Project Study Report

Interstate 215/ Palm-Kendall Interchange

California State Polytechnic University, Pomona Department
of Civil Engineering Senior Project 2019-2020

On Route _____ _____

Between _____ _____

And _____ _____

APPROVAL RECOMMENDED:

Belen Gomez	Mark Jardiolin
PROJECT MANAGER	*PROJECT MANAGER*

APPROVED:

_____	_____	_____
CIVIL ENGINEERING DEPARTMENT CHAIR	*CIVIL ENGINEERING DEPARTMENT ASSISTANT PROFESSOR*	*DATE*

1. INTRODUCTION

Palm Avenue and Kendall Drive is an intersection in San Bernardino, California. Interstate 215 runs North to South and is in conjunction with Palm Ave. and Kendall Dr. Due to the regional population growth and expansion of commercial business in the city of San Bernardino, Caltrans has determined that the existing design will not provide adequate services to the community and commercial business in the years to come.

The purpose of this project is to conduct a feasibility study to provide interchange improvements at Palm Ave./Kendall Dr. and Interstate 215. Caltrans has given a team of 16 students from California State Polytechnic University of Pomona the task of redesigning the Palm Ave./Kendall Dr. interchange in order to improve capacity operations and operations. The project will allow for future regional population growth for years to come.

This project study report summarizes the results of the year-long traffic and environmental analysis, as well as the geometric design that was evaluated in order to determine the best design alternative for the Palm Ave./Kendall Dr. interchange and I-215 interchange. A detailed summary of the traffic and environmental analysis can be found in the Intersection Control Evaluation (ICE) and Preliminary Environmental Analysis Report (PEAR), which accompanies this report.

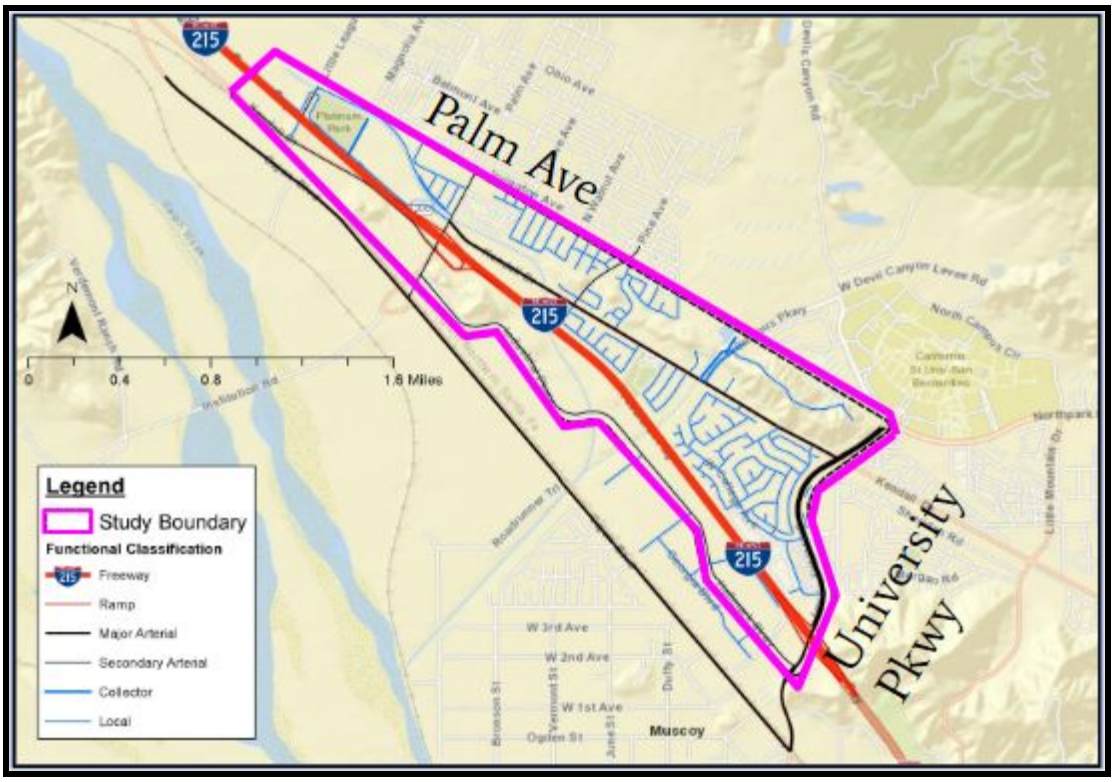


Figure 1. Project study and design in San Bernardino County

The project location was divided into a study boundary and a design boundary, Figure 1 above shows the mapped outline. The study boundary is denoted in black in Figure 1 and the design boundary is denoted in cyon. Within the project boundary, a traffic analysis was performed of the existing intersections along Palm Ave. and Kendall Dr. A preliminary environmental analysis was also performed to determine the level of impact that the project would have on the surrounding area. Within the project design boundary, several alternatives were designed and assessed.

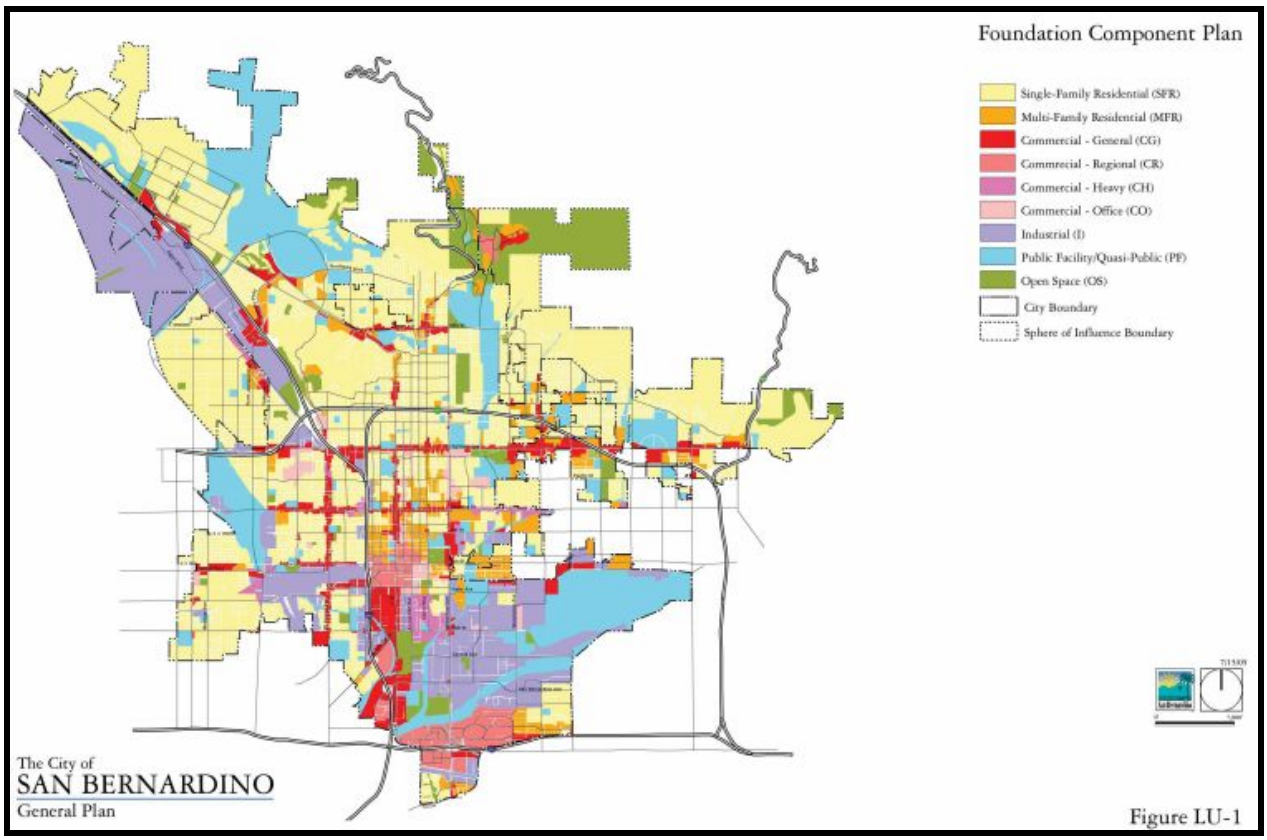


Figure 2: San Bernardino Land Use
(San Bernardino General Plan, 2005)

The city of San Bernardino's general plan, seen in Figure 2 above, shows that the project study boundary could be used for both residential and commercial land use. Under the "Land Use" chapter of the general plan it states that it wants to"Promote development that is compact, pedestrian-friendly, and served by a variety of transportation options along major corridors and in key activity areas" by working in collaboration with Caltrans (San Bernardino General Plan, 2005).

2. BACKGROUND

The project is located in San Bernardino County, California. The project involves the improvement of the Palm Ave./Kendall Dr. and I-215 interchange from postmile 14.106 to 14.304 (Caltrans, 2019). The section of the I-215 that the project team looked into has two mixed flow lanes and is classified as an auxiliary interstate highway by the California Road System. This segment of I-215 serves as a bypass auxiliary route of Interstate 15.

The primary purpose of this project is to improve or replace the existing interchange to accommodate expected future traffic conditions in year 2045. Palm Ave. and Hallmark Pkwy. intersection spacing needs to be corrected due to its close proximity to other intersections. One other local road along Kendall Dr., Little League Drive was taken into consideration during the design process.

The final project deliverable will closely resemble a feasibility study of the aforementioned improvements. Local road design recommendations will be provided to the City of San Bernardino based on the Traffic Impact Analysis. The study and design boundary were determined based on the area needed for preliminary environmental and traffic analyses in addition to the area necessary for the proposed geometric improvements.

3. PURPOSE AND NEED

Purpose

The purpose of this project is to increase capacity, accommodate future demand, address the intersection spacing, and improve pedestrian and active transportation mobility

Needs

1. Improve capacity to accommodate regional population growth in San Bernardino.
2. Improve intersection spacing between Kendall Dr. and Hallmark Pkwy. to relieve congestion.
3. Integrate pedestrian access, active transportation, and complete street elements.

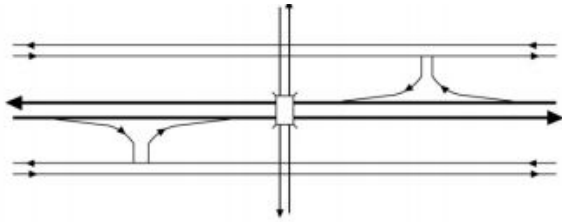
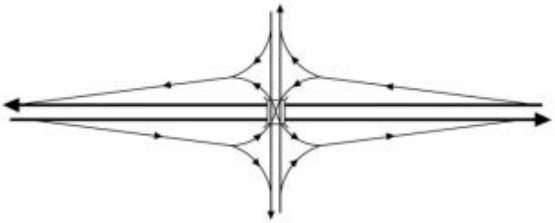
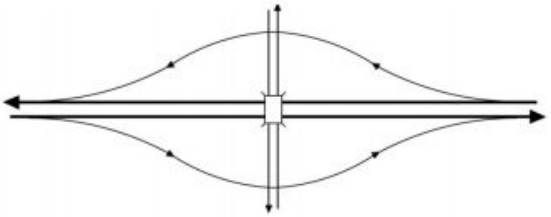
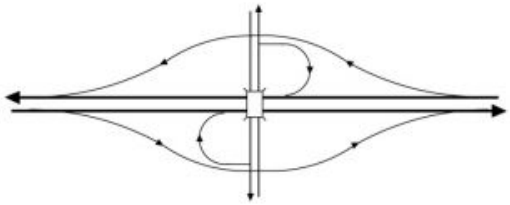
4. DEFICIENCIES

Synchro 10 software was used for all traffic analyses for different intersection controls. Given the design volumes, the team determined two to three lanes in each direction was necessary. Synchro 10 was unable to report an intersection level of service for roundabouts with more than two approach lanes. This is due to HCM 2016 not detailing the analysis of three lane roundabout. Due to our need of three lanes and the rarity of a three lane roundabout in the state of California, we reported all roundabout levels of service as not applicable and do not recommend this control type for any intersections in this project.

Due to current events of the covid-19 pandemic, campus was shut down which allowed limited access to campus resources such as certain software for the analysis and graphics of this project. Outside resources were used for the successful completion of this project.

5. ALTERNATIVES

Table 1: Interchange types used for the design of viable alternatives

Interchange Types	
Hook Ramps	
Single Point Urban Interchange	
Spread Diamond	
Partial Cloverleaf	

Kendall Plaza Tee

The Kendall Plaza Tee interchange will relocate the two ramps, currently a tight spread diamond, of the northbound on and off movement located on Palm Ave. of the I-215. The spread diamond that exists will be replaced with the implementation of two hook ramps which will be relocated on Kendall Dr. The loop ramps that currently exist for the southbound on and off movement will be redesigned as well. The southbound spreadiamond ramps, that have on and off ramps that run parallel, will omit the southbound off movement and keep the southbound on movement. An additional southbound on ramp will be designed with a hook ramp across the existing southbound on ramp. Kendall Dr., south of I-215, will be realigned and be used as an additional southbound off ramp, ending with two lanes to allow for right and left turn movements on Palm Ave. The purpose of this layout was to increase intersection spacing along Palm Ave. by removing the tight diamond northbound on and off ramps with hook ramps next to Kendall Plaza. The design alternative increases the level of service by decreasing the amount of left turns being made on the southbound ramps.

The following dimensions were chosen to meet the requirements given by the Caltrans Highway Design Manual (HDM): 12-15 foot lane width, 4 foot left ramp shoulder, 8 foot right ramp shoulder and the mainline shoulder widths range from 3 to 8 feet. The HDM was used to meet all other requirements, including cross-section design.

The traffic analysis was performed using Trafficware Synchro 10 and SimTraffic. The traffic volumes were found using the Jack in the Box Traffic Impact Analysis (TIA) and HDR Traffic Operation Analysis Report (TOAR) to approximate the level of service. The analysis was performed for both the AM and PM peak hour volume; results can be found in the ICE report (Attachment B).

The addition of the northbound hook ramps and the southbound hook ramp will encroach on the property of private owners and businesses; therefore, a right of way may need to be purchased at the discretion of decisions drafted by the geometric design team. The alternative design for the northbound hook ramps is near a channel used for flood control. Preliminary environmental analysis suggested that the ramps be elevated or shifted to a certain distance away from the channel. Additionally, electric pole utilities will have to be relocated in order to implement the design at this location.

An Advance Planning Study (APS) aids in the development of a cost estimate and illustrates any requirements or constraints for the structures involved in the project. Each structure will have an APS that consists of a plan sheet that contains the typical cross sections, elevations, and basic dimensions, along with a cost estimate for the structure.

Figure 3: Kendall Plaza Tee design alternative.

Single Point Urban Interchange

The single point urban interchange (SPUI) is an undercrossing of I-215 and controls all traffic movements at a single intersection. The SPUI will replace the existing ramp intersections. The SPUI is a grade-separated interchange design where all freeway ramps begin or end at a single signalized intersection. A single traffic signal at the center of the SPUI will control all left turns. This alternative will combine the two diamond ramp interchanges into one large at-grade intersection. However, this design alternative is not favorable to pedestrians due to the complex layout of the ramps.

The following dimensions were chosen to meet the requirements given by the Caltrans Highway Design Manual (HDM): 12-15 foot lane width, 4 foot left ramp shoulder, 8 foot right ramp shoulder and the mainline shoulder widths range from 3 to 8 feet. The HDM was used to meet all other requirements, including cross-section design.

The traffic analysis was performed using Trafficware Synchro 10 and SimTraffic. The traffic volumes were found using the Jack in the Box Traffic Impact Analysis (TIA) and HDR Traffic Operation Analysis Report (TOAR) to approximate the level of service. The analysis was performed for both the AM and PM peak hour volume; results can be found in the ICE report (Attachment B).

The SPUI does not encroach on the property of private owners and businesses and requires a minimal amount of right of way. Additionally, utility lines located aboveground and underground must be relocated in order to implement the design at this location.

An Advance Planning Study (APS) aids in the development of a cost estimate and illustrates any requirements or constraints for the structures involved in the project. Each structure will have an APS that consists of a plan sheet that contains the typical cross sections, elevations, and basic dimensions, along with a cost estimate for the structure.

Figure 4: Single Point Interchange design alternative.

Partial Cloverleaf Interchange

The partial cloverleaf design will relocate the two ramps, currently a tight spread diamond, of the northbound on and off movement located on Palm Ave. of the I-215. The spread diamond that exists will be replaced with the implementation of two northbound on ramps consisting of a loop ramp and a tight diamond ramp. The implementation of the loop and tight diamond ramp will allow users to get on the northbound I-215 from either direction of Palm Ave. Additionally, the spread diamond's off movement will be replaced with the implementation of a hook ramp located along Kendall Dr. The southbound spreadiamond ramps, that have on and off ramps that run parallel, will omit the southbound off movement and keep the southbound on movement. An additional southbound on ramp will be designed with a hook ramp across the existing southbound on ramp. Kendall Dr., south of I-215, will be realigned and be used as an additional southbound off ramp, ending with two lanes to allow for right and left turn movements on Palm Ave. The purpose of this design alternative was to allow yield control movements for all on ramps, to decrease the amount of left turn movements, and to decrease the amount of time a vehicle spends at a traffic signal. Intersection spacing is also improved with the removal of the northbound on and off tight spread diamond.

The following dimensions were chosen to meet the requirements given by the Caltrans Highway Design Manual (HDM): 12-15 foot lane width, 4 foot left ramp shoulder, 8 foot right ramp shoulder and the mainline shoulder widths range from 3 to 8 feet. The HDM was used to meet all other requirements, including cross-section design.

The traffic analysis was performed using Trafficware Synchro 10 and SimTraffic. The traffic volumes were found using the Jack in the Box Traffic Impact Analysis (TIA) and HDR Traffic Operation Analysis Report (TOAR) to approximate the level of service. The analysis was performed for both the AM and PM peak hour volume; results can be found in the ICE report (Attachment B).

The addition of the two northbound on ramps and the southbound off ramp will encroach on the property of private owners and businesses; therefore, the right of way may need to be purchased at the discretion of decisions drafted by the geometric design team. Additionally, utility lines located aboveground and underground must be relocated in order to implement the design at this location.

An Advance Planning Study (APS) aids in the development of a cost estimate and illustrates any requirements or constraints for the structures involved in the project. Each structure will have an APS that consists of a plan sheet that contains the typical cross sections, elevations, and basic dimensions, along with a cost estimate for the structure.

Figure 5: Partial Cloverleaf Interchange design alternative.

Little League Tee

The Little League Tee design will consist of two hook ramps for northbound on and off movement, a spread diamond for southbound on and off movement, and a loop ramp for southbound on movement. This design, also, realigns Little League Dr. parallel to Cable Creek to maximize storage length for cars on the ramps. This design alternative will increase the level of service by improving intersection spacing along Palm Ave. and create a new intersection, which will divert traffic from congested intersections.

The following dimensions were chosen to meet the requirements given by the Caltrans Highway Design Manual (HDM): 12-15 foot lane width, 4 foot left ramp shoulder, 8 foot right ramp shoulder and the mainline shoulder widths range from 3 to 8 feet. The HDM was used to meet all other requirements, including cross-section design.

The traffic analysis was performed using Trafficware Synchro 10 and SimTraffic. The traffic volumes were found using the Jack in the Box Traffic Impact Analysis (TIA) and HDR Traffic Operation Analysis Report (TOAR) to approximate the level of service. The analysis was performed for both the AM and PM peak hour volume; results can be found in the ICE report (Attachment B).

An Advance Planning Study (APS) aids in the development of a cost estimate and illustrates any requirements or constraints for the structures involved in the project. Each structure will have an APS that consists of a plan sheet that contains the typical cross sections, elevations, and basic dimensions, along with a cost estimate for the structure. Little League Tee will require a bridge widening of the I-215 bridge over Palm Ave. in order to create an eight lane configuration. The total span of the bridge is 74’00” and 104’00” wide. The clearance height is 15’00”. Lane width is 12’00” , outside shoulder width is 10’00” , and sidewalks are 6’ to 6.5’00”
in width.

Figure 6: Little League Tee design alternative.

6. COMMUNITY INVOLVEMENT

Once construction begins on the new intersection configuration, users will see a delay in their trip. Caltrans must take steps to ensure that travel is not completely stopped or heavily delayed. During construction planning, the project will have to be divided into multiple stages to prevent having to shut down local streets and I-215 completely. A community impact assessment (CIA) should be conducted to determine how the area will be impacted if it is built. Other complications such as access to utility roads and commercial businesses may be present on the southwest side of the Palm Ave. near the southbound off ramp for the I-215. Additionally, commuters who are enrolled at Calstate University of San Bernardino, residents, and business owners must be informed of possible delays and reroutes must be implemented and displayed. A representative from Caltrans should be present at the town hall meeting for the city of San Bernardino to point out the benefits of the I-215 Palm Ave./Kendall Dr. Interchange Project and address concerns that may be brought up.

7. ENVIRONMENTAL DETERMINATION/DOCUMENTATION

After the project design boundary and project study boundary were established, a preliminary environmental report (PEAR) was written to evaluate how environmental concerns will affect the project's scope, schedule, and costs for environmental compliance. The most pressing concerns found in the report include: flood zones, community impact, utility lines, wildlife/endangered species, native lands, and USGS (seismic, paleontological, and geological).

Data for each section of the PEAR were acquired from federal, state, and local databases. ArchGIS was utilized to map the Federal Emergency Management Agency's (FEMA) flood zones. Cable Creek Channel, along Little League Dr. and Kendall Dr., was identified as a flood zone "A" to redirect water for flood control. It was advised to the geometric design team not to design the alternatives directly on the channel. During construction phasing, this channel must be considered due to potential harmful runoff. Additionally, construction of the selected design alternative might impact the surrounding community. Little League Baseball field is near our design parameters, therefore alternative routes must be made so as to not disrupt community events and gatherings. Preliminary environmental research identifies the San Bernardino kangaroo rat (Dipodomys merriami parvus) as both an endangered and protected species. The San Bernardino kangaroo rats are found on alluvial fans and flood plains, much like environments such as the Cajon Wash. If this species were identified in our study boundary, the project would be delayed in order to protect the endangered species.

Figure 7: Cable Creek Channel flood zone (top left), San Bernardino kangaroo rat (top right), and Little League Baseball (bottom center).

8. BENEFIT AND COST ANALYSIS

Cost Analysis

The costs for the four interchange alternatives were calculated based on sixteen categories that are typically included in any Caltrans Planning Level Type Study. The categories are as follows: earthwork, pavement structural section, structure items, right-of-way, drainage, speciality items, environmental, traffic items, detours, minor items, mobilization, supplemental, state furnished materials, support cost, and time related overhead. In addition, the contingency was calculated as 25% of the overall total project cost to include unpredicted items and any quantified risk . The Caltrans Basic Engineering Estimation System was used to determine standard unit prices for materials and labor, based on the size and estimated completion date of the project. A detailed summary of the costs associated with each interchange alternative can be viewed in Table 2 below.

The Partial Cloverleaf is the most cost effective design alternative at $73,129,000. Following is the Little League Tee at $75,560,000 and Kendall Plaza Tee at $87,460,00. The SPUI is the most expensive alternative at $122,636,000 due to its high pavement and structural item cost.

Table 2: Cost for each design alternative.

ITEM	Kendall Plaza T.	SPUI	Par-Clo	Little League T.
Earthwork	$105,000	$40,000	$869,000	$804,000
Pavement Structure	$3,894,000	$11,727,000	$5,708,000	$10,115,000
Structure Items	$35,208,000	$51,623,000	$25,855,000	$25,344,000
Right of Way	$6,006,000	$6,000	$5,373,000	$2,798,000
Drainage	$2,261,000	$3,170,000	$1,890,000	$1,953,000
Speciality Items	$904,000	$1,268,000	$756,000	$781,000
Environmental	$2,261,000	$3,170,000	$1,890,000	$1,953,000
Traffic Items	$2,261,000	$3,170,000	$1,890,000	$1,953,000
Detours	$2,261,000	$3,170,000	$1,890,000	$1,953,000
Minor Items	$904,000	$1,268,000	$756,000	$781,000
Mobilization	$2,803,000	$3,931,000	$2,344,000	$2,422,000
Supplemental	$1,121,000	$1,572,000	$938,000	$969,000
State Furnished Materials	$2,803,000	$3,931,000	$2,344,000	$2,422,000
Time Related Overhead	$2,803,000	$3,931,000	$2,344,000	$2,422,000
Contingencies	$14,016,000	$19,653,000	$11,719,000	$12,109,000
Support Cost	$7,849,000	$11,006,000	$6,563,000	$6,781,000
Total	**$87,460,000**	**$122,636,000**	**$73,129,000**	**$75,560,000**

Benefit Analysis

The benefits of implementing each new design alternative were determined by comparing the No Build alternative to each of the new design alternatives. The total delay, emissions, fuel and operation cost from the no build were all compared to the new design alternatives. The comparison was made to determine the decrease in all of the categories listed above, this shows the benefits that the new designs will have on this location. Each of the categories taken into account were found using Synchro 10. Each alternative provided us with a different delay, emission and fuel discharge values, the units vary. The difference between the new alternatives and the No Build design was then found and calculated using the unit prices. The future unit prices were determined from the Caltrans Vehicle Operation Cost Parameters. The benefits for each alternative can be found below (Table 3).

Table 3: Benefit analysis for each design alternative.

ITEM	Kendall Plaza T.	SPUI	Par-Clo	Little League Tee
Total Cost	$87.5 M	$122.6 M	$73.1 M	$75.5 M
Total Benefit	$387.5 M	$392.4 M	$435 M	$423.1 M
B/C Ratio	4.4	3.2	5.9	5.6

9. RECOMMENDED ALTERNATIVE

In order to compare the interchange alternatives and select the design that best satisfies the purpose and needs of the project, the Caltrans' Weighted Decision Matrix was used to evaluate the alternatives. The Weighted Decision Matrix allowed for the comparison of the alternatives against specific categories with varying degrees of weights.

The four alternatives were evaluated and compared against ten categories: traffic LOS, benefit/cost ratio, environmental issues, user expectations, achieved purpose and need, R/W impacts, pedestrian and bike access, constructability, ease of maintenance, and future adaptability. Ten criteria were given a weight of 1-10. 10 being the most important and 1 being the least. An objective scale was developed for each criteria to grade the alternatives on how well they fulfilled the needs of that category. After assigning values for all categories and alternatives Little League Tee scored the highest. As a result Little League Tee was chosen to be our recommended alternative given all proposed for the study area.

Table 4: Weighted Decision Matrix

Alternatives Weighted Decision Matrix					
	Weighted	Kendall Plaza T.	SPUI	Par-clo	Little League T.
Traffic LOS	10	8	6	8	7
Benefit/Cost Ratio	9	6	5	8	8
Environmental Issues	8	6	4	6	6
User Expectations	7	6	4	7	6
Achieve Purpose & Need	6	7	5	7	7
R/W Impacts	5	1	10	2	6
Pedestrian & Bike Access	4	4	3	4	8
Constructibility	3	7	2	6	6
Ease of Maintenance	2	2	5	4	2
Future Adaptability	1	3	2	6	3
Final Weight		**315**	**275**	**349**	**361**

The Little League Tee had the highest final score of 361 compared to the Partial Cloverleaf and Kendall Plaza Tee alternatives which scored 349 and 315. This alternative best satisfies the purpose and needs of the project and provides the best benefit/cost ratio and pedestrian and bike access. From there, a geometric approval drawing (GAD) was drafted (see Attachment C).

10. PROJECT PERSONNEL

Project Managers

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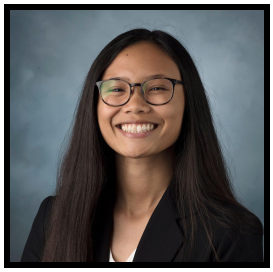
Mark Jardiolin

Geometric Design Team

Christopher Joeb

Shane Shein

Marcos Amancio



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11. ATTACHMENTS

- **Attachment A -Preliminary Environmental Analysis Report (PEAR)**
- **Attachment B - Intersection Control Evaluation (ICE)**
- **Attachment C - Geometric Approval Drawing (GAD)**
- **Attachment D - Advanced Planning Study (APS)**

12. RESOURCES

San Bernardino. (2005). *San Bernardino General Plan.* San Bernardino, pp. 45

Caltrans. (2019). *Postmile.* State of California. n.d.