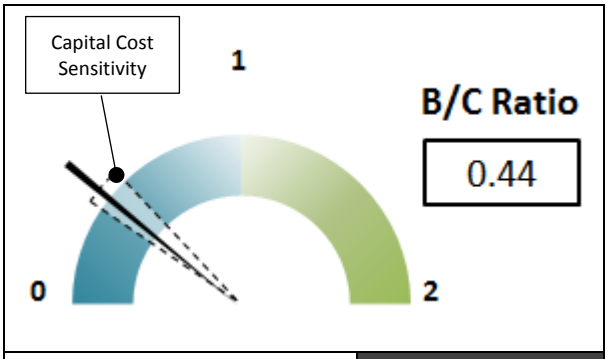


ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	5.6	49 (EB)	A	6.8	73 (EB)
2040	A	9.5	113 (EB)	B	14.1	206 (EB)

NOTES:

SHERWOOD DRIVE AT SHERWOOD PLACE



Result:
Based on the Life Cycle Benefit Cost ratio

Signal

The Benefit Cost (B/C) ratio for Sherwood Drive at Sherwood Place is 0.44. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Signal.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design. The B/C ratio would increase to 1.00 if initial capital costs for the construction of the roundabout do not exceed $1,340,000.

Safety is a notable performance metric driving the B/C Ratio. The estimated safety costs of the signal are over 4 times higher than that of the roundabout.

The total life cycle benefits of the roundabout are estimated at $760,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $6,500 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, both the roundabout and signal alternatives are expected to improve overall intersection operations. Compared to the roundabout alternative, the signal alternative is expected to provide superior operations during the forecast 2030 PM peak period.

The intersection evaluation was based on traffic operations for the 2030 design year. The year 2015 was assumed for the baseline "build" condition for a total 15 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number SAL-03 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Sherwood Drive at Sherwood Place intersection is controlled by a stop sign on Sherwood Place.

All parcels, except for the southeasterly parcel, are currently used for agriculture. The southeasterly parcel is a developed parking lot for Mt. Toro High School. The existing intersection is within the City of Salinas right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Sherwood Drive at Sherwood Place	**Sherwood Drive (City of Salinas)**	4 lane divided (two-way-left-turn-lane)	Local	45	Serves residential, institutional, industrial, & agricultural land uses	Service provided by Monterey-Salinas Transit Line 48 Transit stop at intersection.	Sidewalks are provided No crosswalks	Class II bike lanes
	Sherwood Place (City of Salinas)	2 lane undivided	Local	25	Serves institutional & agricultural land uses	No transit services provided.	Sidewalks on south side No crosswalk	No bike lanes provided

Existing design constraints and considerations identified by the City at the study intersection include (see map for locations):

1. Agriculture field
2. Mt. Toro High School
3. Pump station
4. Transit stop

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

No planned improvements were identified.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop (Sherwood Place)	
Proposed Signal Modification	
Proposed Roundabout	

Design Year Traffic

Base year 2014 and design year 2030 traffic data was provided by the City in the *Haciendas Phase III/IV Traffic Impact Analysis*, dated April 8, 2014, and prepared by Hatch Mott MacDonald. 2015 volumes were assumed to be equal to 2014 peak hour volumes.

Stop Control (Existing)

With stop control, demand is adequately served for both peak hours under existing conditions. Operations are expected to degrade as traffic increases towards 2030 forecasts. In 2030, demand is expected to exceed capacity. Westbound Sherwood Place vehicles are expected to experience significant delay while trying to turn left onto Sherwood Drive during both peak periods. Southbound Sherwood Drive left turning vehicles are expected to experience significant delay in the PM peak period. Additional capacity required to improve and maintain stop control operations is not feasible.

Signal Control

The proposed signal is expected to improve intersection performance and provide sufficient capacity for both peak hours under future design year conditions. The number of approach and departure lanes is expected to remain the same as existing.

Crosswalks are currently not stripped at the intersection. Crosswalks with the signal will provide safer movement for pedestrians. Bike lanes along

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Sherwood Drive will not be affected by signalization. Access to transit stops can be maintained with signalization.

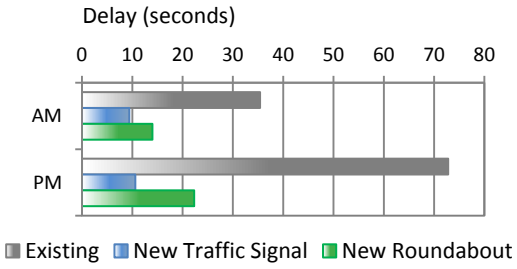
Roundabout Control

With roundabout control, a multi lane roundabout with two approach and departure lanes on Sherwood Drive, two approach lanes and a departure lane on Sherwood Place will be required to serve forecast traffic. Pedestrian crossings with refuges are provided on each leg. Consideration should be given to relocating the transit stop to the departure side of the roundabout, north of Sherwood Place.

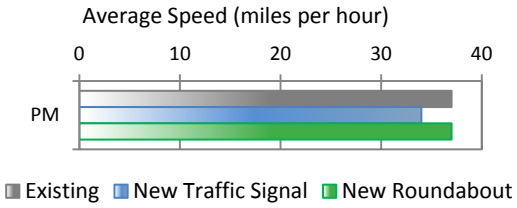
The proposed roundabout is expected to improve intersection performance and provide sufficient capacity for both peak hours under future design year conditions.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Preliminary engineering and additional site investigations
- Evaluation of pump station
- Development or extension of Sherwood Place west of Sherwood Drive.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SAL-03**
01/16

Intersection Cost Comparison

Sherwood Drive at Sherwood Place
Salinas, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.16	$ 24,183	$ 268,875	0.88	$ 129,391	$ 1,438,625
Predicted PDO Crashes	1.00	$ 10,206	$ 113,474	1.52	$ 15,463	$ 171,929
Subtotal - Safety Costs	**-**	**$ 34,389**	**$ 382,349**	**-**	**$ 144,855**	**$ 1,610,553**
DELAY						
Delay to Persons in Vehicles (hours)	6689	$ 82,925	$ 1,326,805	4216	$ 53,437	$ 854,999
Subtotal - Delay Costs	-	**$ 82,925**	**$ 1,326,805**	-	**$ 53,437**	**$ 854,999**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 100	1,112
Cost of Power for Signal				-	$ 720	8,005
Cost of Illumination	6	$ 873	$ 9,702	4	$ 582	6,468
Cost of Landscaping Maintenance	-	$ 2,000	$ 22,237			
Cost of Signal Maintenance				-	$ 8,000	88,947
Cost of Pavement Rehabilitation			$ 80,569			$ 99,240
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 112,508**	-	**$ 9,402**	**$ 203,772**
EMISSIONS						
Tons of ROG	0.26	$ 245	$ 2,721	0.22	$ 210	$2,332
Tons of NOX	0.96	$ 12,344	$ 137,246	0.96	$ 12,344	$137,246
Tons of PM10	0.0110	$ 1,101	$ 12,239	0.0110	$ 1,101	$12,239
Subtotal - Emissions Costs		**$ 13,690**	**$ 152,206**		**$ 13,655**	**$ 151,818**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,558,045			$ 415,545
Construction Cost - Structures			$ -			$ -
Capital Support			$ 297,000			$ 79,000
Right-of-Way			$ 451,000			$ -
Subtotal - Initial Capital Costs			**$ 2,306,045**			**$ 494,545**
NET PRESENT VALUE			**$ 4,279,914**			**$ 3,315,687**

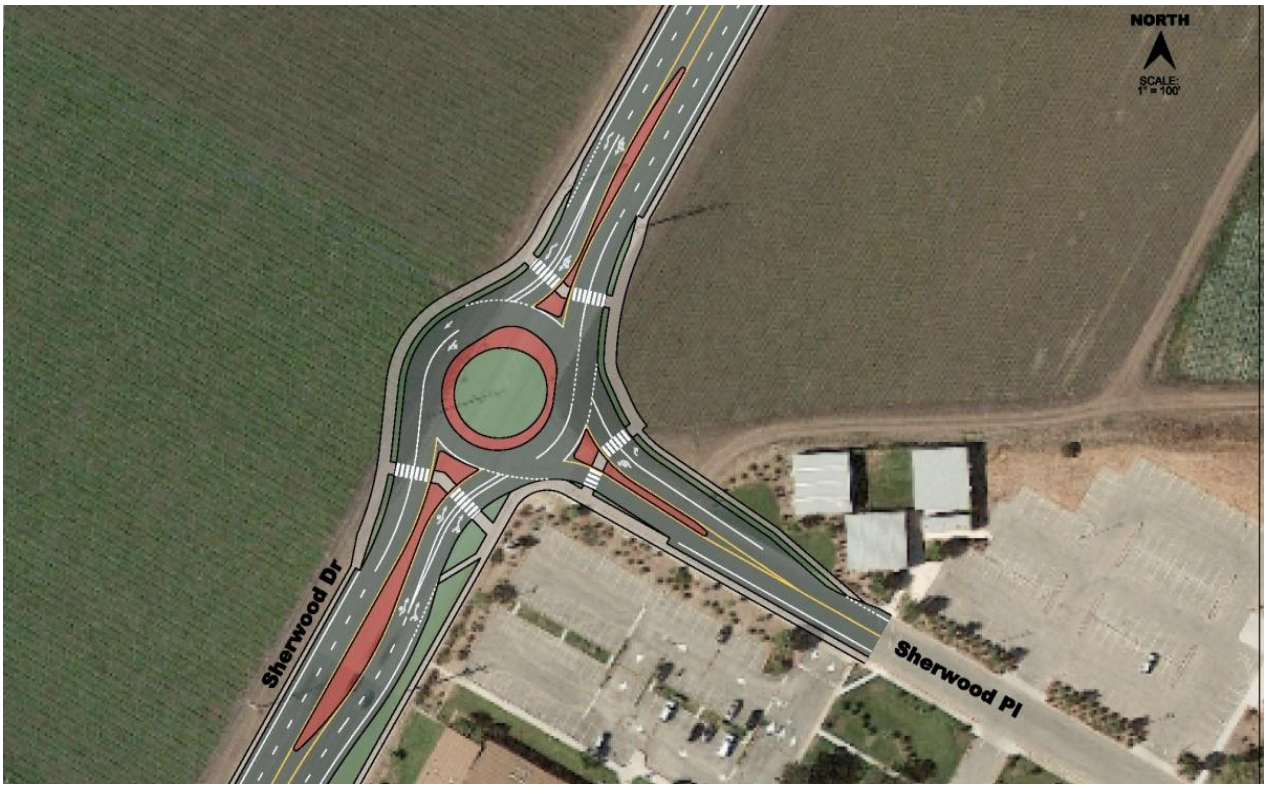
LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$1,228,204	**LIFE CYCLE (15 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	-$471,806	
Emission Reduction Benefit of Roundabout	-$389	
Total Benefits	**$756,009**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$91,264	**0.44**
Added Capital Costs of a Roundabout	$1,811,500	
Total Costs	**$1,720,236**	

B/C Preferred: Signal Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	Emissions increase	0
Cost Per Pound Per Life	Emissions increase	N/A - No emissions change
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**Emissions increase**	**N/A - No emissions change**

Intersection Improvement Alternatives

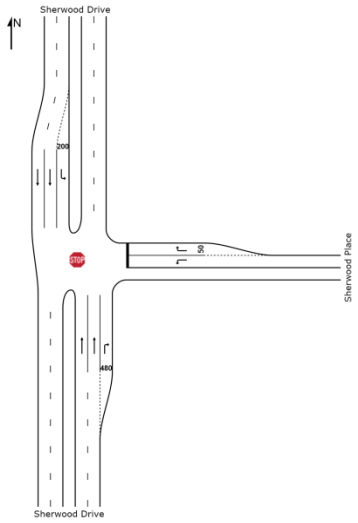
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

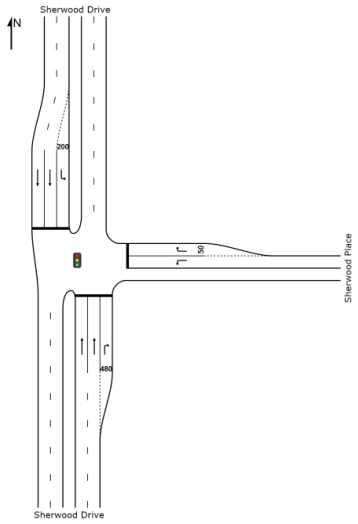
Intersection Control Alternative Summary



EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	C	18.8	23 (WBL)	D	27.5	15 (WBL)
2030	E	35.4	43 (WBL)	F	72.8	88 (WBL)

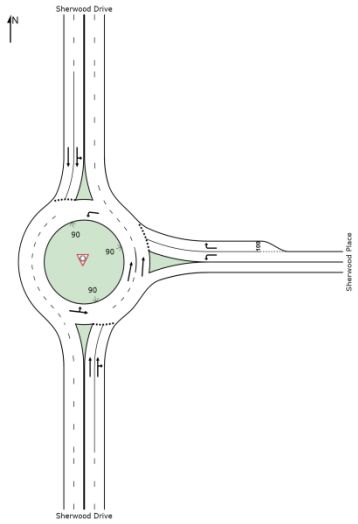
NOTES:



ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	7.9	#138 (SBL)	A	7.0	287 (NBT)
2030	A	9.4	287 (SBT)	B	10.6	705 (NBT)

NOTES:



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2014	A	7.9	126 (SB)	A	9.1	157 (NB)
2030	B	14.0	391 (SB)	C	22.3	747 (NB)

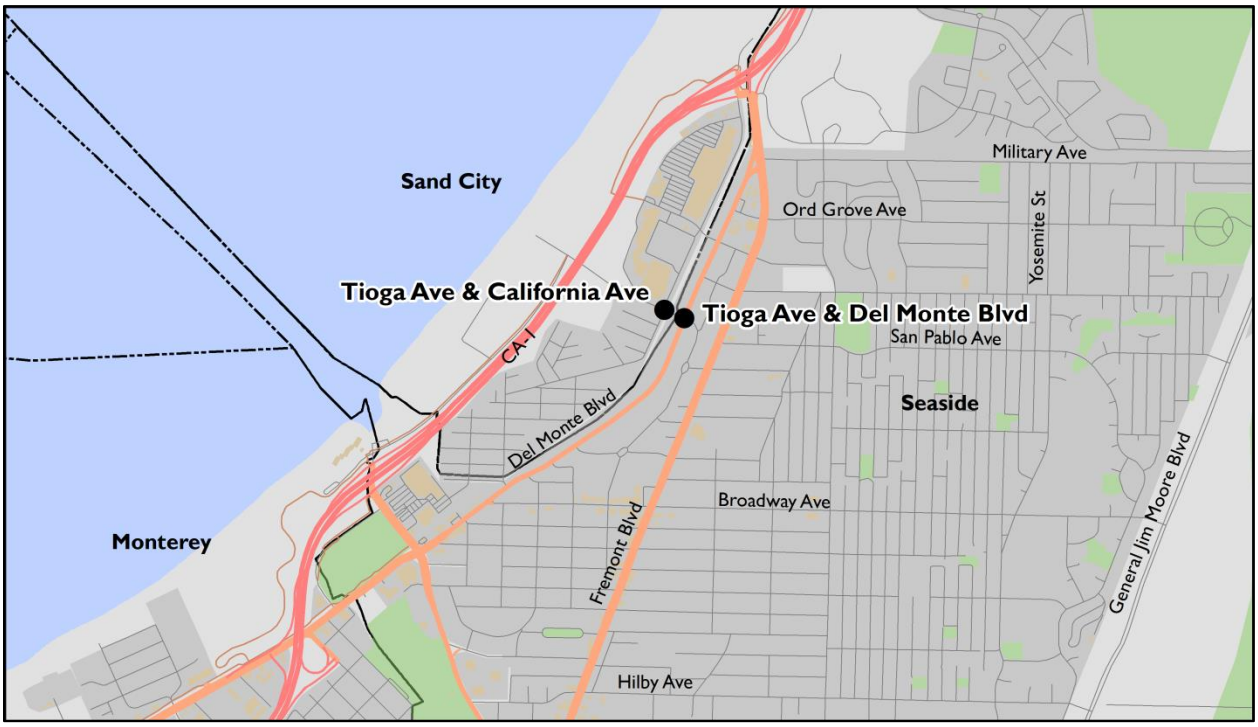
NOTES:

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 9:

Sand City

Study Intersections:

- TIOGA AVENUE AT CALIFORNIA AVENUE
- TIOGA AVENUE AT DEL MONTE BOULEVARD



SAND CITY SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Tioga Avenue at California Avenue	SCY-01
Tioga Avenue at Del Monte Boulevard	SCY-02

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under Sand City jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the Sand City, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Tioga Avenue at California Avenue	**1.33**	
Tioga Avenue at Del Monte Boulevard	**0.69**	

SUMMARY OF KEY PERFORMANCE MEASURES

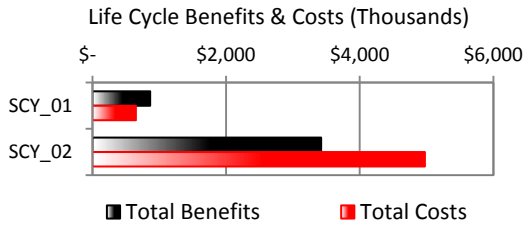
As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



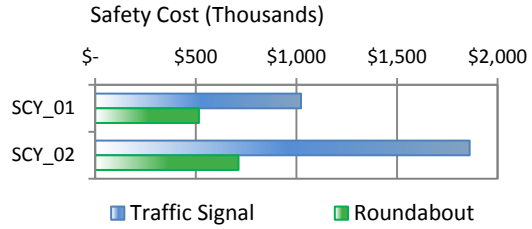
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

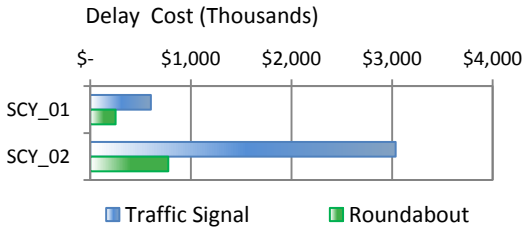


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

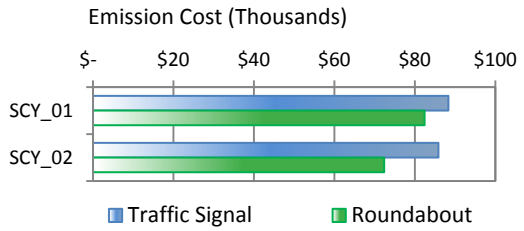


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

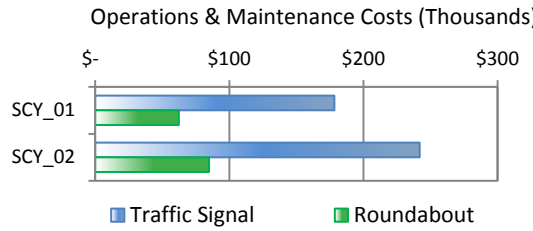
Emissions **Study Intersection**	**Preferred Control**
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

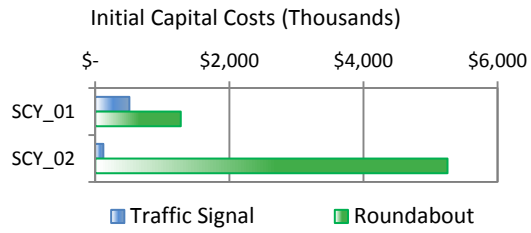


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance **Study Intersection**	**Preferred Control**
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

Summary of B/C Performance Measures

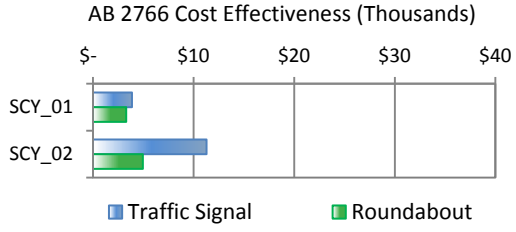
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	**Safety**	**Delay**	**Ops. & Maint.**	**Emission**	**Capital Cost**	**B/C**
Tioga Avenue at California Avenue						
Tioga Avenue at Del Monte Boulevard						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and Sand City.

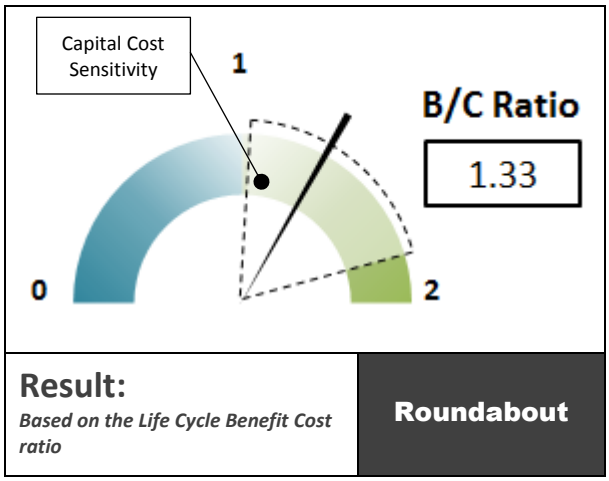


Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Tioga Avenue at California Avenue	
Tioga Avenue at Del Monte Boulevard	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

TIOGA AVENUE AT CALIFORNIA AVENUE



The Benefit Cost (B/C) Ratio for this intersection is 1.33. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C Ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C Ratio's sensitivity to estimated capital costs, the preferred intersection control type is may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

The total life cycle benefits of the roundabout are estimated at $860,000 when compared to a traffic signal..

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, is at capacity with westbound queues exceeding available storage during the pm peak hour. Queues are expected to increase over time with delay degrading to an LOS E during the pm peak hour. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration. Any improvements at this intersection should be coordinated with improvements at the Tioga Avenue / Del Monte Boulevard intersection.

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C Ratio.

Refer to the Intersection Cost Comparison for intersection Number SCY-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Tioga Avenue at California Avenue is controlled by stop signs on all approaches.

Parcels in the immediate vicinity of the project are developed with dwelling set-backs exceeding 100 feet from the existing edge of pavement. The Monterey Peninsula Fixed Guideway Corridor is east of the intersection. The existing intersection is within Sand City right of way.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Tioga Avenue at California Avenue	**Tioga Avenue**	2 lane with on street parking along west leg	Urban	25	Serves commercial & industrial land uses Provides coastal access	No transit services provided	Sidewalks Crosswalk on westerly leg	No bike lanes provided
	California Avenue	2 lane with on street parking	Urban	25	Serves commercial & industrial land uses North leg: driveway	No transit services provided	Sidewalk limited to east side of south leg Crosswalk on both legs	No bike lanes provided

Existing design constraints at the study intersection include (see map for locations):

1. Potential right of way constraint
2. Intersection separation with Del Monte Boulevard
3. At-grade crossing provision for future Monterey Peninsula Fixed Guideway

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The 2012 Monterey Peninsula Fixed Guideway Study prepared by TAMC identifies the existing rail corridor east of the intersection as the preferred alignment for a future light rail or bus rapid transit corridor.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

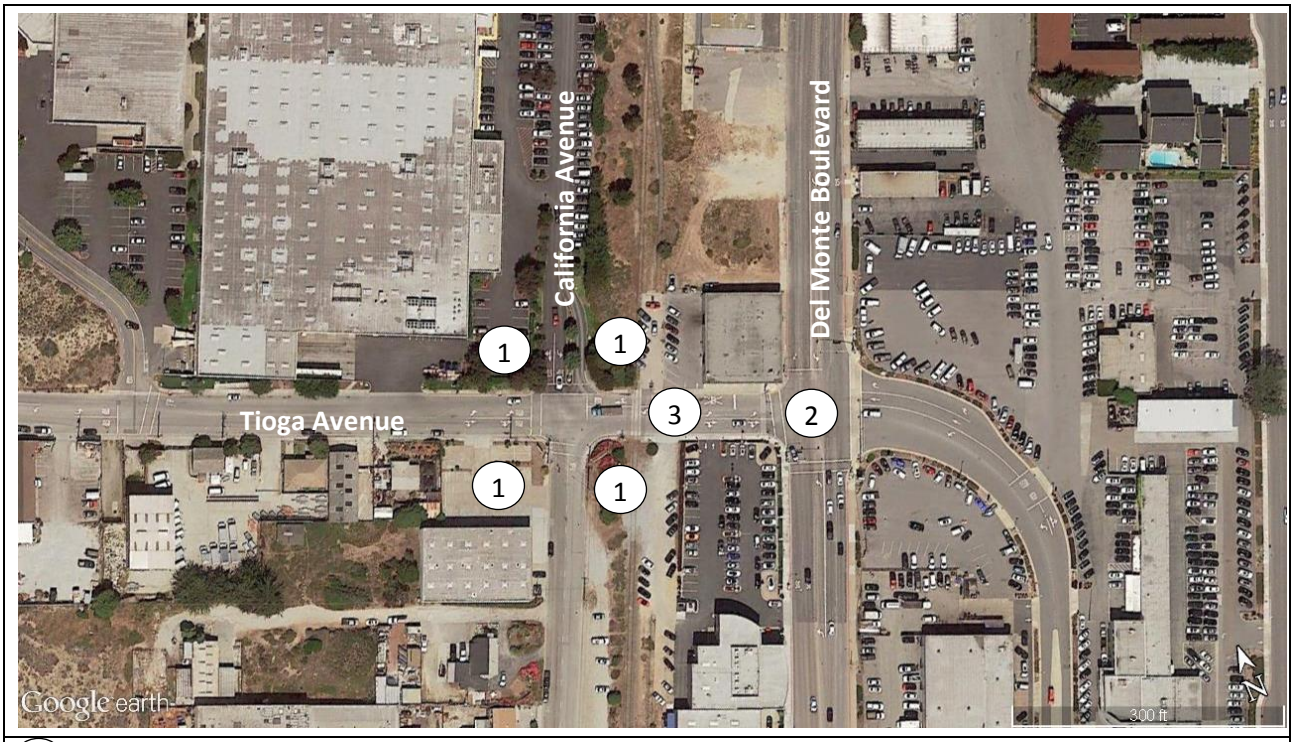
Traffic data for 2012 AM and PM peak hour volumes was provided by the City. Design year 2040 peak hour volumes were calculated with an assumed annual growth rate of 2%.

Stop Control (Existing)

With stop control, demand exceeds available vehicle storage capacity for the pm peak hour under existing conditions. Additional capacity required to improve stop control operations is not feasible based on forecast demand and project constraints.

Signal Control

With signal control, the basic lane configurations existing today would remain. The proposed signal would require coordination with the signal at Del Monte Boulevard to mitigate queuing between intersections. It is expected that traffic signal control



1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

would improve intersection performance for the pm peak period for existing and design year demand. However, southbound queues for left turning vehicles are expected to exceed available storage during the pm peak period.

No physical changes are proposed to the existing intersection therefore there will be no impacts to pedestrian facilities. Bike lanes and transit stops are not provided.

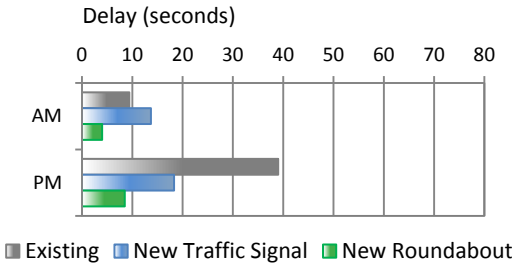
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for both peak periods under existing and design year conditions.

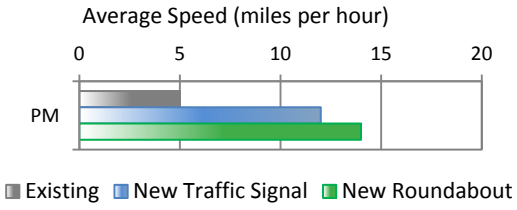
Crosswalks will be improved and provide midway refuge areas. Bike lanes and transit stops are not provided at the intersection therefore the roundabout alternative will not impact either facility.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Operations and coordination of signal and active warning device infrastructure needed for future light rail transit line.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SCY_01**
01/16

Intersection Cost Comparison

Tioga Avenue at California Avenue
Sand City, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.17	$ 25,757	$ 402,373	0.39	$ 57,237	$ 894,163
Predicted PDO Crashes	0.71	$ 7,243	$ 113,145	0.81	$ 8,239	$ 128,707
Subtotal - Safety Costs	**-**	**$ 32,999**	**$ 515,519**	**-**	**$ 65,476**	**$ 1,022,870**
DELAY						
Delay to Persons in Vehicles (hours)	923	$ 9,695	$ 252,061	2198	$ 23,182	$ 602,726
Subtotal - Delay Costs	-	**$ 9,695**	**$ 252,061**	-	**$ 23,182**	**$ 602,726**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 17,452			$ 21,100
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 62,329**	-	**$ 10,063**	**$ 178,312**
EMISSIONS						
Tons of ROG	0.17	$ 162	$ 2,537	0.19	$ 182	$2,836
Tons of NOX	0.34	$ 4,410	$ 68,900	0.36	$ 4,670	$72,953
Tons of PM10	0.0070	$ 702	$ 10,963	0.0080	$ 802	$12,530
Subtotal - Emissions Costs		**$ 5,275**	**$ 82,401**		**$ 5,653**	**$ 88,318**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,004,675			$ 427,500
Construction Cost - Structures			$ -			$ -
Capital Support			$ 191,000			$ 82,000
Right-of-Way			$ 80,000			$ -
Subtotal - Initial Capital Costs			**$ 1,275,675**			**$ 509,500**
NET PRESENT VALUE			**$ 2,187,984**			**$ 2,401,727**

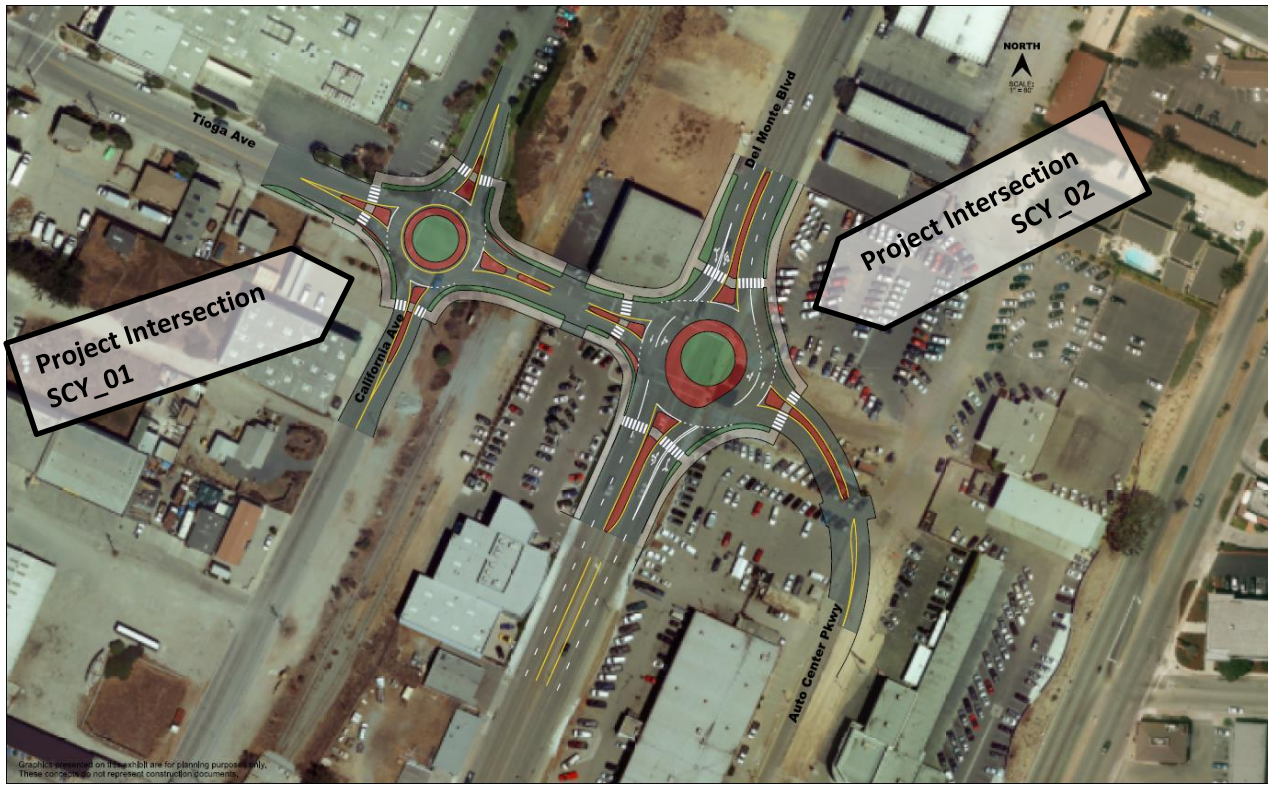
LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$507,352	**LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	$350,665	
Emission Reduction Benefit of Roundabout	$5,918	
Total Benefits	**$863,934**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$115,983	**1.33**
Added Capital Costs of a Roundabout	$766,175	
Total Costs	**$650,192**	

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	557	475
Cost Per Pound Per Life	$41.23	$48.40
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$3,299**	**$3,872**

Intersection Improvement Alternatives

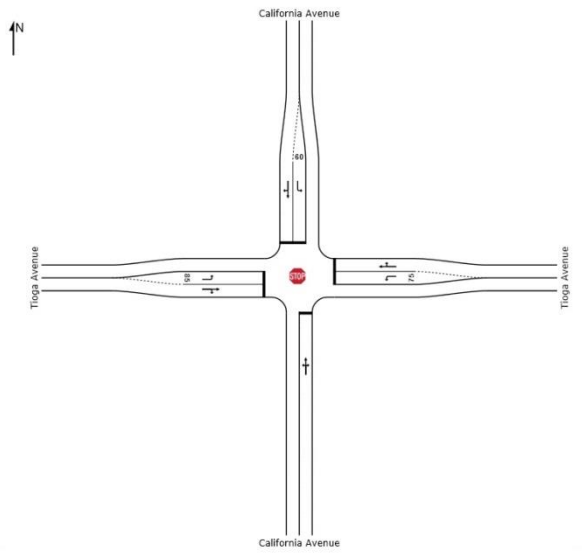
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

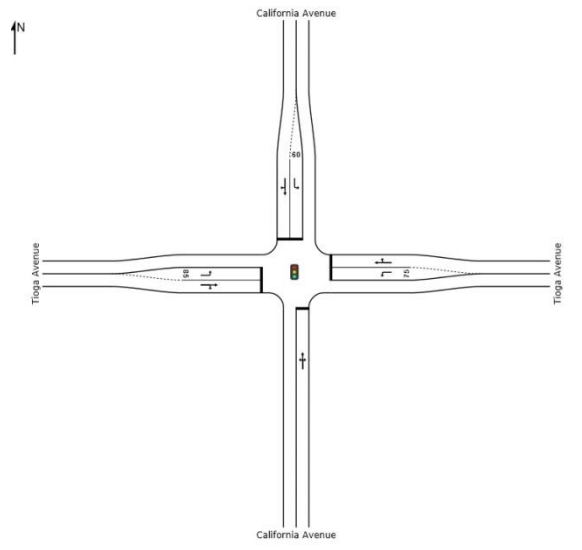
Intersection Control Alternative Summary



EXISTING INTERSECTION
ALL WAY STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	A	8.3	10 NBT)	C	24.3	270 (WBT)
2040	A	9.4	20 (NBT)	E	39.0	353 (WBT)

NOTES:
1. SBL queues exceed capacity during 2040 p.m. peak hour.
2. WB queues exceed capacity during 2012 and 2040 p.m. peak hours.

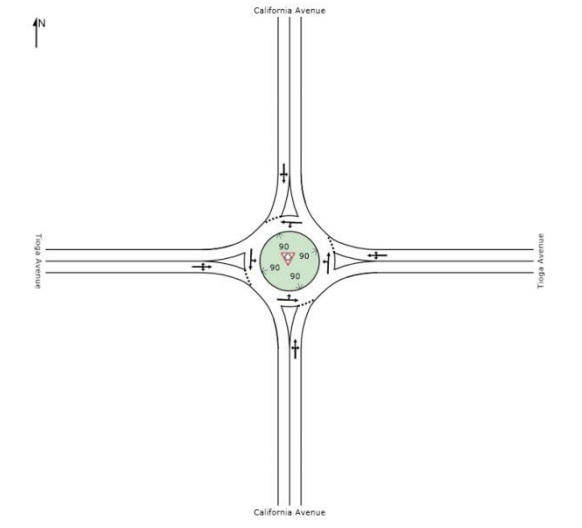


ALTERNATIVE 1
SIGNAL WITH IMPROVEMENTS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	12.3	33 (NBT)	B	15.2	122 (SBL)
2040	B	13.7	57 (WBL)	B	18.3	#226 (SBL)

NOTES:

1. SBL queues exceed capacity during 2040 p.m. peak hour
2. Assumes signal coordination with project intersection SCY_02

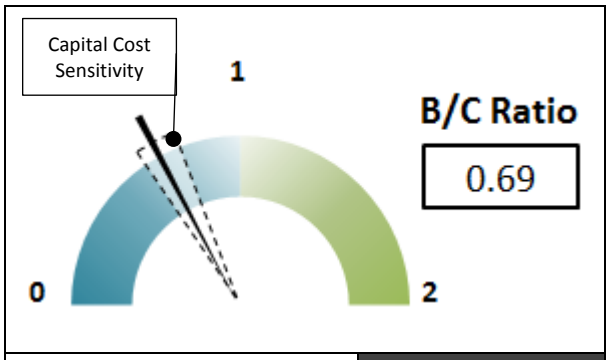


ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	A	5.0	41 (WB)	A	6.2	91 (WB)
2040	A	4.0	23 (WB)	A	8.5	145 (WB)

NOTES:

TIOGA AVENUE AT DEL MONTE BOULEVARD



Result: *Based on the Life Cycle Benefit Cost ratio*	**Signal Modification**

The Benefit Cost (B/C) ratio for this intersection is 0.69. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a signal modification.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs, especially right of way. Right of way costs are estimated to account for nearly half of the estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety, delay, and *right of way* are notable performance metrics driving the B/C Ratio. The estimated safety costs of the signal are 2 times higher than that of the roundabout. The estimated delay costs of the signal are 3.5 times higher than that of the roundabout. The estimated initial capital costs of the roundabout are 30 times higher than that of the signal. The total life cycle benefits of the roundabout are estimated at $3,420,000. The total life cycle benefit includes an estimated $7,200 in reduced operations and maintenance costs when compared to a traffic signal. The estimated right of way costs are $2,340,000 for construction of the roundabout alternative.

Operationally, the roundabout configuration is a superior alternative to serve forecast traffic. The existing signal control, or no project alternative, is near capacity in the PM peak hour with northbound left turn queues exceeding available storage. The proposed signal alternative is limited to modification of the signal timing. Modifications assume construction of a signal at study intersection SCY_01, Tioga Avenue at California Avenue. With the proposed signal modifications, an overall reduction in delay is expected. However, available storage for queued vehicles will be insufficient to meet demand in the am and pm peak periods. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Tioga Avenue at Del Monte Boulevard	**Tioga Avenue (west) / The Mall (east)**	2 lane undivided	Urban	25	Serves commercial & industrial land uses Provides coastal access west	No transit services provided	Sidewalks Crosswalk on both legs	No bike lanes provided
	Del Monte Boulevard	4 lanes with two-way-left-turn-lane and on street parking	Urban	35	Commercial corridor Alternate, parallel route to SR 1	Service provided by Monterey-Salinas Transit for Lines 8, 10, 18, 20, & 55 Stop at intersection	Sidewalks Crosswalk on south leg	No bike lanes provided

The intersection evaluation was based on traffic operations for the 2040 design year. The year 2015 was assumed for the baseline "build" condition for a total 25 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number SCY-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Tioga Avenue at Del Monte Boulevard is controlled by a traffic signal.

Parcels in the immediate vicinity of the project are developed. A commercial building with zero set-back is located at the northwest corner. The remaining corner parcels are frontage for car dealerships. The existing intersection is within Sand City right of way.

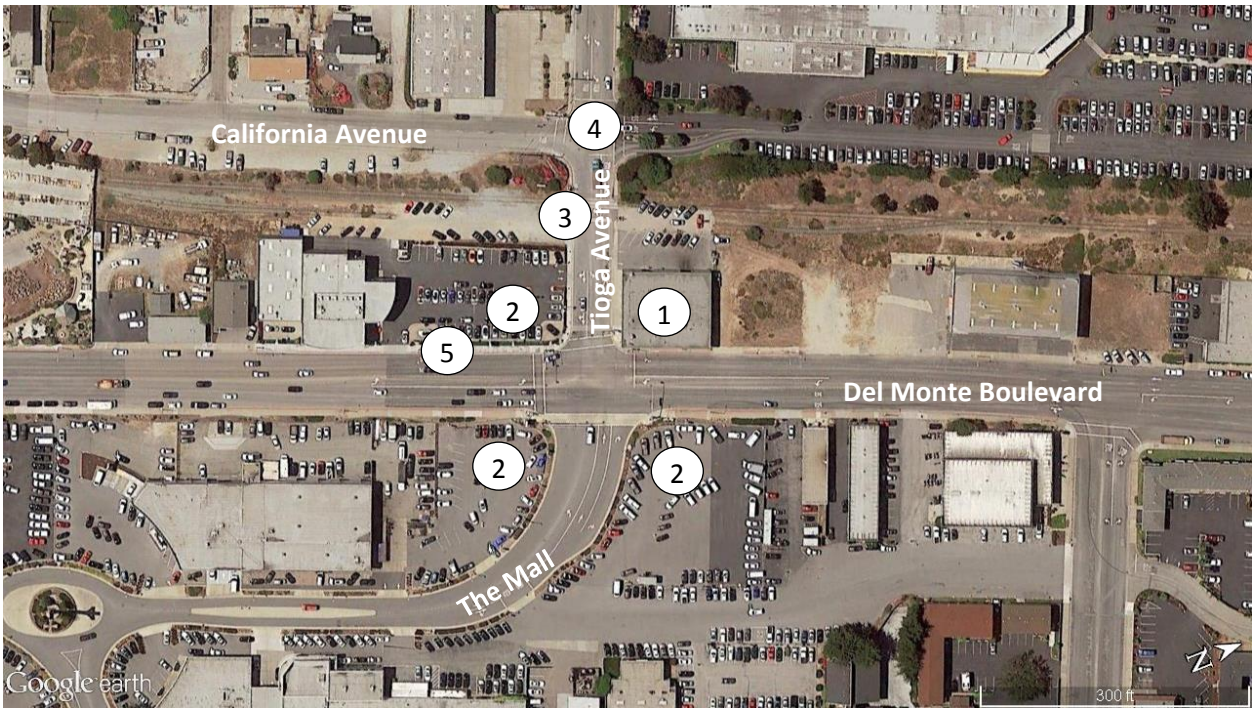
Existing design constraints and considerations at the study intersection include (see map for locations):

1. Commercial building
2. Car dealership
3. At-grade crossing provision for future Monterey Peninsula Fixed Guideway
4. Intersection separation with California Avenue
5. Transit stop

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The 2012 Monterey Peninsula Fixed Guideway Study prepared by TAMC identifies the existing rail corridor east of the intersection as the preferred alignment for a future light rail transit corridor.



(1) Refer to the Existing Conditions section on the previous page for description of the design constraint.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2012 AM and PM peak hour volumes was provided by the City. Design year 2040 peak hour volumes were calculated with an assumed annual growth rate of 2%.

Signal Control (Existing)

The existing signal control, or no project alternative, is near capacity in the PM peak hour with northbound left turn queues exceeding available storage.

Signal Control – Signal Timing Modifications

With signal control, the proposed traffic signal improvements at Tioga Avenue and California Avenue described in SCY_01 are assumed to exist. The proposed signal timing modifications on Tioga Avenue at Del Monte Boulevard are coordinated with improvements at California Avenue. As a result, the proposed signal timing modifications provide a reduction in vehicle delay at Del Monte Boulevard. However, vehicle queuing demand will exceed available storage capacity for southbound traffic during the am and pm peak hours and for northbound traffic during the pm peak hour.

It should be noted that the signal control alternative was limited in scope to signal timing modifications. Capacity improvements needed to mitigate vehicle queuing deficiencies will likely require acquisition of right of way, widening of Tioga Avenue, and additional improvements at California Avenue.

No physical changes are proposed to the existing intersection therefore there will be no impacts to pedestrian facilities and transit stops. Bike lanes are not provided.

Roundabout Control

With roundabout control, two approach and departure lanes are required on Del Monte Boulevard for the northbound and southbound directions. Based on design year traffic assumptions, it is unlikely that a road diet with fewer lanes on Del Monte Boulevard can be applied at this location.

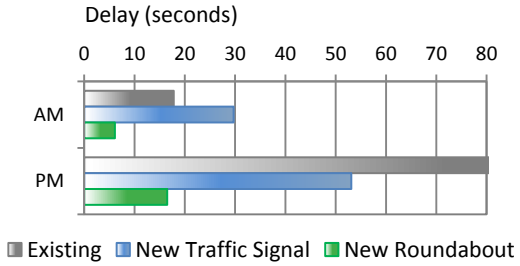
Compared to the proposed signal alternative, the roundabout improvements provide a superior form of traffic control. However, the roundabout will likely require right of way acquisition in all four quadrants.

The multi-lane roundabout is expected to perform below capacity for both peak hours under future design year conditions.

Crosswalks will be improved and provide midway refuge areas. Bike lanes are not provided at the intersection therefore the roundabout alternative will not impact bike access. Access to transit stops can be maintained with the proposed roundabout.

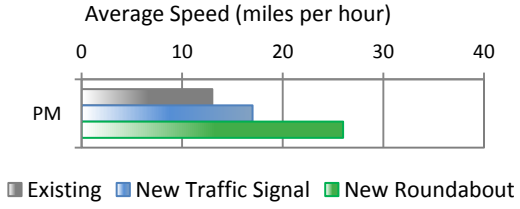
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to

the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Forecast design year traffic volumes at the study intersection.
- Operations and coordination of signal and active warning device infrastructure needed for future light rail transit line.
- Refinement of potential right of way acquisition costs.
- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SCY_02**
01/16

Intersection Cost Comparison

Tioga Avenue at Del Monte Boulevard
Sand City, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.21	$ 30,490	$ 476,316	0.71	$ 105,138	$ 1,642,469
Predicted PDO Crashes	1.48	$ 15,105	$ 235,976	1.37	$ 13,989	$ 218,534
Subtotal - Safety Costs	**-**	**$ 45,595**	**$ 712,292**	**-**	**$ 119,126**	**$ 1,861,003**
DELAY						
Delay to Persons in Vehicles (hours)	2970	$ 29,833	$ 775,650	11330	$ 116,767	$ 3,035,940
Subtotal - Delay Costs	-	**$ 29,833**	**$ 775,650**	-	**$ 116,767**	**$ 3,035,940**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	8,853
Cost of Power for Signal				-	$ 4,255	66,472
Cost of Illumination	6	$ 873	$ 13,632	4	$ 582	9,088
Cost of Landscaping Maintenance	-	$ 2,000	$ 31,244			
Cost of Signal Maintenance				-	$ 4,660	72,799
Cost of Pavement Rehabilitation			$ 39,987			$ 84,683
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 84,864**	-	**$ 10,063**	**$ 241,894**
EMISSIONS						
Tons of ROG	0.10	$ 97	$ 1,510	0.16	$ 150	$2,350
Tons of NOX	0.32	$ 4,085	$ 63,809	0.36	$ 4,668	$72,925
Tons of PM10	0.0045	$ 451	$ 7,045	0.0068	$ 676	$10,568
Subtotal - Emissions Costs		**$ 4,632**	**$ 72,365**		**$ 5,495**	**$ 85,842**
INITIAL CAPITAL COSTS						
Construction Cost			$ 2,447,250			$ 101,200
Construction Cost - Structures			$ -			$ -
Capital Support			$ 465,000			$ 20,000
Right-of-Way			$ 2,341,000			$ -
Subtotal - Initial Capital Costs			**$ 5,253,250**			**$ 121,200**
NET PRESENT VALUE			**$ 6,898,421**			**$ 5,345,879**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$1,148,711
Delay Reduction Benefit of Roundabout	$2,260,290
Emission Reduction Benefit of Roundabout	$13,477
Total Benefits	**$3,422,478**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$157,030
Added Capital Costs of a Roundabout	$5,132,050
Total Costs	**$4,975,020**

LIFE CYCLE (25 YEAR) BENEFIT/COST RATIO

0.69

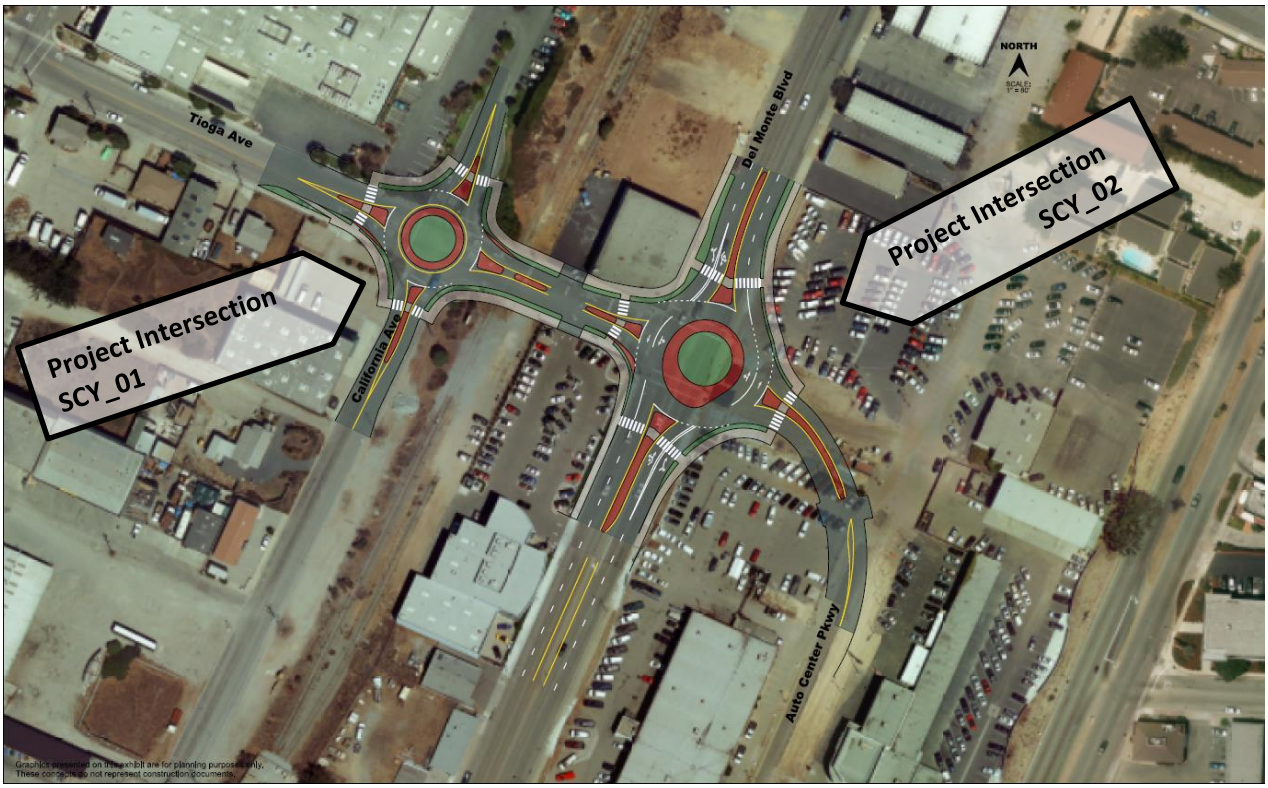
B/C Preferred: Signal Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	371	163
Cost Per Pound Per Life	$61.93	$141.07
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$4,955**	**$11,285**

Intersection Improvement Alternatives

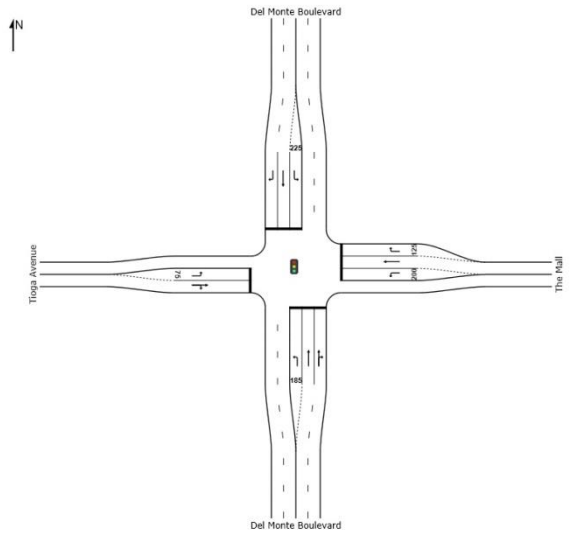
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

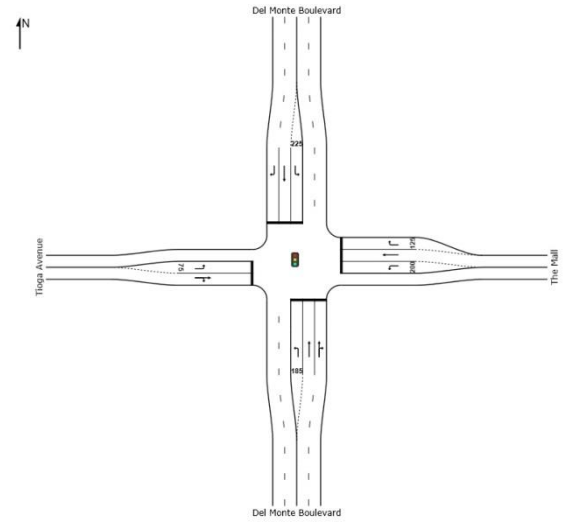


EXISTING INTERSECTION
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	13.0	192 (SBT)	D	40.7	#372 (NBL)
2040	B	17.8	#525 (SBT)	F	140.6	#538 (NBL)

NOTES:

1. Referenced Existing and calculated volumes were adjusted for volume balance with Tioga Avenue/California Avenue.
2. NBL queues exceed storage capacity during the 2012 and 2040 p.m. peak hours
3. EBL queues exceed storage capacity during the 2012 and 2040 p.m. peak hours

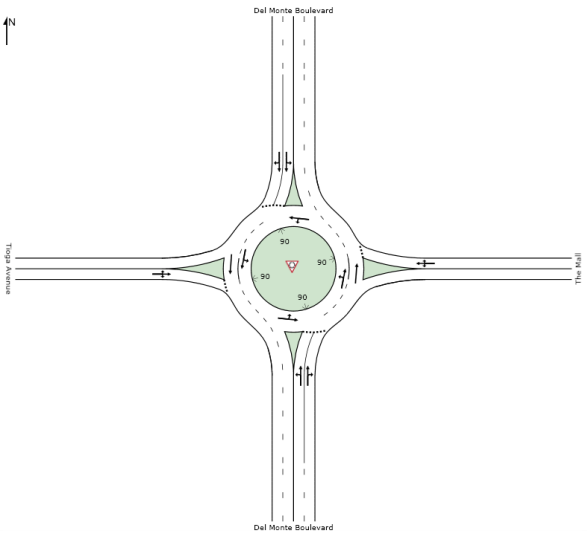


ALTERNATIVE 1
SIGNAL TIMING MODIFICATIONS

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	C	21.0	243 (SBT)	D	35.6	#328 (NBL)
2040	C	29.7	#592 (SBT)	D	53.1	#745 (SBT)

NOTES:

1. Referenced Existing and calculated volumes were adjusted for volume balance with Tioga Avenue/California Avenue
2. NBL queues exceed storage capacity during the 2012 and 2040 p.m. peak hours
3. EBL queues exceed storage capacity during the 2012 and 2040 p.m. peak hours



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	A	4.2	30 (SB)	A	7.2	59 (NB)
2040	A	6.1	66 (SB)	C	16.5	222 (NB)

NOTES:

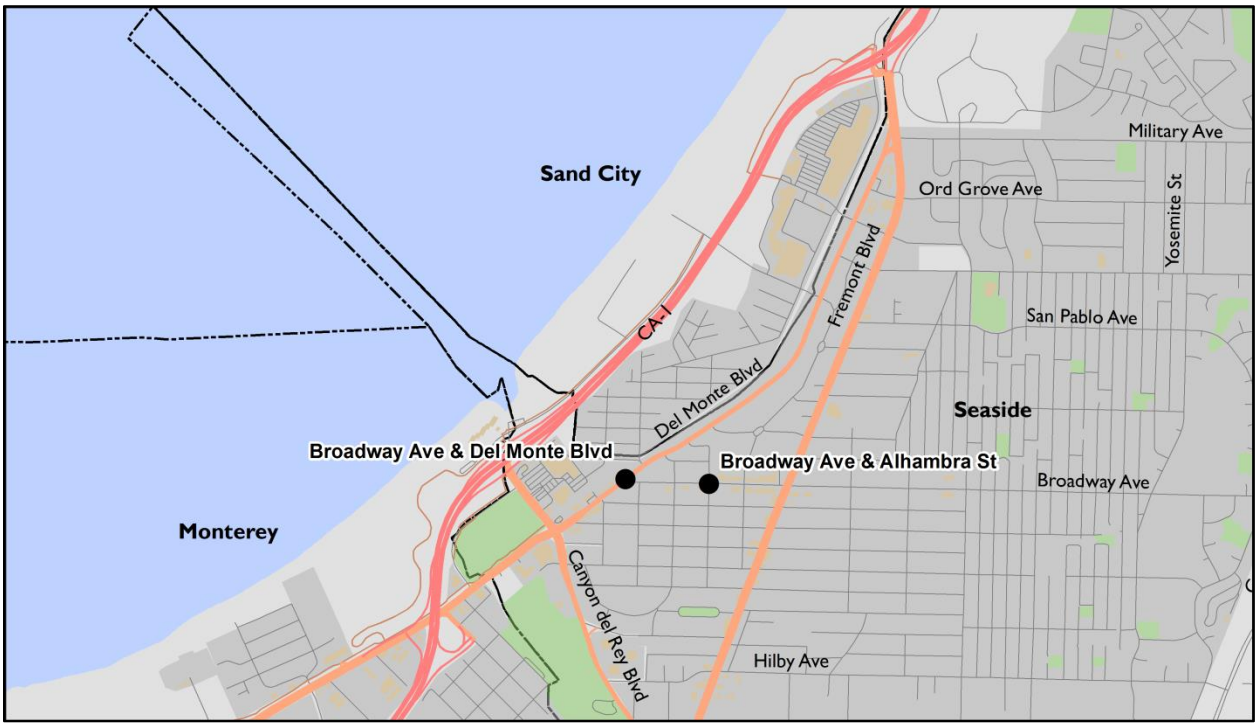
1. Referenced Existing and calculated volumes were adjusted for volume balance with Tioga Avenue/California Avenue

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 10:

City of Seaside

Study Intersections:

- BROADWAY AVENUE AT DEL MONTE BOULEVARD
- BROADWAY AVENUE AT ALHAMBRA STREET



CITY OF SEASIDE SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	SEA-01
Broadway Avenue at Alhambra Street	SEA-02

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Seaside jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Seaside, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	**0.95**	
Broadway Avenue at Alhambra Street	**4.63**	

SUMMARY OF KEY PERFORMANCE MEASURES

As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to

calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

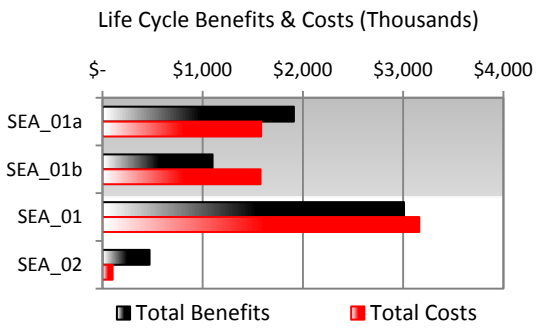
- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:

NOTE: Due to the close proximity of the Broadway Avenue intersection and the Contra Costa Street intersection with Del Monte Boulevard, the performance measures for the Broadway Avenue / Contra Costa Street at Del Monte Boulevard study intersection, SEA-01, are a summation of performance measures at each of the intersections. As a reference, the performance measures for each intersection are reported in the following bar charts to illustrate the performance measure benefits and the performance measure costs that were used to calculate the "study intersection" performance measures. Broadway Avenue at Del Monte Boulevard is assigned intersection number SEA-01a. Contra Costa Street at Del Monte Boulevard is assigned intersection number SEA-01b. SEA-01a and SEA-01b are illustrated with a grey background in the following bar charts. Only the preferred control for the study intersection, SEA-01, is reported in the summary tables for each performance measure.



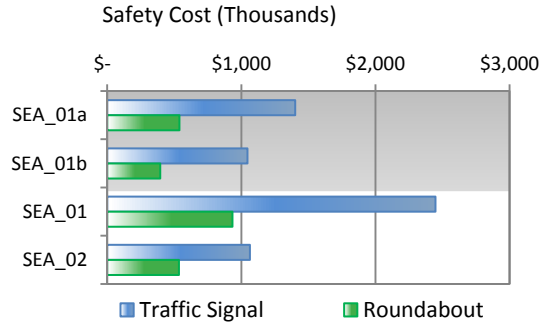
A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.



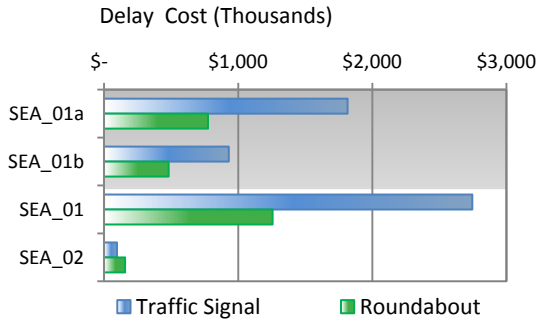
Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	
Broadway Avenue at Alhambra Street	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters*

2012, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

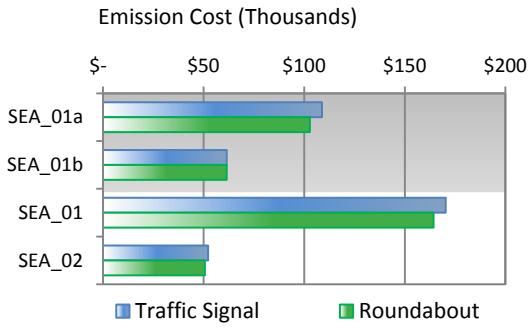


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	
Broadway Avenue at Alhambra Street	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

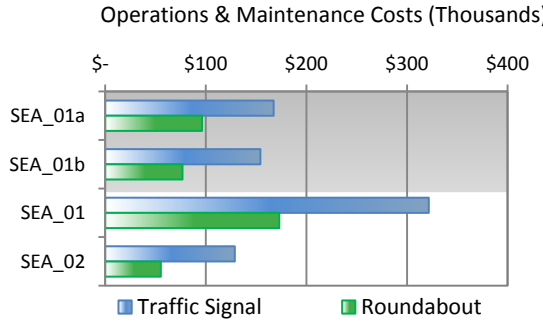
Emissions **Study Intersection**	**Preferred Control**
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	
Broadway Avenue at Alhambra Street	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.



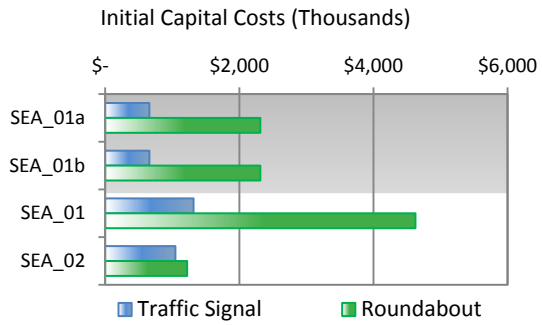
Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance Study Intersection	Preferred Control
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	
Broadway Avenue at Alhambra Street	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.

Specific design requirements for each jurisdiction were not evaluated and any specific design standards or features required by a jurisdiction will be evaluated in future phases of the project. If the specific design standard or feature would impact the cost of the overall intersection, the guiding principle of this study is that design exemptions can be implemented.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost Study Intersection	Preferred Control
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	
Broadway Avenue at Alhambra Street	

Summary of B/C Performance Measures

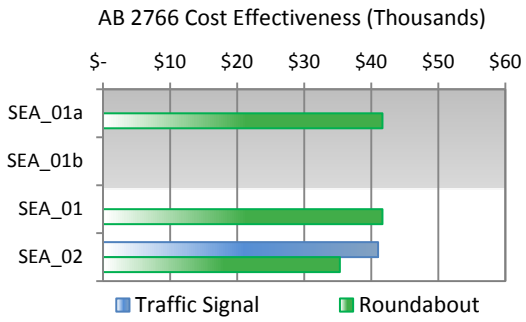
The following table summarizes the five performance measures evaluated at each project location.

	Preferred Intersection Control by Performance Measure					
Study Intersection	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Broadway Ave. / Contra Costa St. at Del Monte Boulevard						
Broadway Avenue at Alhambra Street						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Seaside.



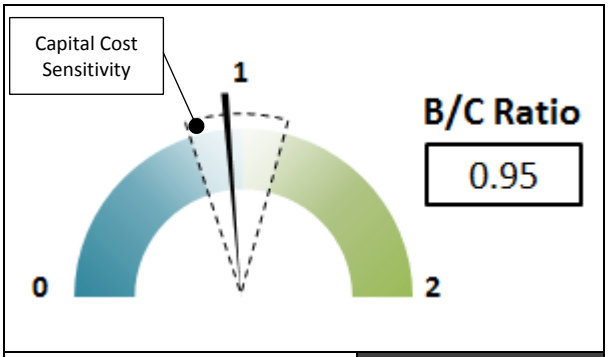
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness **Study Intersection**	**Preferred Control**
Broadway Ave. / Contra Costa St. at Del Monte Boulevard	NONE
Broadway Avenue at Alhambra Street	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

BROADWAY AVENUE / CONTRA COSTA STREET AT DEL MONTE BOULEVARD



Result:
Based on the Life Cycle Benefit Cost ratio

Signal

The Benefit Cost (B/C) ratio for Broadway Avenue / Contra Costa Street at Del Monte Boulevard is 0.95. The B/C ratio of 0.95 represents the combination of performance measures for the Broadway Avenue at Del Monte Boulevard intersection and the Contra Costa Street at Del Monte Boulevard intersection. The intersections were combined into a single project due to the short distance between intersections and the traffic volumes on Del Monte Boulevard. The individual B/C scores for each intersection are as follows:

Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a traffic signal.

Study Intersection	Intersection Number	B/C Ratio
Broadway Avenue at Del Monte Boulevard	SEA-01a	1.21
Contra Costa Street at Del Monte Boulevard	SEA-01b	0.70

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is likely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

Safety, delay, and *right of way* are notable performance metrics driving the B/C ratio. The estimated safety costs of the signal are 3 times higher than that of the roundabout. The estimated delay costs of the signal are 2 times higher than that of the roundabout. The estimated initial capital costs of the signal are 3 times higher than that of the roundabout. The total life cycle benefits of the roundabout are estimated at $3,000,000 when compared to the traffic signal alternative. The total life cycle benefit includes an estimated $14,400 reduction in annual operations and maintenance costs when compared to the traffic signal alternative. The estimated right of way costs are $1,875,000. A capital cost reduction of $152,700 or more would yield a B/C ratio greater than 1.00.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
							Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context	Transit Service	Pedestrian Considerations	Bicycle Routes
Broadway Avenue and Contra Costa Street at Del Monte Boulevard	**Broadway Avenue (City of Seaside)**	4 lane undivided with on street parking	Local	30	Serves business & commercial land uses (commercial corridor)	Service provided by Monterey Salinas Transit for Line 12	Sidewalks Crosswalk with 2 pedestrian refuges	No bike lanes provided
	Contra Costa Street (City of Seaside)	2 lane undivided	Local	30	Serves business & commercial land uses	None	No Sidewalks Crosswalk	No bike lanes provided
	Del Monte Boulevard (City of Seaside)	4 lane undivided with on street parking	Local	35	Commercial corridor Alternate, parallel route to SR 1	Service provided by Monterey-Salinas Transit for Lines 8, 10, 12, 18, 20, & 55 Stop at intersection	Sidewalks Crosswalk north of Broadway Avenue & north of Contra Costa Street	No bike lanes provided

Initial capital costs for the intersection were estimated as one project and evenly split for each intersection.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic while providing improved pedestrian and bicycle facilities. The existing signal control, or no project alternative, will provide adequate vehicle capacity to serve forecast traffic. The proposed signal alternative will provide pedestrian and bicycle improvements while adequately serving forecast traffic demand. The project assumes improvements are made at Broadway Avenue and the Contra Costa Street intersections with Del Monte Boulevard. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2027 design year. The year 2015 was assumed for the baseline "build" condition for a total 12 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Numbers SEA-01a and SEA-01b on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

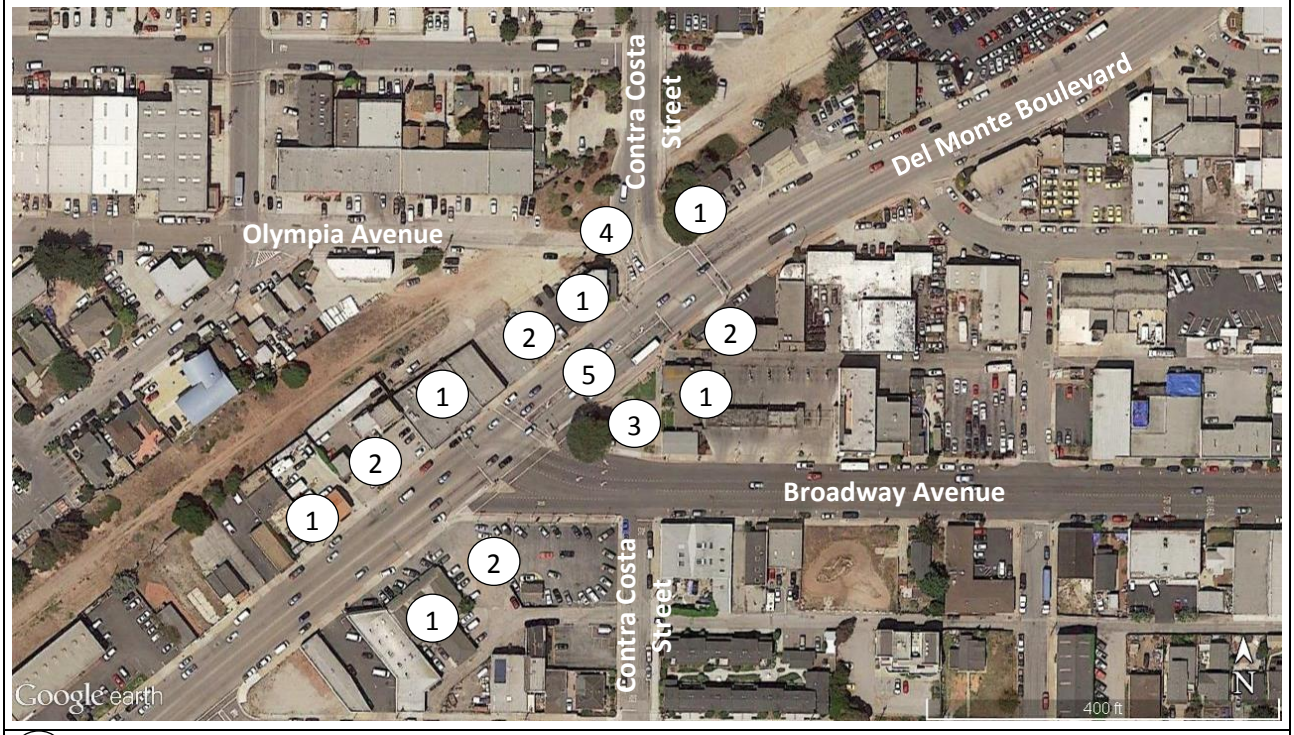
The existing Broadway Avenue at Del Monte Boulevard and the Contra Costa Street at Del Monte Boulevard intersections are controlled by coordinated traffic signals.

Parcels adjacent to the intersections are developed with commercial structures located at the back of existing sidewalks. Off street parking is adjacent to commercial structures. Del Monte Boulevard and Broadway Avenue is City of Seaside right of way. Contra Costa Street is Sand City right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Commercial building
2. Parking lot (private)
3. Parking lot (City of Seaside)
4. At-grade crossing provision for future Monterey Peninsula Fixed Guideway
5. Intersection separation between Broadway Avenue and Contra Costa Street.

The Summary of Existing Conditions table describes the study area roadways. Below, an aerial view of the project location with existing design constraints is provided.



(1) Refer to the Existing Conditions section on the previous page for description of the design constraint.

PLANNED IMPROVEMENTS

The Broadway Avenue at Del Monte Boulevard intersection is located within the City of Seaside West Broadway Urban Village Specific Plan. The West Broadway Urban Village Specific Plan identifies a reduction in traffic lanes on Broadway Avenue from four lanes to two lanes. Additional improvements include intersection modifications at Broadway Avenue and Del Monte Boulevard and installing bicycle lanes on Del Monte Boulevard.

The 2012 Monterey Peninsula Fixed Guideway Study prepared by TAMC identifies the existing rail corridor east of the intersection as the preferred alignment for a future light rail transit corridor.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Signal	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for the 2011 AM /PM peak hour and the 2027 AM / PM peak hour volumes were taken from the West Broadway Urban Village Specific Plan provided by the City.

Signal Control (Existing)

The existing signal control, or no project alternative, operates with coordination between the two closely spaced intersections. The signal is phased to allow vehicles traveling north/south along Del Monte Boulevard to traverse both intersections. Vehicles turning from Del Monte Boulevard have protected left turns. The critical queue areas are northbound left at Contra Costa Avenue and southbound left at Broadway Avenue as the queue here will spill back and affect the other intersection. Queues exceed capacity in the AM peak hour for the northbound left turn and in the PM peak hour for the southbound left under both existing and future design year conditions.

Signal Control Modifications

With the modified signal control alternative, roadway improvements include the addition of bicycle lanes on Del Monte Boulevard and Broadway Avenue, removal of the northbound Del Monte Boulevard right turn lane at Broadway Avenue, removal of the westbound right turn lane on Broadway Avenue, and the removal of one lane in each direction on Broadway Avenue.

Protected phasing for the left turns as well as coordination between the two intersections will be maintained with changes in coordination patterns. The signal is phased to give priority to vehicles traveling north along Del Monte Boulevard as well as turning left onto Contra Costa Street during the AM peak hour. For the PM peak hour priority is given to vehicles traveling south along Del Monte Boulevard as well as turning left onto Broadway Avenue. This proposed coordination plan will help address the queue spill back from turning vehicles on the short segment between the two intersections.

Proposed intersection and roadway reconfiguration will improve pedestrian and bike facilities and maintain transit stops.

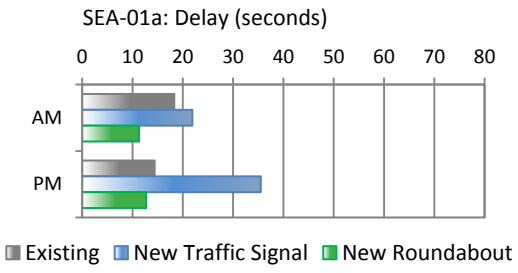
Roundabout Control

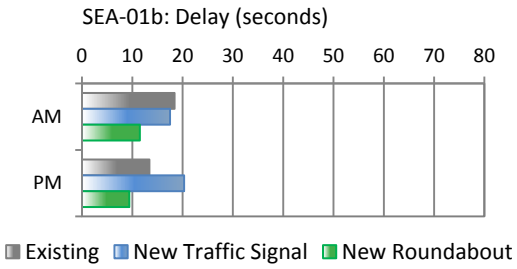
With roundabout control, two multilane roundabouts are proposed. Roadway improvements include the addition of bicycle lanes on Del Monte Boulevard and Broadway Avenue, removal of one lane in each direction on Broadway Avenue, and a lane drop for the southbound Del Monte Boulevard approach to Contra Costa Street. The proposed roundabouts will improve performance at the study intersections for AM and PM peak hours under both existing and future design year conditions.

Proposed intersection and roadway reconfiguration will improve pedestrian and bike facilities and maintain transit stops.

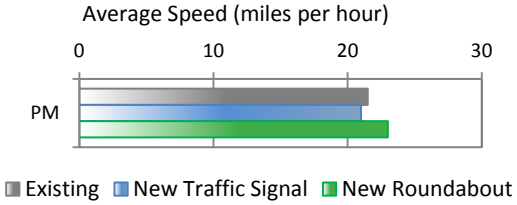
TRAFFIC OPERATIONS SUMMARY

The following bar charts illustrate the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.





The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



NOTE: The average speed identified in the bar chart above is the average of SEA-01a and SEA-01b.

PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary Performance Measure	Preferred Control
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	NONE

NONE: Indicates that neither the signal nor roundabout alternative has a cost effectiveness value less than $20,000.

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- Preliminary engineering and additional site investigations.
- Refinement of right of way costs.
- Evaluation of operations with a 2040 design year.
- Evaluation and consideration of removing the westbound Broadway Avenue right turn lane (This option will increase westbound vehicle queuing and increase the westbound approach delay to LOS E for the 2027 PM peak hour).
- Operations and coordination of signal and active warning device infrastructure needed for future light rail transit line.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SEA-01a**
01/16

Intersection Cost Comparison

Broadway Avenue at Del Monte Boulevard
Seaside, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.26	$ 38,099	$ 357,563	0.89	$ 131,376	$ 1,232,976
Predicted PDO Crashes	1.89	$ 19,272	$ 180,867	1.76	$ 17,970	$ 168,647
Subtotal - Safety Costs	**-**	**$ 57,371**	**$ 538,430**	**-**	**$ 149,346**	**$ 1,401,623**
DELAY						
Delay to Persons in Vehicles (hours)	4373	$ 59,620	$ 775,057	10284	$ 139,668	$ 1,815,686
Subtotal - Delay Costs	-	**$ 59,620**	**$ 775,057**	-	**$ 139,668**	**$ 1,815,686**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	5,318
Cost of Power for Signal				-	$ 4,255	39,933
Cost of Illumination	6	$ 873	$ 8,190	4	$ 582	5,460
Cost of Landscaping Maintenance	-	$ 2,000	$ 18,770			
Cost of Signal Maintenance				-	$ 4,660	43,734
Cost of Pavement Rehabilitation			$ 69,252			$ 72,969
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 96,212**	-	**$ 10,063**	**$ 167,415**
EMISSIONS						
Tons of ROG	0.23	$ 222	$ 2,080	0.29	$ 271	$2,543
Tons of NOX	0.75	$ 9,699	$ 91,026	0.78	$ 10,033	$94,164
Tons of PM10	0.0104	$ 1,034	$ 9,704	0.0130	$ 1,292	$12,129
Subtotal - Emissions Costs		**$ 10,955**	**$ 102,810**		**$ 11,597**	**$ 108,837**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,003,987			$ 480,600
Construction Cost - Structures			$ -			$ -
Capital Support			$ 371,500			$ 178,000
Right-of-Way			$ 937,500			$ -
Subtotal - Initial Capital Costs			**$ 2,312,987**			**$ 658,600**
NET PRESENT VALUE			**$ 3,825,496**			**$ 4,152,161**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$863,193
Delay Reduction Benefit of Roundabout	$1,040,630
Emission Reduction Benefit of Roundabout	$6,027
Total Benefits	**$1,909,849**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$71,202
Added Capital Costs of a Roundabout	$1,654,387
Total Costs	**$1,583,185**

LIFE CYCLE (12 YEAR) BENEFIT/COST RATIO

1.21

Roundabout Preferred

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	161	N/A - Same as existing
Cost Per Pound Per Life	$250.00	N/A - Same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$41,666**	**N/A - Same as existing**

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TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SEA-01b**
01/16

Intersection Cost Comparison

Contra Costa at Del Monte Boulevard
Seaside, California

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.20	$ 28,829	$ 270,558	0.67	$ 99,409	$ 932,958
Predicted PDO Crashes	1.30	$ 13,299	$ 124,815	1.18	$ 12,013	$ 112,744
Subtotal - Safety Costs	**-**	**$ 42,128**	**$ 395,373**	**-**	**$ 111,422**	**$ 1,045,702**
DELAY						
Delay to Persons in Vehicles (hours)	2727	$ 37,053	$ 481,694	5239	$ 71,538	$ 929,995
Subtotal - Delay Costs	-	**$ 37,053**	**$ 481,694**	-	**$ 71,538**	**$ 929,995**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	5,318
Cost of Power for Signal				-	$ 4,255	39,933
Cost of Illumination	6	$ 873	$ 8,190	4	$ 582	5,460
Cost of Landscaping Maintenance	-	$ 2,000	$ 18,770			
Cost of Signal Maintenance				-	$ 4,660	43,734
Cost of Pavement Rehabilitation			$ 49,858			$ 59,805
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 76,818**	-	**$ 10,063**	**$ 154,251**
EMISSIONS						
Tons of ROG	0.15	$ 144	$ 1,347	0.15	$ 144	$1,347
Tons of NOX	0.44	$ 5,653	$ 53,058	0.44	$ 5,653	$53,058
Tons of PM10	0.0076	$ 753	$ 7,070	0.0076	$ 753	$7,070
Subtotal - Emissions Costs		**$ 6,550**	**$ 61,475**		**$ 6,550**	**$ 61,475**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,003,987			$ 480,600
Construction Cost - Structures			$ -			$ -
Capital Support			$ 371,500			$ 178,000
Right-of-Way			$ 937,500			$ -
Subtotal - Initial Capital Costs			**$ 2,312,987**			**$ 658,600**
NET PRESENT VALUE			**$ 3,328,348**			**$ 2,850,022**

LIFE CYCLE BENEFIT/COST ANALYSIS

BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$650,329
Delay Reduction Benefit of Roundabout	$448,300
Emission Reduction Benefit of Roundabout	$0
Total Benefits	**$1,098,629**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$77,433
Added Capital Costs of a Roundabout	$1,654,387
Total Costs	**$1,576,954**

LIFE CYCLE (12 YEAR) BENEFIT/COST RATIO

0.70

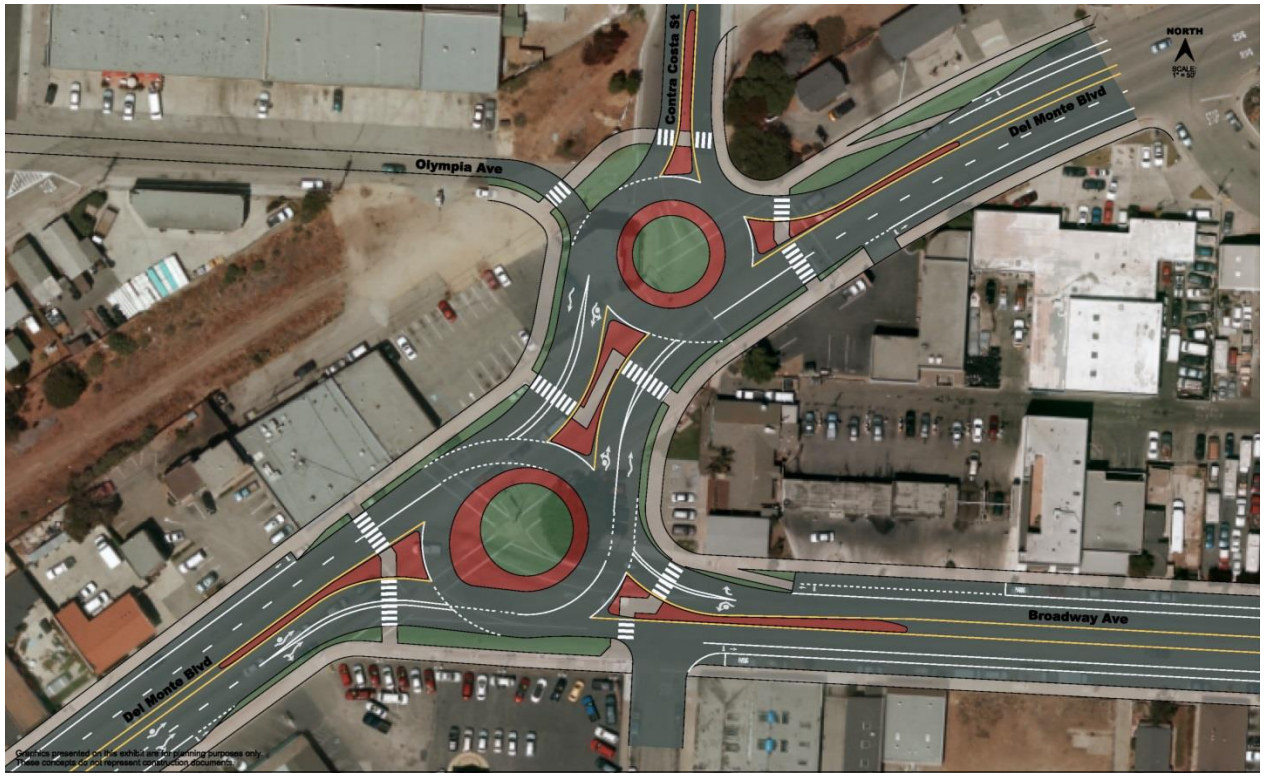
B/C Preferred: Signal Alternative

AIR QUALITY ANALYSIS

AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	0	N/A - Same as existing
Cost Per Pound Per Life	N/A - No emissions change	N/A - Same as existing
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**N/A - No emissions change**	**N/A - Same as existing**

Intersection Improvement Alternatives

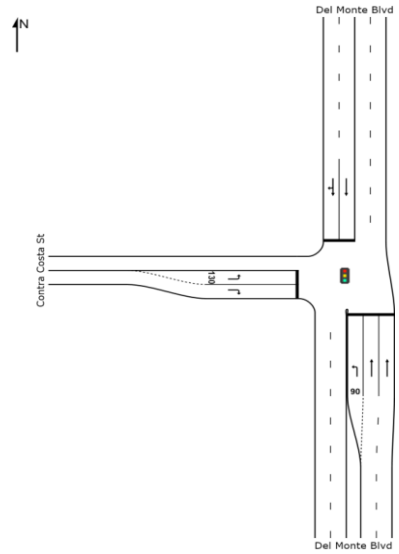
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

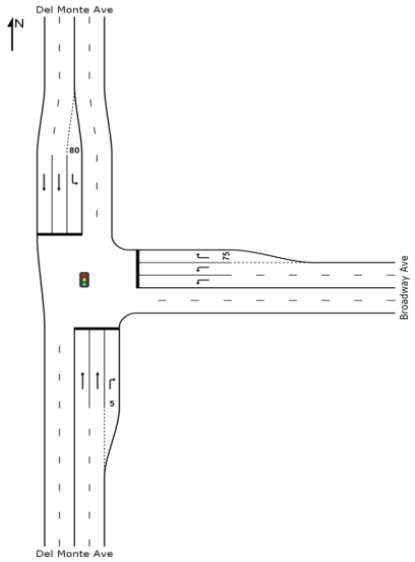
Intersection Control Alternative Summary



EXISTING INTERSECTION – Contra Costa at Del Monte
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	16.0	181 (NBL)	A	9.0	116 (SBT)
2027	B	18.4	229 (NBL)	B	13.4	157 (SBT)

NOTES:
1. NBL queue exceeds available storage during all peak hours.

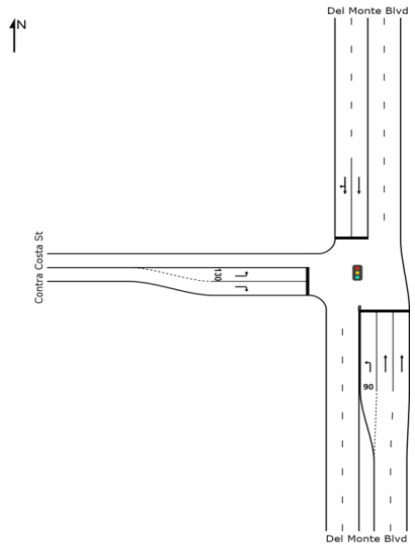


EXISTING INTERSECTION – Broadway at Del Monte
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	13.6	187 (WBL)	B	14.4	277 (NBR)
2027	B	18.3	206 (WBL)	B	14.1	343 (NBR)

NOTES:

1. NBR significant queuing during all peak hours.
2. SBL queue exceeds available storage during 2012 and 2027 p.m. peak hours.



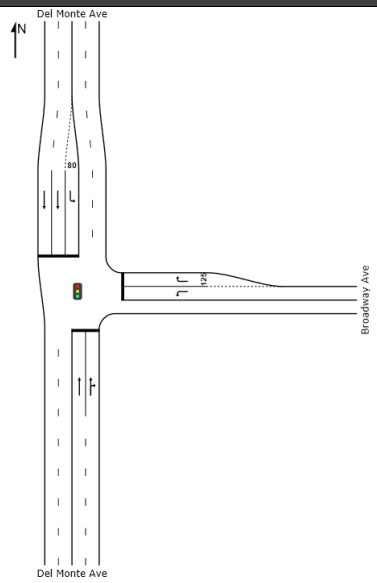
ALTERNATIVE 1– Contra Costa at Del Monte
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	13.1	140 (NBL)	B	18.6	113 (SBT)
2027	B	17.5	161 (NBL)	C	20.3	154 (SBT)

NOTES:

1. NBL queue exceeds available storage during all peak hours.

Intersection Control Alternative Summary

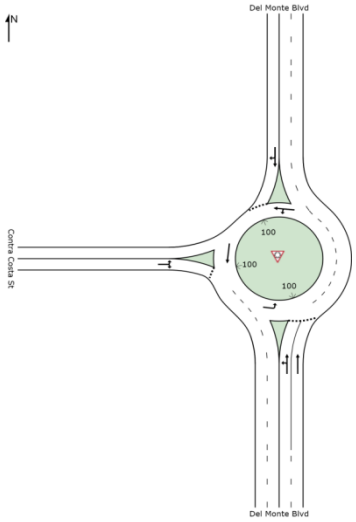


ALTERNATIVE 1 - Broadway at Del Monte SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	B	18.6	293 (WBL)	C	23.2	486 (NBT)
2027	C	21.9	376 (WBL)	D	35.5	657 (NBT)

NOTES:

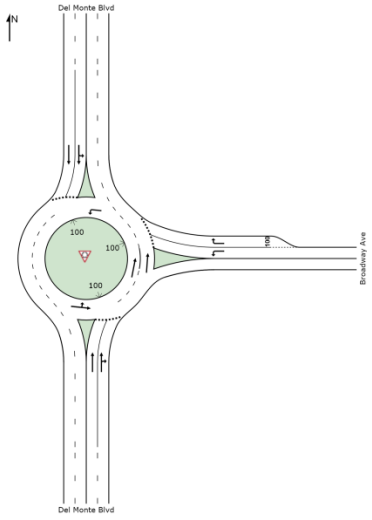
1. NBT significant queuing during all peak hours.
2. SBL queue exceeds available storage during 2012 and 2027 p.m. peak hours



ALTERNATIVE 2 – Contra Costa at Del Monte ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	A	8.3	116 (SB)	A	7.5	88 (SB)
2027	B	11.5	172 (SB)	A	9.4	121 (SB)

NOTES:

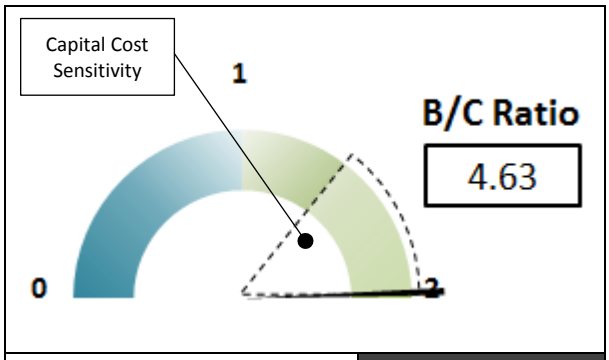


ALTERNATIVE 2 – Broadway at Del Monte ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2012	A	8.9	85 (SB)	A	9.9	116 (NB)
2027	B	11.3	119 (SB)	B	12.7	157 (NB)

NOTES:

BROADWAY AVENUE AT ALHAMBRA STREET



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

The Benefit Cost (B/C) ratio for Broadway Avenue at Alhambra Street is 4.63. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs, especially the costs to acquire right of way. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change to the traffic signal alternative with further refinement of the project costs as proposed improvements progress through detailed planning and design.

As an example, the potential cost to acquire right of way for the construction of the roundabout is not included in the calculated B/C ratio. However, if right of way acquisition costs are greater than $540,000, this will result in a B/C ratio less than 1.0. A change in the B/C ratio to a value less than 1.0 will make the traffic signal alternative more preferable to the roundabout when comparing the potential return on investment for the proposed intersection improvements. So, if the costs to acquire right of way exceed $540,000 in constructing the roundabout, then the traffic signal is the more favorable alternative. Refer to Appendix B10, Capital Cost Worksheet, line item "Custom 1", which shows a B/C ratio of 0.67 with an assumed right of way acquisition cost of $600,000 for the roundabout alternative.

The total life cycle benefits of the roundabout are estimated at $470,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $7,200 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, will provide adequate vehicle capacity through the design year. Reducing the number of through lanes on Broadway Avenue to one lane each direction, while maintaining stop control, is not expected to provide adequate capacity for the design year. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2027 design year. The year 2015 was assumed for the baseline "build" condition for a total 12 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection number SEA-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Broadway Avenue at Alhambra Street	**Broadway Avenue (City of Seaside)**	4 lane undivided with on street parking	Local	30	Serves business & commercial land uses Commercial corridor	Service provided by Monterey Salinas Transit for Line 12	Sidewalks Crosswalk on east & west legs	No bike lanes provided
	Alhambra Street (City of Seaside)	2-lane undivided with on street parking	Local	25	Serves residential, business, & residential land uses	No Service	Sidewalks Crosswalk on south & north legs	No bike lanes provided

Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Broadway Avenue at Alhambra Street is controlled by stop signs on all approaches.

Parcels in the northwest, northeast, and southeast quadrants are developed with commercial structures located at the back of existing sidewalks. The southwesterly parcel provides customer parking for the adjacent business. The existing intersection is within the City of Seaside.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Existing commercial structure – identified as fatal flaw if disturbed.
2. Existing parking lot

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Broadway Avenue at Alhambra Street intersection is located within the City of Seaside West Broadway Urban Village Specific Plan. The West Broadway Urban Village Specific Plan identifies a reduction in traffic lanes on Broadway Avenue from 4 lanes to 2 lanes.

As part of this process, the City of Seaside has prepared plans for improvements to Broadway Avenue, including installation of a traffic signal at the study intersection. The calculated B/C ratio in this report assumes similar effort and capital support costs for both the roundabout and traffic signal alternatives. Since the City of Seaside has already completed work on the traffic signal alternative, the estimated capital support costs assumed in this report for the traffic signal alternative could be reduced to the amount of effort required to complete the design, if any. The reduction in estimated capital support costs would in turn reduce the B/C ratio.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for the 2011 PM peak hour and the 2027 PM peak hour volumes were taken from the West Broadway Avenue Corridor Transportation Analysis provided by the City. Volumes were not provided for the AM peak hour.

Stop Control (Existing)

With stop control and four travel lanes on Broadway Avenue, there is adequate capacity to serve forecast demand for the PM peak hour. Reducing the number of travel lanes on Broadway Avenue from four to two, while maintaining all way stop control, will not provide adequate capacity to serve forecast demand for either design period during the PM peak hour. Operations for the reduced lane stop control option are provided in the Operations Summary. A B/C ratio was not calculated for this alternative.

Signal Control

With signal control, two travel lanes on Broadway Avenue will provide adequate capacity to serve forecast demand for the PM peak hour. Intersection improvements, such as bulb outs, are suggested to reduce pedestrian crossing distances.

The proposed traffic signal is expected to improve intersection performance and provide adequate capacity for the PM peak hours under both existing and future design year conditions.

Proposed intersection and roadway reconfiguration will improve pedestrian and bike.

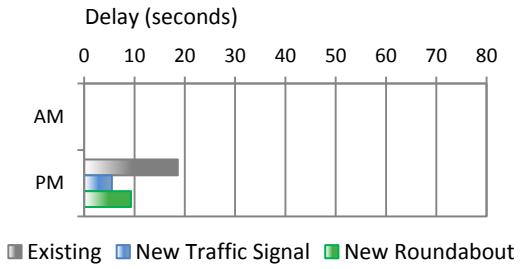
Roundabout Control

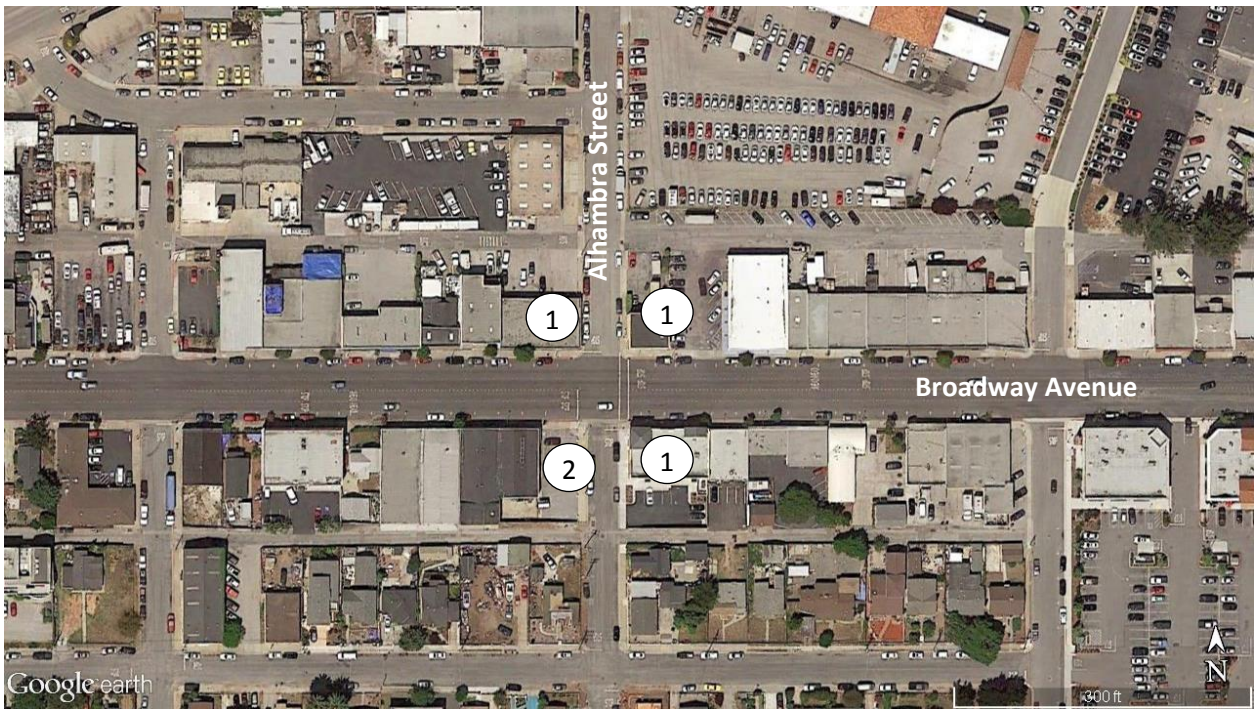
With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to improve intersection performance and provide sufficient capacity for AM and PM peak hours under both existing and future design year conditions.

Proposed intersection and roadway reconfiguration will improve pedestrian and bike facilities and maintain transit stops.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.

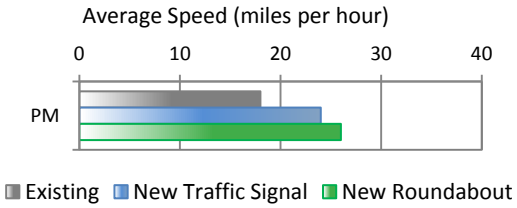




1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

NOTE: AM data was not provided.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	NONE

NONE: Indicates that neither the signal nor roundabout alternative has a cost effectiveness value less than $20,000.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- AM peak hour traffic data.
- Preliminary engineering and additional site investigations, especially topographic and boundary survey.
- Cost to acquire right of way.
- The width of sidewalks and buffer treatments between the sidewalks and roundabouts at property corners (increased sidewalk width could change B/C ratio and preferred intersection control type or result in a fatal flaw if impacts to existing structures are unavoidable).
- Evaluation of pedestrian and bicycle flows through the intersection and evaluation of multi-use paths.
- Impact to surface parking lot operations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SEA-02**
01/16

Intersection Cost Comparison

Broadway Avenue at Alhambra Street
Seaside, CA

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.30	$ 44,856	$ 420,976	0.67	$ 99,680	$ 935,503
Predicted PDO Crashes	1.19	$ 12,120	$ 113,750	1.34	$ 13,682	$ 128,406
Subtotal - Safety Costs	**-**	**$ 56,976**	**$ 534,727**	**-**	**$ 113,362**	**$ 1,063,910**
DELAY						
Delay to Persons in Vehicles (hours)	892	$ 12,067	$ 156,870	546	$ 7,416	$ 96,412
Subtotal - Delay Costs	-	**$ 12,067**	**$ 156,870**	-	**$ 7,416**	**$ 96,412**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 567	5,318
Cost of Power for Signal				-	$ 4,255	39,933
Cost of Illumination	6	$ 873	$ 8,190	4	$ 582	5,460
Cost of Landscaping Maintenance	-	$ 2,000	$ 18,770			
Cost of Signal Maintenance				-	$ 4,660	43,734
Cost of Pavement Rehabilitation			$ 28,325			$ 34,384
Subtotal - Operations and Maintenance Costs	-	**$ 2,873**	**$ 55,285**	-	**$ 10,063**	**$ 128,830**
EMISSIONS						
Tons of ROG	0.12	$ 113	$ 1,057	0.12	$ 113	$1,057
Tons of NOX	0.37	$ 4,757	$ 44,642	0.38	$ 4,927	$46,237
Tons of PM10	0.0053	$ 525	$ 4,929	0.0053	$ 525	$4,929
Subtotal - Emissions Costs		**$ 5,395**	**$ 50,628**		**$ 5,564**	**$ 52,222**
INITIAL CAPITAL COSTS						
Construction Cost			$ 891,775			$ 763,650
Construction Cost - Structures			$ -			$ -
Capital Support			$ 330,000			$ 283,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,221,775**			**$ 1,046,650**
NET PRESENT VALUE			**$ 2,019,285**			**$ 2,388,024**

LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$529,183	**LIFE CYCLE (12 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	-$60,458	
Emission Reduction Benefit of Roundabout	$1,594	
Total Benefits	**$470,320**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$73,545	**4.63**
Added Capital Costs of a Roundabout	$175,125	
Total Costs	**$101,580**	

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	190	163
Cost Per Pound Per Life	$211.90	$246.08
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$35,317**	**$41,014**

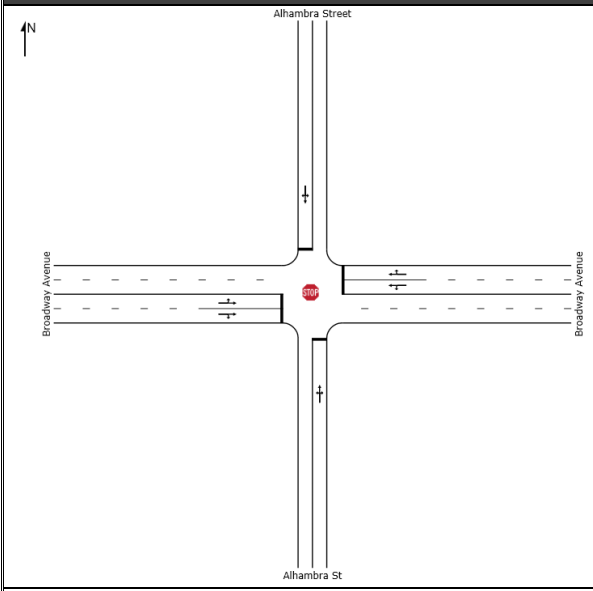
Intersection Improvement Alternatives

Signal Alternative

Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

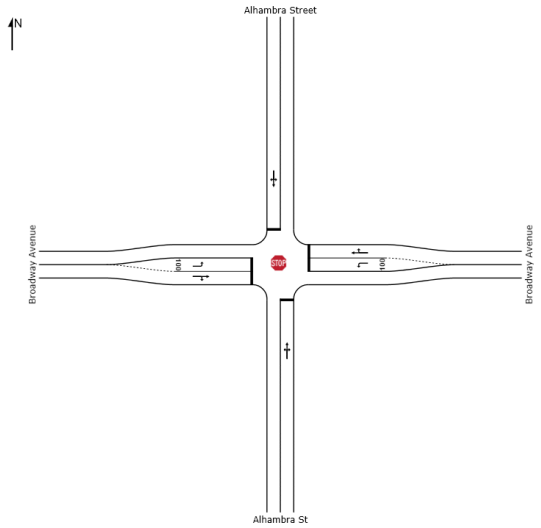


EXISTING INTERSECTION
STOP

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	-	-	-	B	12.4	73 (EBT)
2027	-	-	-	C	18.6	133 (EBT)

NOTES:

1. AM traffic data was not provided.

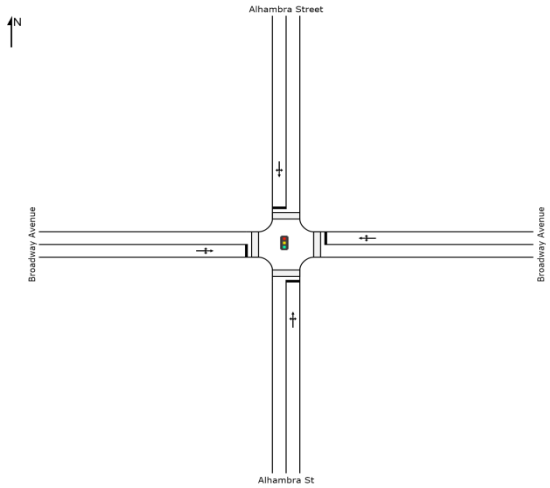


ALTERNATIVE 1
STOP (BROADWAY AVENUE LANE REDUCTION)

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	-	-	-	E	37.2	385 (EBT)
2027	-	-	-	F	53.1	373 (WBT)

NOTES:

1. AM traffic data was not provided.



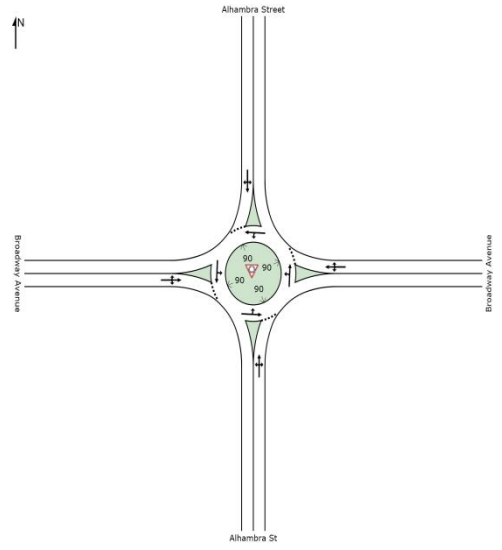
ALTERNATIVE 2
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	-	-	-	A	4.6	161 (EB)
2027	-	-	-	A	5.5	267 (EB)

NOTES:

1. AM traffic data was not provided.

Intersection Control Alternative Summary



ALTERNATIVE 3
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2011	-	-	-	A	7.1	102 (EB)
2027	-	-	-	A	9.3	144 (EB)

NOTES:

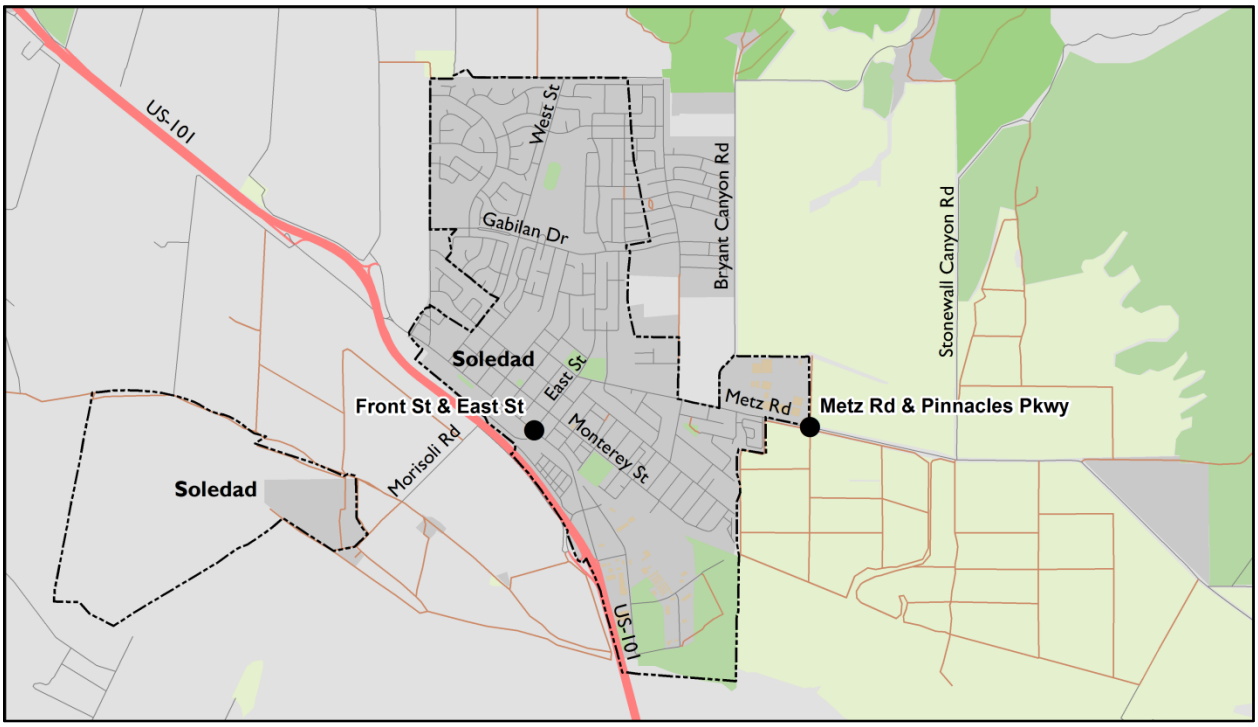
1. AM traffic data was not provided.

Regional Roundabout Study – Utilizing Caltrans' Intersection Control Evaluation
Section 11:

City of Soledad

Study Intersections:

- METZ ROAD AT PINNACLES PARKWAY (PROPOSED)
- FRONT STREET AT EAST STREET



CITY OF SOLEDAD SCREENING SUMMARY

STUDY OVERVIEW

An Intersection Control Evaluation (ICE) was performed to objectively evaluate and screen intersection control alternatives at the following intersection(s):

Study Intersection	Intersection Number
Metz Road at Pinnacles Parkway (Proposed)	SOL-01
Front Street at East Street	SOL-02

This screening summary provides an overview of performance measures used to calculate the return on investment for study intersections under City of Soledad jurisdiction. Results of the analysis and preferred traffic control type are presented in graphical form for quick reference.

Following the screening summary, a section is provided for each study intersection summarizing the design year peak hour operations, site constraints, concept layouts, and benefit cost calculations for each control alternative.

The table below lists the symbols of intersection control types evaluated (refer to the intersection summary for the list of alternatives evaluated at each intersection).

Control Type	Legend	
	Existing	Proposed
Stop Sign		
Traffic Signal		
Roundabout	N/A	

RETURN ON INVESTMENT SUMMARY

Benefit Cost Ratio Scoring

Benefit cost (B/C) ratios were calculated for each study intersection. The B/C ratio measures the expected return on investment when either a proposed stop control or a proposed signal controlled intersection is compared relative to a proposed roundabout controlled intersection.

B/C = 1.00: A B/C ratio of 1.00 is a neutral rating. This indicates that the return on investment for either stop or signal control improvement is equal to a roundabout.

B/C < 1.00: A B/C ratio less than 1.00 indicates that a stop/signal will provide a better return on investment when compared to a roundabout.

B/C > 1.00: A B/C ratio greater than 1.00 indicates that a roundabout provides a better return on investment when compared to either stop or signal control.

B/C = NA-R: When the cost of a roundabout is less than the cost of a stop/signal and the roundabout provides benefits over the stop/signal, a B/C ratio cannot be computed. This special case is denoted by "NA-R" and indicates that a roundabout provides a better return on investment when compared to a stop/signal.

Benefit Cost Ratio Results

Based on data provided by the City of Soledad, a holistic B/C score was developed based on the net present value (i.e., life cycle duration using a discount rate of 4%) for the following five performance measures:

- ***Safety Benefit***
- ***Delay Reduction Benefit***
- ***Emission Reduction Benefit***
- ***Operations and Maintenance Costs***
- ***Initial Capital Costs***

The resulting B/C ratio and the preferred intersection control type based on return on investment for each study intersection(s) is as follows:

Study Intersection	B/C Ratio	Preferred Control
Metz Road at Pinnacles Parkway (Proposed)	**NA-R**	
Front Street at East Street	**1.98**	

SUMMARY OF KEY PERFORMANCE MEASURES

As stated above, five performance metrics were evaluated at each study intersection to calculate the B/C ratio. The performance measures used to

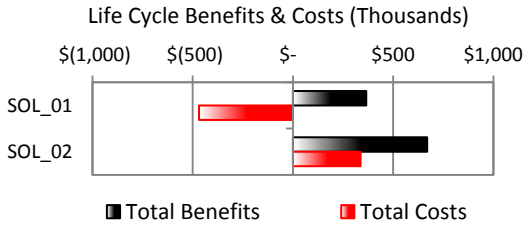
calculate the ***benefits*** of a roundabout compared to a stop or traffic signal are:

- ***Safety Benefit*** (of a roundabout)
- ***Delay Reduction Benefit*** (of a roundabout)
- ***Emission Reduction Benefit*** (of a roundabout)

Performance measures used to calculate the ***costs*** of a roundabout compared to a stop or traffic signal are:

- ***Operations and Maintenance Cost (***added costs of a roundabout)
- ***Initial Capital Cost*** (added costs of a roundabout)

The summation of the performance measure benefits and performance measure costs are illustrated below for each intersection:



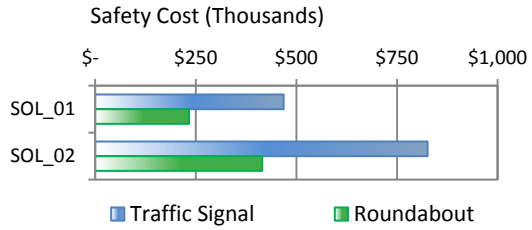
A negative cost is shown for SOL_01 as the comparison calculates roundabout cost minus signal control and for this intersection the intersection initial cost is greater than that of the roundabout. A brief overview of each performance measure and the assumptions used to calculate the performance measure costs are provided below. A bar chart illustrating the calculated cost of each performance measure by intersection control type is provided for each intersection. Following the performance measure overview is a table summarizing the preferred form of intersection control based solely on the results of individual performance measure.

Benefit Performance Measures

The following performance measures are used to calculate the benefit, or cost savings, of a roundabout compared to stop or signal control. For each performance measure, the roundabout provides a benefit if the calculated life-cycle cost of the roundabout is less than the life-cycle cost of stop or signal control. The magnitude of the benefit is the difference between the life-cycle cost of the stop or signal less the life-cycle cost of the roundabout.

Safety

Safety measures the societal cost associated with the predicted number and severity of collisions that may occur for each proposed intersection control type. The number of predicted collisions was calculated using Highway Safety Manual predictive methods and crash modification factors. The societal cost of property damage only (PDO) collisions is consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*. The societal cost of fatal/injury collisions are a weighted average based on the 2012 SWITRS proportion of fatal/injury collisions. Safety costs are the summation of predicted PDO and fatal/injury collisions.

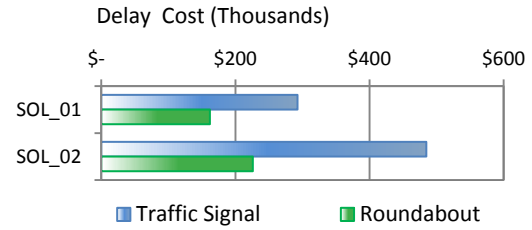


Based solely on the lowest predicted life-cycle cost for safety, the preferred intersection control type for each study intersection is as follows:

Safety **Study Intersection**	**Preferred Control**
Metz Road at Pinnacles Parkway (Proposed)	
Front Street at East Street	

Delay

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Consistent with the *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012*, vehicle occupancy of 1.15 is used to convert delay to person-hours of delay at a value of $17.35 per vehicle-hour of delay.

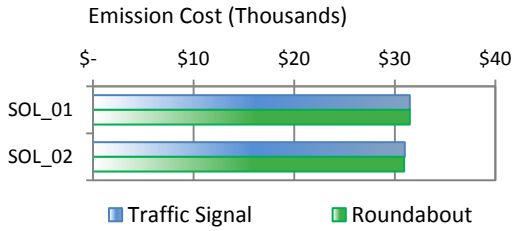


Based solely on lowest expected person hours of delay, the preferred intersection control type for each study intersection is as follows:

Delay **Study Intersection**	**Preferred Control**
Metz Road at Pinnacles Parkway (Proposed)	
Front Street at East Street	

Emissions

The emissions performance measure calculates the societal cost associated with exposure to health based pollutants emitted by motor vehicles. Pollutant emissions are running emissions based on the average speed of vehicles traveling through the intersection during the study period. Pollutant emissions evaluated include reactive organic gasses (ROG), nitrogen oxides (NOx), and particulate matter (PM10). The societal cost of emissions is calculated using emission data from the California Air Resource Board (CARB) *Methods to Find the Cost-Effectiveness of Funding Air Quality Projects, Table 4 Emission Factors by Speed, April 2013* and cost per ton data from *Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2012* for emissions (Note: VOC is assumed to be synonymous with ROG).



Based solely on fewer tons per year of mobile source pollutant emissions (i.e., fewer vehicle stops, fewer hard acceleration events, higher average speeds through the intersection) and the societal cost associated with exposure to these health based pollutant emissions, the preferred intersection control type for each study intersection is as follows:

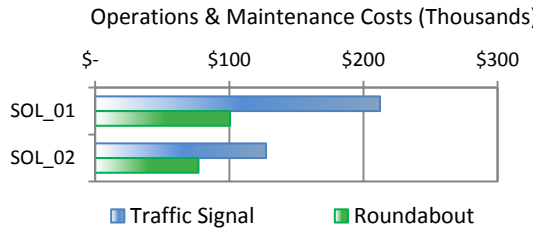
Emissions **Study Intersection**	**Preferred Control**
Metz Road at Pinnacles Parkway (Proposed)	EQUAL
Front Street at East Street	

Cost Performance Measures

The following performance measures are used to calculate the added cost of a roundabout compared to stop or signal control. For each performance measure, the roundabout adds to the cost of the intersection if the calculated life-cycle cost of the roundabout is greater than the life-cycle cost of stop or signal control. The magnitude of the cost is the difference between the life-cycle cost of the roundabout less the life-cycle cost of the stop or signal.

Operations and Maintenance

The operations and maintenance performance measure incorporates common annualized costs associated with operating and maintaining the proposed type of intersection control. Common costs include signal timing and maintenance, power consumption for signal operations and intersection illumination, landscape maintenance, and pavement rehabilitation. Average annualized costs were used if intersection specific costs were not provided.

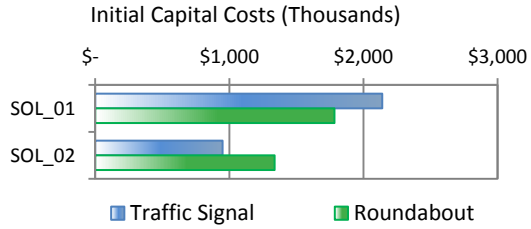


Based solely on lowest expected annual operations and maintenance costs, the preferred intersection control type for each study intersection is as follows:

Operations and Maintenance **Study Intersection**	**Preferred Control**
Metz Road at Pinnacles Parkway (Proposed)	
Front Street at East Street	

Initial Capital Costs

The initial capital costs performance measure estimates the capital costs needed to plan, design, and construct the proposed intersection improvement. The capital costs include construction, capital support, and right of way.



Based solely on lowest estimated initial capital cost, the preferred intersection control type for each study intersection is as follows:

Initial Capital Cost **Study Intersection**	**Preferred Control**
Metz Road at Pinnacles Parkway (Proposed)	
Front Street at East Street	

Summary of B/C Performance Measures

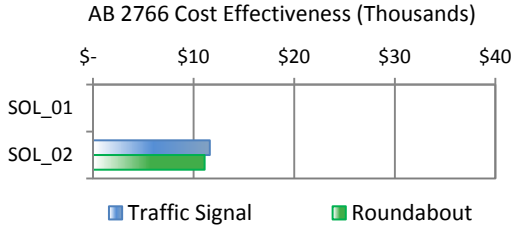
The following table summarizes the five performance measures evaluated at each project location.

Study Intersection	Preferred Intersection Control by Performance Measure					
	Safety	Delay	Ops. & Maint.	Emission	Capital Cost	B/C
Metz Road at Pinnacles Parkway (Proposed)				EQUAL		
Front Street at East Street						

COST EFFECTIVENESS TO REDUCE POLLUTANT EMISSIONS (AB 2766 GRANT)

The cost effectiveness to reduce pollutant emissions measures the return on investment of funding intersection improvements based on the California Air Resources Board (CARB) Cost Effectiveness Analysis Tools for the Motor Vehicle Registration Fees Program (AB 2766) and the Congestion Mitigation and Air Quality (CMAQ) Program. The emission factors used in the calculations are based on the year 2013 Table 4 Emission Factors by Speed for Project Life 6-10 years. The assumed funding amount is $400,000 with an effectiveness period equaling the life cycle analysis period. The discount rate for emissions is 3% and the capital recovery factor (CRF) is 0.12.

Intersection alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less should be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD). This funding source could help with the cost to TAMC and the City of Greenfield.



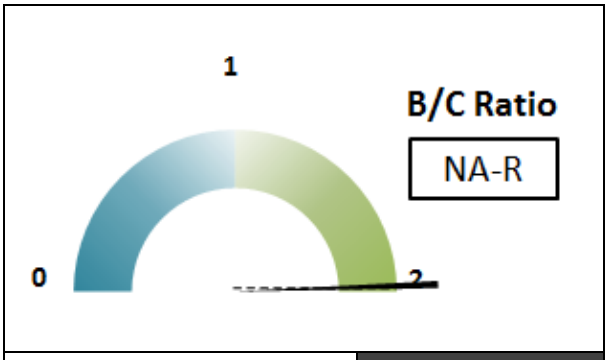
Based solely on lowest cost per ton in reducing pollutant emissions, the preferred intersection control type for each study intersection is provided below.

AB 2766 Cost Effectiveness Study Intersection	Preferred Control
Metz Road at Pinnacles Parkway (Proposed)	NONE
Front Street at East Street	

NOTE: Only the alternative with the lowest cost effectiveness score is reported. Both alternatives may be cost effective to reduce pollutant emissions.

None: The average speeds of the proposed improvements are similar to existing and do not provide a benefit.

METZ ROAD AT PINNACLES PARKWAY (PROPOSED)



Result: *Based on the Life Cycle Benefit Cost ratio*	**Roundabout**

The Benefit Cost (B/C) ratio for Metz Road at Pinnacles Parkway is NA-R. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is not sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type is unlikely to change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

The B/C ratio is assigned a value NA-R due to the higher initial capitol cost of the signal alternative compared to the roundabout alternative. The key contributing factor to the higher estimated signal cost is the length of left turn channelization that is required for each leg approaching the intersection. The total life cycle benefits of the roundabout are estimated at $370,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $4,500 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. Since no intersection exists today, non-roundabout intersection operations were evaluated for stop control and traffic signal control. The stop control alternative assumed a side-stop for the minor road on the proposed Pinnacles Parkway. Demand is expected to exceed capacity of the stop control intersection. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2035 design year. The year 2015 was assumed for the baseline "build" condition for a total 20 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number SOL-01 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
						Transit Service	Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context		Pedestrian Considerations	Bicycle Routes
Metz Road at Pinnacles Parkway (Proposed)	**Metz Road (SR 146) (Caltrans)**	2 lane undivided	Conventional highway	55 east, 35 west	Serves recreational, residential, institutional, industrial, & agricultural land uses SR 146 provides access to Pinnacles National Park	No transit service provided	No sidewalks provided	No bike lanes provided
	Pinnacles Parkway (Proposed)	2 lane undivided (Proposed)	Arterial	35 assumed	Serves residential, institutional, industrial, & agricultural land uses	TBD	TBD	TBD

Metz Road, or State Route 146 (SR 146), is currently a conventional highway with private, farm access driveways at the intersection with the proposed Pinnacles Parkway and the future Gabilan Drive extension.

Parcels in the immediate vicinity of the project are vacant or have dwelling set-backs exceeding 100 feet from the existing edge of pavement. The existing intersection is within City of Soledad and Caltrans right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Potential right of way constraint
2. High speed approach

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

Planned improvements by the City of Soledad include the northerly extension of Los Coches Road (proposed as Pinnacles Parkway) and the southerly extension of Gabilan Drive to create the proposed intersection at Metz Road. For the purpose of this study, Pinnacles Parkway is assumed to exist for existing and future design year conditions. Gabilan Drive is assumed to be constructed at beyond the year 2035 and is therefore not considered in the B/C ratio calculations. However, intersection operations including the Gabilan Drive extension were evaluated for signal and roundabout control alternatives for the 2035 design year. Refer to the Intersection Control Alternative Summary table.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Proposed Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for 2015 / 2035 AM and PM peak hour volumes were taken from the Soledad Business Park TIA provided by the City. Design year 2035 AM and PM peak hour volumes for the future intersection with Gabilan Drive were taken from the Gabilan Drive Extension Study provided by the City.

Stop Control

With stop control, operations were evaluated with Metz Road maintaining uninterrupted flow and stop control installed for northbound Pinnacles Parkway

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

traffic. Roadway improvements include the widening of Metz Road to accommodate westbound left turn channelization in both directions. Design year PM peak hour demand is expected to exceed capacity for northbound Pinnacles Parkway. Northbound Pinnacle Parkway vehicles are expected to experience significant delay while trying to enter Metz Road.

Based on the design year PM peak hour operations, a B/C ratio was not developed for this alternative. The costs to construct the left turn channelization improvements are comparable to the cost of the signal control, less the signal equipment. In addition, the added cost in delay is over $1,500,000 more than the signal alternative.

Signal Control

With signal control, roadway improvements include the widening of Metz Road to accommodate westbound left turn channelization in both directions. Demand is adequately served for AM and PM peak hours under both existing and future design year conditions.

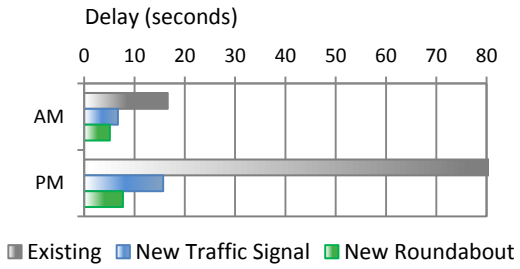
Crosswalks are currently not stripped at the intersection but with signalization can be provided with increased safety. Bike lanes and transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access. Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to perform below capacity for AM and PM peak hours under both existing and future design year conditions.

Crosswalks are currently not stripped at the intersection but can be provided with midway refuge areas. Bike lanes and transit stops are not provided at the intersection therefore the necessary lane additions will not impact transit access.

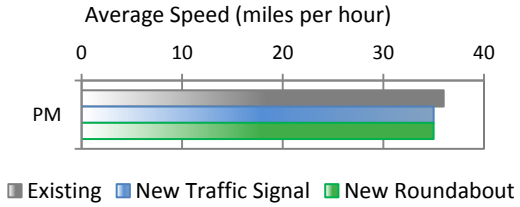
TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



NOTE: Intersection delay is limited to 80 seconds in the chart above. 80 seconds is equivalent to a Level of Service F (LOS F) for signal control.

The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



NOTE: Traffic is not controlled on Metz Road and is able to travel at a high rate of speed for the existing condition.

PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Table below. Intersection control alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	EQUAL
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	N/A - New Intersection

RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations for further study will likely have the greatest effect on the B/C Ratio and the potential return on investment:

- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SOL-01**
01/16

Intersection Cost Comparison

Metz Road at Pinnacles Parkway
Soledad, CA

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.09	$ 13,909	$ 189,022	0.21	$ 30,908	$ 420,048
Predicted PDO Crashes	0.32	$ 3,244	$ 44,089	0.35	$ 3,548	$ 48,215
Subtotal - Safety Costs	**-**	**$ 17,153**	**$ 233,111**	**-**	**$ 34,456**	**$ 468,263**
DELAY						
Delay to Persons in Vehicles (hours)	724	$ 7,715	$ 162,017	1310	$ 13,937	$ 292,667
Subtotal - Delay Costs	-	**$ 7,715**	**$ 162,017**	-	**$ 13,937**	**$ 292,667**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 500	6,795
Cost of Power for Signal				-	$ 1,500	20,385
Cost of Illumination		$ 1,000	$ 13,590		$ 1,000	13,590
Cost of Landscaping Maintenance	-	$ 1,000	$ 13,590			
Cost of Signal Maintenance				-	$ 3,500	47,566
Cost of Pavement Rehabilitation			$ 73,307			$ 124,000
Subtotal - Operations and Maintenance Costs	-	**$ 2,000**	**$ 100,488**	-	**$ 6,500**	**$ 212,337**
EMISSIONS						
Tons of ROG	0.04	$ 36	$ 484	0.04	$ 36	$484
Tons of NOX	0.16	$ 2,095	$ 28,468	0.16	$ 2,095	$28,468
Tons of PM10	0.0019	$ 187	$ 2,539	0.0019	$ 187	$2,539
Subtotal - Emissions Costs		**$ 2,317**	**$ 31,491**		**$ 2,317**	**$ 31,491**
INITIAL CAPITAL COSTS						
Construction Cost			$ 1,188,700			$ 1,426,100
Construction Cost - Structures			$ -			$ -
Capital Support			$ 595,000			$ 714,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,783,700**			**$ 2,140,100**
NET PRESENT VALUE			**$ 2,310,806**			**$ 3,144,858**

LIFE CYCLE BENEFIT/COST ANALYSIS	
BENEFITS - Roundabout compared to Traffic Signal	
Safety Benefit of Roundabout	$235,153
Delay Reduction Benefit of Roundabout	$130,650
Emission Reduction Benefit of Roundabout	$0
Total Benefits	**$365,802**
COSTS - Roundabout compared to Traffic Signal	
Added O&M Costs of a Roundabout	-$111,850
Added Capital Costs of a Roundabout	-$356,400
Total Costs	**-$468,250**

LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO

N/A

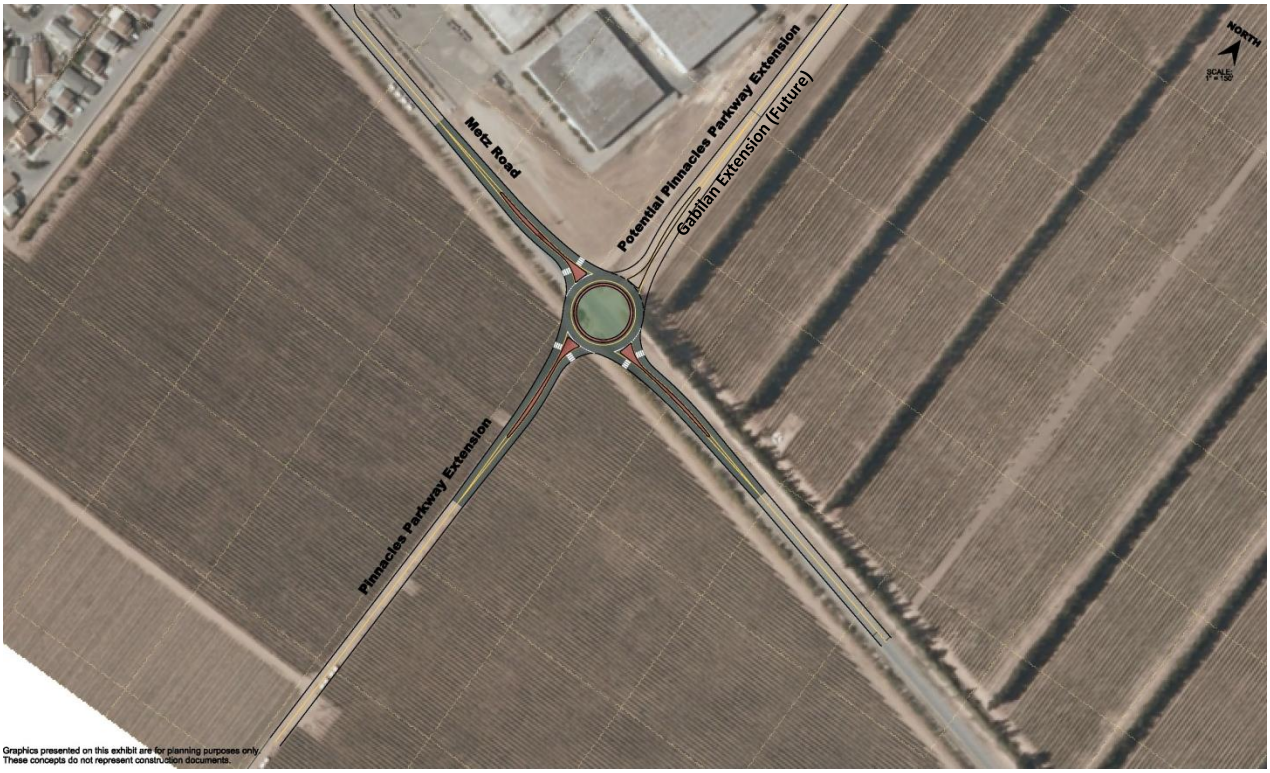
B/C Preferred: Roundabout Alternative

Roundabout Preferred
Cost of Roundabout is less than cost of Traffic Signal, and Roundabout offers benefits compared to Traffic Signal.

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	N/A - New intersection	N/A - New intersection
Cost Per Pound Per Life	N/A - New intersection	N/A - New intersection
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**N/A - New intersection**	**N/A - New intersection**

Intersection Improvement Alternatives

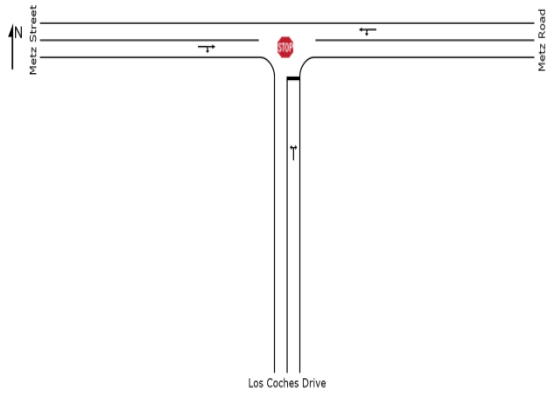
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

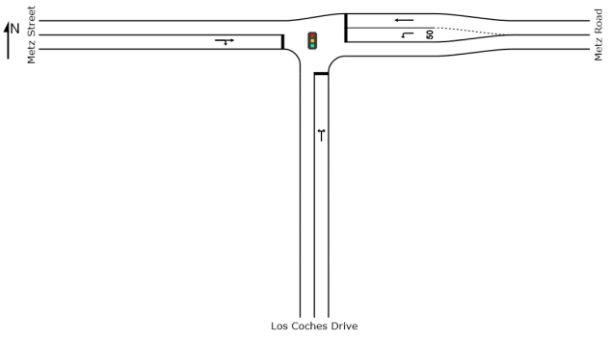
Intersection Control Alternative Summary



ALTERNATIVE 0
STOP CONTROL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	9.4 (NB)	3 (NB)	B	10.3 (NB)	23 (NB)
2035	C	16.6 (NB)	48 (NB)	F	149.5 (NB)	565 (NB)

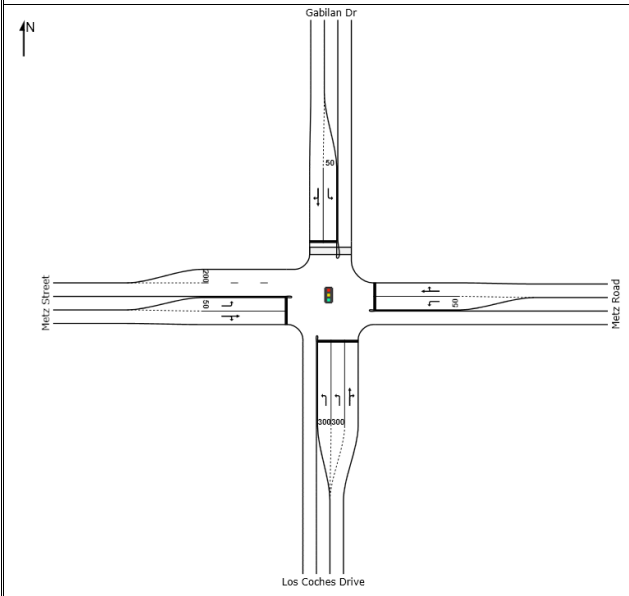
NOTES:



ALTERNATIVE 1
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	6.1	16 (EBT)	A	5.4	21 (EBT)
2035	A	6.7	66 (NB)	B	15.7	292 (NB)

NOTES:

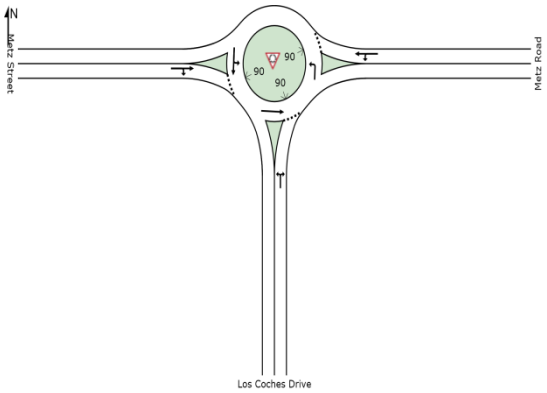


ALTERNATIVE 1
SIGNAL (With Gabilan Extension)

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	Not Evaluated					
2035	B	11.6	135 (EBT)	B	18.1	373 (EBT)

NOTES:

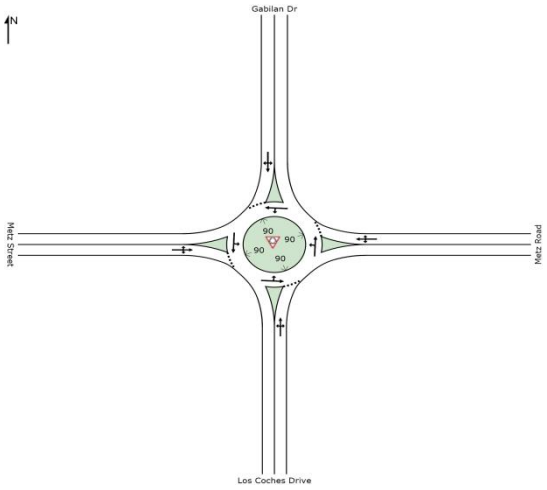
Intersection Control Alternative Summary



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	A	3.1	10 (EB)	A	3.4	14 (EB)
2035	A	5.1	56 (EB)	A	7.7	91 (NB

NOTES:

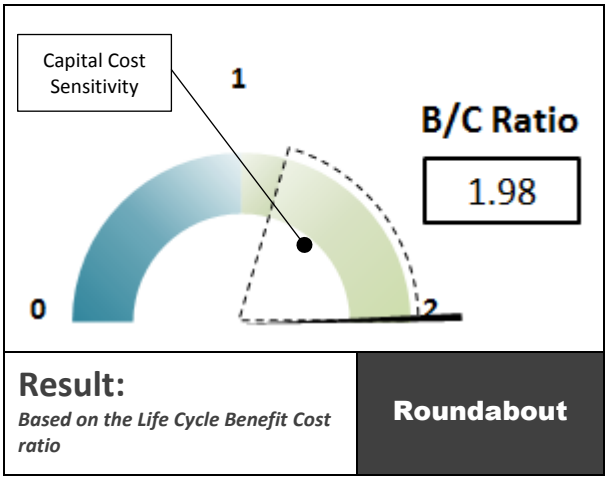


ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	Not Evaluated					
2035	A	5.8	63 (EB)	B	10.6	172 (NB)

NOTES:

FRONT STREET AT EAST STREET



Result:
Based on the Life Cycle Benefit Cost ratio

Roundabout

The Benefit Cost (B/C) ratio for Front Street at East Street is 1.98. Based on the B/C ratio, the form of intersection control with the greatest potential return on investment is a Roundabout.

CAPITAL COST SENSITIVITY

The B/C ratio for this study intersection is sensitive to estimated capital costs. Based on the B/C ratio's sensitivity to estimated capital costs, the preferred intersection control type may change with further refinement of the project costs as proposed improvements progress through detailed planning and design.

The total life cycle benefits of the roundabout are estimated at $670,000 when compared to a traffic signal. The total life cycle benefit includes an estimated $4,500 reduction in annual operations and maintenance costs when compared to a traffic signal.

Operationally, the roundabout configuration is a viable alternative to serve forecast traffic. The existing stop-control or, no project alternative, is near capacity in the PM peak hour and will continue to degrade over time. Signal control is a viable alternative considering the project constraints given for this evaluation. There may be other considerations, constraints, and project factors identified in future design evaluations that could affect the feasibility and prioritization of a specific configuration.

The intersection evaluation was based on traffic operations for the 2035 design year. The year 2015 was assumed for the baseline "build" condition for a total 20 year life cycle duration to determine the B/C ratio.

Refer to the Intersection Cost Comparison for intersection Number SOL-02 on the following pages for a complete summary of the Life Cycle Benefit/Cost Analysis.

EXISTING CONDITIONS

This section provides a brief overview of the transportation facilities and geometric characteristics of the roadways within the study area. This section also describes the existing conditions and constraints identified at the study location.

Front Street at East Street is controlled by stop signs on all approaches.

Parcels in the north, east, and south quadrants are developed with commercial structures located at the back of existing sidewalks. The westerly parcel is undeveloped. The existing intersection is within the

Summary of Existing Conditions

Intersection	Roadway	Corridor Context				Multimodal Transportation		
							Active Transportation Links	
		Cross Section	Functional Classification	Speed (mph)	Regional Context	Transit Service	Pedestrian Considerations	Bicycle Routes
Front Street at East Street	**Front Street (SR 146 south of East Street)**	2 lane divided north of East St.	Local	25	Serves business & commercial land uses SR 146 provides access to Pinnacles National Park.	Service provided by Monterey Salinas Transit for Line 23 on Front Street south of East Street	Sidewalks Crosswalk on north leg	Class II Bike lanes south of East Street
	East Street (SR 146)	2 lane undivided	Local	25	Serves residential, business, & commercial land uses SR 146 provides access to Pinnacles National Park	Service provided by Monterey Salinas Transit for Line 23	Sidewalks Crosswalk on east and west leg	Class II Bike lanes

City of Soledad. The south leg of Front Street and the north leg of East Street are part of State Route 146 (SR 146) and Caltrans right of way.

Existing design constraints and considerations at the study intersection include (see map for locations):

1. Existing commercial structure – identified as fatal flaw if disturbed.
2. Identified as potential future parking lot

The Summary of Existing Conditions table describes the study area roadways. An aerial view of the project location with existing design constraints is provided below.

PLANNED IMPROVEMENTS

The Front Street at East Street intersection is located within the City of Soledad Downtown Specific Plan area.

INTERSECTION CONTROL ALTERNATIVES

The existing and proposed intersection control options that were evaluated at the study intersection include:

Control Type	Legend
Existing Stop	
Proposed Signal	
Proposed Roundabout	

Design Year Traffic

Traffic data for the 2015 PM peak hour and the 2035 AM and PM peak hour volumes were taken from the Soledad Business Park TIA provided by the City. Volumes were not provided for the existing AM peak hour.

Stop Control (Existing)

With stop control, demand is approaching capacity for the PM peak hour under existing conditions. Westbound Front Street vehicles experience significant delay and queuing. Improvements to increase capacity while maintaining stop control operations for the design year PM peak hour demand are not feasible based on existing site constraints.

1 Refer to the Existing Conditions section on the previous page for description of the design constraint.

Signal Control

With signal control, additional lanes are not required to achieve acceptable design year operations. Intersection improvements, such as bulb outs, are suggested to reduce pedestrian crossing distances.

The proposed traffic signal is expected to improve intersection performance and provide sufficient capacity for AM and PM peak hours under both existing and future design year conditions.

No physical changes are proposed to the existing intersection therefore there will be no impacts to pedestrian facilities. Bike lanes and transit stops are not provided.

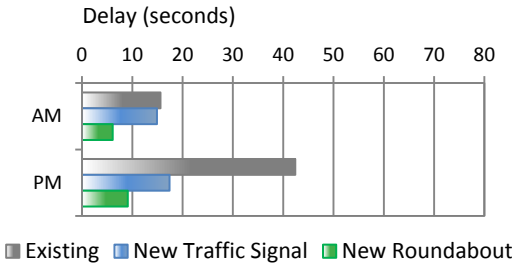
Roundabout Control

With roundabout control, a single lane roundabout with single lane approaches and departures will improve intersection performance. The single lane roundabout is expected to improve intersection performance and provide sufficient capacity for AM and PM peak hours under both existing and future design year conditions.

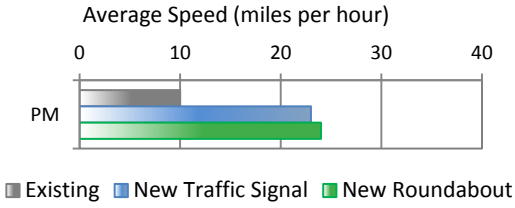
Crossing distances will be reduced with the one lane roundabout and midway refuge areas can also be provided. Bike lanes along Front Street and East Street can be maintained with a one lane roundabout. Transit stops can be maintained with a one lane roundabout.

TRAFFIC OPERATIONS SUMMARY

The following bar chart illustrates the peak hour intersection delay for design year traffic operations by intersection control form. Refer to the Intersection Control Alternative Summary table for additional information.



The following bar chart illustrates the calculated average speeds through the study intersection used to determine AB 2766 cost effectiveness.



PERFORMANCE MEASURE SUMMARY

The following table summarizes the five performance measures evaluated to calculate the B/C ratio and the cost effectiveness to reduce pollutant emissions. Refer to the Screening Summary for a brief overview of each performance measure and the assumptions used to calculate the performance measure costs. Refer to the Intersection Cost Comparison table for performance measure costs and B/C ratio calculations.

Intersection alternatives that may be considered for grant funding through the Motor Vehicle Registration Fees Program (AB 2766) administered by the Monterey Bay Unified Air Pollution Control District (MBUAPCD) are noted in the Performance Measure Summary Table. Alternatives with a cost effectiveness to reduce pollutant emissions of $20,000 or less are identified.

Performance Measure Summary **Performance Measure**	**Preferred Control**
Benefits	
Safety	
Delay	
Emission	
Costs	
Operations and Maintenance	
Initial Capital Cost	
Return on Investment	
Life Cycle B/C Ratio	
AB 2766 Cost Effectiveness	
Cost effectiveness < $20,000	

Neutral: Indicates that the value of the performance measure is equal for each proposed alternative.

Recommendations for Further Study

The following recommendations for further study will likely have the greatest effect on the B/C ratio and the potential return on investment:

- Preliminary engineering and additional site investigations.

KITTELSON & ASSOCIATES, INC.
TRANSPORTATION ENGINEERING/PLANNING

TAMC Regional ICE Study
Intersection Number **SOL-02**
01/16

Intersection Cost Comparison

Front Street at East Street
Soledad, CA

Cost Performance Measure	Intersection Type					
	Roundabout			Traffic Signal		
	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost	Annual Quantity	Annual Cost	Total Discounted Life Cycle Cost
SAFETY						
Predicted Fatal/Injury Crashes	0.16	$ 24,051	$ 326,867	0.36	$ 53,448	$ 726,371
Predicted PDO Crashes	0.64	$ 6,495	$ 88,273	0.72	$ 7,331	$ 99,636
Subtotal - Safety Costs	**-**	**$ 30,547**	**$ 415,140**	**-**	**$ 60,779**	**$ 826,007**
DELAY						
Delay to Persons in Vehicles (hours)	945	$ 10,763	$ 226,032	2015	$ 23,083	$ 484,744
Subtotal - Delay Costs	-	**$ 10,763**	**$ 226,032**	-	**$ 23,083**	**$ 484,744**
OPERATIONS & MAINTENANCE						
Cost of Signal Retiming				-	$ 500	6,795
Cost of Power for Signal				-	$ 1,500	20,385
Cost of Illumination		$ 1,000	$ 13,590		$ 1,000	13,590
Cost of Landscaping Maintenance	-	$ 1,000	$ 13,590			
Cost of Signal Maintenance				-	$ 3,500	47,566
Cost of Pavement Rehabilitation			$ 49,815			$ 39,010
Subtotal - Operations and Maintenance Costs	-	**$ 2,000**	**$ 76,995**	-	**$ 6,500**	**$ 127,347**
EMISSIONS						
Tons of ROG	0.05	$ 46	$ 626	0.05	$ 51	$695
Tons of NOX	0.16	$ 2,015	$ 27,380	0.16	$ 2,015	$27,380
Tons of PM10	0.0022	$ 215	$ 2,919	0.0022	$ 215	$2,919
Subtotal - Emissions Costs		**$ 2,275**	**$ 30,924**		**$ 2,281**	**$ 30,994**
INITIAL CAPITAL COSTS						
Construction Cost			$ 891,525			$ 632,600
Construction Cost - Structures			$ -			$ -
Capital Support			$ 446,000			$ 317,000
Right-of-Way			$ -			$ -
Subtotal - Initial Capital Costs			**$ 1,337,525**			**$ 949,600**
NET PRESENT VALUE			**$ 2,086,616**			**$ 2,418,692**

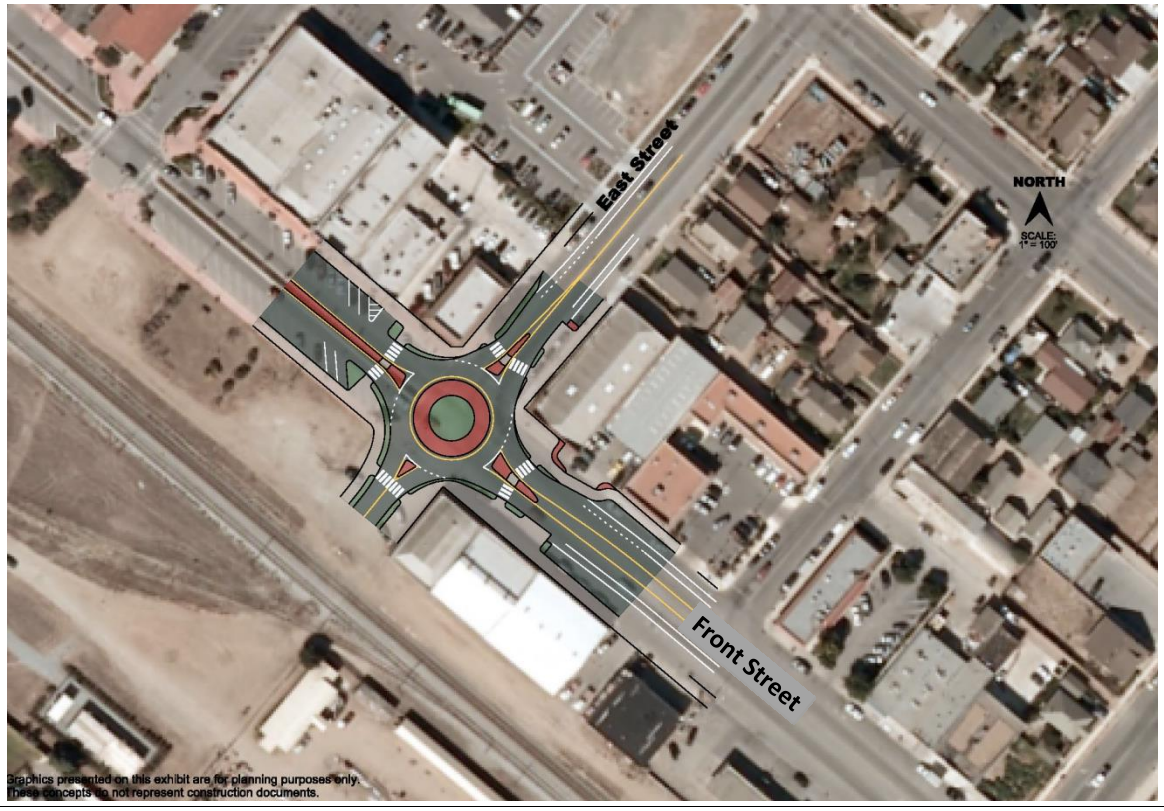
LIFE CYCLE BENEFIT/COST ANALYSIS		
BENEFITS - Roundabout compared to Traffic Signal		
Safety Benefit of Roundabout	$410,867	**LIFE CYCLE (20 YEAR) BENEFIT/COST RATIO**
Delay Reduction Benefit of Roundabout	$258,713	
Emission Reduction Benefit of Roundabout	$70	
Total Benefits	**$669,649**	
COSTS - Roundabout compared to Traffic Signal		
Added O&M Costs of a Roundabout	-$50,352	**1.98**
Added Capital Costs of a Roundabout	$387,925	
Total Costs	**$337,573**	

B/C Preferred: Roundabout Alternative

AIR QUALITY ANALYSIS		
AIR QUALITY	**Roundabout (vs. existing)**	**Traffic Signal (vs. existing)**
Annual Emission Reduction (lb/year)	242	232
Cost Per Pound Per Life	$110.94	$116.10
AIR QUALITY COST EFFECTIVENESS ($ / ton / year)	**$11,094**	**$11,610**

Intersection Improvement Alternatives

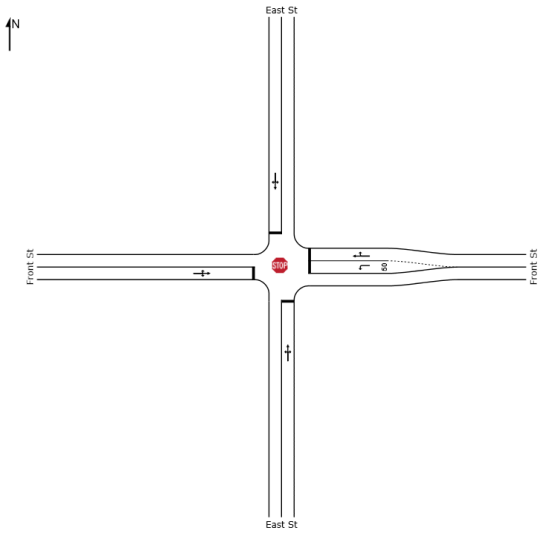
Signal Alternative



Roundabout Alternative

Note: Intersection alternative improvements are conceptual and for planning purposes only. Alternatives are not to scale.

Intersection Control Alternative Summary

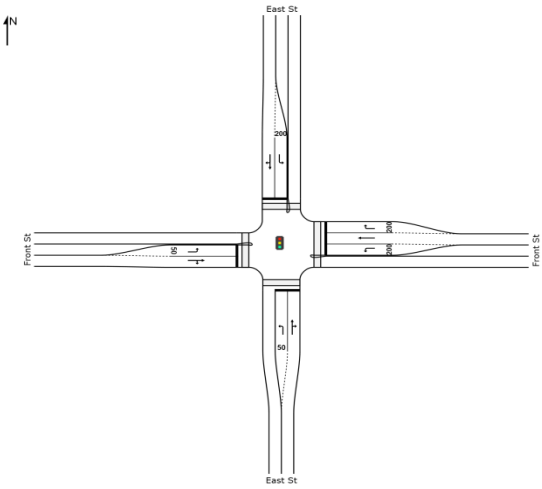


EXISTING INTERSECTION
SIGNAL

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	D	32.7	323 (WBT)
2035	C	15.6	108 (SB)	E	42.4	365 (WBL)

NOTES:

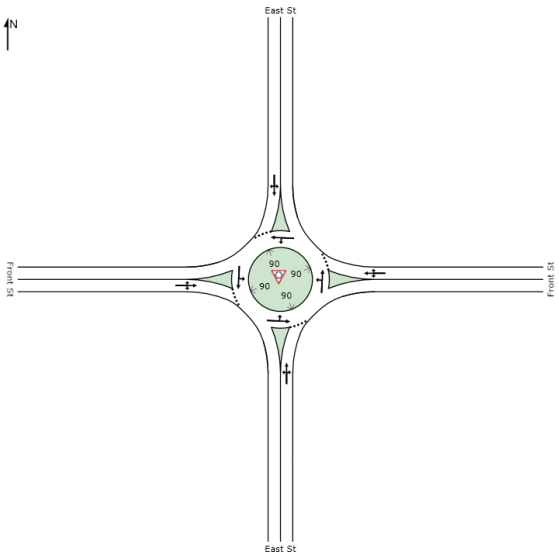
1. WB queue exceeds available storage for the 2015 and 2035 p.m. peak hours and operations at Dixie Street.



ALTERNATIVE 1
SIGNAL MODIFICATION PER COUNTY PLAN

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	B	15.7	197 (WBT)
2035	B	14.9	141 (SBL)	B	17.4	248 (WBT)

NOTES:



ALTERNATIVE 2
ROUNDABOUT

Summary of Operations						
	AM			PM		
Design Year	LOS	Delay (s)	95% Queue (ft)	LOS	Delay (s)	95% Queue (ft)
2015	-	-	-	A	6.9	81 (WB)
2035	A	6.1	48 (SB)	A	9.1	148 (WB)

NOTES: