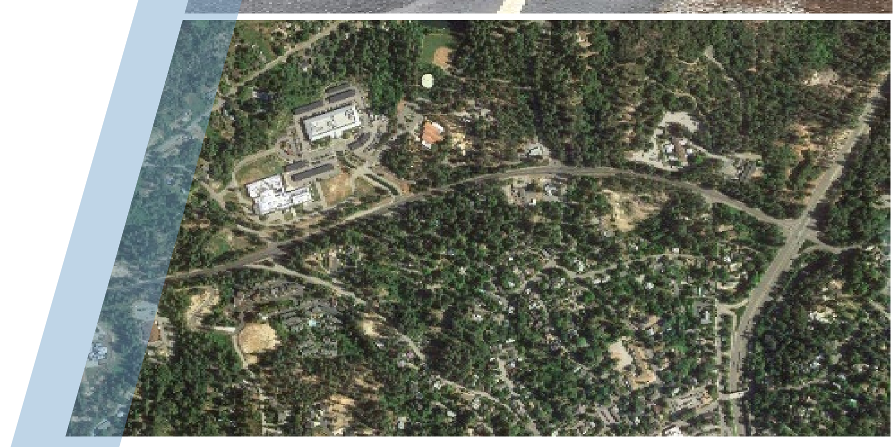
Nevada City SR 49 Multimodal Corridor Plan



Nevada County
Transportation Commission

GHD | 943 Reserve Drive Suite 100 Roseville, CA 95678 | 11194668 | November 7 2019

Table of Contents

Figure Index

Table Index

Appendix Index

1. Introduction

The Nevada County Transportation Commission (NCTC) commissioned a multimodal corridor plan for State Route (SR) 49 in Nevada City following input from the community at the May 2018 NCTC governing board meeting. As shown in Figure 1.1 through Figure 1.3, the study corridor is approximately one mile in length and extends from the intersection at SR 20 and Uren Street to the Nevada County Juvenile Hall driveway. There are four intersections and two driveways within these limits that provide access to SR 49 for residential, non-residential, and recreational land uses. One intersection within the study area is signalized, at East Broad Street/ North Bloomfield Road. The remaining intersections are two-way stop controlled where motorists traveling on SR 49 do not have to stop. Given that the posted speed limit entering the corridor is 55 mph and 45 mph within the corridor, the lack of stop controls and marked crosswalks can make crossing and traversing along SR 49 by bike or foot difficult. The driveways at the Nevada City Elks Lodge and The Nevada County Juvenile Hall feature stop control at each driveway egress.

Community members expressed the following concerns:

- safety concerns associated high vehicle speeds on SR 49;
- lack of pedestrian and bicycle treatments/accommodations along SR 49;
- need for improved crossings for those who desire to walk or bike across SR 49; and
- lack of pedestrian and bicycle connectivity to points of interest along the corridor.

This study examined infrastructure characteristics, corridor operations, and collision history to inform recommended improvements for safety, operational efficiency, and active transportation accommodation. Recommendations also include design elements that serve to calm traffic (i.e., reduce vehicle speeds) and improve visibility of pedestrians and bicyclists by motorists. Lastly, all recommended improvements include aesthetic treatments that reflect the historic character of Nevada City while accommodating vehicular traffic, including heavy vehicles.

Preferred and Lower Cost concepts are provided to offer NCTC flexibility in implementation, with Lower Cost Alternatives designed to offer economical solutions at selected locations that can be installed on short timelines. Preferred Recommended Improvements provide more robust safety and operations benefits but may be more challenging to implement due to right of way needs or other complexities. Analysis results and recommendations are presented in three corridor segments:

Segment 1: SR 20/Uren Street and Coyote Street intersections to North Bloomfield Road/East Broad Street intersections

Segment 2: North Bloomfield Road/East Broad Street intersection to Maidu Avenue/Orchard Street intersection

Segment 3: Cement Hill Road/West Broad Street intersection; Elks Lodge Driveway and Nevada County Juvenile Hall Driveway

The conceptual drawings and designs in the SR 49 Multimodal Corridor Plan present a vision of potential transportation improvements in the plan area. A project, on the other hand, utilizes specific tasks within a scope, schedule and budget to construct transportation infrastructure such as a Class I bike path, sidewalk, or roadway improvement. Concepts presented in the SR 49 Multimodal Corridor Plan may become a project when one of the agencies in the plan area that have jurisdictional authority to implement a project are able to move forward with a project within their jurisdiction. The project would then follow an approximately five to ten year process of project development before it can be constructed. The process to deliver a transportation project includes the following phases:

- allocation of funding through all project phases including construction;
- execution of Project Initiation Documents (PID);
- completion of environmental documentation required for project development under CEQA and NEPA, which includes mandatory public review and comment periods;
- acquisition of any needed right-of-way;
- completion of 100% Plans, Specifications & Estimates; and
- construction of the project.

The recommended proposed improvement concepts will serve to inform and guide future infrastructure and programming decisions based on available funding. To facilitate implementation options, alternative improvement concept packages were developed and prioritized based on potential return on investment. Benefit-cost assessments were based on: safety; mobility; health; air quality; recreation; and decreased auto-use. These criteria are key drivers for a variety of transportation funding sources, including competitive grant funding programs such as ATP, HSIP, etc. Information presented in this plan will serve as a resource for NCTC, Nevada City or Nevada County for developing competitive grant applications.

Nevada City SR 49 Multimodal Corridor Plan - Segment 1

FIGURE 1.1

0 200 400 600 800 1000 ft

Nevada City SR 49 Multimodal Corridor Plan - Segment 2

FIGURE 1.2

0 200 400 600 800 ft

Nevada City SR 49 Multimodal Corridor Plan - Segment 3

FIGURE 1.3

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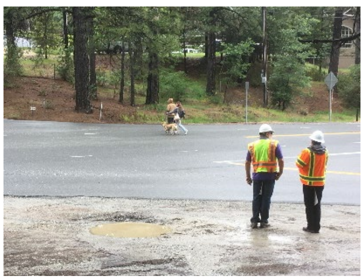
2. Analysis

2.1 Roadside Safety Audit – Lite

A modified version of a Roadside Safety Audit (RSA) was conducted on May 21, 2019 to review bicycle and pedestrian conditions along the project corridor and identify challenging locations to be addressed with improvements. Participants in the modified RSA included staff from NCTC, Nevada City, Nevada County, the Federal Highway Administration (FHWA), Caltrans, and the consultant team, in addition to a walkability advocate from the public.



A couple crosses SR 49 at Coyote Street

No facilities are provided for people walking or bicycling along SR 49, and curves in the roadway create sight distance challenges

A free right turn lane from SR 49 onto W Broad Street allows for high-speed turns

The methodology for this RSA is based on a process developed by the FHWA. The FHWA process is centered on two questions:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

In addition to prescribing that RSAs be conducted by an independent team of multidisciplinary reviewers, the FHWA process emphasizes a proactive approach that considers all potential road users and modes of transportation. Participants are encouraged to consider not only challenges demonstrated by collision data or documented in near-miss reports, but to identify safety issues that may occur in the future as a result of the roadway design, road user behavior or expectations, or other factors like weather or lighting conditions. All modes of transportation are considered in an RSA, including people walking, bicycling, driving, or riding transit. Reviewers are also directed to consider unique challenges faced by elderly people, children, and those with vision or mobility impairments as well as transportation, recreation, commercial, and agricultural trips.

Prior to conducting the RSA, the team reviewed available collision data and comments from the public to inform the audit. Members of the RSA team then drove and walked along the corridor to observe conditions. Emphasis was placed on observing intersections, which had higher rates of collisions than segments between intersections.

Discussion items and findings were summarized following the field visit and circulated to the RSA team for review. These results were then used in conjunction with the technical analyses to inform the recommended improvement concepts.

2.1.1 Summary of Roadway Safety Audit Lite

A Road and Pedestrian Safety Assessment (RPSA) was planned and conducted to identify missing infrastructure, a range of practical traffic and speed control strategies, and treatments focused on improving the safety and mobility of pedestrians and cyclists.

A multi-disciplinary team with diverse perspectives (but common goal) was formed and met to walk and drive throughout the corridor. The team “stopped” at each access/conflict point (a total of 7 intersections), in order to observe, discuss and more quickly reach a general consensus on the following list of findings and viable improvement concepts.

Based on the severe crash (type) history, a significant pedestrian crossing demand, and the existing vehicle-centric geometry at the Cement Hill Road intersection, the RSA team assigned top priority to improvement of the rural and highest-speed segment of SR 49 - upstream, approaching (from the west), and including the Cement Hill Road intersection.

For this top-priority area, the team identified three infrastructure improvement concepts - each focused on reducing speed, producing effective traffic control, and complete pedestrian crossings. The team reached a strong consensus on implementation of a roundabout intersection.

Once vehicle speed and the awareness of drivers was improved at and approaching Cement Hill Road (from the west), the team’s top objective shifted to maintaining vehicle speed throughout the rest of the study corridor, and a further reduction of the speed differential among conflicting intersection movements and travelers.

Ultimately, the preferred solution is the appropriate number (and spacing) of single-lane roundabouts. Investment in converting to roundabout control will:

- reduce and limit vehicle speeds, and pavement width throughout the corridor;
- reduce speed differential and pavement (crossing) width at each conflict point;
- calm vehicular traffic without incurring noticeable or significant impacts to motor vehicle travel time and the natural environment (throughout the corridor); and
- facilitate implementation of phased and low-cost improvements with minimal “throwaway” costs.

The conversion of all existing two-way stop-controlled intersections to a single-lane roundabout is an effective, practical and justified solution alternative. Additionally, roundabouts have been proven to reduce severe crashes and transform car-centric operating and infrastructure conditions in order to make it easier and safer for all users to cross major streets and highways.

2.2 Roadway Operations

2.2.1 Overview

Based on Caltrans most recently published traffic volumes (2017), annual average daily traffic on SR 49 ranges between roughly 6,500 and 8,000 vehicles within the study area depending on location. Peak hour volumes on SR 49 within the study area on a typical weekday range between 650 and 1300 peak hour vehicles depending on location and peak hour (i.e., AM, Midday or PM peak). Average daily traffic on SR 20 at the juncture of SR 49 ranges between 16,000 and 17,000. Peak hour volumes at SR 20/ SR 49 on a typical weekday range between 1,400 and 1,600 peak hour vehicles depending on peak hour (i.e., AM, Midday or PM peak).

Future growth was projected using the 2035 NCTC travel demand model. Projected volumes along the study corridor were forecast to grow to between roughly 6,500 and 14,000 vehicles per day, depending on location. Peak hour volumes were projected to range between roughly 1,000 and 7,000 peak hour vehicles depending on peak period and location.

Operational conditions at seven key intersections along the SR 49 corridor were analyzed. These intersections include:

- SR 20/SR 49/Uren St;
- SR 49/Coyote St;
- SR 49/East Broad Street/Bloomfield Road;
- SR 49 Orchard Street/Maidu Avenue;
- SR 49/West Broad Street/Cement Hill Road;
- SR 49/Elks Lodge Entrance; and
- SR 49/Juvenile Hall Entrance.

Intersection operations were based on existing peak hour traffic counts collected by Caltrans in 2019. These counts are provided in Appendix A. Existing AM, Noon, and PM peak hour intersection operations were analyzed utilizing the existing intersection lane geometrics and controls and the existing peak hour traffic volumes. Details on technical analysis parameters, methodology, and assumptions are provided in the following sections.

2.2.2 Level of Service Methodology

Traffic operations are measured through "Level of Service" (LOS), a qualitative metric for traffic conditions. Letter grades A through F are assigned to intersections or roadway segments and represent progressively worsening traffic conditions. In general, LOS A represents free-flow conditions with very little delay, and LOS F represents over-capacity conditions with long delays and queues.

The project intersections were analyzed using the procedures and methodologies in the *Highway Capacity Manual (HCM)* (Transportation Research Board, 2016). The methodology for the roundabout alternative is based on the 6^{th} edition of the HCM which draws from an FHWA report on capacity modeling for roundabouts.[1] At signalized intersections and roundabouts, the HCM specifies that LOS is based on the average control delay for the entire intersection. At intersections with two-way stop controls, the HCM specifies that LOS and vehicle delay are based on the worst minor street approach. Table 2.1 displays the control delay range associated with each LOS grade.

Table 2.1 Intersection Level of Service Criteria

Level of Service	Average Control Delay (Seconds/Vehicle)		Description
	Signalized	Two-Way or All-Way Stop Control	
A	<10.0	<10.0	Very low delay. At signalized intersections, most vehicles do not stop.
B	10.0 to 20.0	10.0 to 15.0	Generally good progression of vehicles. Slight delays.
C	20.1 to 35.0	15.1 to 25.0	Fair progression. At signalized intersections, increased number of stopped vehicles.
D	35.1 to 55.0	25.1 to 35.0	Noticeable congestion. At signalized intersections, large portion of vehicles stopped.
E	55.1 to 80.0	35.1 to 50.0	Poor progression. High delays and frequent cycle failure.
F	>80.0	>50.0	Oversaturation. Forced flow. Extensive queuing.

Highway Capacity Manual (Transportation Research Board 2016)

2.2.3 Level of Service Policies and Thresholds

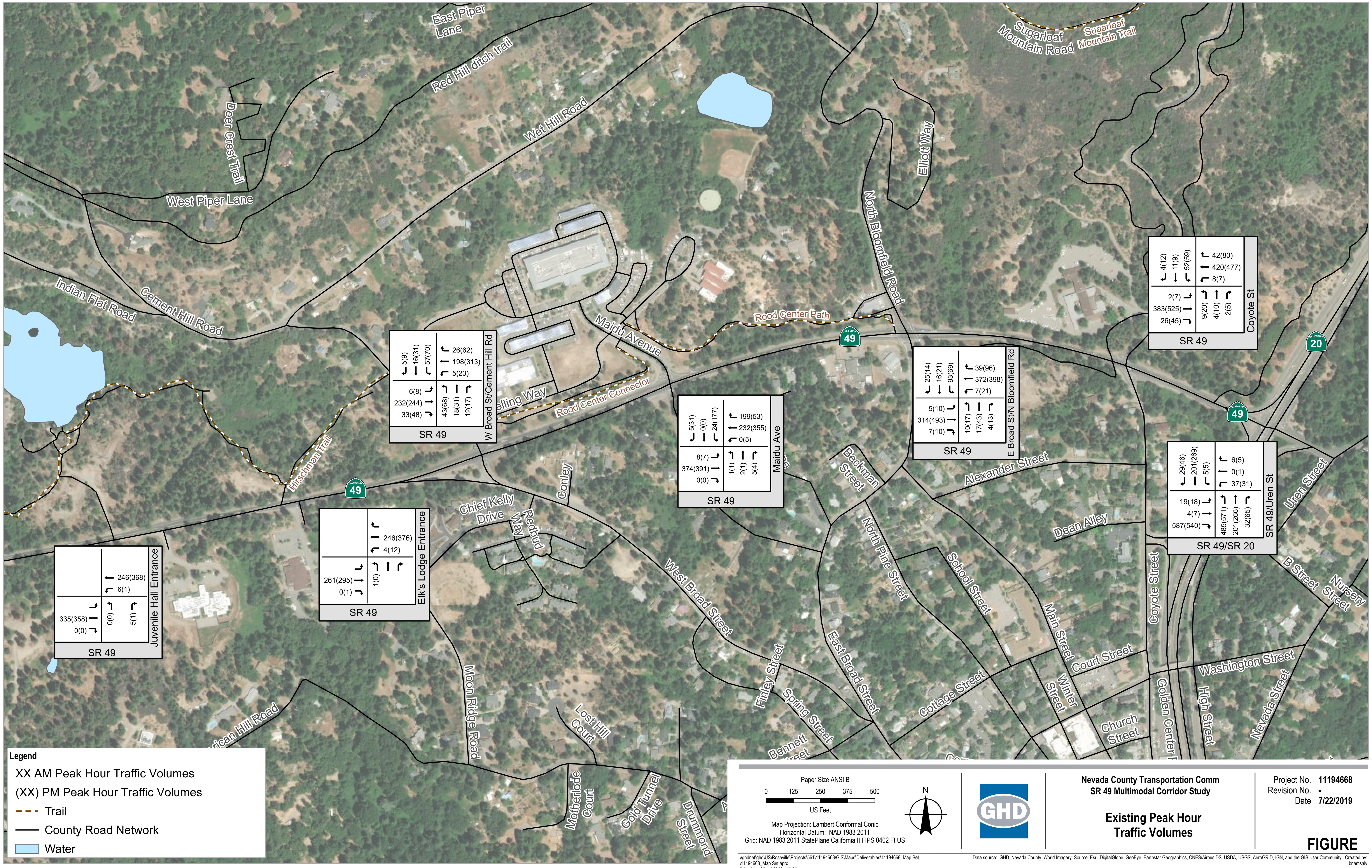
Caltrans' Guide for the Preparation of Traffic Impact Studies contains the following policy pertaining to LOS standards within Caltrans jurisdiction:

> *Caltrans endeavors to maintain a target LOS at the transition between LOS C and LOS D on State highway facilities, however, Caltrans acknowledges that this may not always be feasible and recommends the lead agency consult with Caltrans to determine the appropriate target LOS.*

2.2.4 Existing Traffic Operations

Caltrans performed the AM and PM peak hour turn movement counts for each study intersection. These turn movements are shown in Figure 2.1. The intersection count data sheets are provided in Appendix A. Delay and LOS results by intersection are summarized in Table 2.2. The Synchro LOS worksheets are provided in Appendix B.

[1] Assessment of Roundabout Capacity Models for the Highway Capacity Manual: Volume 2 of Accelerating Roundabout Implementation in the United States (Report FHWA-SA-15-070)



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Existing Peak Hour Traffic Volumes

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Revision No. -
Date 7/22/2019

FIGURE

Data source: GHD, Nevada County, World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: bnamsaly

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Table 2.2 Existing Traffic Operations for SR 49 Study Area

Cross Street	Control[1]	AM		PM	
		Delay[2]	LOS[3]	Delay[2]	LOS[3]
SR 20/Uren Street	SSSC	112.3	F	355.2	F
Coyote Street	SSSC	34.7	D	39.5	E
East Broad Street/ North Bloomfield Road	Signal	6.9	A	7.0	A
Orchard Street/Maidu Avenue	SSSC	16.3	C	37.9	E
West Broad Street/Cement Hill Road	SSSC	14.4	B	24.8	C
Elks Lodge Entrance	SSSC	10.8	B	10.2	B
Juvenile Hall Entrance	SSSC	10.6	B	10.4	B

1 SSSC = Side Street Stop Control

2 Delay is reported in seconds per vehicle

3 Overall LOS is based on worst minor street approach for SSSC intersections and average for all approaches for signalized intersections

In the study area, most intersections currently operate within the established LOS C threshold for both the AM and PM peak hours. The intersection at Orchard Street/Maidu Avenue meets the LOS threshold during the AM peak at LOS C but not during the PM peak hour at LOS E. The intersection at Coyote Street currently exceeds the LOS threshold during the AM peak (LOS D) and during PM peak (LOS E). The intersection with SR 20/Uren Street currently operates at LOS F during both AM and PM peak hours, indicating long delays for motorists waiting for an acceptable gap to either access SR 20 or cross it from Uren Street or SR 49.

2.3 Bicycle Level of Traffic Stress

Traffic stress is the perceived risk or comfort level experienced by a person bicycling in or adjacent to motor vehicle traffic. Because high traffic stress is one of the most common deterrents to bicycling, providing more comfortable bikeways can encourage more people to bicycle for more trips.

Bikeways that are considered low-stress minimize potential conflicts with motor vehicles by providing greater separation between people bicycling and driving. As vehicle speeds and traffic volumes on a roadway increase, a higher level of separation is necessary to create a low-stress experience.

2.3.1 Bicycle LTS Methodology

Bicycle Level of Traffic Stress (LTS) is a data-driven evaluation of the comfort experienced in different roadway environments, based on research conducted by the Mineta Transportation Institute, which can be found in *MTI Report 11-19 Low-Stress Bicycling and Network Connectivity*. Streets are evaluated based on a variety of characteristics including the posted speed limit, number of vehicle lanes, presence and type of bikeway, curb radii and design speed at corners, and the number of driveways and other potential conflicts. This study considered Bicycle LTS for three categories:

- **Segments** 1, 2, and 3
- **Approaches** to intersections where right turn lanes may increase stress for bicyclists, especially when bicycle facilities end to accommodate these lanes
- **Crossings** at unsignalized intersections

Based on this evaluation, street segments, approaches, and crossings are assigned a score from 1 to 4 with 1 being the most comfortable and 4 being the most stressful.

- LTS 1 includes roads that are likely to be suitable for most children, as well as shared use paths that are completely separate from the roadway
- LTS 2 includes roads that are likely comfortable for most adults
- LTS 3 includes roads that are comfortable for confident, experienced bicyclists but are likely not appealing to others
- LTS 4 includes roads tolerable only to highly skilled and fearless riders who are comfortable bicycling in high-traffic situations and mixing with vehicle traffic

For the purposes of this study, LTS 1 and 2 are considered acceptable “Low-Stress” environments. LTS 3 and 4 are considered “High-Stress” environments that can discourage bicycling and should be improved to reduce stress where possible.

2.3.2 Existing Bicycle LTS

Segments 1, 2, and 3 along the study corridor all received a High-Stress score, indicating an experience tolerable only to the most confident and experienced bicyclists. A lack of bicycle facilities combined with a posted speed limit of 45 mph contribute to this High-Stress designation. Segment LTS scores are shown in Figure 2.1.

All approaches on the study corridor received a High-Stress score.

For a bicyclist traveling along SR 49, all side-street crossings received Low-Stress scores. For a bicyclist traveling along a side street and attempting to cross SR 49, all unsignalized intersections received a High-Stress score.

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SR 49 Multimodal Corridor Study

Project No. **11194668**
Revision No. **-**
Date **11/7/2019**

Level of Traffic Stress

FIGURE 2.2

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Data source: SWITRS (2013-2017), GHD 2019, Nevada County Open Data Portal 2019 World Imagery: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: jclark2

2.4 Safety

A safety assessment and collision analysis was performed to identify the concentration, severity, and contributing factors of collisions within the study area. Collision data for roadways and intersections was obtained from Caltrans TASAS tables and TSAR reports, and California Highway Patrol SWITRS data. Caltrans data for a five-year period was reviewed, from 2014 through 2018, while SWITRS data was reviewed for the five-year period between 2013 and 2017. There is discrepancy between the two data sources, which is partially attributed to difference in study years as well as processing differences. SWITRS is subject to reporting-level inaccuracies. Thus, the two data sources are not directly comparable.

2.4.1 Caltrans TASAS and TSAR Collision Data

Between 2014 and 2018, 47 collisions were reported along the corridor. Of these, one was fatal and 21 resulted in injuries. Only two collisions occurred at a location other than an intersection, one of which resulted in an injury. A summary of collisions and injuries reported by Caltrans TASAS and TSAR reports by intersection is provided in Table 2.3 below and mapped in Figure 2.2 and Figure 2.3.

Table 2.3 TSAS and TSAR Collisions by Intersection

Intersection with SR 49	Total Collisions	Injuries	Fatalities
SR 20/Uren Street	20	9	-
Coyote Street	7	3	-
East Broad Street/ North Bloomfield Road	8	3	-
Orchard Street/Maidu Avenue	3	1	1
West Broad Street/Cement Hill Road	7	4	-

The only fatal collision on the corridor occurred at the intersection with Orchard Street/Maidu Avenue. The intersection with SR 20 had the highest number of collisions and injuries on the corridor, with 20 collisions resulting in nine injuries.

2.4.2 California Highway Patrol SWITRS Collision Data

Between 2013 and 2017, there were a total of 29 collisions reported by CHP within the study area. Of these collisions, none were reported as fatal, while 4 injuries were reported. The remaining collisions resulted in property damage only. A summary of collisions by intersection reported by CHP by intersection is provided in Table 2.4 and mapped in Figure 2.4.

Table 2.4 SWITRS Collisions by Intersection

Intersection with SR 49	Total Collisions	Injuries	Fatalities
SR 20/Uren Street	16	2	-
Coyote Street	2	-	-
East Broad Street/ North Bloomfield Road	5	1	-
Orchard Street/Maidu Avenue	3	1	-
West Broad Street/Cement Hill Road	3	2	-

2.4.3 Safety Conclusions

Taken together, the two collision analysis data sources highlight opportunities to improve safety in several locations. Both data sources iterate the opportunities to improve safety at each intersection, with a specific emphasis on the intersection of SR 20 and SR 49, and the intersection and eastbound approach at Cement Hill Road/ SR 49. Note that these locations bookend the corridor. Safety improvements at these locations will provide opportunity to temper speeds at each end of the corridor, which should improve safety throughout the corridor.

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SR 49 Multimodal Corridor Study

Collisions
2014-2018

Project No. **11194668**
Revision No. **-**
Date **11/7/2019**

FIGURE 2.3

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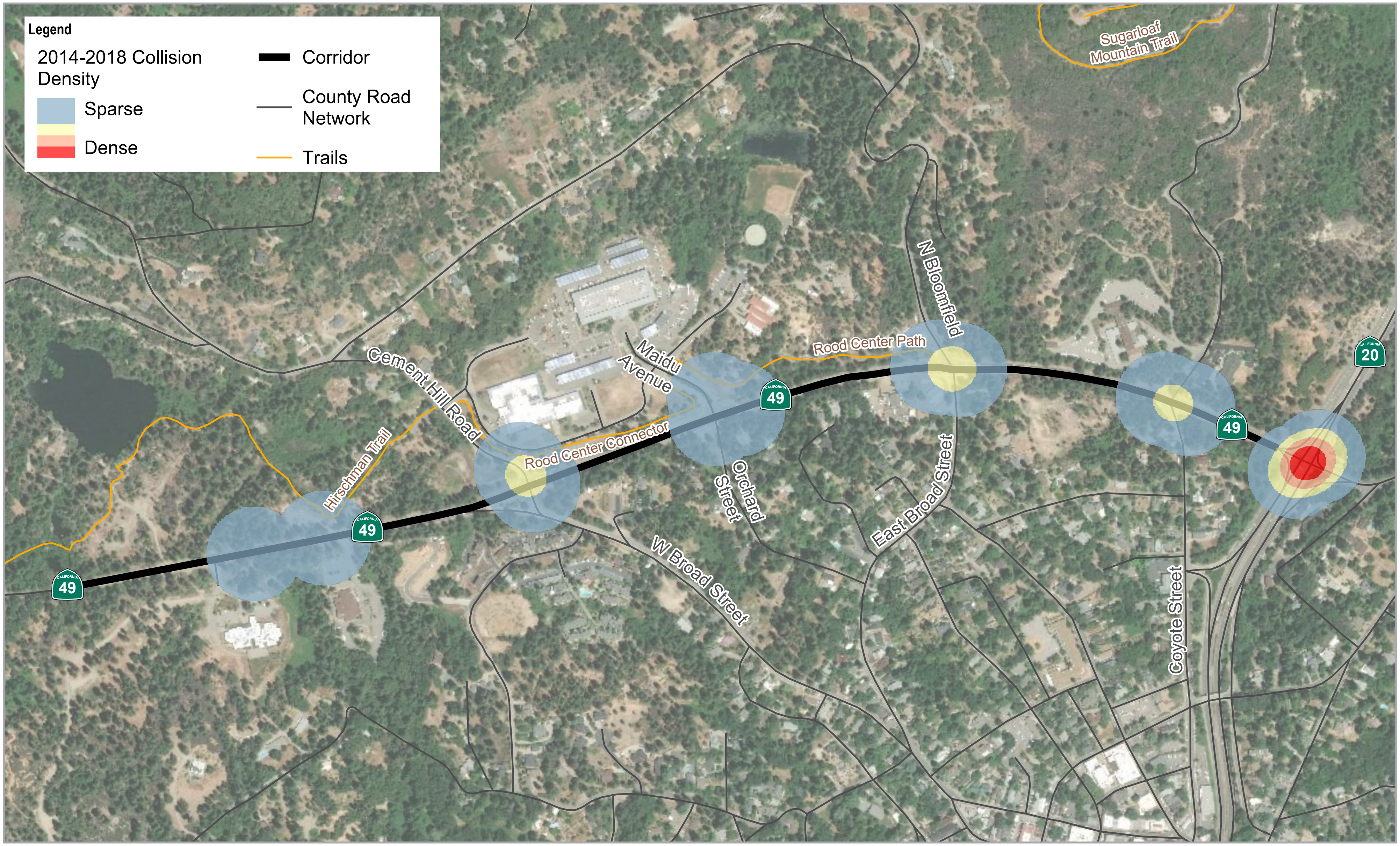

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SR 49 Multimodal Corridor Study

Collision Heat Map
2014-2018

Project No. **11194668**
Revision No. **-**
Date **11/7/2019**

FIGURE 2.4

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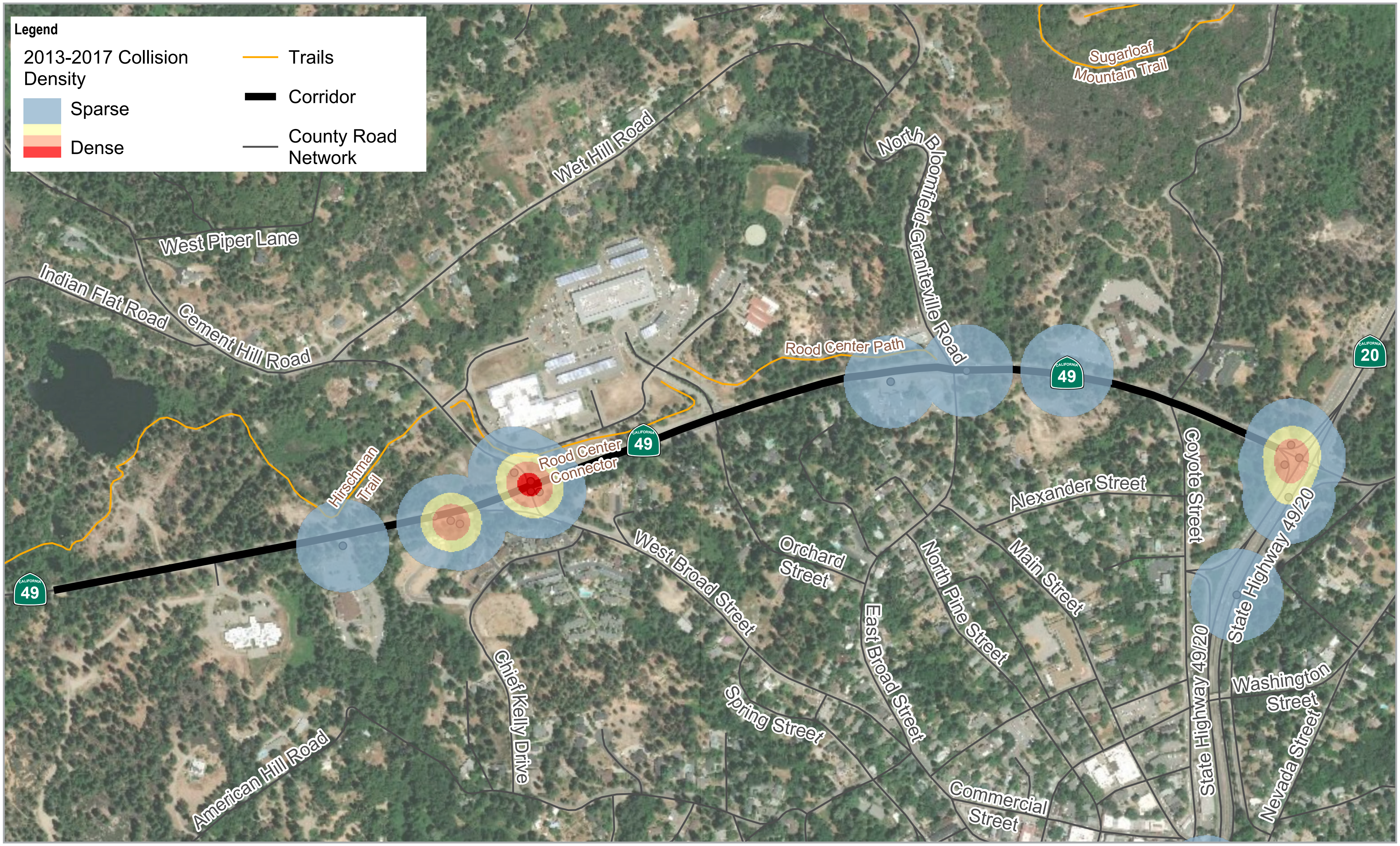

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SR 49 Multimodal Corridor Study

Collision Heat Map
2013-2017

Project No. **11194668**
Revision No. **-**
Date **11/7/2019**

FIGURE 2.5

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3. Outreach

3.1 Community Workshop #1

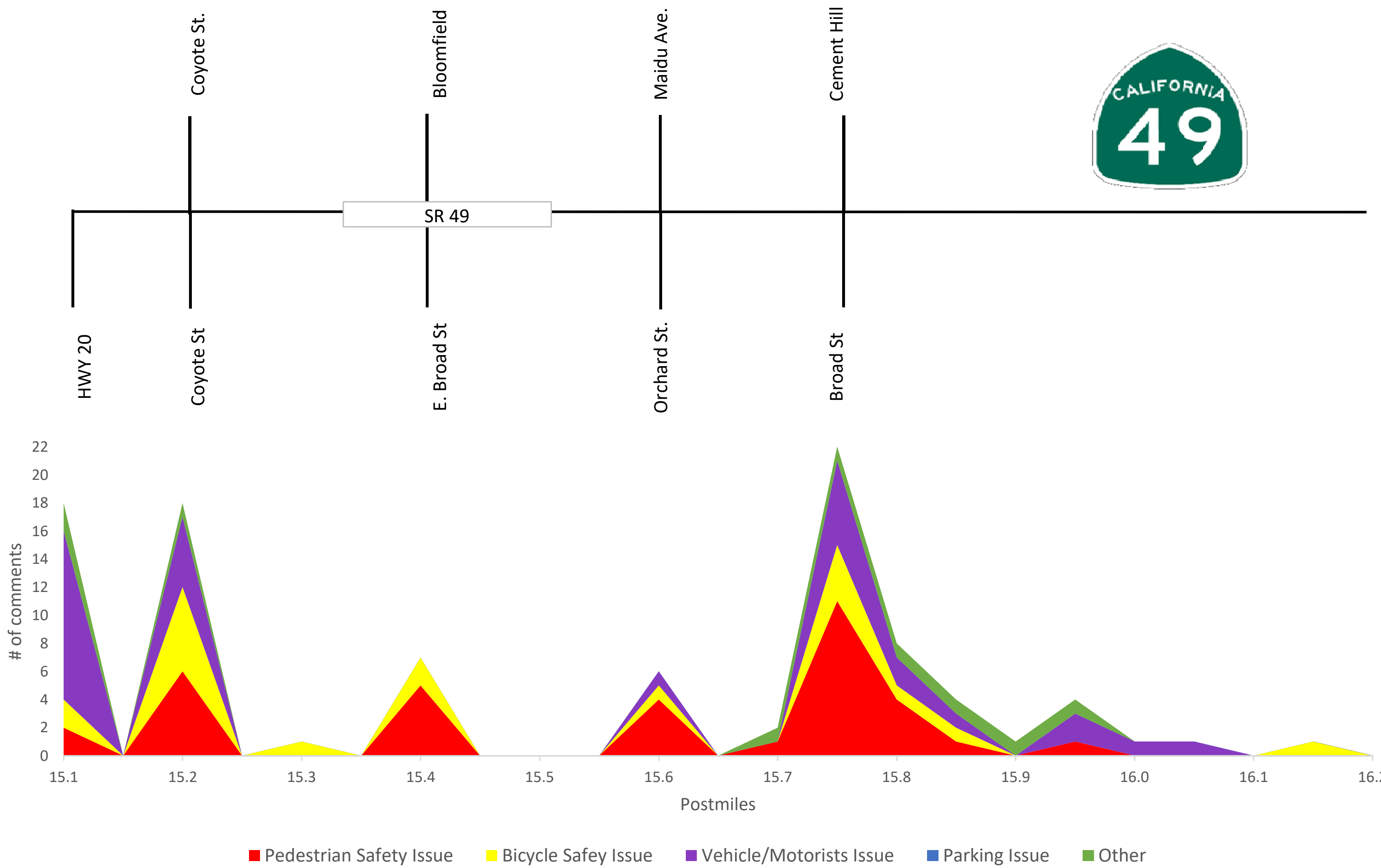
NCTC hosted a community open house on May 28, 2019 to introduce the project to the public and gather input on pedestrian and bicycle travel along the corridor. The workshop was attended by approximately 30 community members.

As part of the workshop, community members were encouraged to place comments on study area maps to indicate locations of challenges and opportunities for improvement. Colors indicate the type of concern, and the height of the cartogram at a given location indicates the number of comments received. The colors correspond to the following concerns:

- Red reflects a pedestrian safety concern
- Yellow reflects a bicycle safety concern
- Purple reflects vehicle or motorist concerns, or operational issues
- Blue reflects a parking concern
- Green reflects “other” issues that do not fit into other categories

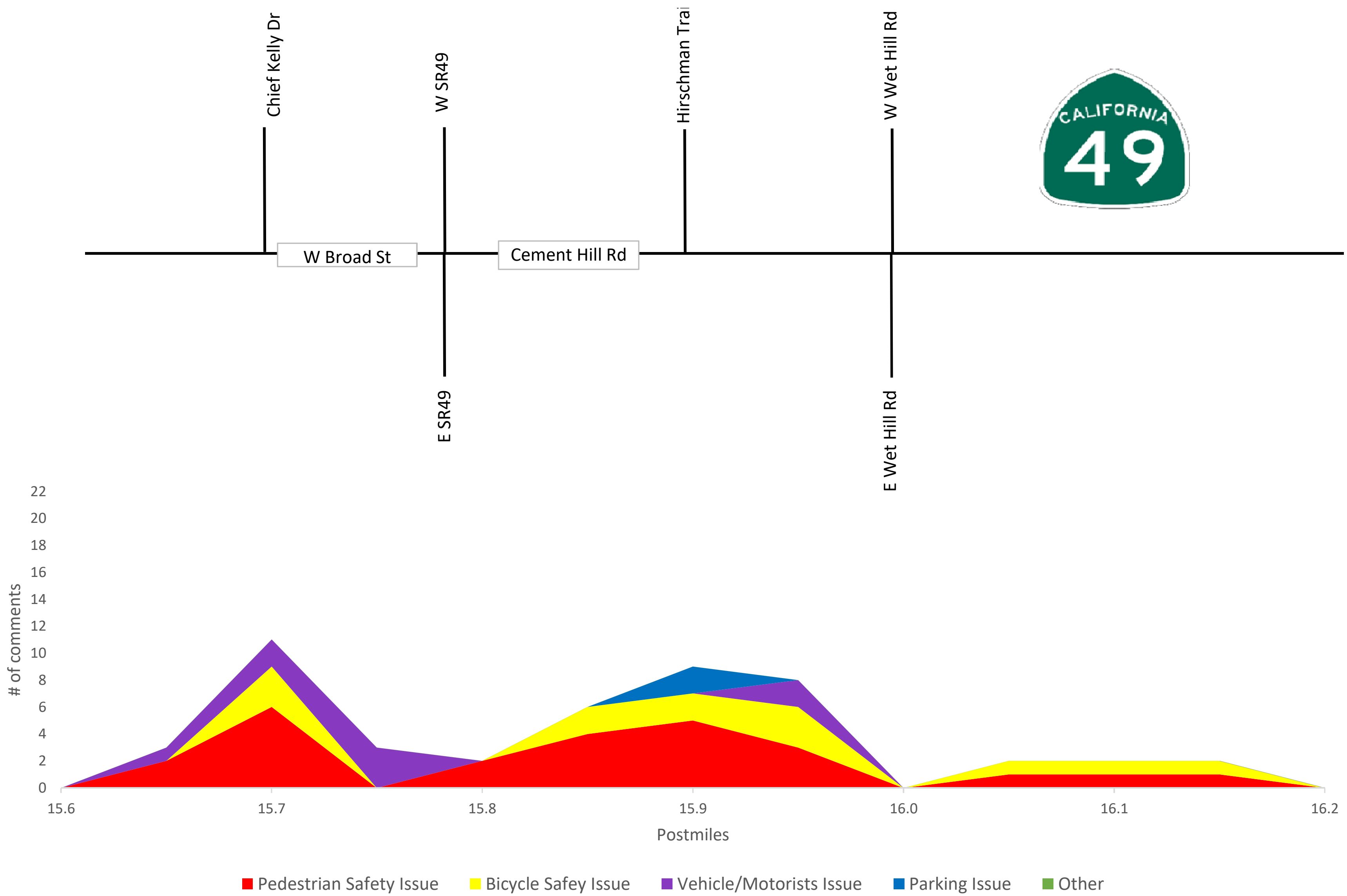
Those comments were geo-coded and are shown in cartograms in Figure 3.1 and Figure 3.2.

Most concerns reported by the community involved the intersections of SR 49 with Coyote Street and with West Broad Street/Cement Hill Road. Both locations show reported concerns about driving, bicycling, and walking, with pedestrian concerns making up the overwhelming majority of comments about the West Broad Street/Cement Hill Road location. Concerns about speeding were reported near SR 20 and near Cement Hill Road, where a free-right turn is configured to allow high speed turns.



SR 49 Cartogram

FIGURE 3.1



Cement Hill/ West Broad Cartogram

FIGURE 3.2

Concerns along Cement Hill Road were primarily related to walking or bicycling, with the largest numbers of comments focused around Chief Kelly Drive and Hirschman Trail. Some concerns about driving were also documented at these locations, and parking issues were noted near Hirschman Trail.

In addition to these location-based comments, workshop attendees expressed a need for vegetation maintenance throughout the corridor to improve visibility of signs.

3.2 Community Workshop #2

Draft recommendations were presented to the community for feedback at a workshop on July 23, 2019. The workshop was attended by about 12 members of the community. General themes of the feedback included:

- Concerns about vehicle speeds and potential conflicts with pedestrians crossing SR 49 at uncontrolled locations
- Desire for off-street bicycle and pedestrian paths along the corridor
- Need for bicycle and pedestrian connectivity to the Sugarloaf Trail and Hirschman's Pond north of the Cement Hill Street and West Broad Street intersection
- Concerns about truck speeds and brakes overheating on the downhill southbound approach to a proposed roundabout at SR 49 and SR 20/Uren Street

The recommended improvements were refined based on comments received at this event, and input from the RSA-Lite team.

4. Improvement Recommendations

Recommendations were developed based on the stated objectives of the study, technical analyses and findings, RSA findings, and input from the community. All recommended improvements are based on current best practices in transportation planning and engineering with the goal of improving safety, operational efficiency, and accommodating bicyclists and pedestrians.

Recommendations are presented for three corridor segments:

- **Segment 1:**
    - SR 20/Uren Street Intersection
- **Segment 2:**
    - Coyote Street Intersection
    - North Bloomfield Road/East Broad Street Intersection
    - Maidu Avenue/Orchard Street Intersection
    - Cement Hill Road/West Broad Street Intersection
- **Segment 3:**

- Elks Lodge Driveway
- Nevada County Juvenile Hall Driveway

For some locations, lower cost alternatives are shown in addition to the preferred project concepts. These are intended to provide NCTC with lower-cost options that may be implemented on a shorter timeline compared to the preferred concepts. A corridor map showing Preferred Recommended Improvements is presented in Figure 4.1. Lower Cost Alternatives are summarized in Figure 4.2.

Conceptual renderings of preferred recommended improvements are presented at the end of this section in Figure 4.3 through Figure 4.6. Lower cost alternative concepts are presented in Appendix C.

4.1 Segment 1 Improvement Recommendations

4.1.1 Preferred Recommended Improvements

Single-lane roundabouts are proposed at the intersection of SR 49/SR 20 and SR 49/Coyote Street. Due to concerns about downhill speeds on southbound SR 20, particularly for trucks and large vehicles, the proposed improvements include plateaus to moderate speeds. Upstream speed reduction measures should also be considered. A roundabout at the intersection of SR 49 and SR 20 will improve traffic operations compared to the existing two-way stop configuration. This will be achieved by reducing high speeds of vehicles traveling on SR 20 and SR 49 and making it easier for drivers to cross or turn at each leg of these intersections. Moreover, this will improve crossing safety and connectivity for bicyclists and pedestrians. Converting to roundabout control at this location would also improve safety by reducing the number of potential conflict points at the intersection, and would likely reduce the severity of collisions that occur due to lower speeds and angles of impact.

A shared use path along the north side of SR 49 is proposed from Coyote Street to SR 20. This would eliminate a critical connectivity gap for pedestrian and bicycle movements along SR 49. The path would improve safety and connectivity for bicyclists and pedestrians by providing a path completely separated from motor vehicle traffic. Moreover, this facility would provide continuity between the existing Rood Center Path, Rood Center Connector Path, and Hirschman Trail, as well as the proposed Sugar Loaf Trail Realignment.

All four legs of the roundabouts include high visibility marked crosswalks, with splitter islands that create refuge areas. Connectivity for people bicycling and walking is provided by shared use paths between all crosswalks, and a shared use path on the north side of SR 49 that is proposed to connect to the intersection at East Broad Street/North Bloomfield Road. In addition to providing pedestrian connectivity, these paths provide an option for bicyclists who would prefer not to merge with traffic to navigate the roundabout. This will improve safety and connectivity for bicyclists and pedestrians by providing a path completely separated from motor vehicle traffic.

A rectangular rapid flashing beacon (RRFB) or high-intensity activated crosswalk (HAWK) beacon is proposed for both the north and south legs of the roundabout to enhance visibility of the marked crosswalks across SR 20 and SR 49.

Segment one preferred recommended improvements are displayed in Figures 4.1, 4.3 and 4.4.

4.1.2 Lower Cost Alternatives

Several viable lower-cost options exist for the intersection of SR 49 and SR 20 using striping to reconfigure approaches, and/or providing high visibility crosswalks for two-stage crossings from Uren Street to SR 49.

At the intersection of SR 49 and Coyote Street, a raised center median and “pork chop” islands at free-right turn lanes would temper vehicle speeds and provide a refuge area for a pedestrian crossing west of the intersection. This restricts access to Coyote Street to right-in and right-out only, with emergency vehicle access accommodated by a low place in the center median. A HAWK beacon or RRFB is proposed for the crosswalk west of Coyote Street to increase visibility of the crossing and improve motorist yielding to pedestrians.

4.2 Segment 2 Improvement Recommendations

4.2.1 Preferred Recommended Improvements

A single-lane roundabout is proposed at the intersection of Orchard Street/Maidu Avenue. A roundabout will improve traffic operations compared to the existing two-way stop configurations by reducing speeds of vehicles traveling on SR 49 and making it easier for drivers on side streets to cross or turn onto SR 49. Roundabouts also improve safety by reducing the number of potential conflict points at each intersection, and reducing the severity of collisions that occur due to lower speeds and angles of impact.

Marked high visibility crosswalks are proposed on all legs, with shared use paths providing connections between the crosswalks. In addition to providing pedestrian connectivity, these paths provide an option for bicyclists who would prefer not to merge with traffic to navigate the roundabouts.

At the signalized intersection of SR 49 and North Bloomfield Road/East Broad Street, the existing marked crosswalks are recommended to be improved with high visibility markings.

Segment two preferred recommended improvements are displayed in Figures 4.1, 4.4 and 4.5.

4.2.2 Lower Cost Alternatives

At East Broad Street/ North Bloomfield Road, improvements to the existing traffic signal and a new marked crosswalk on the north leg of the intersection are proposed. This will improve connectivity for pedestrians and increase visibility of crossings for oncoming motorists.

At the intersection of SR 49 and Orchard Street/Maidu Avenue, marked crosswalks are proposed on the north, west, and east legs of the intersection. Two “pork chop” islands on the northwest and northeast corners will formalize right-turn lanes and provide a refuge area for pedestrians waiting to cross. A HAWK beacon or RRFB should be installed on the west leg of the intersection to aid pedestrians crossing SR 49.

4.3 Segment 3 Improvement Recommendations

4.3.1 Preferred Recommended Improvements

A Single-lane roundabout is proposed at the intersection of West Broad Street/Cement Hill Road. Additionally, the free right turn lane for eastbound SR 49 onto southbound West Broad Street will be closed to motor vehicles and converted to a shared use path. Closing this high-speed free right-turn lane will improve safety at the intersection by reducing speeds and eliminating additional conflict points.

A sidewalk is also proposed on the west side of Cement Hill Road to provide connectivity to the Hirschman Trail.

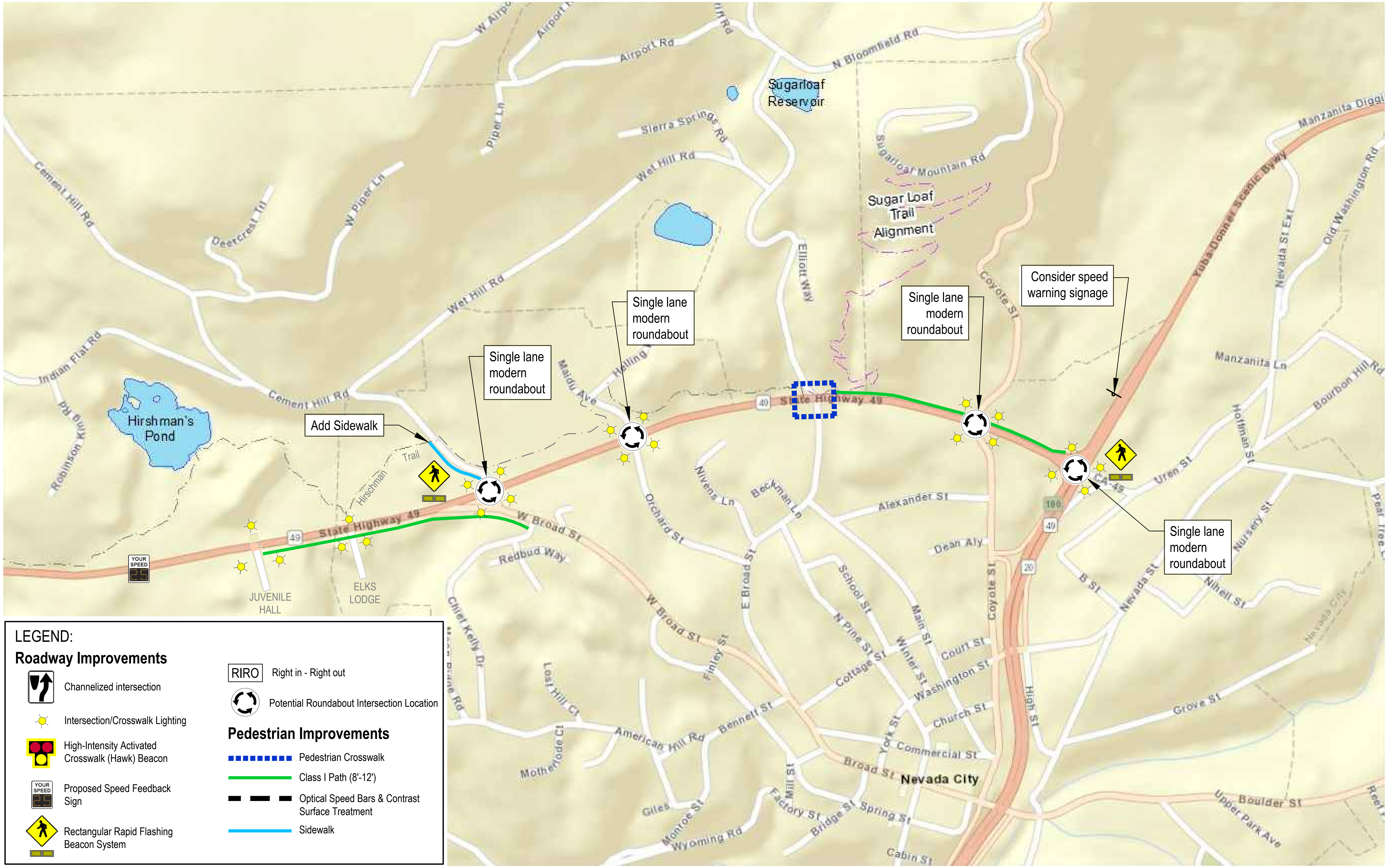
A shared use path is proposed along the south side of SR 49 from the intersection with West Broad Street/Cement Hill Road to the Juvenile Hall Driveway. This will improve safety and connectivity for bicyclists and pedestrians by providing a path separated from motor vehicle traffic.

Segment two preferred recommended improvements are displayed in Figures 4.1, 4.5 and 4.6.

4.3.2 Lower Cost Alternatives

A speed feedback sign is proposed for eastbound traffic on SR 49. Additional lighting near the two driveways is also proposed to improve visibility.

At the intersection of SR 49 and West Broad Street/Cement Hill Road, the free right turn onto West Broad Street is proposed to be closed to motor vehicles and converted to a shared use path. A new marked crosswalk with a HAWK beacon or RRFB is proposed on the west leg of the intersection to aid pedestrians crossing SR 49. In addition, optical speed bars are proposed for eastbound traffic on SR 49 to reduce driver speeds.



Nevada County Transportation Comm
SR 49 Multimodal Corridor Study

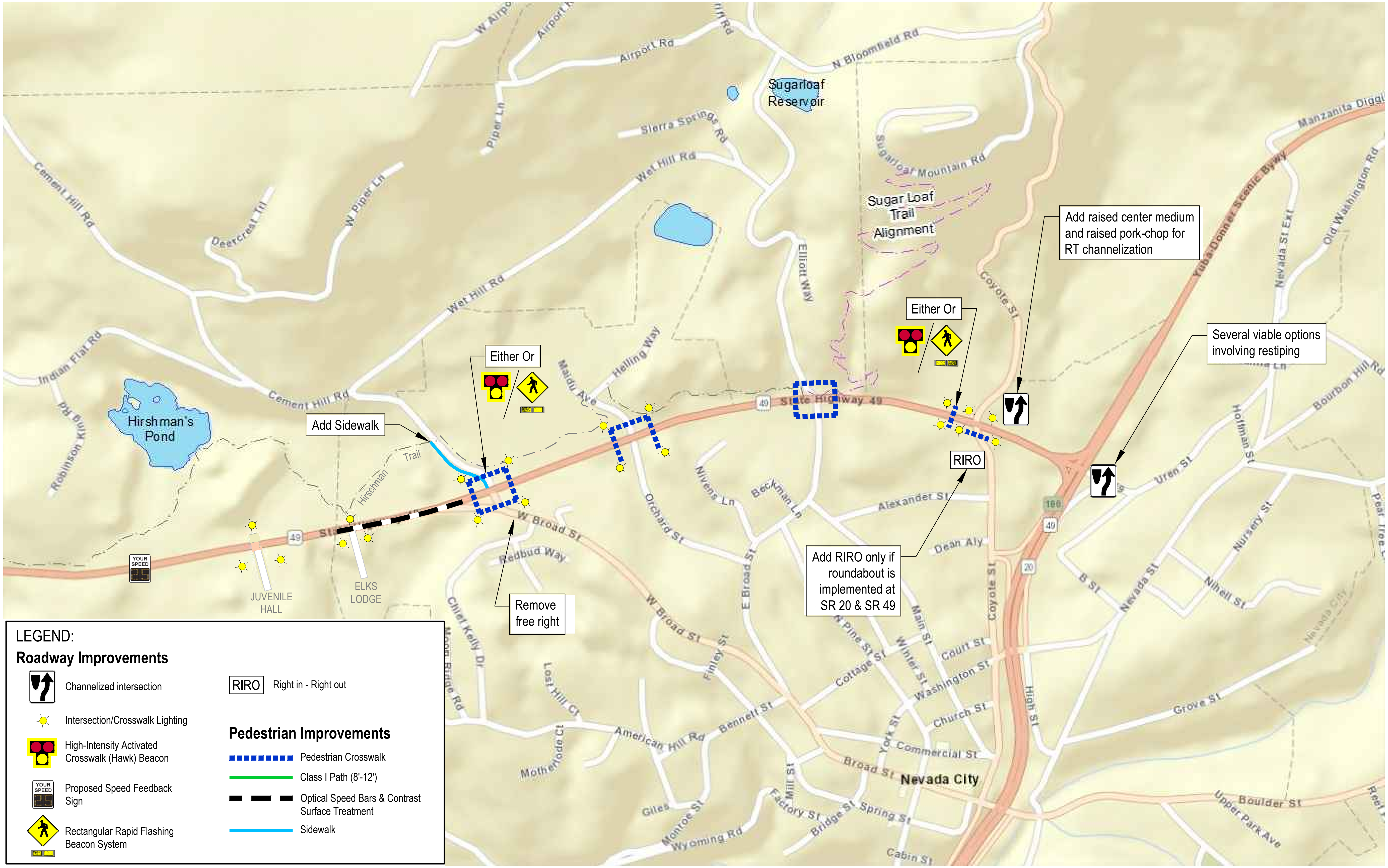
Project No. 11194668
Report No.
Date 09.04.2019

VICINITY MAP OF RECOMMENDED ULTIMATE IMPROVEMENT CONCEPTS

FIGURE 4.1

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX003.dwg Plot Date: 4 September 2019 - 11:37 AM

Source:



Nevada County Transportation Comm
SR 49 Multimodal Corridor Study

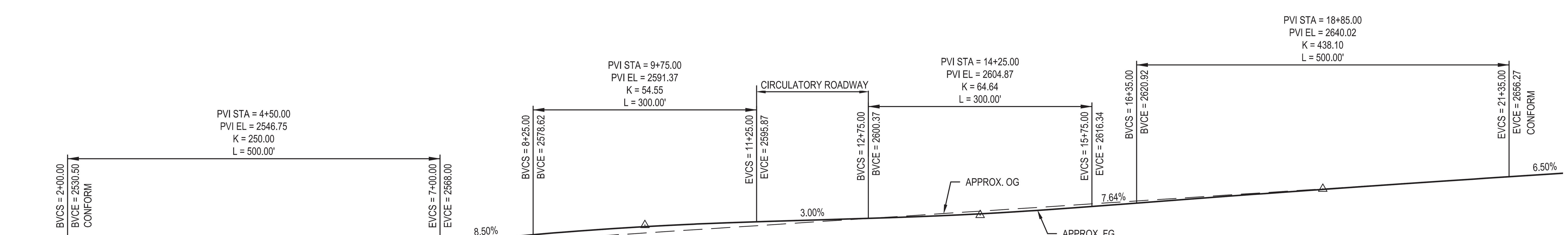
VICINITY MAP OF RECOMMENDED LOW-COST IMPROVEMENT CONCEPTS

Project No. 11194668
Report No.
Date 09.04.2019

FIGURE 4.2

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX003.dwg Plot Date: 4 September 2019 - 10:28 AM

Source:



SAMPLE PROFILE

NO SCALE

LEGEND

- MOUNTABLE TRUCK APRONS AND BLISTERS
- POTENTIAL HARDSCAPING AREA
- RECTANGULAR RAPID FLASHING BEACON (RRFB)
- POTENTIAL LANDSCAPING AREA
- DETECTABLE WARNING SURFACE
- INTERSECTION / CROSSWALK LIGHTING

0 50' 100'

NEVADA COUNTY TRANSPORTATION COMMISSION
STATE ROUTE 49 MULTIMODAL CORRIDOR STUDY
ULTIMATE IMPROVEMENT CONCEPT

SR 49 / SR 20

Project No. **11194668**
Comp. No. **2646**
Date **AUGUST 2019**

FIGURE 4.3

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX002.dwg
Plot Date: 28 August 2019 2:40 PM

Data Source: Google

LEGEND

- MOUNTABLE TRUCK APRONS AND BLISTERS
- POTENTIAL HARDSCAPING AREA
- RETAINING WALL
- POTENTIAL LANDSCAPING AREA
- DETECTABLE WARNING SURFACE
- INTERSECTION / CROSSWALK LIGHTING

N

0 50' 100'

GHD

NEVADA COUNTY TRANSPORTATION COMMISSION
STATE ROUTE 49 MULTIMODAL CORRIDOR STUDY
ULTIMATE IMPROVEMENT CONCEPT

SR 49 / COYOTE St
AND
SR 49 / N BLOOMFIELD Rd / E BROAD St

Project No. **11194668**
Comp. No. **2646**
Date **AUGUST 2019**

FIGURE 4.4

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX002.dwg
Plot Date: 25 September 2019 11:41 AM

Data Source: Google

LEGEND

- SURFACE MOUNTED CHANNELIZER, 6' O.C.
- MOUNTABLE TRUCK APRONS AND BLISTERS
- POTENTIAL HARDSCAPING AREA
- INTERSECTION / CROSSWALK LIGHTING
- POTENTIAL LANDSCAPING AREA
- DETECTABLE WARNING SURFACE

N

0 50' 100'

GHD

NEVADA COUNTY TRANSPORTATION COMMISSION
STATE ROUTE 49 MULTIMODAL CORRIDOR STUDY
ULTIMATE IMPROVEMENT CONCEPT

SR 49 / MAIDU Ave / ORCHARD St
AND
SR 49 / CEMENT HILL Rd / W BROAD St

Project No. **11194668**
Comp. No. **2646**
Date **AUGUST 2019**

FIGURE 4.5

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX002.dwg
Plot Date: 25 September 2019 11:42 AM

Data Source: Google

LEGEND

- SURFACE MOUNTED CHANNELIZER, 6' O.C.
- MOUNTABLE TRUCK APRONS AND BLISTERS
- POTENTIAL HARDSCAPING AREA
- INTERSECTION / CROSSWALK LIGHTING
- POTENTIAL LANDSCAPING AREA
- DETECTABLE WARNING SURFACE

N

0 50' 100'

GHD

NEVADA COUNTY TRANSPORTATION COMMISSION
STATE ROUTE 49 MULTIMODAL CORRIDOR STUDY
ULTIMATE IMPROVEMENT CONCEPT

SR 49 / CEMENT HILL Rd / W BROAD St AND ELKS LODGE / JUVENILE HALL DRIVEWAYS

Project No. 11194668
Comp. No. 2646
Date AUGUST 2019

FIGURE 4.6

Filename: \\ghdnet\ghd\US\Roseville\Projects\561\11194668\Digital_Design\2646EX002.dwg
Plot Date: 28 August 2019 1:30 PM

5. Improvement Assessments

5.1 Intersection Operations

Intersection operations with roundabout control improvements in the AM and PM peak periods are summarized in Table 5.1. As shown, the proposed roundabouts would improve operations at all intersections. The most significant improvement would result at SR 20/Uren Street from LOS F (reported in Table 2.2), to LOS B reported below. Moreover, the remaining intersections would improve to LOS A with the implementation of roundabouts.

Table 5.1 Traffic Operations with Roundabout Improvements

Cross Street	Control[1]	AM		PM	
		Delay[2]	LOS[3]	Delay[2]	LOS[3]
SR 20/Uren Street	RAB	13	B	17.4	B
Coyote Street	RAB	7.4	A	8.0	A
Orchard Street/Maidu Avenue	RAB	6.6	A	6.6	A
West Broad Street/Cement Hill Road	RAB	4.7	A	6.1	A

1 RAB = Roundabout
2 Delay is reported in seconds per vehicle
3 Overall LOS is based on worst minor street approach for SSSC intersections and average for all approaches for signalized intersections

5.2 Bicycle Level of Traffic Stress

Bicycle Level of Traffic Stress improvements are mapped in Figure 5.2. As displayed, the corridor-wide high level of traffic stress is reduced significantly. This is achieved by a connected network of Class I Paths, Class II bike lanes, widened shoulders and foot trails. The Class I path proposed from SR 20/ SR 49 to North Bloomfield Road connects to the existing Rood Center Path. Furthermore, an existing connector footway path traversing the frontage of the Rood Center provides connectivity to the existing Hirschman Trail, and a proposed 10-foot shared use concrete paths at Cement Hill and SR 49. While this path provides connectivity between low-stress proposed improvements, it should be noted that this path illustrates a well-used desire line, is not paved, and is not ADA compliant. The path on Rood Center property exists as an opportunity to improve accessible, safe and low-stress connectivity within the study area. A Class I path proposed from the juvenile hall driveway and extending through the repurposed free right turn lane at the West Broad Street intersection will provide low stress connectivity through the remainder of the study area.

Additionally, each roundabout intersection includes 10-foot shared use concrete sidewalks/ paths. Striped crosswalks at each leg of the roundabout provides safe and connected access to the low stress proposed improvements throughout the corridor. Moreover, if approaches at roundabouts are striped, this will provide Class II bike lanes and/ or ample room for shoulder-riding along SR 49, resulting in a moderate stress environment for stronger and more confident riders.

Legend

- LTS 1 (line)
- LTS 4 (line)
- LTS 3 (line)
- LTS 1 (point)
- Road Network

Data disclaimer: crossing scores include unsignalized crossings only

Paper Size ANSI A

0 0.03 0.06 0.09 0.12

Miles

Map Projection: Lambert Conformal Conic
Horizontal Datum: NAD 1983 2011
Grid: NAD 1983 2011 StatePlane California II FIPS 0402 Ft US

N

Nevada County Transportatio Comm
SR 49 Multimodal Corridor Study

Improved Level of Traffic Stress

Project No. **11194668**
Revision No. **-**
Date **09/04/2019**

FIGURE 5.1

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Print date: 05 Sep 2019 - 11:06

Data source: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: pthornton

6. Benefit-Cost Analysis

A comprehensive benefit-cost analysis incorporated air quality, safety, and demand-related impacts to monetize the benefits likely to result from the improvements recommended in this report. Analysis of monetized benefits was based on the societal cost information from Caltrans' 2016 Economic Parameters. This analysis was completed for the overall study area, as well as each identified segment area. Additionally, by accounting for operations and maintenance costs associated with improvements over a 20-year life cycle, the results of the benefit-cost analysis was annualized and projected to reflect a 20-year design condition.

6.1 Benefits

6.1.1 Demand Benefits

To estimate the induced demand associated with the improvements proposed in the SR 49 MMCP, the methodology described in the National Cooperative High Way Research Program (NCHRP) *Report 552: Guidelines for Analysis of Investments in Bicycle Facilities* was employed.

Bicyclists are more likely to utilize a facility if they live within a 1.5 mile buffer than if they live outside of this distance. Moreover, the highest likelihood of a member of the population to use the facility exists if they live within a 0.5 mile buffer around the facility. The NCHRP 552 methodology suggests that bicycle commute mode share can be utilized to estimate the number of existing and future bicycle ridership based on the population, and low, moderate, and high likelihood multipliers at 1.5 mile, 1 mile, and 0.5 mile buffers that surround a facility. Benefit values are based on the following assumptions:

- Existing bicyclists near a new facility will shift from a nearby facility to a new facility
- The new facility will induce new bicyclists as a function of the number of existing bicyclists relative to the attractiveness of the proposed facilities

The benefits of the induced demand resulting from improvements were monetized into mobility, health, recreation, and decreased auto-use benefits. These benefits were compared against the estimated costs of improvements to calculate a benefit-cost ratio on a project area-wide basis and by segment.

Each buffer area—at 0.5, 1, and 1.5 miles from the proposed improvements were created using a network-based analysis in a GIS environment. Nevada County parcel data was utilized to estimate the population associated with each buffer area by multiplying occupied parcels by a factor of 2.9, which represents that average number of persons per household.

A summary of monetized bicycle facility benefits is presented in Table 6.1. Annual benefits are estimated to be between $494,517 and $758,977.

Table 6.1 **Bicycle Facility Benefits**

Benefit	Value
Annual Mobility Benefit	
Off-Street Trail	$82,807
Bicycle Lane without Parking	$218,793
Annual Health Benefit	
High Estimate	$19,840
Moderate Estimate	$12,416
Low Estimate	$10,880
Annual Recreation Benefit	
High Estimate	$427,050
Moderate Estimate	$215,350
Low Estimate	$171,550
Annual Decreased Auto Use Benefit	**$10,487**
Total Annual Benefit, High	**$758,977**
Total Annual Benefit, Moderate	**$539,853**
Total Annual Benefit, Low	**$494,517**

6.1.2 Safety Benefits

The Highway Safety Improvement Program (HSIP) is a fundamental program providing federal aid under the Fixing America's Surface Transportation (FAST) Act, enacted in 2015. The programmatic purpose of HSIP is to reduce the number of serious and fatal traffic crashes on all public roads. While a federal program, HSIP funds are funneled through state Departments of Transportation to disperse funding. Caltrans' Division of Local Assistance (DLA) manages California's local share of HSIP funds.

In order to estimate the safety benefits associated with proposed improvements, a collision modification factor (CMF) analysis was performed using Caltrans' Highway Safety Improvement Program (HSIP) Analyzer tool. Collision modification factors are multiplicative factors used to calculate the expected reduction in collisions associated with a particular countermeasure. Crash Modification Factors (CMFs) have been established based on safety research over the last several decades; however, CMFs may not be available for all countermeasure types—despite the safety improvements provided by the improvement. The HSIP analyzer utilizes the CMFs published in the Local Roadway Safety Manual (Version 1.4, June 2018) and the societal crash cost based on the California 2016 Economic Parameters, which are also resident in Cal B/C—the statewide analysis tool for cost-benefit analyses. Completed HSIP Analyzer documents are provided in Appendix E.

The proposed improvements, collision data and estimated costs were utilized to compute benefit-cost ratios for roadway and intersection control improvements within each concept area. A maximum of three safety countermeasures are allowed for selection when applying for HSIP funding, and each are chosen based on the Collision Modification Factor (CMF) associated with the selected countermeasure and applicable crash data. This reduction in collisions is translated to a monetized safety benefit, which is compared against the countermeasure cost to produce a benefit-cost ratio.

6.1.3 Delay and Air Quality Benefits

In addition to mode shift and collision reduction benefits, two additional performance metrics were evaluated at each study intersection proposed for conversion to roundabout control. Consistent with the Caltrans Intersection Control Evaluation (ICE) process, the additional performance measures used to calculate the benefits of a roundabout compared to a stop control are:

- Delay Reduction Benefit (of a roundabout); and,
- Emissions Reduction Benefit (criteria pollutants only)

Delay measures the societal cost associated with the number of person-hours of delay at the intersection during the study period. Analysis tools used to calculate delay were developed using SIDRA (roundabouts and unsignalized intersections). The lower the delay cost the greater the relative benefit associated with the estimated amount of person hours of delay at a given intersection. Consistent with the Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2018, 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 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. Given that average vehicular speed is the key on-road activity input for estimating emissions, the effects of delay (vehicle idling) are not explicitly captured by this analysis. Pollutant emissions evaluated include carbon monoxide (CO) and nitrogen oxides (NOx). The societal cost of emissions is calculated using emission data from the SIDRA software and cost per ton data from Caltrans Life-Cycle Benefit-Cost Analysis Economic Parameters 2018 for emissions.

Tables 6.2, 6.3, 6.4, and 6.5 provide the life-cycle monetized delay and emissions reduction benefit results for each intersection proposed for roundabout control (compares the life-cycle benefit of the estimated delay and emissions reduction costs between a stop control versus roundabout control type).

Table 6.2 SR 20/ SR 49 Life Cycle Roundabout Comparison (Segment 1)

Life Cycle Costs (20 year design)	No Build Alternative (Signal Controlled)	Roundabout Alternative
Mobility Costs		
Delay Costs	$35,100,000	$1,060,000
Fuel and GHG Costs	$2,101,000	$2,041,000
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$37,201,000**	**$3,101,000**

Table 6.3 SR 49/ Coyote Life Cycle Roundabout Comparison (Segment 1)

Life Cycle Costs (20 year design)	No Build Alternative (Signal Controlled)	Roundabout Alternative
Mobility Costs		
Delay Costs	$7,290,000	$270,000
Fuel and GHG Costs	$458,000	$633,000
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$7,748,000**	**$903,000**

Table 6.4 SR 49/Maidu/ Orchard Life Cycle Roundabout Comparison (Segment 2)

Life Cycle Costs (20 year design)	No Build Alternative (Signal Controlled)	Roundabout Alternative
Mobility Costs		
Delay Costs	$3,560,000	$190,000
Fuel and GHG Costs	$433,000	$609,000
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$3,993,000**	**$799,000**

Table 6.5 SR 49/Cement Hill/ West Broad Life Cycle Roundabout Comparison (Segment 3)

Life Cycle Costs (20 year design)	No Build Alternative (Signal Controlled)	Roundabout Alternative
Mobility Costs		
Delay Costs	$860,000	$140,000
Fuel and GHG Costs	$462,000	$571,000
Total Life Cycle Costs (Opening Year $ - Net Present Value)	**$1,322,000**	**$711,000**

6.2 Costs

Planning level cost estimates were developed based on per unit costs, quantities and right-of-way needs of overall improvements and by each segment. Unit costs were derived using the Caltrans cost database and industry standard values. Additionally, operations and maintenance costs were determined in order to calculate the projected cost of improvements over a 20-year design life cycle. Cost estimates for the overall project area and each intersection comprising the segment area, as well as operations and maintenance costs are provided in Appendix E.

Overall, the preferred recommended improvements for the entire corridor are estimated to cost approximately $20,725,000 to construct. Annual operations and maintenance costs are estimated at approximately $3 million.

6.3 Benefit-Cost Analysis

Table 6.6, Table 6.5, Table 6.6 and Table 6.7 summarize the results of the mode shift, and safety-associated benefit-cost analyses completed for the comprehensive study area, and each segment area in 2019. Additionally, these results were annualized to reflect a 20-year life cycle, which is also summarized in the following sections.

6.3.1 Corridor-Wide Benefit-Cost Analysis

Table 6.6 displays the benefit-cost summary for the overall study area. The selected counter measures associated with safety benefits result in an overall B/C of 1.66 in 2019 and through the 20-year cycle. This static safety benefit-cost is due to the 20-year life cycle of all of the selected countermeasures. While roundabouts yielded the highest costs associated the safety B/C analysis, these proposed improvements also provided the highest safety benefits, supporting strong safety B/C ratios throughout the study area.

The benefit-cost related to bicycle mode shift is nominal in 2019; however, the annualized benefit over a 20-year life cycle reflect a robust B/C of 1.33. Taken together, the total benefit-cost associated with the preferred recommended improvement concepts offer strong B/C calculations under existing and projected conditions, at 1.80 and 2.96, respectively.

Table 6.6 Benefit-Cost Summary (Comprehensive Study Area)

Total Annualized Benefit	2019		B/C	20 Year Adjusted		B/C
	Benefit	Cost		Benefit	Cost	
Bicycle Mode Shift Benefit	$758,977	$4,895,036	0.16	$10,587,686	$7,959,176	1.33
Safety Benefit	$35,600,261	$21,460,200	1.66	$35,600,261	$21,460,200	1.66
Delay	$2,237,500	$9,165,000	0.24	$44,750,000	$14,679,000	3.05
Total Benefit	**$38,596,738**	**$21,460,200**	**1.80**	**$90,937,947**	**$30,763,340**	**2.96**

Notes:

1. *Mode shift to Bicycle Transportation induced demand benefit was calculated using NCHRP 552 methodology; 20-year benefit estimated by multiplying the annualized benefit by a factor of 20 and applying a 4% year of year discount rate to account for the present worth of future dollars.*
2. *20-year life cycle cost was estimated using planning-level cost estimates and include 20 year life cycle of Class I shared use paths and Class II bicycle lanes*
3. *Safety Benefit analyzed using Caltrans HSIP analyzer and considers full project costs including set-aside for pedestrian improvements*
4. *This calculation was derived by adding the total project cost to the operations & maintenance costs associated with Class I paths*

6.3.2 Segment 1 Benefit-Cost Analysis

Table 6.7 displays the benefit-cost associated with Segment One preferred improvements. As displayed, the mode shift benefits under existing conditions are low at a B/C ratio of .16, due to the high-cost proposed Class I multi-purpose path in the segment area. The 20-year life cycle adjustment increases this B/C to 1.78. The safety benefit is a strong 1.92 over the 20-year life cycle, which buttresses the 2019 total B/C at 4.23.

Table 6.7 Benefit-Cost Summary (Segment 1)

Total Annualized Benefit	2019		B/C	20 Year Adjusted		B/C
	Benefit	Cost		Benefit	Cost	
Bicycle Mode Shift Benefit	$758,977	$4,745,583	0.16	$10,587,686	$5,934,213	1.78
Safety Benefit	$24,541,406	$12,813,000	1.92	$24,541,406	$12,813,000	1.92
Delay, Fuel & GHG Benefit	$2,047,250	$4,795,000	0.43	$40,945,000	$8,799,000	4.65
Total Benefit	**$27,347,633**	**$12,813,000**	**2.13**	**$76,074,092**	**$18,005,630**	**4.23**

Notes:

1. *Mode shift to Bicycle Transportation induced demand benefit was calculated using NCHRP 552 methodology; 20-year benefit estimated by multiplying the annualized benefit by a factor of 20 and applying a 4% year of year discount rate to account for the present worth of future dollars.*
2. *20-year life cycle cost was estimated using planning-level cost estimates and include 20 year life cycle of Class I shared use paths and Class II bicycle lanes*
3. *Safety Benefit analyzed using Caltrans HSIP analyzer and considers full project costs including set-aside for pedestrian improvements*
4. *This calculation was derived by adding the total project cost to the operations & maintenance costs associated with Class I paths*

6.3.3 Segment 2 Benefit-Cost Analysis

Table 6.8 displays the benefit-cost summary associated with Segment Two improvements. The safety benefit analysis results in a strong B/C of 1.46 over the 20-year life cycle. Similar to the comprehensive study area and segment one, the mode shift-associated benefit-cost becomes much stronger with a 20-year life cycle adjustment. However, in segment two, the B/C under existing is also strong. This is due to the Class I paths being comprised of concrete material—rather than decomposed granite—which have no associated operations and maintenance costs. This results in a much higher B/C of 15.36 with the 20-year adjustment. This strong B/C associated with both mode shift and safety benefits results in promising total benefit-cost ratios of 1.75 and 3.97 under existing and projected conditions, respectively.

Table 6.8 Benefit-Cost Summary (Segment 2)

Total Annualized Benefit	2019		B/C	20 Year Adjusted		B/C
	Benefit	Cost		Benefit	Cost	
Bicycle Mode Shift Benefit	$758,977	$689,347	1.10	$10,587,686	$689,347	15.36
Safety Benefit	$4,481,260	$3,079,400	1.46	$4,481,260	$3,079,400	1.46
Delay, Fuel & GHG Benefit	$159,700	$2,185,000	0.07	$3,194,000	$2,984,000	1.07
Total Benefit	**$5,399,937**	**$3,079,400**	**1.75**	**$18,262,946**	**$4,603,400**	**3.97**

Notes:

1. *Mode shift to Bicycle Transportation induced demand benefit was calculated using NCHRP 552 methodology; 20-year benefit estimated by multiplying the annualized benefit by a factor of 20 and applying a 4% year of year discount rate to account for the present worth of future dollars.*
2. *20-year life cycle cost was estimated using planning-level cost estimates and include 20 year life cycle of Class I shared use paths and Class II bicycle lanes*
3. *Safety Benefit analyzed using Caltrans HSIP analyzer and considers full project costs including set-aside for pedestrian improvements*
4. *This calculation was derived by adding the total project cost to the operations & maintenance costs associated with Class I paths*

6.3.4 Segment 3 Benefit-Cost Analysis

Table 6.9 displays the benefit-cost for Segment Three improvements. A 20-year adjustment results in a robust B/C of 3.10 for mode shift associated benefits, while existing conditions result in a weak B/C of .49. However, safety benefits support a strong total B/C of 2.18 throughout the 20-year life cycle, and 1.32 under existing conditions.

Table 6.9 Benefit-Cost Summary (Segment 3)

Total Annualized Benefit	2019		B/C	20 Year Adjusted		B/C
	Benefit	Cost		Benefit	Cost	
Bicycle Mode Shift Benefit	$758,977	$1,538,121	0.49	$10,587,686	$3,413,631	3.10
Safety Benefit	$6,577,595	$5,567,800	1.18	$6,577,595	$5,567,800	1.18
Delay, Fuel & GHG Benefit	$30,550	$2,185,000	0.01	$611,000	$2,896,000	0.21
Total Benefit	$7,367,122	$5,567,800	1.32	$17,776,281	$8,154,310	2.18

Notes:

1. *Mode shift to Bicycle Transportation induced demand benefit was calculated using NCHRP 552 methodology; 20-year benefit estimated by multiplying the annualized benefit by a factor of 20 and applying a 4% year of year discount rate to account for the present worth of future dollars.*
2. *20-year life cycle cost was estimated using planning-level cost estimates and include 20 year life cycle of Class I shared use paths and Class II bicycle lanes*
3. *Safety Benefit analyzed using Caltrans HSIP analyzer and considers full project costs including set-aside for pedestrian improvements*
4. *This calculation was derived by adding the total project cost to the operations & maintenance costs associated with Class I paths*

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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