APPENDIX B

Circulation/Roadway Improvements Technical Memorandum

ROADWAY IMPROVEMENTS REPORT
PARADISE TRANSPORTATION MASTER PLAN

April 5, 2022

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Introduction

As redevelopment efforts in downtown Paradise continue to increase, it is essential to assess daily circulation and capacity needs on roadways and at key intersections. This report documents the existing roadway network, identifies future roadway and intersection needs, and provides summaries and cost estimates for recommended projects. This Roadway Improvements Technical Memorandum has been prepared as part of the *Paradise Transportation Master Plan (TMP)*.

Other transportation-related technical memorandums in the *TMP* are:

- *Evacuation Recommendations Technical Memorandum* – Documents efforts to date following the Camp Fire of 2018 and transportation recommendations related to evacuation needs.
- *Local Road Safety Plan (LRSP)* – Documents crash data patterns and provides recommendations for roadway and intersection safety improvements.
- *Active Transportation Plan (ATP)* – Documents recommendations for pedestrian and bicycle facilities.
- *Parking Analysis* – Identifies parking supply, current usage, planned changes, and long-term recommendations for the downtown area.
- *Public Outreach* – Documents the traffic and evacuation planning public outreach and survey results.

This plan was developed by working closely with local officials and residents to understand the unique needs and challenges of the Town of Paradise. The Town experienced an unprecedented disaster and evacuation during the 2018 Camp Fire. Recovery efforts have provided an opportunity to build a more resilient roadway network to better serve the Town as recovery continues. This plan supports the Long-Term Community Recovery Plan, a program created in response to the 2018 Camp Fire to coordinate resources and planning efforts and establish a vision for a safer, stronger, and more resilient Paradise.

This plan builds upon previous planning efforts with updates to reflect changes in priorities where appropriate. The following previous studies were reviewed and incorporated in this memorandum:

- *1994 Town of Paradise General Plan*
- *2000 Downtown Master Plan*
- *2015 BCAG Butte County Transit and Non-Motorized Plan*
- *2020 BCAG Regional Transportation Plan & Sustainable Communities Strategy*
- *2018 Town of Paradise Pavement Management Plan*
- *2019 Camp Fire Roadway Damage Assessments*
- *2019 BCAG Federal Transportation Improvement Program*
- *2019 Long-Term Community Recovery Plan*

Roadway Inventory and Analysis

Existing Roadway Network Inventory

A roadway network inventory was performed to provide a baseline for determining existing and future circulation needs. **Figures 1-6** show the existing functional classification (from the *1994 General Plan*), number of lanes on Town roadways, intersections controls, "on-system" designated roadways (those eligible for the use of Federal funds), public versus private roadways, and culvert locations in the Town.

Multimodal Facilities

An inventory of multimodal facilities including sidewalk, bicycle facilities, and multiuse paths is presented in the *Active Transportation Plan*.

Transit, Aviation, and Rail Service

The *2020 BCAG Regional Transportation Plan & Sustainable Communities Strategy (2020 RTP SCS)* details transit, aviation, and rail service in Paradise and outlines the projects, policies, and programs that are recommended to be implemented over the next 20 years.

Public transit service in Paradise, Chico, Oroville, and other communities in Butte County is provided via the *B-Line Butte Regional Transit*. This transit service provides fixed routes and paratransit; however, scheduled routes to and from Paradise have been suspended (as of August 2021) due to reduced ridership following the Camp Fire. A new park-and-ride lot and transit center is planned for Paradise, to be located on Black Olive Drive adjacent to the Paradise Community Park. The Paradise transit center project is currently awaiting Federal Transit Administration (FTA) funding approval.

Aviation access to Paradise is provided via the privately-owned Paradise Skypark Airport. To our knowledge, there are no formal plans to expand aviation services or construct a commercial airport.

Passenger and freight rail are provided in Butte County, but not to Paradise directly. No current plans exist to expand rail services to the Town of Paradise.

Existing and Future Conditions Roadway Analysis

Daily roadway segment volumes for primary roadways in the Town of Paradise were derived from the Butte County Association of Governments' (BCAG) 2017-2018 data (pre-fire). Current traffic volumes (2022) are known to be considerably lower than those recorded in 2017-2018, but volumes are consistently increasing as the Town rebuilds.

Future Year (20-year horizon) traffic volume forecasts were developed for the Town of Paradise roadways to determine the number of vehicle travel lanes needed to accommodate long-term traffic levels. Future Year forecasts were developed using data collected by the Butte County Association of Governments (BCAG) in 2017 and 2018, prior to the Camp Fire. A 20 percent growth factor was applied to the BCAG data to develop Future Year

forecasts. The basic premise for conservative roadway planning is that the Town will recover to pre-fire activity levels, plus an additional 20 percent, in the 20-year horizon.

The *Highway Capacity Manual (HCM), 2010 Edition, Chapter 16 – Urban Street Facilities* includes methods for determining "Generalized Daily Service Volumes for Urban Street Facilities." This methodology was used to estimate the number of travel lanes needed on the major roadways in Paradise to serve existing and future conditions and maintain Level of Service D consistent with the General Plan goals and policies.

Level of Service (LOS) is designated using letters A through F, with LOS A representing the best operating conditions, and LOS F the worst. Many municipalities designate LOS D or better to be "acceptable" operating conditions. LOS D was used as the threshold for determining the needed number of travel lanes.

Exhibit 16-14 of the *HCM 2010* (provided in **Appendix A**) provides guidance for determining general roadway capacities based on targeted level of service goals. The following data is needed to develop threshold traffic volumes corresponding to a particular level of service:

- K-Factor – percent of Annual Average Daily Traffic (AADT) in both directions during the peak hour
- D-Factor – percent of traffic in the peak direction during the peak hour
- Posted Speed Limit

The BCAG data collected in 2017/2018 includes Daily, AM peak hour, and PM peak hour volumes and was used to determine the overall average K-Factor for the Town of Paradise roadways. A K-Factor of 0.9 was used in this analysis.

The most currently available directional traffic volume data (separate volumes for each direction) was used to determine an overall average D-factor of 0.55 for the Town of Paradise.

Table 1 shows the generalized traffic volume capacity thresholds for LOS D conditions on Town of Paradise roadways.

Table 1. Daily Traffic Volume Thresholds

Posted Speed Limit	Traffic Volume Threshold for LOS D	
	2 Travel Lanes	4 Travel Lanes
30 mph	15,400	31,400
35 mph	16,500	33,300
45 mph	18,600	37,200

Source: Headway Transportation, 2021

Table 2 shows the roadway segments, number of lanes, daily volumes in 2017/2018, and the Future Year traffic volume forecasts (20-year horizon) on key Town of Paradise roadways, as well as the recommended number of travel lanes on each roadway to maintain LOS D.

Table 2. Roadway Segment Capacity Analysis Summary

Route	Location	Number of Lanes	Pre-Camp Fire (2017/2018)		20-year Horizon	
			Daily Traffic Volumes	Lanes Needed for LOS "D"	Daily Traffic Volumes	Lanes Needed for LOS "D"
BILLE ROAD	E of OLIVER RD	2	1822	2	2190	2
BILLE ROAD	W of SKYWAY	2	2719	2	3260	2
BILLE ROAD	E of SKYWAY	2	8373	2	10050	2
BILLE ROAD	E of CLARK RD	2	7673	2	9210	2
BILLE ROAD	W of PENTZ RD	2	5595	2	6710	2
BUSCHMANN RD	E of FOSTER RD	2	2527	2	3030	2
BUSCHMANN RD	W of CLARK RD	2	3725	2	4470	2
CLARK RD	S of SKYWAY	2	7865	2	9440	2
CLARK RD	N of WAGSTAFF RD	2	10519	2	12620	2
CLARK RD	N of BILLE RD	4/5	15537	2	18640	4
CLARK RD	N of CENTRAL PARK DR	5	16106	2	19330	4
CLARK RD	N of ELLIOTT RD	5	15644	2	18770	4
CLARK RD	N of NUNNELEY RD	5	18693	4	22430	4
CLARK RD	N of PEARSON RD	5	15637	2	18760	4
CLARK RD	N of BUSCHMANN RD	2	11596	2	13920	2
ELLIOTT RD	E of SKYWAY	2	8718	2	10460	2
ELLIOTT RD	W of CLARK RD	2	9823	2	11790	2
ELLIOTT RD	E of CLARK RD	2	5540	2	6650	2
FOSTER RD	N of ROE RD	2	2087	2	2500	2
NEAL RD	S of SKYWAY	2	4042	2	4850	2
NEAL RD	N of ROE RD	2	2308	2	2770	2
OLIVER RD	S of BILLE RD	2	2180	2	2620	2
OLIVER RD	W of SKYWAY	2	5151	2	6180	2
PEARSON RD	E of SKYWAY	4	9647	2	11580	2
PEARSON RD	W of CLARK RD	3	11927	2	14310	2
PEARSON RD	E of CLARK RD	2	8971	2	10770	2
PEARSON RD	E of SAWMILL RD	2	7669	2	9200	2
PEARSON RD	W of PENTZ RD	2	6071	2	7290	2
PEARSON RD	S of SKYWAY	4	3388	2	4070	2
PENTZ RD	N of WAGSTAFF RD	2	6567	2	7880	2
PENTZ RD	N of BILLE RD	2	5713	2	6860	2
PENTZ RD	N of PEARSON RD	2	4954	2	5940	2

Table 2 continued. Roadway Segment Capacity Analysis Summary

PENTZ RD	S of PEARSON RD	2	6602	2	7920	2
PENTZ RD	N of MALIBU	2	4301	2	5160	2
SAWMILL RD	S of BILLE RD	2	2685	2	3220	2
SAWMILL RD	N of PEARSON RD	2	2770	2	3320	2
SKYWAY	E of PENTZ RD	2	16125	2	19350	4
SKYWAY	W of PENTZ RD	2	15450	2	18540	4
SKYWAY	W of CLARK RD	2	9639	2	11570	2
SKYWAY	N of WAGSTAFF RD	2	10252	2	12300	2
SKYWAY	N of BILLE RD	2	12246	2	14700	2
SKYWAY	N of MAXWELL DR	5	20605	4	24730	4
SKYWAY	N of ELLIOTT RD	5	20341	4	24410	4
SKYWAY	N of FIR ST	3	22591	4	27110	4
SKYWAY	S of PEARSON RD	5	22916	4	27500	4
SKYWAY	N of NEAL RD	5	22253	4	26700	4
SKYWAY	S of NEAL RD	4	22248	4	26700	4
WAGSTAFF RD	W of SKYWAY	2	1721	2	2070	2
WAGSTAFF RD	E of SKYWAY	2	5055	2	6070	2
WAGSTAFF RD	W of CLARK RD	2	5612	2	6730	2
WAGSTAFF RD	E of CLARK RD	2	6243	2	7490	2
WAGSTAFF RD	W of PENTZ RD	2	5406	2	6490	2

Source: Headway Transportation, 2021

As shown in **Table 2**, three roadway segments (indicated in grey highlight) are identified where projected traffic volumes are forecast to exceed current roadway capacity for long-term conditions. The segment of Skyway between Pearson Road and Elliott Road (identified as N of Fir St) is noted as a location where capacity improvements should be prioritized.

The Skyway/Pentz Road intersection and the segments of Skyway east and west of Pentz Road may reach capacity in the 20-year horizon. Consideration should be given to planning capacity improvements/roadway widening at and adjacent to the Skyway/Pentz Road intersection.

All other studied road segments are anticipated to operate within policy level of service D through the 20-year horizon.

Intersection improvements are recommended at the Foster Road/Black Olive Drive and Pearson Road/Pentz Road intersections based on observation and high-level review. Foster Road/Black Olive Drive has an awkward configuration, services evacuation routes, and has been identified in previous studies for reconfiguration. Pearson Road/Pentz Road is an evacuation route and is undersized for the roadway classifications and evacuation importance.

Potential Improvement Concepts

Draft roadway improvement concepts were developed for the purposes of public engagement, further analysis, and refinement through the review process. The initial draft of potential roadway and intersection improvements is shown in **Figure 7.** Potential concepts include:

- Capacity Improvement Concepts
- Circulation and Roadway Extensions
- Striping and Multimodal Projects

Capacity Improvement Concepts

- Widening from 2 lanes to 3 Lanes with a Multiuse Path on:
  - Upper Skyway
  - Upper Clark Road
  - Pentz Road
  - Neal Road
- Other Widening or restriping to add travel lanes
  - Downtown Skyway (Skyway Capacity Improvements, Pearson Road to Elliott Road detailed below)
  - Pearson Reconfiguration (Skyway to Black Olive Drive, detailed below)
  - Clark Road Widening (sub segment between Bille Road and Wagstaff Road)
  - Roe Road Widening (Phase 5 between Neal Road and Scottwood Road)
  - Clark Road Extend Dual Southbound Lanes (south of Pearson Road)
- Intersection Improvements
  - Foster Drive/ Black Olive Drive
  - Pearson Road/ Pentz Road
  - Skyway/ Pentz Road
  - Other intersections improvements as part of roadway extensions

Circulation and Roadway Extensions

- Roe Road Extension (Phases 1-4, Skyway to Neal Road and Scottwood Road to Pentz Road)
- Sawmill Extension
- Elliott Rd Extension (west of Skyway toward Valley View area
- Elliott Rd Extension (east of Sawmill to Pentz)
- Forest Service Rd Extensions (east and west of Clark Rd)
- Buschmann Rd Extensions (west to Skyway and east to Libby)
- Middle Libby Rd Extension
- Bille Rd Extension

- Shay Lane Extension
- Honey Run Roadway Improvements
- Toyon Lane Improvements
- Moore Rd Improvements

Striping and Multimodal Projects

- Transit Center
- Almond Street Multimodal Improvements (striping project – see **Figure 7** for location)
- Gap Closure Complex (downtown striping project – see **Figure 7** for location)

Skyway Capacity Improvements – Pearson to Elliott

Based on the road segment capacity analysis, downtown Skyway between Elliott Road and Pearson Road was a primary focus for improvements. This section of roadway is currently three lanes; however, four to five lanes are likely needed to serve long-term traffic forecasts. Additional lanes would also be valuable in facilitating traffic during evacuations. Four alternative configurations (plus a 'no change' option) were developed for Downtown Skyway to illustrate options for restriping the current roadway width. **Exhibits 1-6** show the conceptual design concepts, including lists of advantages/disadvantages and trade-offs associated with each option.

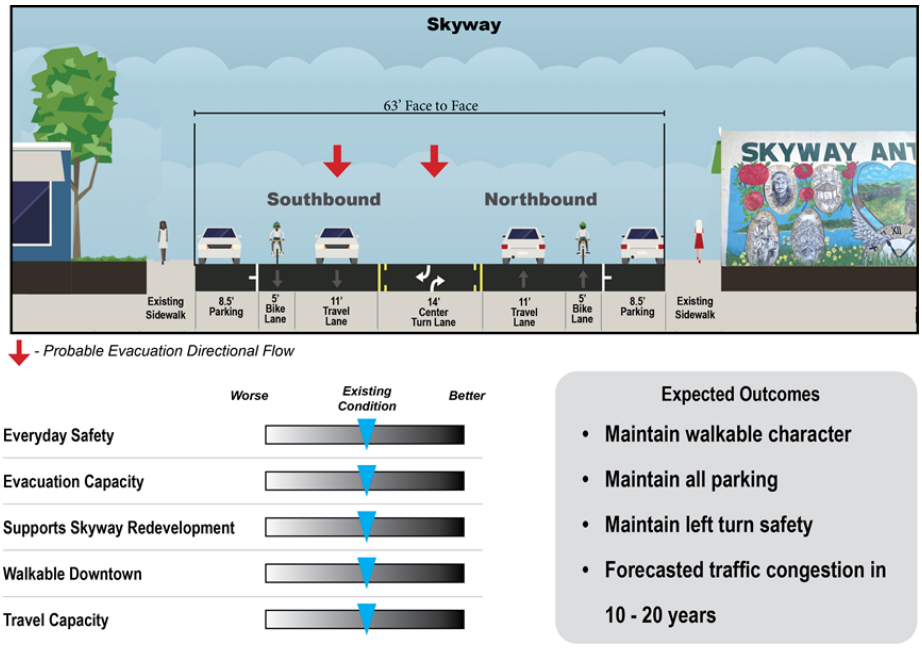
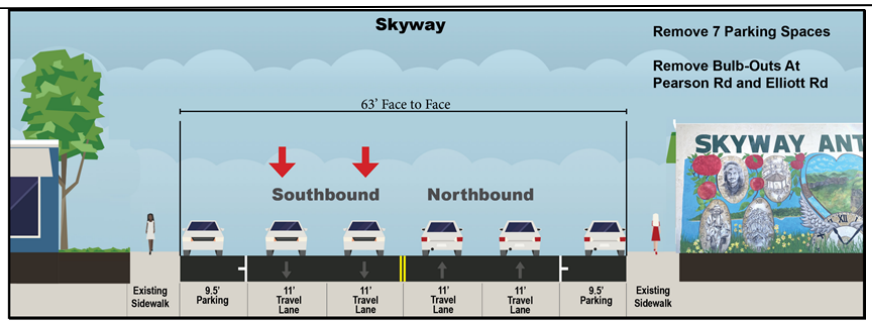
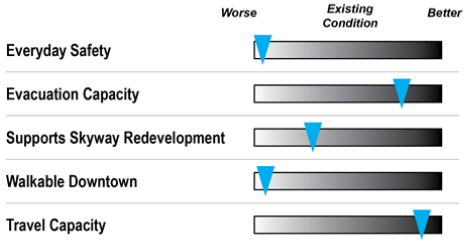


Exhibit 1. Existing Skyway (no change)



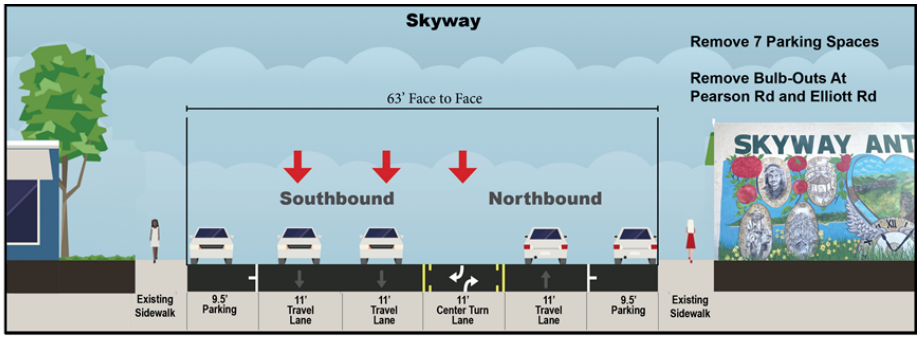
- Probable Evacuation Directional Flow



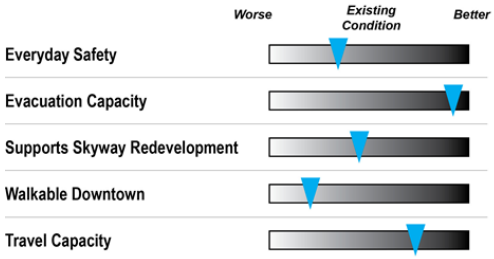
Expected Outcomes

- Very diffcult for pedestrians to cross Skyway
- More rear-end collisions
- Higher Speeds
- Forecasted adequate long-term vehicle capacity

Exhibit 2. Option A – Four Lanes + Parking Both Sides



- Probable Evacuation Directional Flow



Expected Outcomes

- Balanced approach
- Forecasted inadequate northbound capacity in 10 - 20 years

Exhibit 3. Option B – Three Lanes + Center Turn Lane + Parking Both Sides

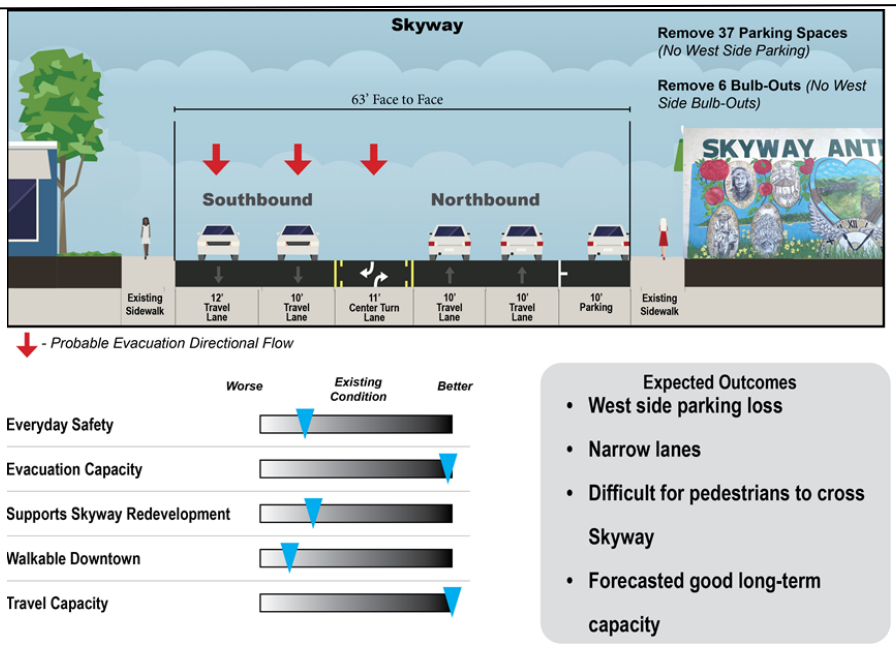


Exhibit 4. Option C – Five Lanes + East Side Parking

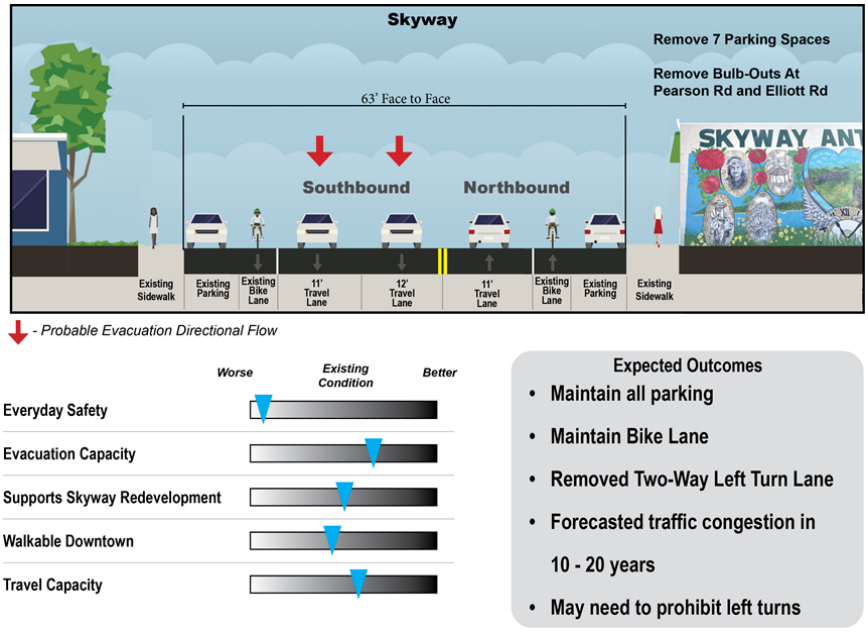


Exhibit 5. Option D – Three Lanes + Bike Lanes + Parking Both Sides

The matrix shown in **Exhibit 6** provides a side-by-side comparison of the Skway options with a sliding scale to indicate how each impacts various categories.

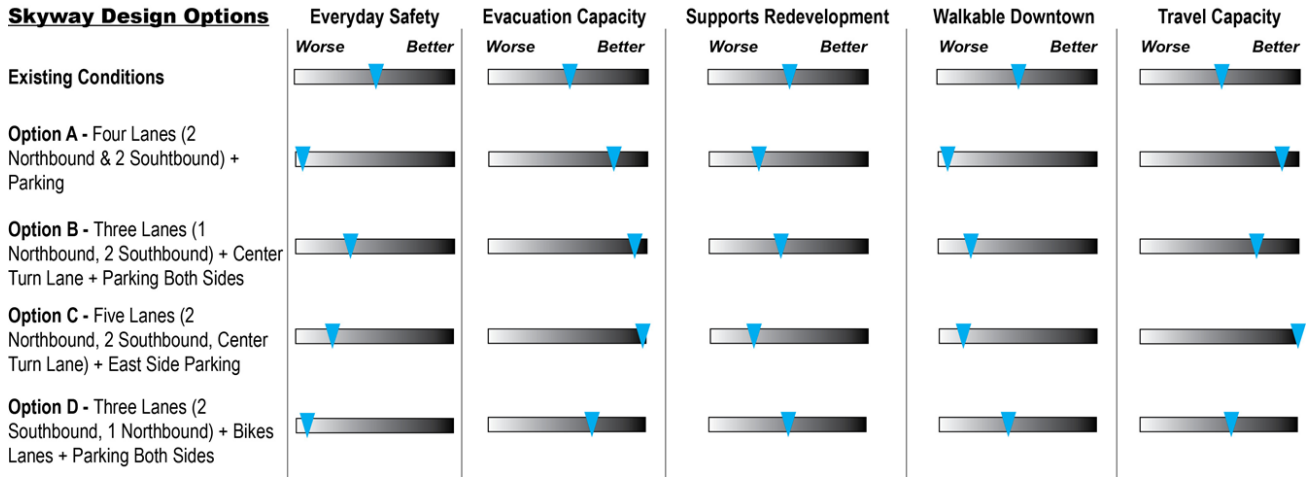
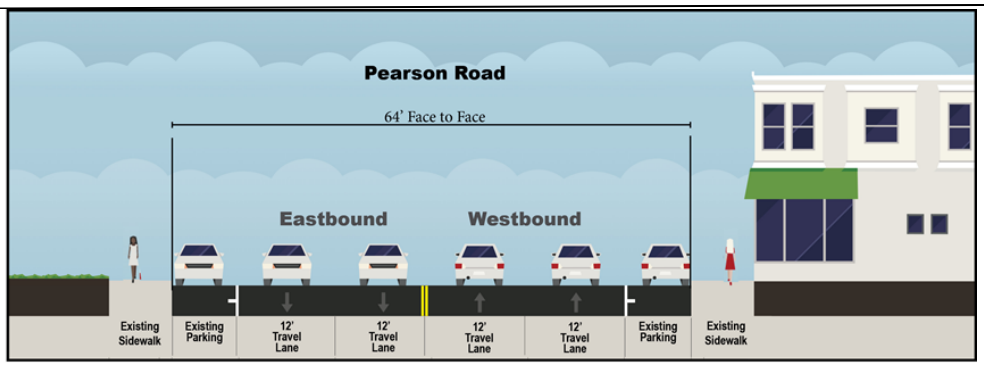


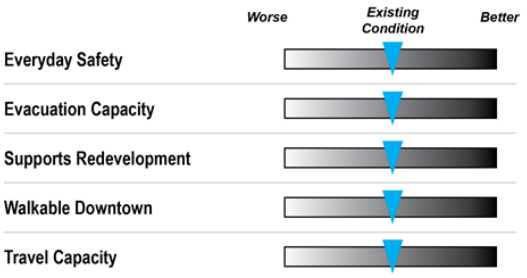
Exhibit 6. Side-by-Side Comparison for Skyway

Weighing the criteria, public preference, and other engineering and cost considerations, **Option B** - *Three Lanes + Center Turn Lane + Parking Both Sides,* was selected as the preferred alternative by Town Council in September 2021.

Pearson Road Reconfiguration – Skyway to Black Olive

The capacity analysis indicates there is an opportunity to revise the configuration of Pearson Road between Skyway and Black Olive Drive since traffic analysis indicates only two through travel lanes (one in each direction) are needed in this segment and the segment east of Black Olive Drive has a three-lane cross-section. Four design concepts (plus a "no change" option) were also developed for Pearson Road between Skyway and Black Olive Drive. **Exhibits 7-12** show the design options, advantages/disadvantages, and expected outcomes with each option.

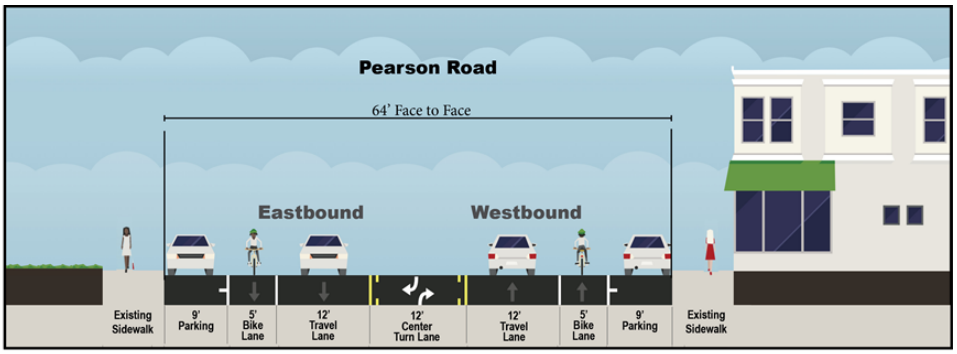


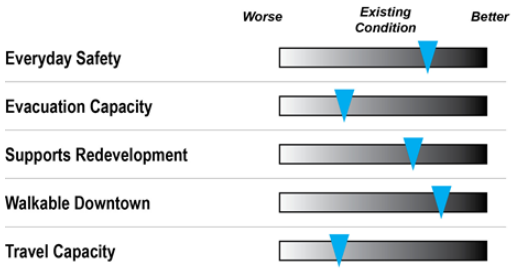


Expected Outcomes

- Difficult pedestrian crossing at Almond St
- Bike lanes end at Black Olive Dr
- High travel speeds
- No median width for left turns at Almond St or Foster Rd
- No buffer adjacent to on-street parking

Exhibit 7. Existing Pearson Road (no change)

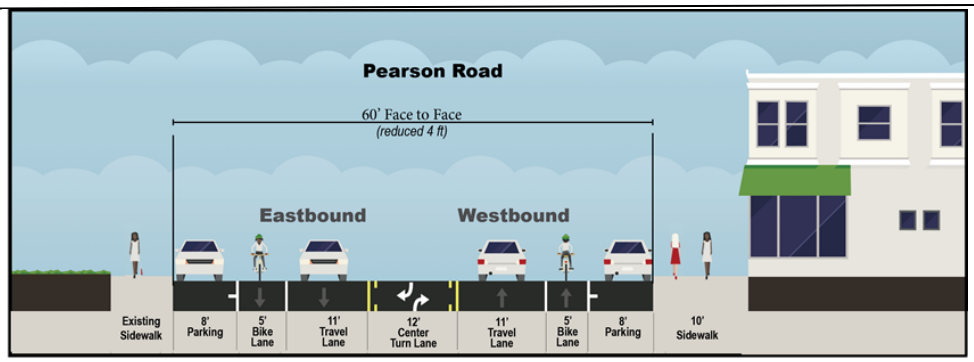


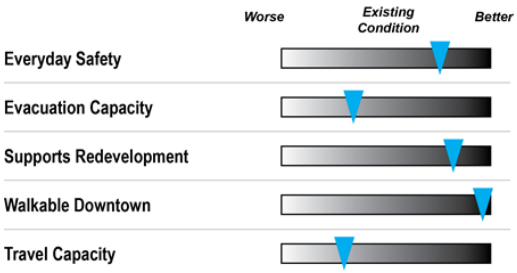


Expected Outcomes

- Improved bicycle & pedestrian safety
- Improved left turns
- Easier to use on-street parking
- Moderate capacity reduction
- Consistent with configuration east of Black Olive Dr

Exhibit 8. Option A – Three Lanes + Bike Lanes

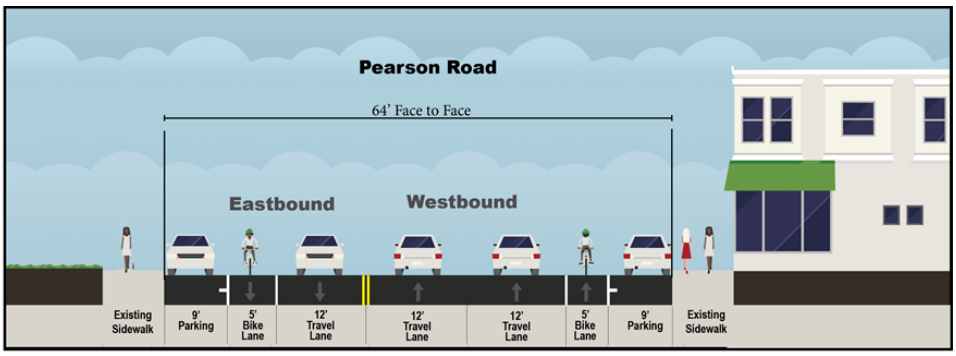


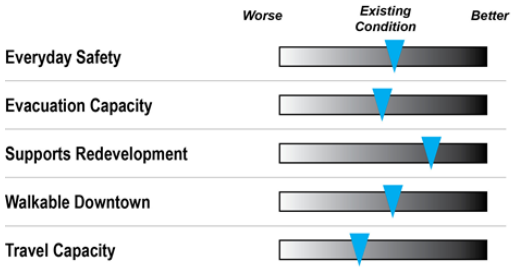


Expected Outcomes

- Improved walking environment supporting redevelopment
- Improved safety
- Easier to use on-street parking
- Moderate capacity reduction
- Balance for all uses

Exhibit 9. Option B – Three Lanes + 4 ft Wider Sidewalk





Expected Outcomes

- Improved bicycle connectivity
- Easier to use on-street parking
- Minor capacity reduction
- Minor safety improvement

Exhibit 10. Option C – Two Westbound Lanes + One Eastbound

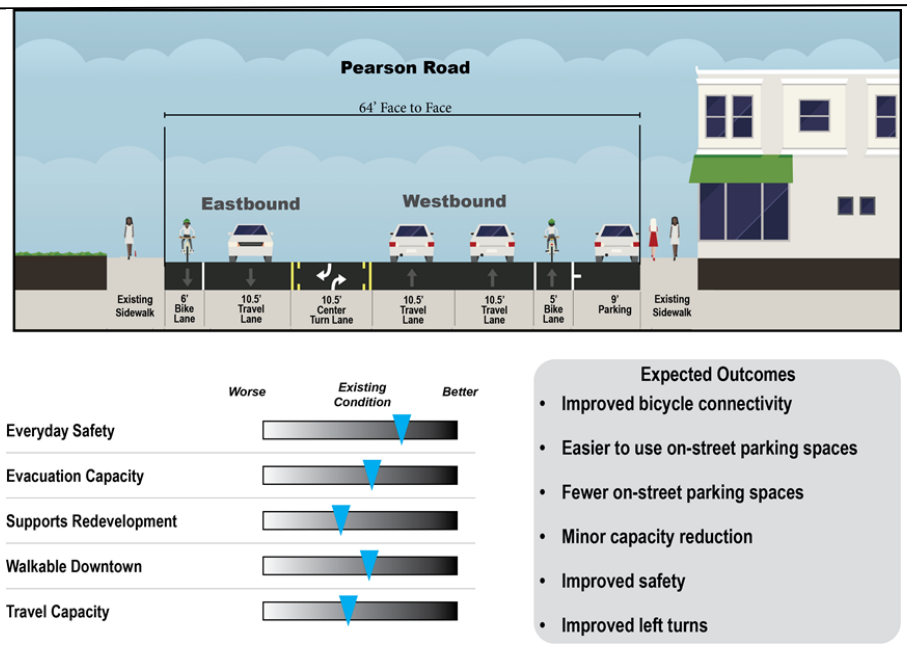


Exhibit 11. Option D – Two Westbound Lanes + One Eastbound + Center Turn Lane

The matrix shown in **Exhibit 12** provides a side-by-side comparison of the Skway options with a sliding scale to indicate how each impacts various categories.

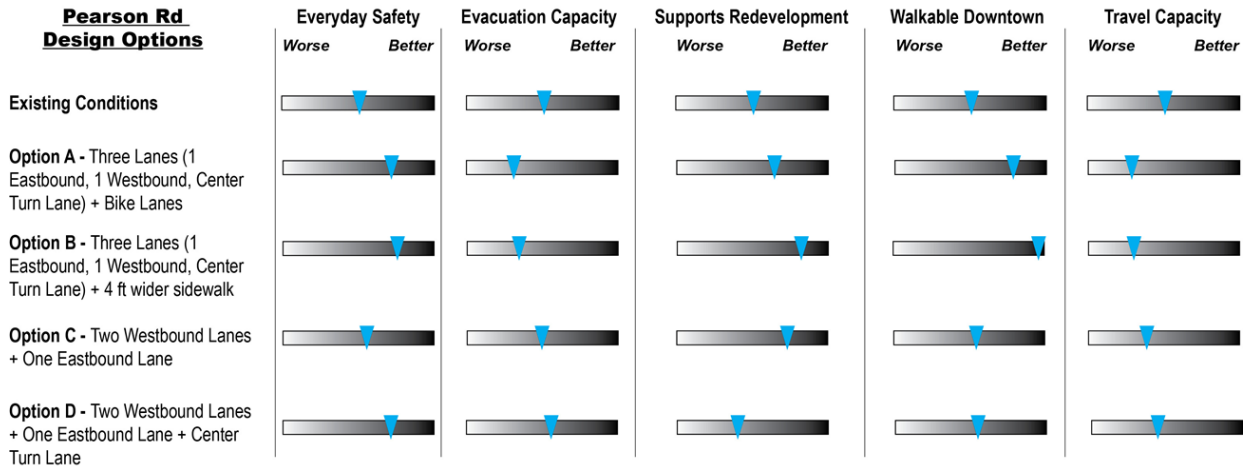


Exhibit 12. Side-by-Side Comparison for Pearson Road

Weighing the criteria, public preference, and other engineering and cost considerations, keeping the **Existing Conditions/No Change** was selected over the various options for change.

Public Outreach

Exhibit 13. Workshop Presentation

Public outreach is a vital component of any transportation master plan to gain important feedback on transportation needs and to guide the development and prioritization of improvement projects. Extensive public outreach was conducted including a Roadway *and Traffic Evacuation Planning* workshop followed by an online public survey conducted from June 22 – July 14, 2021. Public engagement in the TMP process was encouraged using booths at local events, advertisements on the Town of Paradise web page, and through an outreach campaign. The purpose of the roadway specific public outreach and survey was to ensure that improvements recommended within the TMP reflect the priorities of the community. The survey included questions on demographics, concerns related to daily traffic needs, evacuation, and traffic safety, and gauged the preferences of participants on various proposed improvements or concepts. Graphics and maps were provided to illustrate the proposed improvements. The full details of the workshop, survey questions, and results are provided in the *Public Outreach Technical Memorandum*.

A summary of the results related to roadway improvements is provided below:

- Just over half (56%) of the respondents were current residents of Paradise. The remaining were former residents, planning to return as residents, or "other".
- Over 98% of the respondents use a personal vehicle as their primary source of transportation.
- The public favored more lanes on Skyway at the expense of other multimodal accommodations. The most preferred option for the Skyway redesign included Five lanes: two northbound/southbound, one center turn lane, and east side parking. The least preferred option included three lanes.
- The public preferred keeping Pearson Road as it is over the four alternative design options.
- The public favored keeping midblock crosswalks at Terry Ashe Park (71%) and Lucky John Road (65%).

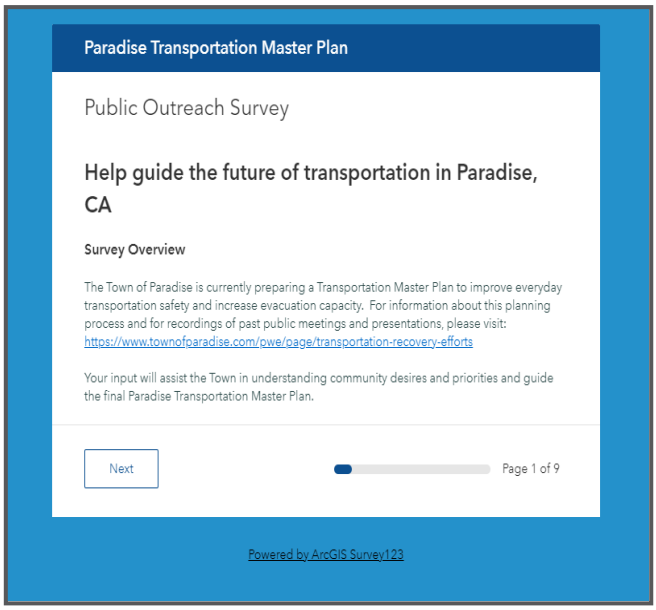


Exhibit 14. Opening Screen of Online Survey

- The public preferred upgrades to the Town's portion of Honey Run Road, with two lanes open, over other options that would restrict vehicular traffic.
- The most preferred projects are:
    - Skyway Capacity Improvements
    - 3 Lanes + multiuse path on Upper Skyway
    - 3 Lanes + multiuse path on Pentz Road
- The most preferred roadway extensions are:
    - Elliott Road (Sawmill Road to Pentz Road)
    - Roe Road Extension Phases 1, 2 and 4
- Just under half (47%) of respondents think that the Town should consider a roundabout or changing the STOP control at the intersection of Black Olive Drive/ Foster Road.
- 75% of respondents favor a Town policy to discourage vertical roadway elements (median islands, bulb outs, splitter islands, etc.) on public roads.
- 75% of respondents also agreed that the Town should remove the raised median islands on Skyway in front of Town Hall and on Pearson Road at Black Olive Drive
- 75% of respondents were in favor of the Town purchasing private property to convert private roads to public roads.

The survey also contained questions related to demographics, evacuations, and several opportunities for open ended responses. The full survey is detailed in the *Public Outreach Technical Memorandum*.

Roadway Classification and Cross-sections

The functional classification of a roadway is used to guide roadway design features, intersection controls, speed limits, access control standards, cross-section elements, and maintain the primary purpose of a roadway in the overall roadway network. The roadway classifications in the Town of Paradise are:

- *Principal Arterial* – Principal Arterials have the primary function of efficiently moving high traffic volumes across a community. They serve regional trip making, support dense commercial activity, have the highest speed limits, have the least access control, and flows should not be interrupted by excessive controls.
- *Minor Arterial* – Minor Arterials have the purpose of serving cross-community trips and volumes lower than Principal Arterials. Efficient travel with limited intersection controls is a priority for these roadways.
- *Collector* – Collectors serve the purpose of connecting local streets through neighborhoods to arterials.
- *Local Street* – Local streets have the primary purpose of providing direct access to residential and other properties. These roads typically have the lowest traffic volumes and speeds. Driveways are closely spaced and intersection controls favor making high quality and safe connections to the roadway network rather than vehicle throughput.

As communities change, roadway improvements/new connections are made, and development/redevelopment occurs, it is necessary to update the classifications to guide how roadways should function and what policies and design considerations should apply. **Figure 8** shows the proposed roadway functional classification.

Typical cross-section elements and required Right-of-Way (ROW) standards were developed through the TMP process. The typical cross-sections are intended to provide roadway widths, multimodal facilities, design features, and right-of-way widths that support the Town's long-term recovery goals. Typical cross sections by roadway type are presented in the *Road Standards Technical Memorandum*.

Truck Route Evaluation

The 1994 General Plan provides the following guidance on the designation of truck routes:

- Circulation Policy (CP) 8 and Noise Policy (NP) 10 – The Town should continue to designate and regulate truck routes to protect residential areas from unwanted noise and traffic.
- Noise element policies require the designation of specific truck routes.
- Truck routes were based on a study conducted in 1982 considering locations of businesses served by large trucks, origin/destination of logging trucks, and locations of residential areas.
- Truck route facilities (per Figure 13-2 in the 1994 General Plan):
    - Skyway from the south town limit to the north town limit
    - Clark Road from the south town limit to Skyway
    - Pearson Road from Skyway to Pentz Road
    - Pentz Road south of Pearson Road to the town limit
- The Town of Paradise Code of Ordinances states that:
    - The town council shall adopt a resolution establishing one or more truck routes through the town as shown on that certain map herein known as the truck route map for the town. The truck route map shall be kept on file in the office of the town engineer.

Caltrans does not identify any local truck routes in Butte County.

Development and travel patterns have changed considerably in the Town since adoption of the 1994 General Plan. Further, a higher level of truck activity and heavy vehicle movement will be necessary for recovery and redevelopment within the Town as whole.

It is recommended that all Principal Arterials, Minor Arterials, and Neal Road (Collector) be designated as truck routes since these roadways serve the primary purpose of vehicle movement and/or serve commercial and institutional uses needing regular deliveries by trucks. All potential new truck routes must be suitable for truck traffic are subject to review prior to designation. Projects or improvements on these roadways, such as the repaving project, should consider truck traffic. Proposed truck routes are shown on **Figure 9**.

Standards and Policies

Standards and policies for roadway designs will ensure consistency going forward in future roadway rehabilitations, widening projects, and new roadways. The following new standards were developed as part of the *TMP*:

- **Striping & Signage Standards** – New standards were developed to ensure that pavement markings and signage are consistent town-wide, conform to the current California Manual on Uniform Traffic Control Devices (CAMUTCD), and are consistent with Caltrans standard plans. The Striping & Signage Standards are attached in **Appendix B**.
- **Crosswalk Policy** – A new policy was developed to consistently guide the installation of marked crosswalks, including enhanced safety features (as additional signage, raised median islands, Rectangular Rapid Flashing Beacons). It is important that marked crosswalks be installed at appropriate locations, however, overuse of marked crossings reduces their effectiveness. Therefore, consistent application of the policy is important. The Crosswalk Policy is attached in **Appendix C**.
- **Vertical Elements in the Roadway Policy** – Vertical elements are discouraged in future public works projects such as raised medians, sidewalk bulb outs, center islands, and splitter islands on emergency access roadways. The need for this policy arose after the Camp Fire evacuation. Evacuating traffic was reportedly impeded by driving around vertical elements in the roadway. Vertical elements commonly include pedestrian crossing refuge islands, bulb-outs, and splitter islands. In particular, the mid-block pedestrian crosswalk refuge center island on Skyway was identified as a hinderance during the evacuation since drivers were not able to use the full pavement width. Public outreach efforts conducted during this *TMP* process indicates the public is supportive of removing or limiting the use of vertical elements. The everyday safety benefit of these elements was weighed against the potential evacuation implications. A recommendation was brought forward to the Town Council in September 2021 to remove the Skyway mid-block crossing at Town Hall and to establish a policy discouraging the use of vertical elements in future roadway projects. The Vertical Elements Policy is attached in **Appendix D**.
- **Arterials Policy** – New, reconstructed, and reconfigured arterials are recommended to include exclusive left turn lanes at all intersections with Collectors, Minor Arterial, and Principal Arterial roadways. New on-street parking should generally not be implemented on arterial roadways. See **Appendix E**.

Recommendations and Planned Projects

Following are recommended key future actions related to roadways:

- The Town should formally adopt the Roadway Functional Classification Map (**Figure 8**)
- The Town should formally adopt the Typical Roadway Sections (*Road Standards Technical Memorandum*)
- The Town should formally adopt the Truck Routes Map (**Figure 9**)
- The Town should formally adopt the Signage & Striping Standards, Crosswalk Policy, Vertical Elements in the Roadway Policy, and Arterials Policy (**Appendix B** through **Appendix E**)

The following projects are underway or have been completed since the draft/ initial concepts improvements were prepared, and are detailed in other *TMP* technical memorandums:

- Remove the median on Skyway at Town Hall
- Almond Street Multimodal Improvements (striping)
- Gap Closure Complex (striping)
- Transit Center (currently awaiting FTA funding approval)

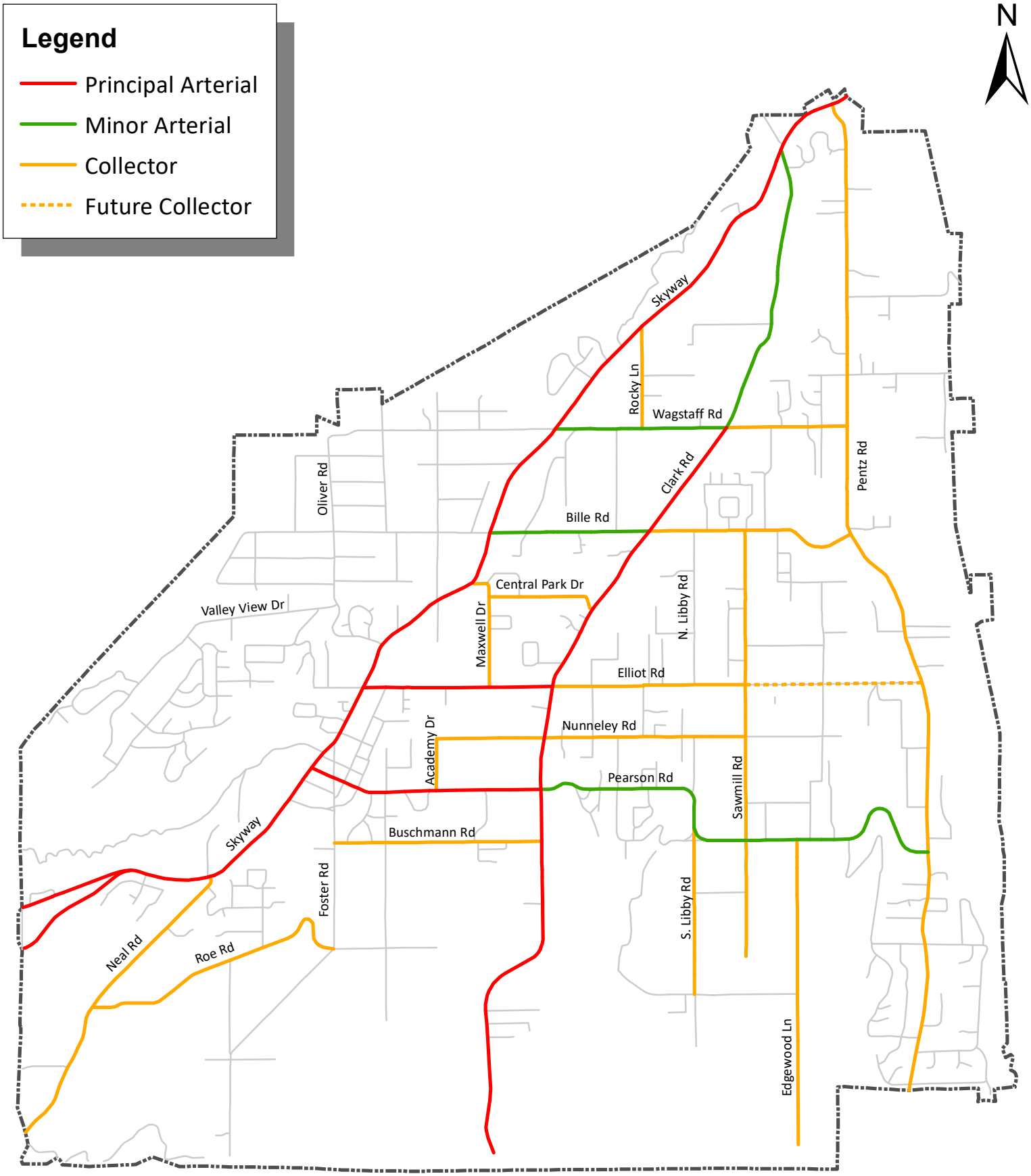
Based on the roadway segment analysis and public comments received, the following capacity projects are identified as the highest priority:

- Skyway Capacity Improvements (Pearson to Elliott) – **Option B** as selected by Town Council consisting of Three Lanes + Center Turn Lane + Parking Both Sides
- Skyway/Pentz Road intersection improvements including the segments of Skyway east and west of Pentz Road
- Foster Road/Black Olive Drive intersection improvements
- Pearson Road/Pentz Road intersection improvements

The final recommended and prioritized roadway and intersection improvements list was developed through an iterative process of creating initial concepts, technical analysis, public review and comment, Town Council direction, refinement, and coordination of *TMP* update activities. The recommended roadway and intersection improvements are shown in **Figure 10** and listed in **Table 3** below. Other projects related to active transportation or evacuation are included in the respective technical memorandums. **Table 3** illustrates how each project supports the Long-Term Recovery Plan, provides cost estimates, and suggests a relative prioritization. Project descriptions are included in **Appendix F**.

Table 3. Project Summary and Prioritization

Projects	Priority Category	Connection to Long Term Recovery	Estimated Costs
Skyway Capacity Improvements (Elliott to Pearson)	**1** - Addresses future capacity needs, and provides improvements along primary evacuation routes and intersections	Capacity & Evacuation	$1,000,000
Foster/Black Olive Intersection Improvements			$5,000,000
Skyway/Pentz Intersection Improvements & adjacent segments			$10,000,000
Pentz/Pearson Intersection Improvements			$5,000,000
Upper Skyway Widening (Bille to Pentz)	**2** - Widens major N/S evacuation routes for daily capacity and evacuation benefits	Capacity & Evacuation	$49,000,000
Pentz Road Widening (Town Limits to Skyway)			$89,000,000
Upper Clark Widening (Wagstaff to Skyway)			$25,000,000
Neal Road Widening (Town Limits to Skyway)			$25,000,000
Clark (spot widening b/t Wagstaff & Bille)			$5,000,000
Clark (extend dual southbound lanes south of Pearson)			$2,000,000
Roe Road Extension Phase 1 (S Libby to Pentz)	**3** - Provides circulation, connectivity, and evacuation benefits on primary E/W routes	Circulation, Connectivity, Evacuation, & Capacity	$60,000,000
Elliott Road Extension (west of Skyway)			$1,000,000
Elliott Road Extension (End to Pentz Road)			$7,000,000
Roe Road Phase 2 (SR-191 to S Libby)	**4** - Provides circulation, connectivity, and evacuation benefits on E/W routes	Circulation, Connectivity, Evacuation, & Capacity	$43,000,000
Roe Road Phase 4 (Skyway to Neal)			$20,000,000
Roe Road Phase 3 (Scottwood to SR-191)			$11,000,000
Roe Road Phase 5 (Neal to Scottwood)			$21,000,000
Buschmann Extension between Clark & Libby			$7,000,000
Sawmill Extension south to Roe Road Extension			$3,000,000
Buschmann Extension West of Foster Road	**5** - Provides circulation, connectivity, and evacuation benefits	Circulation, Connectivity, & Evacuation	$3,000,000
Moore Road (Public, pave)			$1,000,000
Middle Libby Road Extension between Pearson & Elliott			$6,000,000
Forest Service Road Extensions			$2,000,000
Honey Run Road Improvements			$6,100,000
Toyon Lane Improvements (Foster to Roe			$4,000,000
Shay Lane Extension (to Center Pine Drive)			$1,000,000
Bille Road Extension east of Pentz			$3,000,000

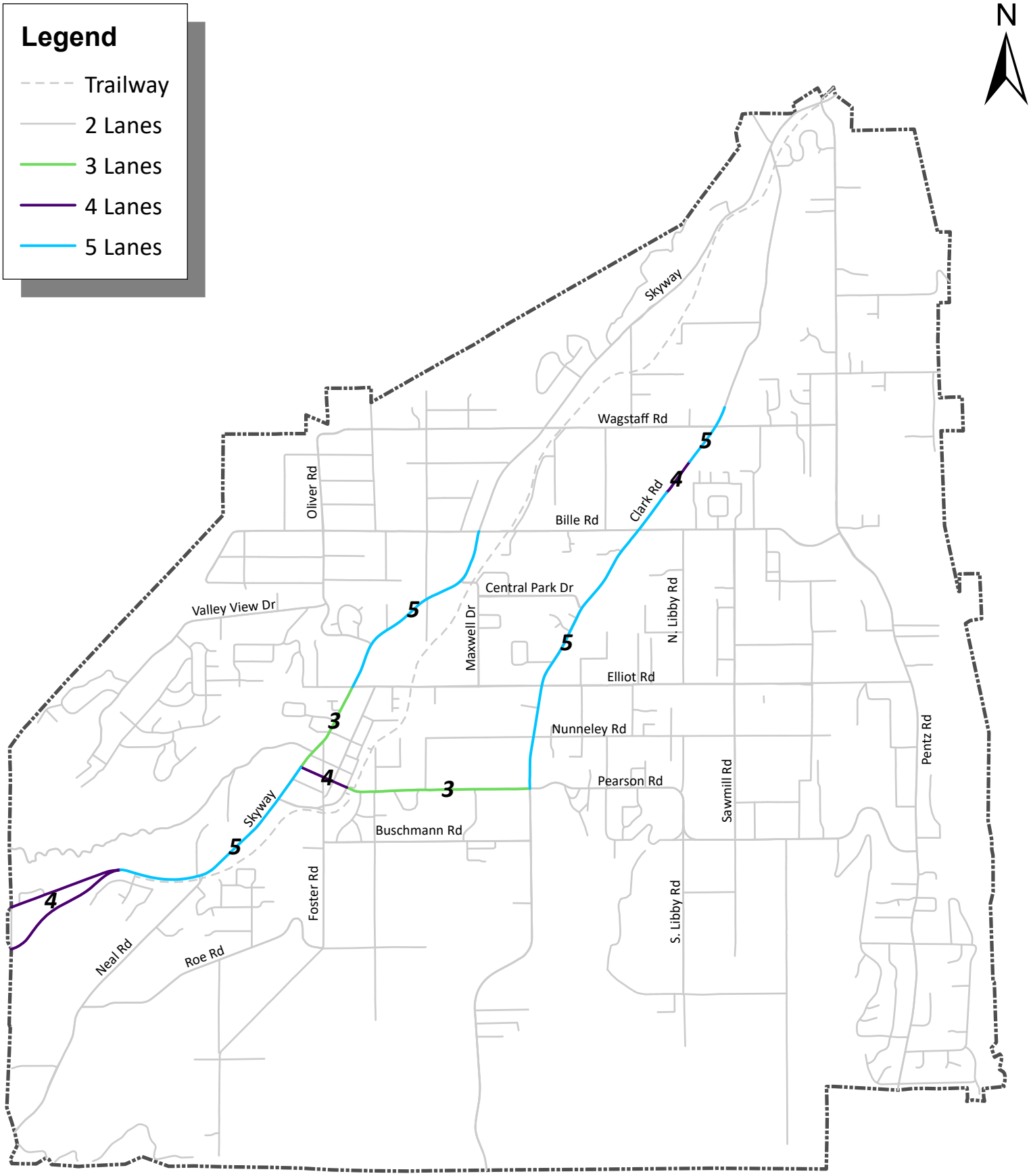


HEADWAY TRANSPORTATION

Town of Paradise

Figure 1

Existing Functional Classification
Roadway Improvements Report for
Town of Paradise Transportation Master Plan



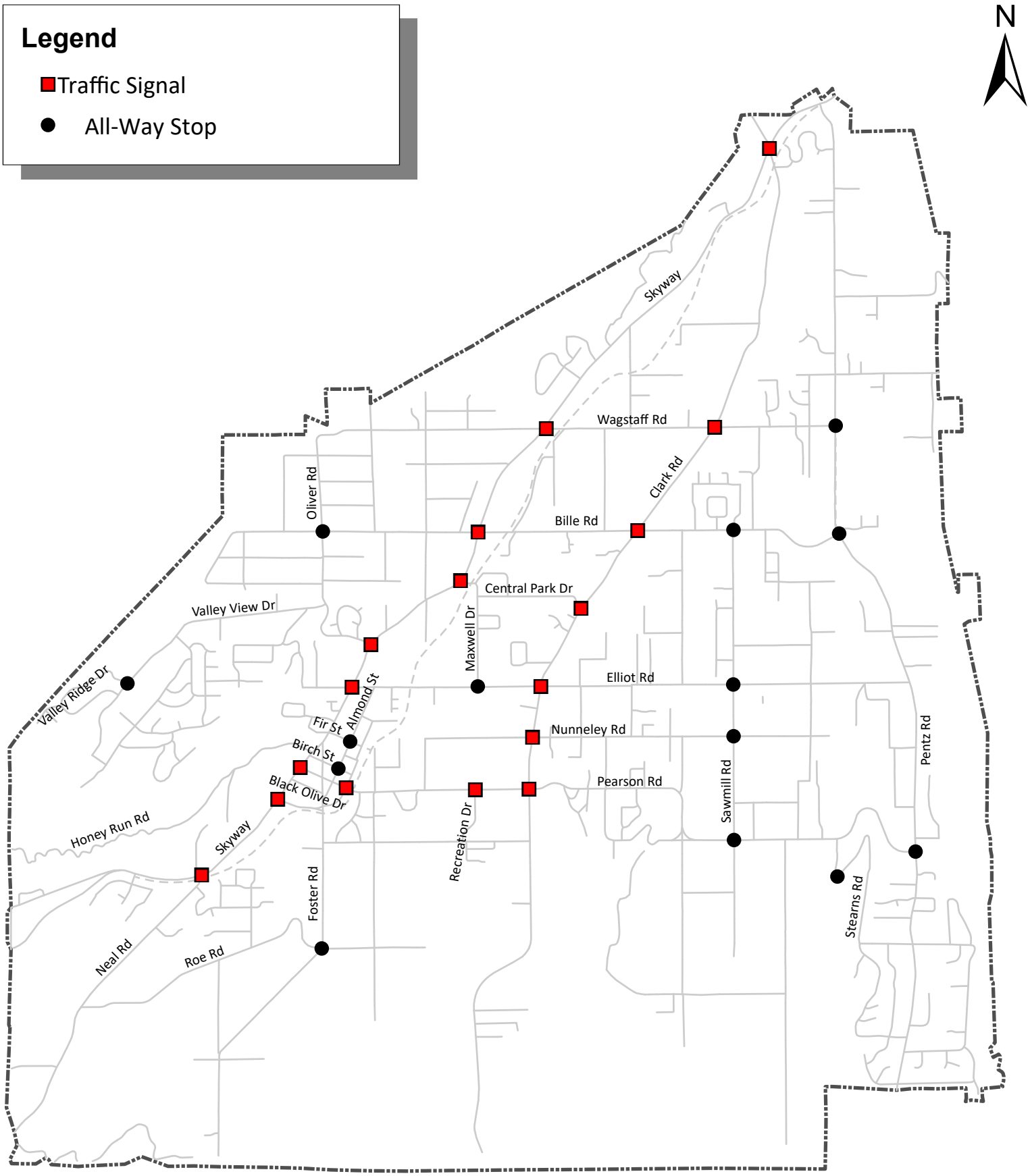
Town of Paradise

Note: Travel lanes include Two-Way Left Turn Lanes (TWLTL)

Figure 2

Existing Travel Lanes

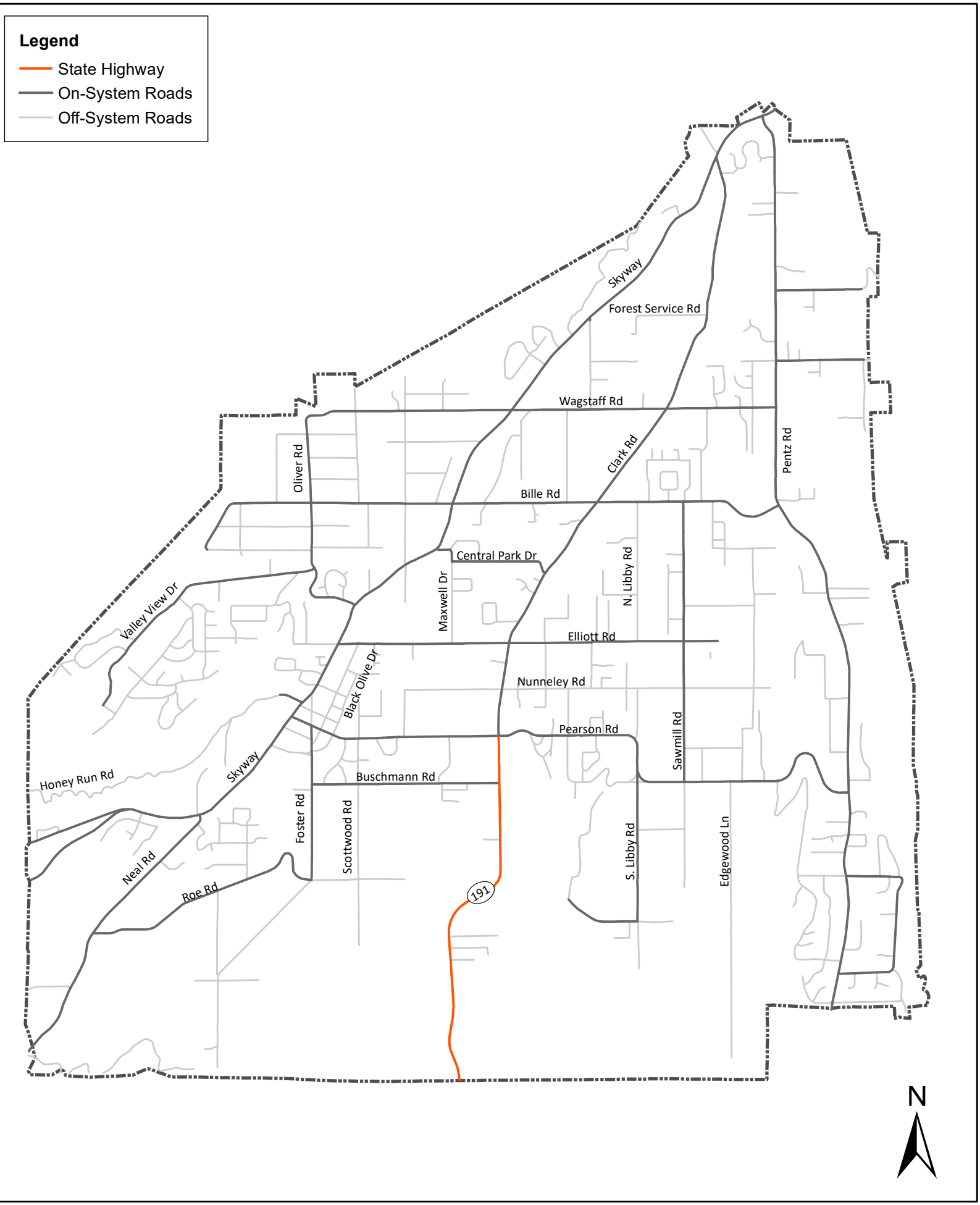
Roadway Improvements Report for
Town of Paradise Transportation Master Plan



Town of Paradise

Figure 3

Existing Major Intersection Controls
Roadway Improvements Report for
Town of Paradise Transportation Master Plan

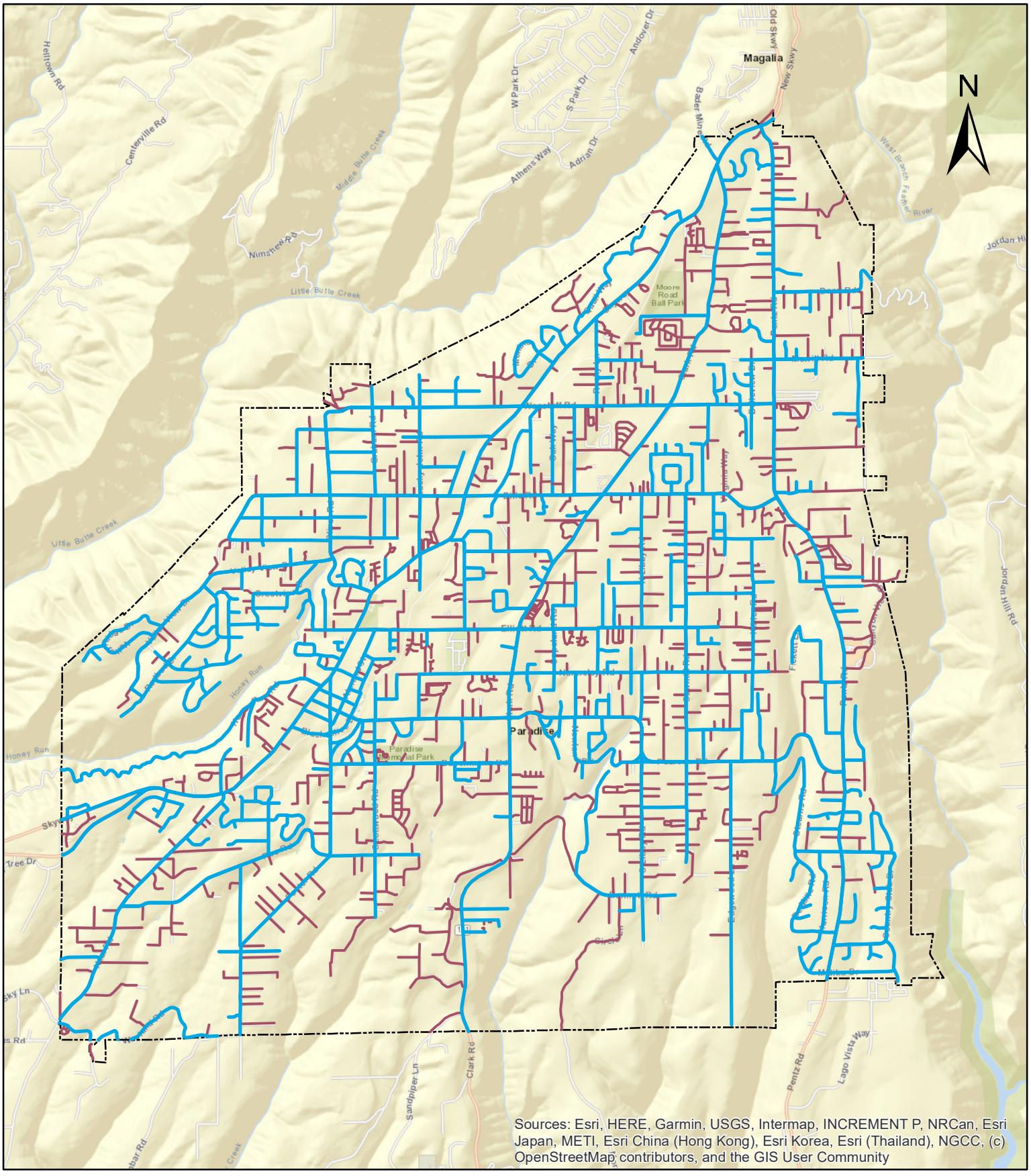


HEADWAY TRANSPORTATION

Town of Paradise

Figure 4

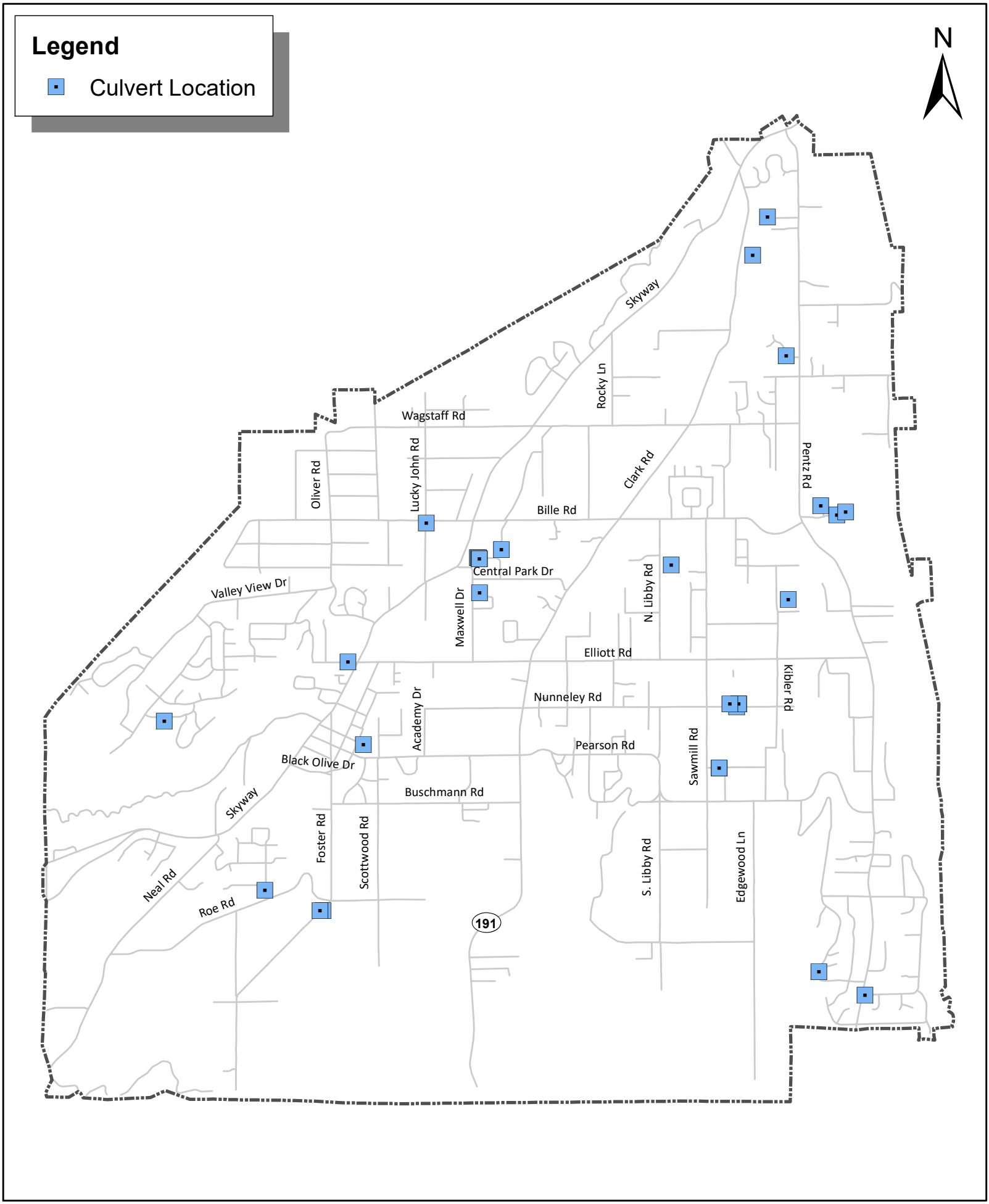
On-System Roadways
Roadway Improvements Report for
Town of Paradise Transportation Master Plan



HEADWAY TRANSPORTATION

PRIVATE
PUBLIC
Town of Paradise

Figure 5
Town of Paradise
Transportation Master Plan for
Public and Private Roadways

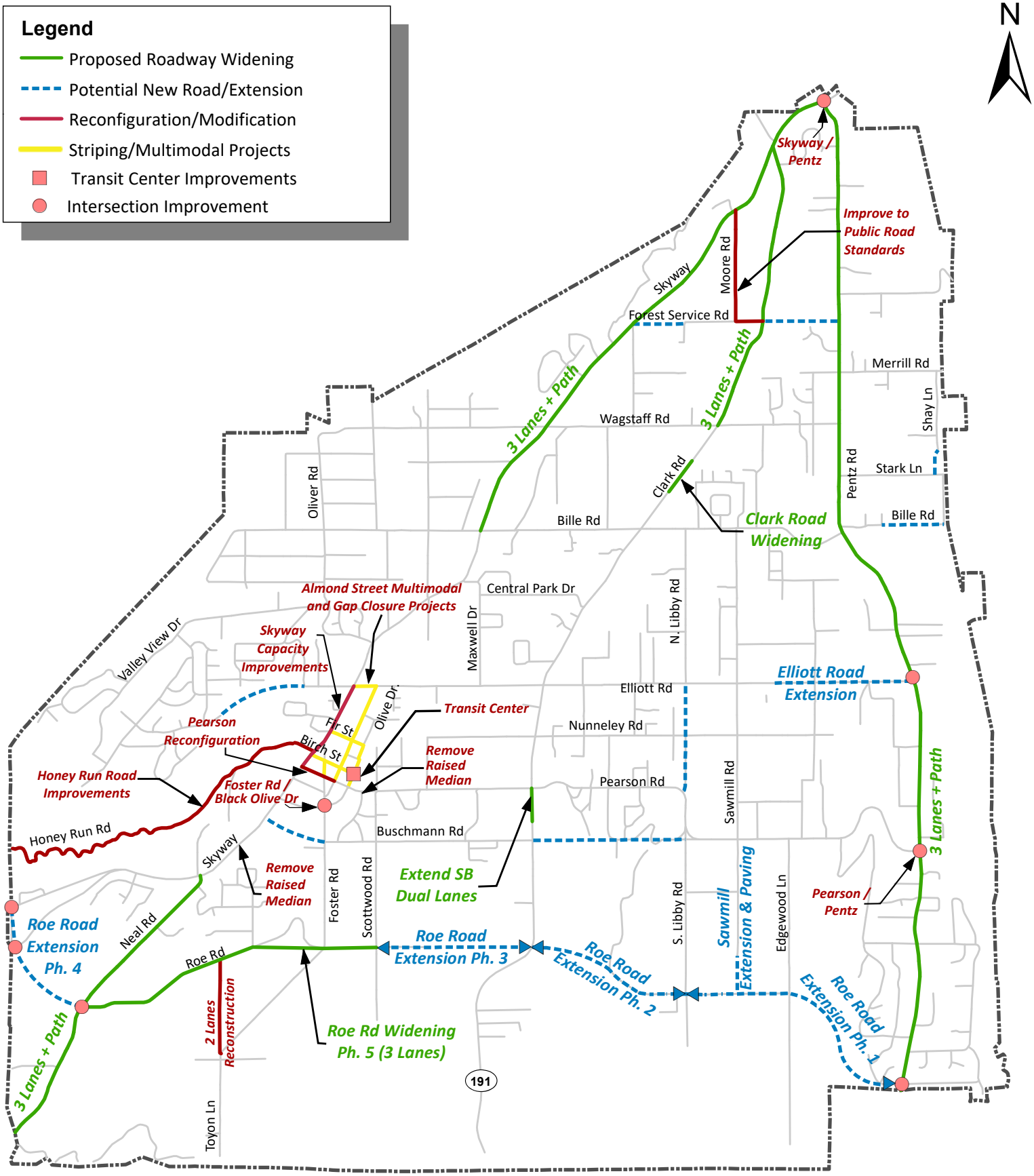


HEADWAY TRANSPORTATION

Town of Paradise

Figure 6

Culvert Locations
Roadway Improvements Report for
Town of Paradise Transportation Master Plan

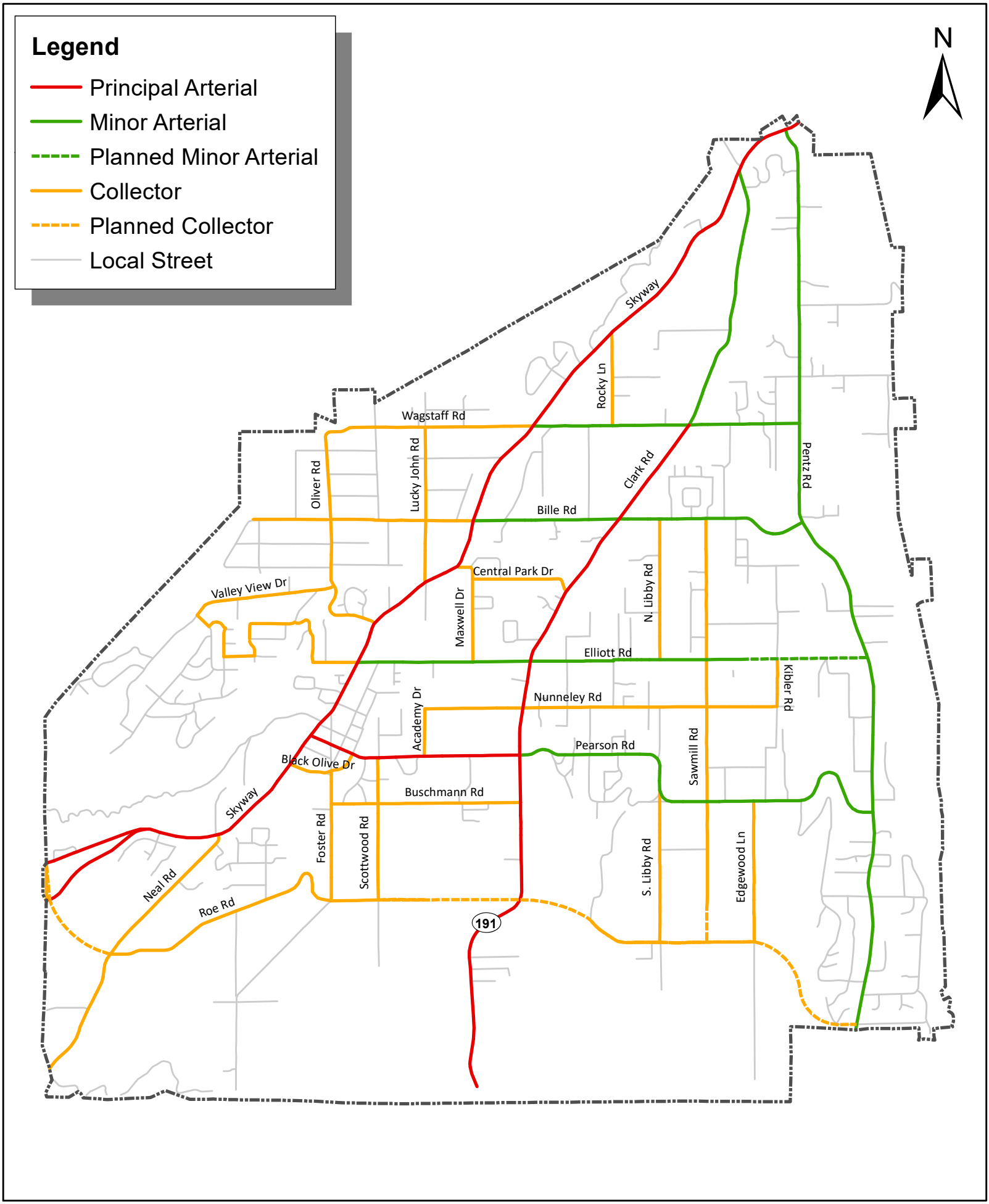


Town of Paradise

Note: Bicycle and pedestrian improvements are shown separately in the Active Transportation Plan.

Figure 7

Draft Improvement Plan
Roadway Improvements Report for
Town of Paradise Transportation Master Plan

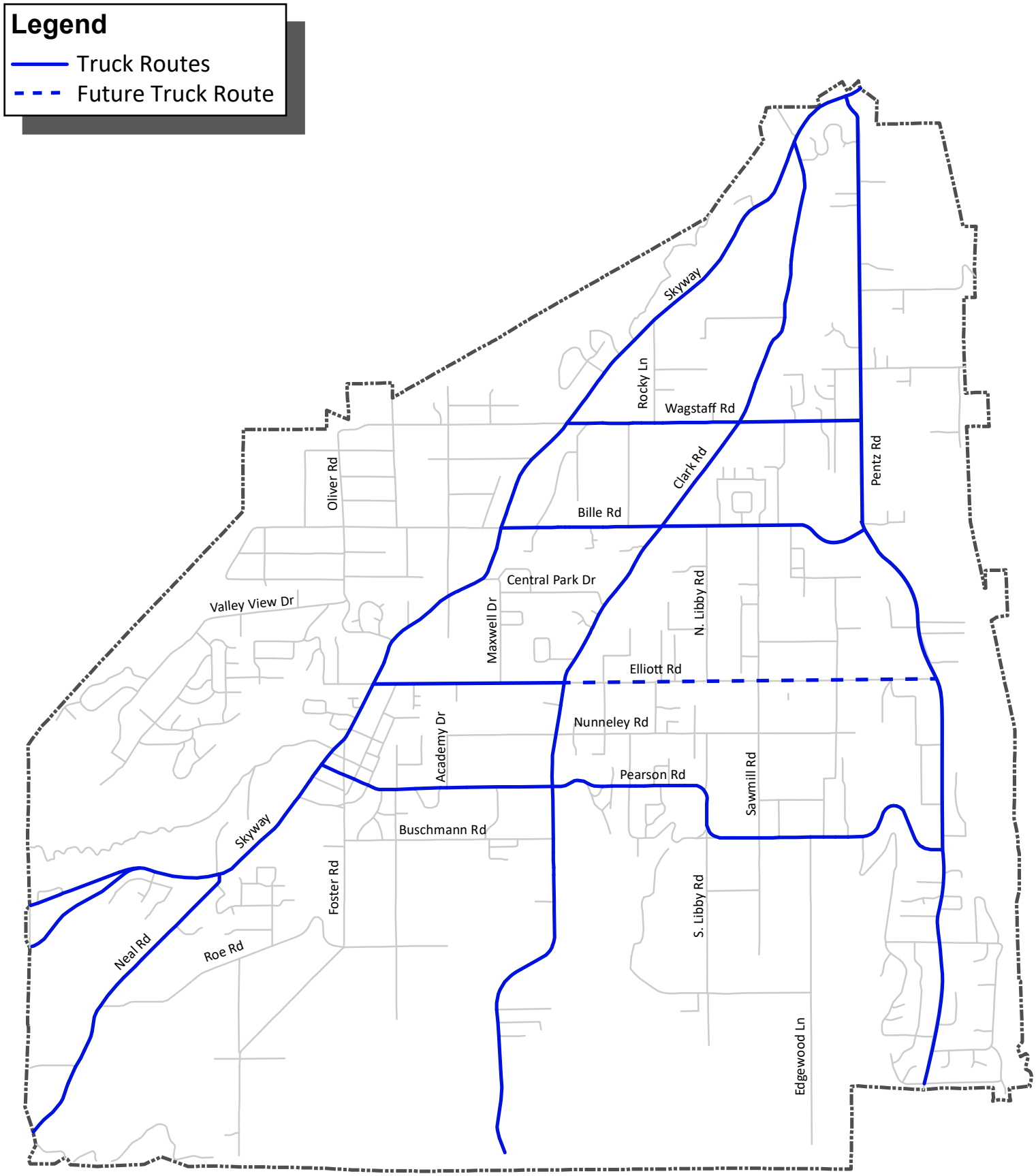


HEADWAY TRANSPORTATION

Town of Paradise

Figure 8

Proposed Functional Classification
Roadway Improvements Report for
Town of Paradise Transportation Master Plan



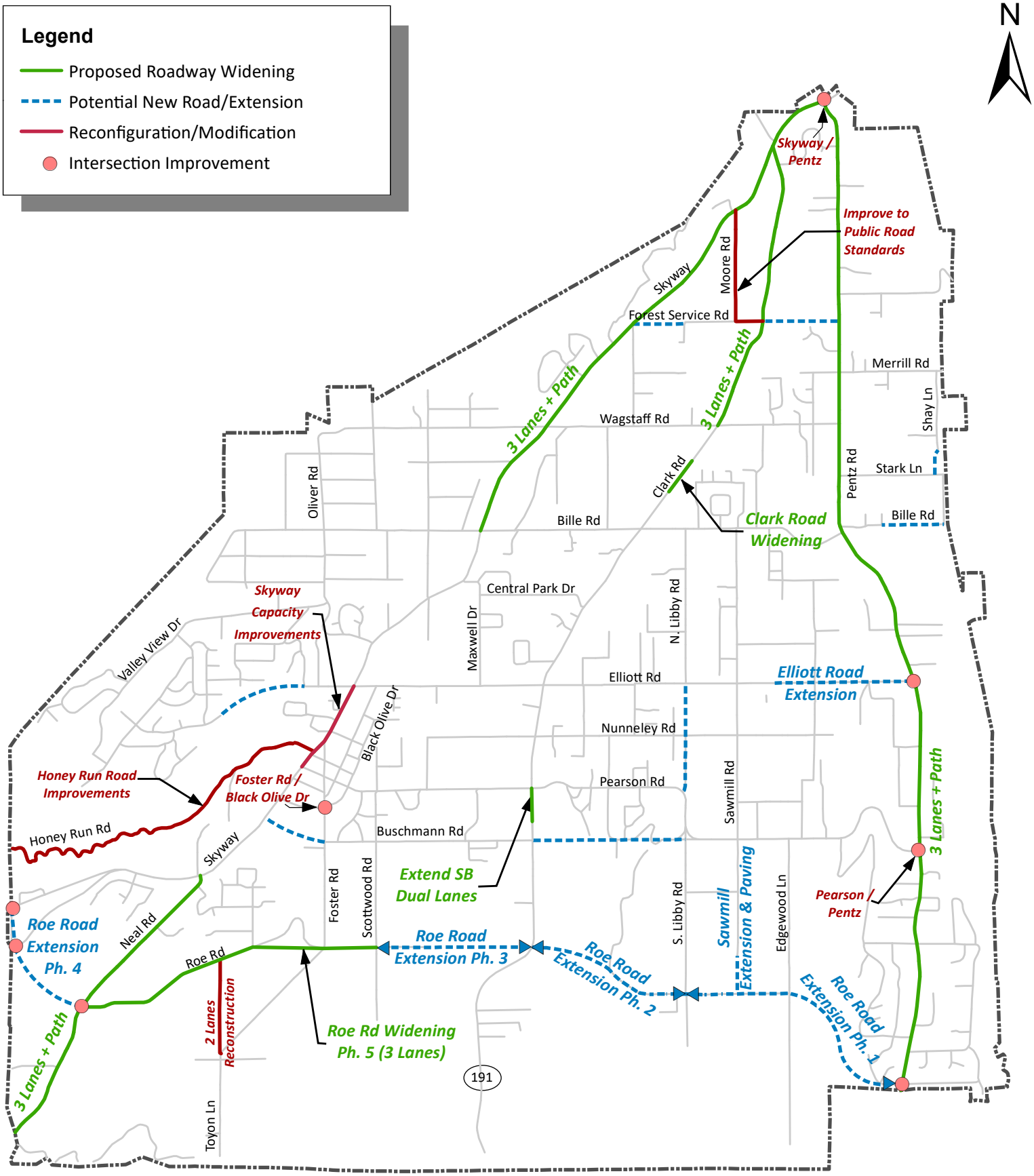
HEADWAY TRANSPORTATION

Town of Paradise

Figure 9

Truck Routes

Roadway Improvements Report for
Town of Paradise Transportation Master Plan



Town of Paradise

Figure 10

Recommended Projects

Roadway Improvements Report for
Town of Paradise Transportation Master Plan

Appendix A

HCM Exhibit 16-14

timing, (*b*) the effect of using a roundabout as a segment boundary, (*c*) the effect of midsegment parking maneuvers on facility operation, and (*d*) the use of simulated vehicle trajectories to evaluate the proportion of time that the back of the queue on the minor-street approach to a two-way STOP-controlled intersection exceeds a specified distance from the stop line.

GENERALIZED DAILY SERVICE VOLUMES FOR URBAN STREET FACILITIES

Generalized daily service volume tables provide a means to assess a large number of urban streets in a region or jurisdiction quickly to determine which facilities need to be assessed more carefully (by using operational analysis) to ameliorate existing or pending problems.

To build a generalized daily service volume table for urban street facilities, a number of simplifying assumptions must be made. The assumptions made here include the following:

- All segments of the facility have the same number of through lanes (one, two, or three) in each direction;
- Only traffic signal control is used along the facility (i.e., no roundabouts or all-way STOP-controlled intersections exist);
- The traffic signals are coordinated and semi-actuated, the arrival type is 4, the traffic signal cycle time C is 120 s, and the weighted average green-to-cycle-length (g/C) ratio for through movements (defined below) is 0.45;
- Exclusive left-turn lanes with protected left-turn phasing and adequate queue storage are provided at each signalized intersection, and no exclusive right-turn lanes are provided;
- At each traffic signal, 10% of the traffic on the urban street facility turns left and 10% turns right;
- The peak hour factor is 0.92;
- The facility length is 2 mi, and no restrictive medians exist along the facility; and
- The base saturation flow rate s_o is 1,900 passenger cars per hour per lane (pc/h/ln).

The weighted average g/C ratio of an urban street is the average of the critical intersection through g/C ratio and the average of all the other g/C ratios for the urban street. For example, if there are four signals with a through g/C ratio of 0.50 and one signal with a through g/C ratio of 0.40, the weighted average g/C ratio for the urban street is 0.45. The weighted g/C ratio takes into account the adverse effect of the critical intersection and the overall quality of flow for the urban street.

Generalized daily service volumes are provided in Exhibit 16-14 for urban street facilities with posted speeds of 30 and 45 mi/h; two, four, or six lanes (both directions); and six combinations of the K-factor and D-factor. To use this table, analysts must select a combination of K and D appropriate for their locality.

The 30-mi/h values further assume an average traffic signal spacing of 1,050 ft and 20 access points/mi, while the 45-mi/h values assume an average traffic signal spacing of 1,500 ft and 10 access points/mi.

Exhibit 16-14
Generalized Daily Service Volumes for Urban Street Facilities (1,000 veh/day)

K-Factor	*D*-Factor	Two-Lane Streets				Four-Lane Streets				Six-Lane Streets			
		LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E	LOS B	LOS C	LOS D	LOS E
Posted Speed = 30 mi/h													
0.09	0.55	NA	5.9	15.4	19.9	NA	11.3	31.4	37.9	NA	16.3	46.4	54.3
	0.60	NA	5.4	14.1	18.3	NA	10.3	28.8	34.8	NA	15.0	42.5	49.8
0.10	0.55	NA	5.3	13.8	17.9	NA	10.1	28.2	34.1	NA	14.7	41.8	48.9
	0.60	NA	4.8	12.7	16.4	NA	9.3	25.9	31.3	NA	13.5	38.3	44.8
0.11	0.55	NA	4.8	12.6	16.3	NA	9.2	25.7	31.0	NA	13.4	38.0	44.5
	0.60	NA	4.4	11.5	14.9	NA	8.4	23.5	28.4	NA	12.2	34.8	40.8
Posted Speed = 45 mi/h													
0.09	0.55	NA	10.3	18.6	19.9	NA	21.4	37.2	37.9	NA	31.9	54.0	54.3
	0.60	NA	9.4	17.1	18.3	NA	19.6	34.1	34.8	NA	29.2	49.5	49.8
0.10	0.55	NA	9.3	16.8	17.9	NA	19.3	33.5	34.1	NA	28.7	48.6	48.9
	0.60	NA	8.5	15.4	16.4	NA	17.7	30.7	31.3	NA	26.3	44.5	44.8
0.11	0.55	NA	8.4	15.3	16.3	NA	17.5	30.5	31.0	NA	26.1	44.2	44.4
	0.60	NA	7.7	14.0	14.9	NA	16.1	27.9	28.4	NA	23.9	40.5	40.7

Notes: NA = not applicable; LOS cannot be achieved with the stated assumptions.
General assumptions include no roundabouts or all-way STOP-controlled intersections along the facility; coordinated, semi-actuated traffic signals; arrival type 4; 120-s cycle time; protected left-turn phases; 0.45 weighted average *g/C* ratio; exclusive left-turn lanes with adequate queue storage provided at traffic signals; no exclusive right-turn lanes provided; no restrictive median; 2-mi facility length; 10% of traffic turns left and 10% turns right at each traffic signal; peak hour factor = 0.92; and base saturation flow rate = 1,900 pc/h/ln.
Additional assumptions for 30-mi/h facilities: signal spacing = 1,050 ft and 20 access points/mi.
Additional assumptions for 45-mi/h facilities: signal spacing = 1,500 ft and 10 access points/mi.

Exhibit 16-14 is provided for general planning use and should *not* be used to analyze any specific urban street facility or to make final decisions on important design features. A full operational analysis using this chapter's methodology is required for such specific applications.

The exhibit is useful, however, in evaluating the overall performance of a large number of urban streets within a jurisdiction, as a first pass to determine where problems might exist or arise, or to determine where improvements might be needed. Any urban street identified as likely to experience problems or need improvement, however, should then be subjected to a full operational analysis before any decisions on implementing specific improvements are made.

Daily service volumes are strongly affected by the *K*- and *D*-factors chosen as typical for the analysis. It is important that the values used for the facilities under study be reasonable. Also, if any characteristic is significantly different from the typical values used to develop Exhibit 16-14, particularly the weighted average *g/C* ratio and traffic signal spacing, the values taken from this exhibit will not be representative of the study facilities. In such cases, analysts are advised to develop their own generalized service volume tables by using representative local values or to proceed to a full operational analysis.

ACTIVE TRAFFIC MANAGEMENT STRATEGIES

Active traffic management (ATM) consists of the dynamic and continuous monitoring and control of traffic operations on a facility to improve facility performance. Examples of ATM measures on urban streets include congestion pricing zones, adaptive/responsive signal control, demand metering, changeable

Appendix B

Striping Standards

TOWN OF PARADISE STRIPING & SIGNAGE STANDARDS

April 5, 2021

Purpose

This document is intended to establish a uniform approach to traffic engineering, striping, and pavement delineation throughout the Town of Paradise to provide clearer messages to drivers, simplify Town maintenance activities, create consistency between multiple funded paving projects, and reduce staff review efforts on future roadway design projects.

Standards, Details, & Specifications

All signing and striping within the Town of Paradise shall be in accordance with the *California Manual on Uniform Traffic Control Devices (CAMUTCD)*, latest edition. In any case of discrepancy between these standard practices and the CAMUTCD, the CAMUTCD shall prevail.

Striping types, legends, dimensions, and details shall be in accordance with the CAMUTCD, latest edition, and *Caltrans Standard Plans*, latest edition, unless otherwise identified herein.

All signing and striping materials and construction practices for projects on Town owned roadways shall be in accordance with *Caltrans Standard Specifications*, latest edition.

Striping layout and intersection design shall be in accordance with the *California Manual on Uniform Traffic Control Devices (CAMUTCD)*, latest edition *and Caltrans Highway Design Manual*, latest edition. *A Policy on Geometric Design of Highways and Streets*, latest edition, published by AASHTO, may be used as an alternate or supplement to the Caltrans Highway Design manual.

Bicycle facilities and multi-use path striping layout and design shall be in accordance with the CAMUTCD, the *Guide for the Development of Bicycle Facilities*, latest edition, published by AASHTO, FHWA Interim Approvals, and supplemented with the *Urban Bikeway Design Guide*, latest edition, published by NACTO.

Designers are directed to avoid the over-use of pavement markings and signs.

Exceptions

It is recognized that unique conditions will occasionally be found requiring exceptions to the Caltrans or Federal guidelines and the Town's standard practices outlined within this document. Where unique conditions dictate a clear need for exceptions, project designers are to identify and present alternate solutions that meet the intent of the standards to the extent feasible, for Town Engineer review and approval. Approval of any and all exceptions is at the sole discretion of the Town Engineer.

Town of Paradise Standard Practices

Travel Lane & Bike Lane Widths:

All vehicular travel lanes and turn pockets shall have a minimum width of 10 feet measured from center of stripe to edge of pavement/lip of gutter or to the edge line on roadways having an edge line. Travel lanes should typically not exceed 12 feet in width.

Edge lines shall be placed at least 6" inward from the edge of pavement (measured to center of stripe).

Two-way left-turn lanes (center turn lanes) shall have a typical width of 12 feet.

Bicycle lanes shall have a minimum width of 5 feet to curb face (6 feet when the posted speed limit is 40 mph or greater) and shall also have a minimum width of 3.5 feet to lip of gutter, both dimensions measured from center of stripe.

Shoulders greater than 8 feet in width should generally be avoided or be properly delineated to avoid the appearance of being a travel lane.

Parallel on-street parking shall have a minimum width of 8 feet measured from center of stripe to curb face. 9 feet parking width is desired where feasible.

Striping Materials:

All longitudinal stripes shall be Paint and include reflective glass beads.

All pavement legends shall be Thermoplastic and include integral reflective beads.

The follow striping types/standard details shall be used for all projects on Town owned roadways. All detail numbers reference the Caltrans Standard Plans/CAMUTCD.

Note that the Town does not utilize raised pavement markers, reflectors, or recessed markings.

Longitudinal Stripes (all longitudinal stripes are 6" width or greater):

Double Yellow - Detail 21

A black line between the yellow lines is not required.

Double yellow centerlines shall be installed continuously on all Arterial and Collector classification roadways unless a two-way left turn lane or other treatment is placed.

Double yellow centerlines shall be installed on other minor roadways which are identified by the Town as "Evacuation Routes".

Centerlines shall not be placed on dead-end roadways except where approved by the Town Engineer.

Single Yellow - Detail 24 (layout at center of stripe, disregard edge of travelled way layout line)

Two-Way Left-Turn Lane - Detail 31

Two-Way Left-Turn Lanes shall be broken though the intersections of public streets but continue through private street intersections and driveways.

White Lane Line (Broken) - Detail 8

White Lane Line (Merge) – Detail 8

Lane Line Through Intersections (Cat Tracks) – Detail 40

Right Edge Line, Solid - Detail 27B (layout at center of stripe, disregard edge of travelled way layout line)

Edge lines shall be placed at least 6" inward from the edge of pavement (measured to center of stripe). Solid edge lines shall be continued through driveways and narrow private street intersections. Right edge line shall be discontinued through all major and 4-way intersections and discontinued through all public side-street intersections less than 50 feet in length.

Right edge lines shall be installed on all Arterial and Collector roadways.

Right Edge Line Extension, Dotted - Detail 27C (to be used only through minor side-street intersection/private street/driveway lengths exceeding 50 feet)

Channelizing Line (Turn Pocket) - Detail 38A

Lane Drop (Advance of Trap Lane) – Detail 37B MOD (no reflectors, 3 ft stripe, 12 ft gap)

Bike Lane – Detail 39 (6" width is to be used on both sides of bike lanes where an outside line is provided). Bike lanes are typically to be discontinued though intersections, but dotted line extensions can be provided to provide control or enhanced visibility consistent with CAMUTCD Section 3B.08 in unique cases.

Bike Lane, Dotted – Detail 39A MOD (6" width is to be used on both sides of bike lanes where an outside line is provided). Dotted line length shall be 100 feet approaching the intersection and when terminating the bike lane at turn pockets or other locations.

Turn Pockets:

Install arrow markings in all exclusive left and right turn pockets and in all shared movement lanes/pockets which include a left turn movement. Through arrows and through/right arrows are <u>not</u> to be used except in unusual circumstances where approved by the Town Engineer.

"ONLY" markings are <u>not</u> to be used in turn pockets. Where "ONLY" markings are shown in standard plans or guides, they shall be replaced with the appropriate arrow legend.

An arrow shall be placed at the beginning (upstream end) of the turn pocket regardless of pocket length and other adjustments to arrow spacing are to be made as needed. Two arrows shall be placed in pockets 50 to 75 feet in length and three arrows shall be placed in pockets 75 to 150 feet in length. Arrow spacing shall generally be 75 feet or more in lanes/pockets exceeding 150 feet in length.

Use Type IV (8 ft) and Type VII (13 ft) arrows for turn pockets and Type IV (8 ft) arrows for two-way left turn lanes.

A minimum pocket length of 50 feet is required for all turn pockets. At least 100 feet of pocket length is desired at all turn pocket locations to the extent feasible. Turn pocket lengths at signalized intersections shall be determined by queuing analysis unless otherwise approved by the Town Engineer. The pocket lengths shall accommodate the 50th percentile queue at a minimum and preferably the 95th percentile queue length to the extent feasible based on 20-year horizon traffic volumes, or based on direction from the Town Engineer.

Turn pocket tapers, bay tapers, tangent lengths between the bay taper and beginning of turn pocket, and other dimensions shall be per CAMUTD Figure 3B-101 (CA) to the extent feasible.

Transitions from two-way left-turn lanes to left turn pockets shall be made with a 50 foot gap between the end of yellow stripes and beginning of white turn pocket stripe.

Tapers & Lane Merges:

Lanes merges shall be in accordance with CAMUTCD Figure 3B-14 (CA) to the extent feasible. Three (3) Type VI Arrows (right lane drop arrow) shall be provided at all merge locations. Existing short/steep tapers should be improved to the extent feasible. The Optional "Do Not Pass" sign is not to be used.

Left lane merges shall only be installed upon approval of the Town Engineer.

Pavement Markings/Legends/Symbols:

In general, the Town prefers the use of symbols rather than words for both pavement markings and signs.

The sizes, shapes, and details of pavement markings shall be in accordance with *Caltrans Standard Plans*, latest edition.

Bike Lane Markings:

Use "Bike Lane Arrow" and "Bike Lane Symbol With Person" pavement markings for all bike lanes. BIKE LANE word markings are not to be used.

Use "Shared Lane Marking" or "Shared Roadway Marking" (sharrow) for shared lanes. The shared lane marking is expected to have limited applicability and shall be installed only where approved by the Town Engineer.

Crosswalks, Stop Bars (Limit Lines), & Yield Lines:

All existing and proposed crosswalk locations shall be reviewed and approved by the Town Engineer before inclusion in project plans. The creation of new crosswalks at mid-block locations and at intersections will subject to approval by the Town Engineer.

Crosswalks – Continental Style, 24" width bars by 10 ft length with 4 ft space between bars. Bars should be positioned so that the wheel tracks fall between bars to the extent feasible.

Stop Bar (Limit Line) – 12" Wide Solid White

Stop bars shall be used at all stop sign locations and are to be typically placed approximately 10 to 15 ft from the effective edge of travel way unless otherwise approved by the Town Engineer.

Stop bars are to be placed with a 4 ft space between the stop bar and near edge of crosswalk.

STOP pavement legend shall be used at all stop sign locations on public streets and should typically be located 8 ft from the stop bar.

STOP signs and markings shall be placed at the intersection of all public streets with public/private street intersections. STOP signs are not required at private driveways, but rather are at the discretion of the property owner.

STOP AHEAD signage and STOP AHEAD pavement legends shall be placed typically 175 feet (for up to 45 mph) in advance of the stop bar on each approach to an All-Way Stop Controlled intersection.

STOP AHEAD signs and markings should be used at two-way stop intersections only where sight lines are limited approaching the stop location.

Yield Line – Yield Line Detail on Caltrans Standard Plan A24E (Sharks Teeth)

At intersections, yield bars (sharks teeth) are to be typically placed 20 ft from the crosswalk on the near approach, and on the far side of the intersection on the opposite approach, unless otherwise approved by the Town Engineer. At midblock locations, yield bars are to be typically placed 20 ft from the crosswalk or as otherwise directed by the CAMUTCD.

Use YIELD LINES on all multi-lane approaches to crosswalks, at enhanced crosswalk locations (those having RRFBs/flashers, etc), and as otherwise required in the CAMUTCD.

Chevrons & Buffers:

Chevron and buffer markings are generally to be avoided due to associated maintenance costs. When deemed necessary, designers are directed to Section 3B.24 of the CAMUTCD. Diagonal lines shall be at 45 degrees, 8" width for less than 45 mph, 12" width for 45 mph and above, and have a typical spacing of 20 feet.

School Zones:

Signing, striping, and markings in school zones and for school crossings shall be in strict accordance with the CAMUTCD (Part 7).

Fluorescent Yellow-Green backgrounds are required for all school warning signs.

Utilize "When Children are Present" signs unless otherwise approved by the Town Engineer.

Utilize Continental style crosswalks, Yellow color where directed by the CAMUTCD.

Red Curb:

Red curb paint should generally only be used in front of fire hydrants and in special cases where approved by the Town Engineer. Existing red curb not perpetuated will be allowed to fade.

Parking Tees:

"T" pavement markings shall be used for indicating the locations of on-street parallel parking. Refer to Section 3B.19 of the CAMUTCD including Figure 3B-21 (CA).

Sign Posts/Foundations:

All standard roadside signs shall be mounted on 2" square perforated sign posts and foundations using a square sleeve accepting the 2" square post with exposed securing bolt at the top of sleeve.

Signs for Bicycles:

Share the Road (W16-1P) plaque in conjunction with the Bicycle (W11-1) warning sign is not to be used due to confusion in meaning as identified by the FHWA.

Where applicable, utilize the Bicycles May Use Full Lane (R4-11) sign on roadways where no bicycle lanes or adjacent shoulders usable by bicyclists are present and where travel lanes are too narrow for bicyclists and motor vehicles to operate side by side (mixed flow including bicycle and motorized traffic). Refer to the CAMUTCD Section 9B.06 for design guidance regarding the R4-11 sign. Bicycle related warning signs are to be used only in unique situations where approved by the Town Engineer.

Typical Striping Layouts

Local Roadways:

Less than 20 ft paved width – no longitudinal striping

Collector/Arterial Roadways:

20 ft to 30 ft paved width – centerline, 10 ft lanes, and edge lines (0 to 5 ft shoulders)

30 ft to 40 ft paved width – centerline, 11 or 12 ft lanes, and edge lines (4 to 8 ft shoulders)

Multi-lane roadway configurations are to be determined on a case by case basis. Travel lanes and turn lanes may range between 10 and 12 feet, two-way left-turn lanes are to be 12 feet wide. The Town generally prefers narrower travel lanes in order to provide a shoulder where feasible. Areas wider than 12 feet in the outside lanes are typically to be delineated with an edge line to create a shoulder.

Appendix C

Pedestrian Crosswalk Policy

Town of Paradise Crosswalk Policy

Guidelines for the Installation of Marked Crosswalks

Purpose

The purpose of the Town of Paradise Crosswalk Policy ("Policy") is to provide a guidance document that will enable the Town to determine appropriate locations for crosswalk installations. The Policy provides information for the Town to use when making decisions about where pedestrian crossing locations should be marked as crosswalks, and when the application of enhanced measures (i.e., special treatments such as flashing beacons, etc.) to marked crosswalks should be considered. The Policy outlines a methodical approach with the goal of improving pedestrian and bicyclist accessibility and maintaining public safety, including policy considerations regarding enhanced crosswalk treatments that may restrict vehicle capacity during an evacuation.

While the *CA Manual on Uniform Traffic Control Devices (CAMUTCD)* is a good resource for information regarding the design aspects of crosswalk pavement markings, pedestrian signals, and pedestrian signage, it does not provide specific guidance for determining where and when to install a marked crosswalk, particularly at locations other than intersections (i.e., mid-block locations). In communities where a crosswalk policy or guideline does not exist, the decisions regarding where and how to install marked crosswalks have been left to human subjectivity (i.e., engineering judgement, political influence, and/or public pressure). Adopting a formal policy for marked crosswalk installation and for marked crosswalk enhancement (when to apply additional treatments), provides more objectivity, transparency, and consistency in decision making and provides a means to respond to marked crosswalk requests while adopting best engineering practices.

This Policy includes consideration of installing marked and enhanced marked crosswalks at various types of uncontrolled locations (i.e., pedestrian and bicyclist crossing locations that *do not* require motorists to stop before entering the crosswalk area via a traffic signal, beacon, or STOP sign) and at controlled locations (i.e., pedestrian and bicyclist crossing locations that *do* require motorists to stop by either a STOP sign, traffic signal, or other traffic control device). It should be noted that the decision-making approach outlined in the Policy can also be used to determine if existing marked or enhanced crosswalks should be removed, relocated, or reduced due to limited pedestrian activity, safety concerns, or evacuation considerations. However, "an existing marked crosswalk may not be removed unless notice and opportunity to be heard is provided to the public not less than 30 days", per the *CA Vehicle Code, Section 21950.5*.

This Policy may need to be amended over time as new engineering best practices become available in the future.

What is a Crosswalk?

The California Vehicle Code (CVC) Legal Definition of a Crosswalk

There can be a legal pedestrian crossing at an intersection even if there are no markings on the pavement. In California, a legal crosswalk (or pedestrian crossing) exists where a sidewalk meets a street, regardless of whether the crosswalk is marked (i.e., with or without striping to denote the crosswalk). Pedestrians may legally cross any street, except at unmarked locations between immediately adjacent signalized crossings or immediately adjacent police officer-controlled intersections (per *CVC Section 21955*), or where crossing is expressly prohibited. Marked crosswalks reinforce the preferred location and legitimacy of a pedestrian crossing.

Under *CVC Section 275*, a crosswalk is defined as either:

i) "That portion of a roadway included within the prolongation or connection of the boundary lines of sidewalks at intersections where the intersecting roadways meet at approximately right angles, except the prolongation of such lines from an alley across a street"; or
ii) "Any portion of a roadway distinctly indicated for pedestrian crossing by lines or other markings on the surface."

However, there shall not be a crosswalk where local authorities have placed signs indicating no crossing.

California's pedestrian and crosswalk laws regulate when and where people can legally walk in public. The foundational rule is found in *CVC Section 21950*, which requires motorists to yield the right-of-way to pedestrians crossing the road within any marked or unmarked crosswalk. However, this *CVC* section also does not relieve a pedestrian from the duty of using due care for his or her safety when using an unmarked crosswalk as no pedestrian may suddenly leave a curb or other place of safety and walk or run into the path of a vehicle that is so close as to constitute an immediate hazard, or the pedestrian may be at fault should an accident occur in this circumstance.

General Crosswalk Types

Crosswalk types are generally defined based on their characteristics such as appearance, location, and the presence (or not) of adjacent traffic control devices and include:

- **Marked** (painted markings on the roadway) or **Unmarked** (no pavement markings)
- **Intersection** (where two or more roadways meet) or **Mid-block** (between intersections) locations
- **Controlled** (traffic signal or STOP sign) or **Uncontrolled** (no traffic control) locations

This Policy primarily focuses on guidelines for the installation of **Marked** crosswalks at **Uncontrolled** locations as well as the guidelines for providing enhancement elements in conjunction with the installation of marked crosswalks at uncontrolled locations.

Marked vs. Unmarked Crosswalks

The decision to install or not to install a marked crosswalk should not be taken lightly. Adding marked crosswalks can in many cases improve pedestrian safety and access. However, adding crosswalks in some scenarios can create a false sense of security and may not necessarily make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Additionally, unjustified, and poorly located marked crosswalks may cause an increased expense to the taxpayers for installation and maintenance costs, which may not be justified in terms of improved public safety.

Advantages of Marked Crosswalks

Some of the advantages of marked crosswalks include:

- Provides pedestrians with a clear pathway to navigate across intersections and roadways.
- Guides pedestrians to consolidated and preferred paths of travel with the least exposure to traffic conflicts.
- Acts as a reminder to drivers that pedestrians may be present at this location (improves the visibility of pedestrians to motorists and vice versa).
- Helps to direct pedestrians to crossing locations that provide the best vehicle stopping sight distance so they can best be seen by oncoming traffic and vice versa.
- Eliminates pedestrian confusion regarding their legal right to cross a roadway, whether it's at an intersection or mid-block crossing.
- Accommodates vulnerable populations such as the disabled, children, and the elderly.

Disadvantages of Marked Crosswalks

Some of the disadvantages of marked crosswalks include:

- Creates a false sense of security for pedestrians, which may result in them placing themselves in a hazardous position with respect to vehicular traffic.
- Causes pedestrians to have the mistaken belief that vehicular traffic can and will always stop for them, even when it is impossible to do so.
- Increases the risk of rear-end and associated collisions due to pedestrians not waiting for adequate gaps in traffic to cross, whereas a pedestrian using an unmarked crosswalk may feel less secure and use more caution in waiting for longer gaps in traffic before crossing.
- Generates disrespect for all pedestrian regulations and traffic controls if marked crosswalks are unjustified or installed in a poor location.

Marked Crosswalks at Uncontrolled Locations

Guidelines for Installation

The following steps provide an uncontrolled intersection pedestrian crossing location evaluation methodology that can be used to determine if a location is suitable for a marked crosswalk. If a marked crosswalk is installed (painted white parallel lines, ladder pattern, or block pattern), it must be consistent with striping allowed by the *CA MUTCD*. Additionally, the evaluation worksheet found in **Attachment A** helps to document the relevant crossing location data needed to be used in conjunction with **Table 1** and **Table 2** to determine if a marked crosswalk should be enhanced with additional safety elements. These

tables also provide guidelines for determining the recommended types of elements that should be applied at a given crossing location. It should be noted that before additional enhanced crosswalk elements are implemented, the Town of Paradise's *Vertical Elements Policy* must first be consulted to be sure the recommended element is consistent with this policy.

Steps to Evaluate

Step 1. *Does the location serve desired pedestrians' and bicyclists' route of travel (i.e., "desire lines") to connect associated land uses such as home, school, work, parks, trails, and commercial center?*
___ yes or ___no

Considerations (any can warrant Step 1 to be a "YES"):

i. A sidewalk or path exists on both sides of location.
ii. A pedestrian volume of 20 pph (pedestrians per hour) in the peak hour or 100 ppd (pedestrians per day) is a national standard, but theses volumes should only be considered guidelines in Paradise, not hard and fast criteria.
iii. Recent pedestrian/bicyclist crash data may indicate a need for pedestrian accommodations and can be used to further prioritize potential locations for marked crossings.
iv. Pedestrian demographics – where slower pedestrian crossing speeds are found (such as high numbers of children, disabled or elderly pedestrians), the users may benefit from a marked crosswalk at a lower pedestrian volume threshold than would a location with average demographics.
v. Next to pedestrian generators – schools, bus stops, parks, trails, neighborhoods, commercial centers, etc., and/or serves a pedestrian need.

Step 2. *Is the location at least 300' from another available marked crossing location?* **___ yes or ___no**

Considerations:

i. A distance of 200' may be used instead, based on factors such as the demographics of the pedestrians using the marked crosswalk (e.g., a high volume of elderly, disabled, or children pedestrians may require a closer marked crossing). Locations within 300' (or 200' if applicable) of another marked crossing location should be signed to direct pedestrians to the other crossing location.

Step 3. *Is the location in a School Zone?* **___ yes or ___no**

Considerations:

i. A traffic engineering study for an individual school or school crossing location may need to be performed in addition to following the guidelines in this policy. Also, specific considerations such as adult crossing guards, etc. may be needed depending on age group of school children.

If the answer to the questions in Steps 1 & 2 and/or Step3 is "YES", then continue to Step 4.

Step 4. *Can pedestrians cross safely at this location or if no, are improvements to the stopping sight distance feasible?* **___ yes or ___no**

Considerations:

i. Does the location meet vehicle stopping sight distance (in both crossing directions) based on Table 6E-1 from the Federal Highway Administration (FHWA)? If "NO", can the sight obstructions be removed, or can vehicle speeds be reduced using traffic calming devices or other countermeasure treatments so that SSD is satisfied? **___ yes or ___ no**
ii. Does the location have adequate lighting and pedestrian crossing times versus available gaps in the vehicle traffic stream?
iii. Average maximum vehicle speeds should be 50 mph or less.

Table 6E-1. FHWA Stopping Sight Distance

Stopping Sight Distance as a Function of Speed	
Speed*	**Distance**
20 mph	115 feet
25 mph	155 feet
30 mph	200 feet
35 mph	250 feet
40 mph	305 feet
45 mph	360 feet
50 mph	425 feet

*Posted Speed, off-peak 85th percentile speed, or the anticipated operating speed.

Source: FHWA Table 6E-1

If "NO", location is not suitable for a marked crosswalk. If "YES", continue to Step 5.

Step 5. *Determine if the marked crosswalk should be supplemented with additional safety enhancements.*

Considerations:

i. Refer to **Table 1** and **Table 2**, provided by the FHWA, to determine if enhanced marked crosswalks are warranted. Use the table matrices to determine if any additional enhancement treatments should be considered to supplement the crosswalk.

ii. Not all the countermeasures listed in an individual matrix cell should necessarily be installed at a crossing location, but rather indicate the countermeasure is a possibility based on roadway configuration, Annual Average Daily Traffic (AADT), speed limit, and compatibility with the Town of Paradise's *Vertical Elements Policy*.

iii. Is there an identified pedestrian crash/safety issue that an enhanced crossing element would resolve?

Guidelines for Enhancements

Enhanced Marked Crosswalks – **Table 1** indicates where enhanced features may be appropriate and should be considered or implemented based on the posted speed, roadway configuration, and AADT.

When marked crosswalks are desired at uncontrolled locations that require improved visibility of the crosswalk to reduce pedestrian conflicts with driving traffic, additional traffic calming, signage, and flashing warning light systems should be considered. These marked crosswalks with additional treatments (or countermeasures) are referred to as "Enhanced Marked Crosswalks" and include additional measures to supplement the high-visibility crosswalk markings.

Table 1. Application of pedestrian crash countermeasures by roadway feature.

Roadway Configuration	Posted Speed Limit and AADT								
	Vehicle AADT <9,000			Vehicle AADT 9,000–15,000			Vehicle AADT >15,000		
	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph	≤30 mph	35 mph	≥40 mph
2 lanes (1 lane in each direction)	❶ 2 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6	❶ 5 6 7 9	① 5 6 ❼ ❾	❶ 4 5 6 7 9	① 5 6 7 9	① 5 6 ❾
3 lanes with raised median (1 lane in each direction)	❶ 2 3 4 5	❶ ❸ 5 7 9	① ❸ 5 ❼ ❾	① 3 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❼ ❾	① ❸ 4 5 7 9	① ❸ 5 ❼ ❾	① ❸ 5 ❾
3 lanes w/o raised median (1 lane in each direction with a two-way left-turn lane)	❶ 2 3 4 5 6 7 9	❶ ❸ 5 6 7 9	① ❸ 5 6 ❾	① 3 4 5 6 7 9	① ❸ 5 6 ❼ ❾	① ❸ 5 6 ❾	① ❸ 4 5 6 7 9	① ❸ 5 6 ❾	① ❸ 5 6 ❾
4+ lanes with raised median (2 or more lanes in each direction)	❶ ❸ 5 7 8 9	❶ ❸ 5 7 8 9	① ❸ 5 8 ❾	① ❸ 5 7 8 9	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 ❼ 8 ❾	① ❸ 5 8 ❾	① ❸ 5 8 ❾
4+ lanes w/o raised median (2 or more lanes in each direction)	❶ ❸ 5 6 7 8 9	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 7 8 9	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ ❼ 8 ❾	① ❸ 5 ❻ 8 ❾	① ❸ 5 ❻ 8 ❾

Given the set of conditions in a cell,

\# Signifies that the countermeasure is a candidate treatment at a marked uncontrolled crossing location.

● Signifies that the countermeasure should always be considered, but not mandated or required, based upon engineering judgment at a marked uncontrolled crossing location.

○ Signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.*

The absence of a number signifies that the countermeasure is generally not an appropriate treatment, but exceptions may be considered following engineering judgment.

1 High-visibility crosswalk markings, parking restrictions on crosswalk approach, adequate nighttime lighting levels, and crossing warning signs
2 Raised crosswalk
3 Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line
4 In-Street Pedestrian Crossing sign
5 Curb extension
6 Pedestrian refuge island
7 Rectangular Rapid-Flashing Beacon (RRFB)**
8 Road Diet
9 Pedestrian Hybrid Beacon (PHB)**

Source: FHWA

Enhanced crosswalk countermeasures should always occur in conjunction with other identified countermeasures if any of the following conditions exist on a roadway where a marked crosswalk is proposed:

- Speed limit exceeds 40 MPH
- Four or more lanes without a raised median or crossing island that has (or is anticipated in the future to have) an AADT of 12,000 or greater
- Four or more lanes with a raised median or crossing island that has (or is anticipated in the future to have) an AADT of 15,000 or greater

Paradise has adopted a vertical elements policy which discourages the use of capacity reducing crosswalk enhancement elements along evacuation routes. These elements include pedestrian refuge islands, curb extensions, and road diets. Other elements such as raised crosswalks and in-street pedestrian crossing signs, may be considered, although these elements would reduce vehicle speeds during an evacuation.

Crosswalk Enhancements Elements Recommended for Paradise

Paradise has adopted a vertical elements policy which discourages the use of capacity reducing crosswalk enhancement elements located along evacuation routes. These include elements such as pedestrian refuge islands and curb extensions. Other elements such as raised crosswalks and in-street pedestrian crossing signs, may be considered, although these elements would reduce vehicle speeds during an evacuation.

- **Crosswalk Visibility Enhancements** include crosswalk lighting, parking restrictions on crosswalk approaches, crossing warning signs, advance stop/yield here lines, and high-visibility crosswalk markings. These help drivers detect pedestrians, especially at night.
- **Advance Yield/Stop Here for Pedestrians Signs** are typically placed 30’ to 50’ in advance of a marked crosswalk along with a painted stop line or yield (“shark’s teeth”) line. Typically, this measure is used on roadways with four or more lanes and vehicle speeds of 35 MPH or greater.
- **Rectangular Rapid Flashing Beacons (RRFB)** are active (user-actuated) or passive (automated detection) amber LEDs that use an irregular flash pattern at mid-block or uncontrolled crossing locations. They tend to significantly increase “driver yielding to pedestrian” behavior, particularly at vehicle speeds of 40 MPH or less. RRFBs should be placed at each end of the marked crosswalk.
- **Pedestrian Hybrid Beacons** (PHBs) are a beneficial intermediate option between RRFBs and a full pedestrian signal. They provide positive stop control in areas without the high pedestrian traffic volumes that typically warrant signal installation.
- **Pedestrian Signals** must meet traffic signal warrant justification per the *CA MUTCD*. They provide a great amount of protection to pedestrians from vehicles, as traffic must stop at a red light when pedestrians activate the traffic signal via a push button when they desire to cross the roadway.

Other countermeasure elements that are “vertical elements” may be considered if located on a non-evacuation route *or* it is determined that the safety benefit to pedestrians and bicyclists outweighs the potential negative impact to motorists during an evacuation.

- **Raised Crosswalks** can reduce vehicle speeds and function as an extension of the sidewalk, allowing pedestrians to cross the street at a constant grade. Typically raised crosswalks are good candidates for low speed, low volume streets that are either 2-lane or 3-lane.
- **In-Street Pedestrian Crossing Signs** are placed in the middle of the roadway at crossing locations. This treatment works best on low-speed roadways (30 MPH or less) and on roadways having 3 lanes or less.
- **Curb Extensions** reduce the roadway width and improve sight distance by creating a "bulb-out" that extends the sidewalk or curb line into the street. Curb extensions can extend into parking lanes, but should not extend into bicycle lanes.
- **Pedestrian Refuge Islands** allow pedestrians a safe place to stop at the midpoint of a two-way street before crossing the remaining distance. This is particularly helpful for older pedestrians or others with limited mobility and when crossing multiple lanes per direction with speed limits of 35 MPH or greater. The minimum width of a pedestrian refuge island should be 6 feet.

Table 2 from FHWA correlates pedestrian countermeasure to specific safety issues that need to be addressed.

Table 2. Safety issues addressed per countermeasure.

Pedestrian Crash Countermeasure for Uncontrolled Crossings	Safety Issue Addressed				
	Conflicts at crossing locations	Excessive vehicle speed	Inadequate conspicuity/ visibility	Drivers not yielding to pedestrians in crosswalks	Insufficient separation from traffic
Crosswalk visibility enhancement	✓	✓	✓	✓	✓
High-visibility crosswalk markings*	✓		✓	✓	
Parking restriction on crosswalk approach*	✓		✓	✓	
Improved nighttime lighting*	✓		✓		
Advance Yield Here To (Stop Here For) Pedestrians sign and yield (stop) line*	✓		✓	✓	✓
In-Street Pedestrian Crossing sign*	✓	✓	✓	✓	
Curb extension*	✓	✓	✓		✓
Raised crosswalk	✓	✓	✓	✓	
Pedestrian refuge island	✓	✓	✓		✓
Pedestrian Hybrid Beacon	✓	✓	✓	✓	
Road Diet	✓	✓	✓		✓
Rectangular Rapid-Flashing Beacon	✓		✓	✓	✓

*These countermeasures make up the STEP countermeasure "crosswalk visibility enhancements." Multiple countermeasures may be implemented at a location as part of crosswalk visibility enhancements.

Source: FHWA

Crosswalk Enhancement Countermeasures List (by Location Type)

The Federal Highway Administration (FHWA) provides a Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE), listing countermeasures that can be applied to marked crosswalks by location type.

A summary list of available countermeasures organized by location are listed below. More detailed information about each countermeasure can be found via the following website link: http://www.pedbikesafe.org/PEDSAFE/

The hyperlinks to all the PEDSAFE Countermeasures and the summary sheets for the most common PEDSAFE countermeasure are included in this Policy as **Attachment B.**

Marked Crosswalks at Controlled Locations

Guidelines for Installation

Marked crosswalks may be considered on any or all legs of stop-controlled or signalized intersections, provided there are adjacent sidewalks or trails for pedestrians and bicyclists to safely connect with, or a landing area on each end of the crosswalk. Stop bars should be provided in advance of each crosswalk. Before installing crosswalks at controlled locations, check for any objects that may block sight distance lines, as an unsafe condition may arise if pedestrians and drivers are unable to see each other from a safe stopping distance. Any obstructions that block the minimum stopping sight distance should be removed if possible, and this may include objects such as landscaping, fencing, or immediately adjacent on-street parking. Additionally, bus stops at controlled intersections should be located on the far-side of the intersection beyond the marked crosswalks so that pedestrians can cross behind the bus (on the marked crosswalk), improving pedestrian visibility to drivers.

Modifying the right-turn lane design can also be an option for improving pedestrian safety at marked crosswalks at controlled locations. As vehicles tend to travel fast through right turns with free movements (or with “pork chop” islands creating a free channelized right-turn movement), reducing the corner radius can reduce vehicle speeds at the crosswalk and provide safer pedestrian and bicyclist accommodation. Where marked crosswalks exist or are planned to be installed at signalized intersections, best practices recommend that permitted pedestrian signal phasing be avoided and that pedestrian signal heads (preferably with pedestrian countdown signal heads) and push buttons be provided for all marked crosswalks with adequate pedestrian clearance intervals (crossing time) to reduce the wait time for pedestrians and bicyclists. Providing directional curb ramps with truncated domes for each crosswalk (i.e., two curb ramps per corner) also helps to improve pedestrian safety by pointing pedestrians directly into the crosswalk and to the curb ramp on the other side of the street.

Guidelines for Enhancements

Crosswalks located at controlled locations (stop-controlled or signalized intersections) typically do not need crossing enhancements beyond standard crosswalk pavement markings as right-of-way is controlled by the traffic signal or STOP signs. However, crossing enhancements can be considered at controlled

intersections at high volume pedestrian crossing locations, in school zones, or other areas designated by the Town as pedestrian zones. These treatments improve drivers' awareness of pedestrians by slowing traffic using enhanced crosswalk visibility or geometric changes, and providing signal timing or phasing modifications to improve visibility.

Examples of enhanced crossing treatments at controlled intersections include:

- High visibility pavement markings
- Textured pavement or colored crosswalks
- Leading Pedestrian Intervals (LPIs)
- Push Button for Extended Greet Time options
- Pedestrian Recall ("Walk" signal on every signal cycle)
- Right Turn on Red Restrictions
- Curb extensions and pedestrian refuge islands may be considered if application is in accordance with the Paradise *Vertical Elements Policy*.

ATTACHMENT A

Pedestrian Crossing Location Evaluation Worksheet

Attachment A

Uncontrolled Intersection Pedestrian Crossing Location Evaluation Worksheet

Location

Major Street: _____ Crossing Location Description: _____

Initial Screening

1. Is this a known pedestrian corridor (connecting generators such as schools, parks, trails, neighborhoods, and commercial centers)? ☐ Yes ☐ No

2. Is the nearest marked or protected pedestrian location ≥ 300'? ☐ Yes ☐ No

3. Is the location within a school zone? ☐ Yes ☐ No

If "Yes" to questions 1 and 2 and/or 3, continue to question 4.

4. Is stopping sight distance (SSD) ≥ Table 6E-1 values and, if no, are improvements to SSD feasible? ☐ Yes ☐ No

If "Yes", continue to next section. If "No", then location is not suitable for marked crosswalk.

Crossing Location

Roadway Configuration:

☐ 2-Lane
☐ 3-Lane w/ Striped Median
☐ 3-Lane w/ Raised Median
☐ 4-Lane
☐ 5-Lane w/ Striped Median
☐ 5-Lane w/ Raised Median
☐ 6-Lane
☐ Other: _____

Posted Speed Limit: _____ mph

Is this location on a planned evaluation route? ☐ Yes ☐ No

AADT of Crossing Location Street: _____ vpd

Pedestrian Volumes (if known) of Crossing Location: _____ pph _____ ppd

Any recent pedestrian crashes?: ☐ Yes ☐ No ☐ Don't Know

If yes, list type of crashes and any known contributing factors (e.g. vehicle speed, poor sight distance, etc.):

_____

_____

Use Crossing Location data and matrices found in Table 1 and Table 2 to determine which types of enhanced crosswalk elements should be considered, if applicable.

Note: Before implementing enhanced crosswalk elements, consult with the Town of Paradise "Vertical Elements Policy" to be sure enhancements are consistent with the policy.

ATTACHMENT B

PEDSAFE Countermeasure Summary Sheets

PEDSAFE Countermeasures

Along the Roadway

Sidewalks, Walkways and Paved Shoulders
Street Furniture/Walking Environment

At Crossing Locations

Curb Ramps
Marked Crosswalks and Enhancements
Curb Extensions
Crossing Islands
Raised Pedestrian Crossings
Lighting and Illumination
Parking Restrictions (at Crossing Locations)
Pedestrian Overpasses/Underpasses
Automated Pedestrian Detection
Leading Pedestrian Interval
Advance Yield/Stop Lines

Roadway Design

Bicycle Lanes
Lane Narrowing
Lane Reduction (Road Diet)
Driveway Improvements
Raised Medians
One-way/Two-way Street Conversions
Improved Right-Turn Slip-Lane Design

Intersection Design

Roundabouts
Modified T-Intersections
Intersection Median Barriers
Curb Radius Reduction
Modify Skewed Intersections
Pedestrian Accommodations at Complex Interchanges

Traffic Calming

Temporary Installations for Traffic Calming
Chokers
Chicanes
Mini-Circles
Speed Humps

Speed Tables
Gateways
Landscaping
Specific Paving Treatments
Serpentine Design

Traffic Management

Diverters
Full Street Closure
Partial Street Closure
Left Turn Prohibitions

Signals and Signs

Traffic Signals
Pedestrian Signals
Pedestrian Signal Timing
Traffic Signal Enhancements
Right-Turn-on-Red Restrictions
Advanced Stop Lines at Traffic Signals
Left Turn Phasing
Push Buttons & Signal Timing
Pedestrian Hybrid Beacon (PHB)
Rectangular Rapid-Flashing Beacon (RRFB)
Puffin Crossing
Signing
In-Street Pedestrian Crossing Sign

Advance Yield/Stop Lines

Advance yield/stop line include the stop bar or “sharks teeth” yield markings placed 20 to 50 feet in advance of a marked crosswalk to indicate where vehicles are required to stop or yield in compliance with the accompanying “STOP Here for Pedestrians” or “YIELD Here to Pedestrians” (signs R1-6, R1-6a, R1-9, and R1-9a). This countermeasure can greatly reduce the likelihood of a multiple-threat crash at unsignalized midblock crossings. The multiple threat crash occurs at crosswalks on multilane roadways, and this occurs when a driver stops too close to the crosswalk and lets a pedestrian cross, masking visibility of the adjacent travel lane. This situation can result in a high-speed crash, which usually leads to fatalities or very severe injuries[8] to allow for better visibility.

This countermeasure discourages drivers from stopping too close to crosswalks and blocking other drivers’ views of pedestrians and pedestrians’ views of vehicles. Pedestrians can see if a vehicle is stopping or not stopping and can take evasive action. Studies have found that advance yield markings at midblock crossings can be particularly useful when combined with signs and beacons, such as the Pedestrian Hybrid Beacon or Rectangular Rapid-Flashing Beacon (RRFB). One study found that use of a "sign alone reduced conflicts between drivers and pedestrians by 67 percent, and with the addition of an advanced stop or yield line, this type of conflict was reduced by 90 percent compared to baseline levels.”[2]

Purpose

Advance stop lines and yield markings improve the visibility of pedestrians to motorists and prevent multiple-threat crashes.[9]

Considerations

• The decision to use an advance stop or yield line depends on state law. Most states require drivers to yield to pedestrians in a crosswalk; about a dozen states require drivers to stop for pedestrians in a crosswalk.
• Effectiveness depends on motorist compliance with the marked stop/yield line. Motorists might ignore markings/signage if placed too far in advance of the crosswalk.
• Parking should be restricted between the stop or yield line and the crosswalk to allow for better visibility.[10]

Estimated Cost

The cost of each advance stop/yield signs and lines are approximately $300 and $320 respectively.

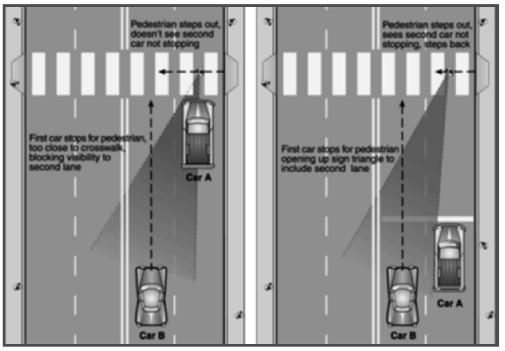
Safety Effects

The installation of advance yield or stop markings and signs can reduce pedestrian crashes by 25%. For more information, see NCHRP Research Report 841: Development of Crash Modification Factors for uncontrolled Pedestrian Crossing Treatments.

Case Studies

Las Vegas, Nevada
Halifax, Nova Scotia
Tampa, Florida
San Francisco, California

View Other At Crossing Locations Treatments



Advance stop lines and yield markings improve the visibility of pedestrians to motorists and prevent multiple-threat crashes.

The advance stop bar is supplemented with the "Stop Here For Pedestrians" signs.
Source: Toole Design Group.

Advance yield markings at a midblock crosswalk with a refuge island.
pedbikeimages.org - Toole Design Group.

Curb Extensions

Curb extensions—also known as bulb-outs or neckdowns—extend the sidewalk or curb line out into the parking lane and reduce the effective street width. Curb extensions must not extend into travel lanes and should not extend across bicycle lanes. This countermeasure improves pedestrian crossings by reducing the pedestrian crossing distance, reducing the time that pedestrians are in the street, visually and physically narrowing the roadway, and improving the ability of pedestrians and motorists to see each other. Curb extensions also create space for the addition of a curb ramp.

Motorists are encouraged to travel more slowly at intersections or midblock locations with curb extensions, as the reduced street width sends a visual cue to motorists. Turning speeds at intersections can be reduced with curb extensions (curb radii should be as tight as is practicable). Additionally, curb extensions placed at an intersection essentially prevent motorists from parking in or too close to a crosswalk and from blocking a curb ramp or crosswalk. Motor vehicles parked too close to corners present a threat to pedestrian safety, since they block sightlines, obscure visibility of pedestrians and other vehicles, and make turning particularly difficult for emergency vehicles and trucks.

View Other At Crossing Locations Treatments

This curb extension at an intersection shortens the crossing distance for pedestrians and creates space for landscaping.
pedbikeimages.org - Carl Sundstrom

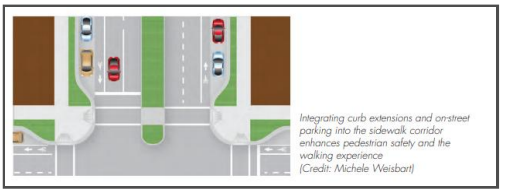
Purpose

Wide roadways can create difficult crossing situations for pedestrians. Not only do pedestrians need more time to cross the roadway, but the roadway width encourages motorists to speed or take turns quickly. Curb extensions improve safety because they increase visibility, reduce speed of turning vehicles, encourage pedestrians to cross at designated locations, shorten the crossing distance, and prevent vehicles from parking at corners.

Curb extensions improving the ability of pedestrians and motorists to see each other.
Living Streets Page 7-13

Considerations

• Curb extensions are only appropriate where there is an on-street parking lane and where transit and bicyclists would be traveling outside the curb edge for the length of the street. They should not extend more than 6 feet from the curb.
• The turning needs of larger vehicles, such as school buses and emergency vehicles, need to be considered in curb extension design, especially at intersections with significant truck of bus traffic. However, speeds should be relatively slow in a pedestrian environment so all vehicles should be traveling at speeds conducive to tight turns.
• Emergency access is often improved using curb extensions if intersections are kept clear of parked cars. Fire engines and other emergency vehicles can climb a curb where they would not be able to move a parked car. At midblock locations, curb extensions can keep fire hydrants clear of parked cars and make them more accessible.
• It is not always necessary for a roadway to be designed for a vehicle to turn from a curb lane to a curb lane. Vehicles can encroach into adjacent lanes safely where volumes are low, or speeds are slow.
• Curb extensions can create additional space for curb ramps, landscaping, and street furniture that are sensitive to motorist and pedestrian sightlines; this is especially beneficial where sidewalks are otherwise too narrow. Care should be taken to ensure that street furniture and landscaping do not block motorists' views of pedestrians.
• Curb extension design should facilitate adequate drainage.



A combination of curb extensions and a median refuge narrow the roadway, reduce the pedestrian crossing distance, and reduce the time that pedestrians are in the street.
Living Streets Page 5-7

Estimated Cost

The cost of a curb extension can range from $2,000 to $20,000, with an average of $13,000 each, depending on the design and site condition. Storm water management impacts, transit stops, large areas, special pavement, street furnishings and planting,

Interim curb extensions can be installed using pavement markings and flexible delineator posts as shown in this

and moving utility poles or controller boxes can significantly increase increase the cost. Retrofitting an existing curb extension by adding vegetation can be relatively inexpensive.

image from Memphis, Tennessee.
pedbikeimages.org - Kristen Brookshire

Curb extension in a residential setting.
pedbikeimages.org - Dan Burden

Safety Effects

A summary of studies that have looked at the safety effects of curb extensions can be found here.

Case Studies

Cambridge, MA
Berkeley, CA
Eureka, CA
Fort Plain, NY
Oneonta, NY
Tempe, AZ
Fort Pierce, FL
West Palm Beach, FL
Cambridge, MA
Bellevue, WA
Portland, OR
Arlington County, VA
El Cajon, California
Bethesda, Montgomery County, MD
Portland, OR
Corvallis, OR
Hendersonville, North Carolina
Village of Great Neck Plaza, New York

Curb Radius Reduction

View Other Intersection Design Treatments

Curb radii designs are determined based on the design vehicle of the roadway (i.e. the types of vehicles using the roadway, such as buses, tractor trailer trucks, fire trucks, etc.). The most important factor for design is using the "effective radius" rather than the "actual radius" to accommodate the chosen design vehicle. Actual curb radius refers to the curvature along the curb line; effective radius refers to the curvature vehicles follow when turning. Larger effective curb radii can be achieved by adding on-street parking, bicycle lanes, or striping advance stop lines on the destination street of multilane roadways.

The smallest practical actual curb radii should be chosen based on how the effective curb radius accommodates the design vehicle. An actual curb radius of 5 to 10 feet should be used wherever possible. An appropriate effective radius for urban streets with high volumes of pedestrians is 15 to 20 ft. For arterial streets with a substantial volume of turning buses and/or trucks, an appropriate effective curb radius is about 25 to 30 ft. Typically the maximum desired effective curb radius is 35 feet for large vehicles. Tighter turning radii are particularly important where streets intersect at a skew. Corners characterized by an acute angle may require a slightly larger radius to accommodate larger vehicles; corners with an obtuse angle should have the smallest feasible radius to prevent high-speed turns.

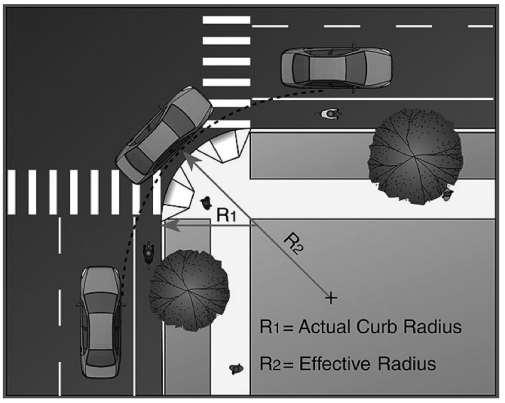


Illustration of actual and effective curb radii. *Source: Institute of Transportation Engineers*

This modified curb radius reduces the speed of turning vehicles and shortens the pedestrian crossing. *Photo by Michael Hintze*

Purpose

Larger curb radii typically result in high-speed turning movements by motorists, which may increase the risk of pedestrians being struck by right-turning vehicles. Smaller radii can improve pedestrian safety by requiring motorists to reduce vehicle speed by making sharper turns, and shortening pedestrian crossing distances which thereby improves signal timing. Also the smaller radii provide larger pedestrian waiting areas at corners, improve sight distances, and allow for greater flexibility of curb ramp placement.

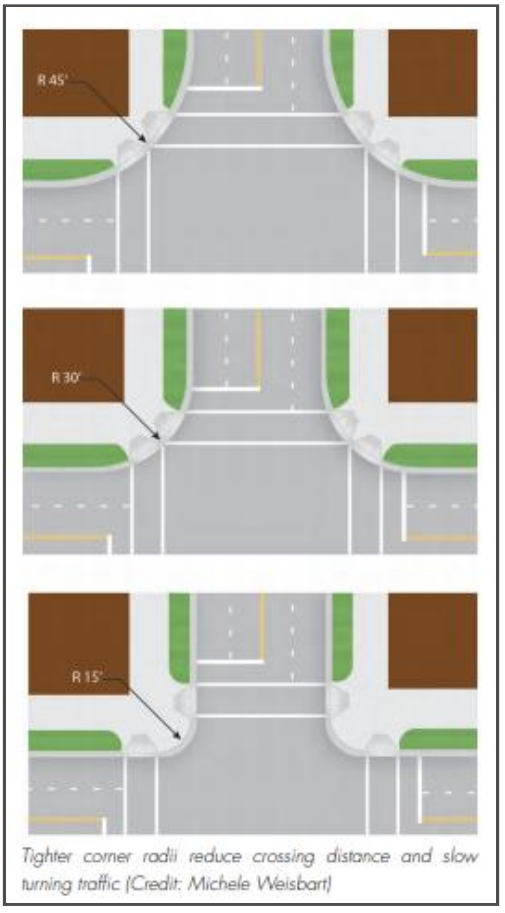
Considerations

• When designing the actual curb radius based on the effective radius, designs should balance the turning needs of the design vehicle with consideration for nearby land uses and the diversity and prevalence of roadway users. If there are high volumes of large vehicles making turns, an inadequate curb radius could cause vehicles to drive over the curb onto the sidewalk, putting waiting pedestrians at risk.
• Consideration should be given to:
• Adding parking and/or bicycle lanes to increase the effective radius of the corner.
• The angle of the intersection, presence of curb extensions, and the receiving lane width.
• Varying the actual curb radius over the length of the turn to create a compound curve where the radius is smaller, slowing vehicles as they approach a crosswalk and larger after the crosswalk to allow for the turn.
• Curb radii reductions are often used if the functional class of a roadway has changed.
• Emergency vehicle access should be considered.[7,8]

Estimated Cost

Construction costs for reconstructing tighter turning radii are approximately $15,000 to $40,000 per corner, depending on site conditions (e.g., drainage and utilities may need to be relocated).

Case Studies



Tighter corner radii reduce crossing distance and slow turning traffic.
Source: Living Streets

In-Street Pedestrian Crossing Sign

View Other Signals and Signs Treatments

In-street pedestrian crossing signs (MUTCD R1-6 or R1-6a) are placed within the roadway, either between travel lanes or in a median. The sign may be used to remind road users of laws regarding right-of-way at an unsignalized pedestrian crossing. The legends “STOP FOR” or “YIELD TO” may be used in conjunction with the appropriate symbol. This countermeasure is used with other crosswalk visibility enhancements to indicate optimal or preferred locations for people to cross and to help reinforce the driver requirement to yield the right-of-way to pedestrians at crossing locations.

For multilane roadway crossings where vehicle volumes are in excess of 10,000 AADT (annual average daily traffic), a marked crosswalk alone is typically not enough. These signs may be appropriate on 2-lane or 3-lane roads where speed limits are 30 mph or less.

In-street crossing sign in Redwood City, California.
pedbikeimages.org - Dan Burden.

In-street crossing sign at a raised crosswalk in Alexandria, Virginia.
Federal Highway Administration.

Purpose

These signs serve to remind road users of laws regarding right-of-way. Other substantial crossing improvements are needed to prevent an increase in pedestrian crash potential.

Considerations

- This sign may not be used a signalized locations.
- The STOP for legend shall only be used in a State where the State law requires that a driver must stop for a pedestrian in a crosswalk.
- The sign be used seasonally to prevent damage in winter because of plowing operations and may be removed at night if the pedestrian activity at night is minimal.
- The sign should be placed on a crossing island if available. The sign must comply with AASHTO breakaway requirements if placed within the roadway.

Estimated Cost

The signs cost $240 each.

Case Studies

Lane Narrowing

View Other Roadway Design Treatments

Lane narrowing can be achieved in several different ways depending on the type and scope of a project. During all projects there are opportunities to reduce lane widths to the recommended minimums (See AASHTO Greenbook for further information):[14]

- 9 feet lanes on rural roadways
- 10 feet for most vehicular travel lanes
- 10 feet for turn lanes
- 11 feet for lanes to accommodate large volumes of trucks, buses, or larger vehicles (typically where volumes of large vehicles are greater than 8 percent)

With the additional space created from narrowing travel lanes, space can be redistributed for the following uses:

- Bicycle lanes or cycle tracks, parking lanes, or transit lanes
- Widened sidewalks, landscaped buffers with street trees, and curb extensions at crossings where on-street parking is present

Lane diet (center lane narrowed) creates space to install bike lanes which also provides additional buffer for pedestrians on sidewalks. Seattle, Washington *Source: Gina Coffman, Toole Design Group*

Lane diet on Harvard Ave in Boston, Massachusetts *Source: Bill Schultheiss, Toole Design Group*

Purpose

On roadways where there are safety and speeding problems, and vehicle lane widths are greater than the recommended minimums, narrowing lane widths (i.e. lane diet), can help improve safety and comfort for pedestrians, bicyclists, transit riders, and motor vehicles. Lane diets provide multiple benefits, including lowering vehicle speeds, reducing crossing widths and pedestrian exposure to motor vehicle traffic, and redistributing roadway space for other users (e.g., create space for bike lanes).

Considerations

- Road narrowing projects should always consider the surrounding land uses, parking turnover, vehicular speeds, and the volumes and types of traffic (including pedestrians, bicyclists, transit, commercial, emergency response, and heavy vehicles).
- Evaluate whether narrowing may encourage traffic to divert to local neighborhood streets.
- On roadways with excess vehicle capacity, a reduction in the number of travel lanes may be feasible (see Lane Reduction).

Estimated Cost

Simply adding striped shoulders or on-street bike lanes can cost as little as .15-.20 per linear foot, or approximately $750 to $1000 per mile. Restriping can cost between $5,000 and $30,000 per mile, depending on how many lanes must be removed, and whether bike lanes are added. Typically the number of striping needed for a block puts the cost between $1,000 and $3,000 per block. If the road must be restriped or reconfigured, the cost is closer to $12,500 per block. Adding a raised median, widening a sidewalk, and adding improvements such as landscaping or curb extensions can significantly increase the cost.

Case Studies

Allegheny County, PA
West Palm Beach, FL
New York City, New York
Phoenix, Arizona

Lighting and Illumination

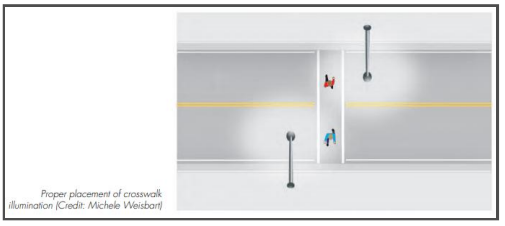
View Other At Crossing Locations Treatments

Appropriate quality and placement of lighting can enhance an environment and increase comfort and safety. Pedestrians may assume that their ability to see oncoming headlights means motorists can see them at night; however, without sufficient lighting, motorists may not be able to see pedestrians in time to stop.

A single luminaire placed directly over the crosswalk does not adequately illuminate the pedestrian for the approaching motorist. It is best to place streetlights along both sides of arterial streets and provide a consistent level of lighting along a roadway. This includes lighting pedestrian crosswalks and approaches to the crosswalks. A study conducted by the Virginia Tech Transportation Institute found that 20 lx (a unit of illuminance) was necessary for motorists to detect a pedestrian in the crosswalk. To achieve 20 lx, the luminaire should be placed 10 feet from the crosswalk, in between the approaching vehicles and the crosswalk. At intersections, the luminaires should also be placed before the crosswalk on the approach into the intersection. This differs from traditional placement of luminaires over the actual intersection.[13]

In commercial areas or in downtown areas, specialty pedestrian-level lighting may be placed over the sidewalks to improve pedestrian comfort, security, and safety. Well-lit pedestrian areas make people walking through the area feel safer. Streetlights and building lights can enhance the ambiance of the area and the visibility of pedestrians in commercial areas with nighttime pedestrian activity. Nighttime pedestrian crossing areas may be supplemented with brighter or additional lighting.

Roadway lighting. *Source: pedbikeimages.org - Annie Lux*



Appropriate quality and placement of lighting can enhance an environment as well as increase comfort and safety. *Source: Living Streets Page 7-18*


Pedestrian-scale lighting in Marion, Iowa. *pedbikeimages.org - Brandon Whyte*

Purpose

Roadway lighting has often focused on the needs of the motorist and not necessarily the safety of the pedestrian. However, it is important to consider lighting that illuminates pedestrian crosswalks and reduces glare to motorists. Pedestrian fatalities occur disproportionately during dark conditions. Adequate roadway lighting enhances the safety of all roadway users, while pedestrian-scale lighting improves nighttime security and enhances commercial districts.

Considerations

• Install lighting on both sides of wide streets and streets in commercial districts.
• Use uniform lighting levels.
• Place lights in advance of midblock and intersection crosswalks on both approaches to illuminate the front of the pedestrian and avoid creating a silhouette.

Estimated Cost

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Lighting	In-pavement Lighting	$18,250	$17,620	$6,480	$40,000	Total	4(4)
Lighting	Streetlight	$3,602	$4,882	$310	$13,895	Each	12(17)

Lighting varies based on the fixture type, manufacturer differences, roadway widths, project-specific factors, and utility service agreement. Usually, in-pavement lights are installed as a system, which is the reason the total cost is included here, as opposed to an individual light cost. Also, though not included above, average approximate underpass lighting costs can range from $350 to $3,400 each, and crosswalk lighting can range from approximately $10,750 to $42,000 per crosswalk.

Safety Effects

A summary of studies that have looked at the safety effects of lighting and illumination can be found here.

Case Studies

Clemson, SC
Grand Junction, CO
Eureka, CA
Ithaca, New York
Fort Plain, NY
Tempe, AZ
University Place, WA
Phoenix, Arizona
Shoreline, Washington
Bellevue, WA
Montgomery County, Maryland
Santa Monica, CA
Asheville, NC
Eureka, California
Englewood, Ohio
San Francisco, California
Cambridge, Massachusetts

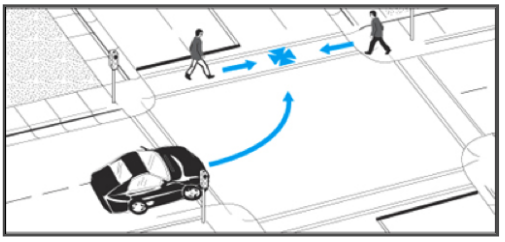
Leading Pedestrian Interval

View Other Signals and Signs Treatments

LPIs can be programmed into traffic signals to minimize conflicts between pedestrians crossing a roadway and left or right turning vehicles. LPIs give the pedestrian the WALK signal 3-7 seconds before the motorists are allowed to proceed through the intersection.[20]

By giving pedestrians a head start, it is less likely that there will be conflict between pedestrians and turning vehicles. LPIs increase the percentage of motorists who yield the right of way to pedestrians because pedestrians are in the crosswalk by the time the traffic signal turns green for parallel vehicle movements.

Vehicle-pedestrian incidents often occur at intersections where a pedestrian is crossing the street during a WALK interval. *Source: Gina Coffman (2012)*



A LPI allows pedestrians to be fully in the crosswalk before motorists attempt to turn.

Purpose

Vehicle-pedestrian incidents often occur at intersections where a pedestrian is crossing the street during a WALK interval. Pedestrians are especially vulnerable to left turning vehicles. Leading pedestrian intervals (LPIs) give pedestrians time to establish their presence in the crosswalk before motorists can start turning.

Considerations

• If an intersection has particularly high pedestrian traffic, you might consider adding an exclusive pedestrian phase instead of a leading pedestrian interval.
• Make sure that the LPI is accompanied by an audible noise that lets visually impaired pedestrians know that it's safe to cross.
• Keep in mind that right turn on red rules might limit the effectiveness of LPIs. Consider restricting right turn on red use at intersections.

Estimated Cost

The cost to alter the timing of a pedestrian signal can be relatively inexpensive (from $0 to $3,500), depending on the site specifications and the size of the city. Installing a new signal can range from $40,000-$100,000.

Safety Effects

A summary of studies that have looked at the safety effects of devices using a leading pedestrian interval can be found here.

Case Studies

St. Petersburg, FL
San Francisco, California
Miami-Dade County, Florida
Reston, Virginia

Marked Crosswalks

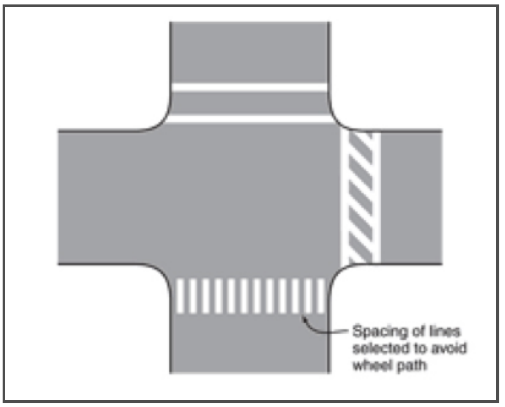
View Other At Crossing Locations Treatments

Marked crosswalks indicate optimal or preferred locations for pedestrians to cross and help designate right-of-way for motorists to yield to pedestrians. Pedestrians are sensitive to out-of-the-way travel, and reasonable accommodation should be made to make crossings both convenient and safe at locations with adequate visibility. Various crosswalk marking patterns are given in the Manual on Uniform Traffic Control Devices (MUTCD),[8] including transverse lines, ladder, and continental markings. However, high-visibility crosswalks are preferred over parallel line crosswalks.

Marked crosswalks are desirable at some high pedestrian volume locations to guide pedestrians along a preferred walking path. Crosswalks are often installed at signalized intersections and other selected locations with appropriate levels of pedestrian and vehicle traffic. Crosswalks should be installed in conjunction with other enhancements that physically reinforce crosswalks and reduce vehicle speeds. Recommended guidelines and priorities for crosswalk installation at uncontrolled locations are given in in the Resources section. These guidelines are based on a major study of 1,000 marked crosswalks and 1,000 unmarked crossings in 30 U.S. cities.[9]

A marked crosswalk with a warning sign and pedestrian refuge island. *pedbikeimages.org - Carl Sundstrom*

A marked crosswalk alone is typically not enough for multilane roadway crossings where annual average daily traffic is in excess of 10,000 vehicles. More substantial crossing improvements are also needed to prevent an increase in pedestrian crash potential. More substantial treatments include the refuge island, PHB, and RRFB.



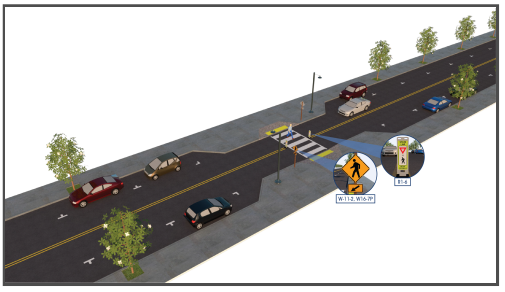
Examples of crosswalk markings.
2009 Manual on Uniform Traffic Control Devices.

Purpose

Any location that is an intersection of two roadways has a natural crossing location. Marked crosswalks warn motorists to expect pedestrian crossings and indicate preferred crossing locations for pedestrians. However, motorists may fail to yield to pedestrians if the crossing is unmarked. All crossings should be accompanied with visibility enhancements to improve safety and reduce crashes.

Considerations

- Crosswalk locations should be convenient for pedestrian access.
- Marked crosswalks are important for pedestrians with vision loss.
- Crosswalk markings must be placed to include the ramp so that a wheelchair does not have to leave the crosswalk to access the ramp.
- One option for enhancing a marked crossing is to install a raised crosswalk.



The enhancements shown in this rendering of a midblock crosswalk include high-visibility markings, curb extensions, in-street pedestrian crossing signs, lighting, and warning signs.
Federal Highway Administration.

Estimated Cost

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Crosswalk	High Visibility Crosswalk	$3,070	$2,540	$600	$5,710	Each	4(4)
Crosswalk	Striped Crosswalk	$340	$770	$110	$2,090	Each	8(8)
Crosswalk	Striped Crosswalk	$5.87	$8.51	$1.03	$26	Linear Foot	12(48)
Crosswalk	Striped Crosswalk	$6.32	$7.38	$1.06	$31	Square Foot	5(15)

The cost of high visibility crosswalk marking can range from $600-$5700 each with an average of $2540. Information about different types of marking patters can be found in the IT TENC Technical Committee 109-01 publication Pavement Marking Patterns Used at Uncontrolled Pedestrian Crossings.[10]

Safety Effects

A summary of studies that have looked at the safety effects of marked crosswalks and crosswalk enhancements can be found here.

Case Studies

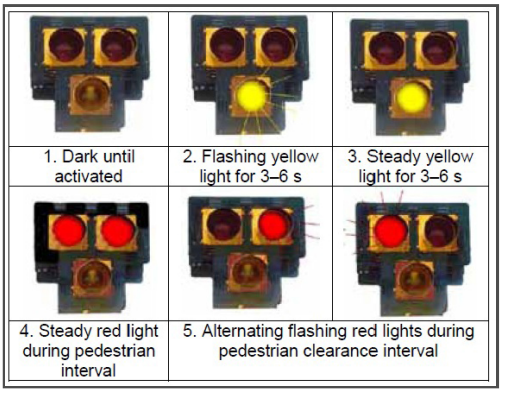
Shoreline, Washington
Eureka, CA
Washington, District of Columbia
Las Vegas, Nevada
Ithaca, New York
Fort Pierce, FL
Cambridge, MA
Seattle, Washington
Portland, OR
Tucson, AZ
Arlington County, VA
Salt Lake City, UT
Tucson, AZ
Queens, New York
Brooklyn, New York
Eureka, California
Cambridge, MA
Tampa, Florida
Washington, District of Columbia
Albemarle, Virginia
Detroit, Michigan
St. Petersburg, Florida
San Francisco, California
Phoenix, Arizona

Pedestrian Hybrid Beacon (PHB)

View Other Signals and Signs Treatments

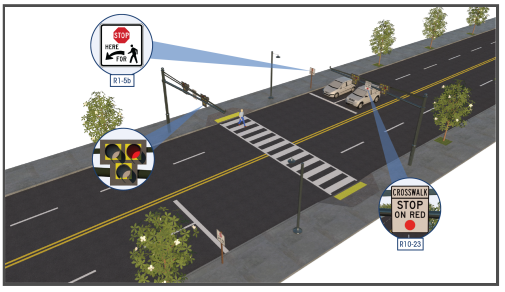
Pedestrian Hybrid Beacons (PHBs) can warn and control traffic at unsignalized locations and assist pedestrians in crossing a street or highway at a marked crosswalk. A PHB should be installed in conjunction with the following:

- Overhead beacons with three sections (circular yellow signal indication centered below two horizontally aligned circular red signals) facing both directions on the major street.
- Overhead signs labeled “CROSSWALK STOP ON RED” to indicate that the location is associated with a pedestrian crosswalk.
- A marked crosswalk on the major street.
- Countdown pedestrian signal heads to control pedestrian crossings at the crosswalk.
- Pedestrian detectors, such as pushbuttons.



The progression of a PHB.

Unlike a traffic signal, the PHB rests in dark until a pedestrian activates it via pushbutton or other form of detection. When activated, the beacon displays a sequence of flashing and solid lights that indicate the pedestrian walk interval and when it is safe for drivers to proceed. A solid red light requires drivers to stop while pedestrians have the right-of-way to cross the street. The overhead beacon flashes red when the pedestrian signals display a flashing DONT WALK indication. Drivers may proceed if the crosswalk is clear.



Pedestrian Hybrid Beacon installation shown with accompanying signs and pavement markings.
Federal Highway Administration.

The PHB is often considered for installation at locations where pedestrians need to cross and vehicle speeds or volumes are high, but traffic signal warrants are not met. These devices have been successfully used at school crossings, parks, senior centers, and other pedestrian crossings on multilane streets. PHBs are typically installed at the side of the road or on mast arms over midblock pedestrian crossings.

Purpose

A PHB is a special type of beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk.

Considerations

- PHBs are a candidate treatment for roads with three or more lanes that generally have annual average daily traffic (AADT) above 9,000.
- Strongly consider a PHB for all midblock and intersection crossings where the roadway speed limits are equal to or greater than 40 miles per hour.
- The MUTCD provides guidance on the pedestrian volume warrants, design features, and restrictions associated with the PHB.
- Can be used at both intersections and midblock locations.
- Works well to counteract multiple threat crashes.

Estimated Cost

Pedestrian Hybrid Beacon phases.
Source: Adapted from FHWA Training Materials.

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Pedestrian Hybrid Beacon	Pedestrian Hybrid Beacon	$51,460	$57,680	$21,440	$128,660	Each	9(9)

Pedestrian Hybrid Beacons are less expensive than a full traffic signal installation. The costs range from $21,000 to $128,000, with an average per unit cost of $57,680.

Safety Effects

The installation of a Pedestrian Hybrid Beacon can reduce pedestrian crashes by 55%, see NCHRP Research Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments.

Case Studies

Tucson, AZ
Detroit, Michigan
Tucson, Arizona

Raised Medians

View Other Roadway Design Treatments

Raised medians are curbed sections that typically occupy the center of a roadway. They can facilitate pedestrian crossings by providing a crossing area that is physically separated from the automobile path of travel, reducing pedestrian crossing distances, and enabling pedestrians to focus on one direction of traffic at a time when crossing the street. Raised medians can be especially helpful for pedestrians who are unable to judge distances accurately or who have difficulty completing wide roadway crossings. They can also improve the visibility of crossing pedestrians to motorists by putting them in middle of the roadway and providing space for lighting to illuminate the crossing.

Example of a well-designed right-turn slip lane with a refuge islands that forces pedestrians to face on-coming traffic, and marked crosswalks. *Source: Living Streets (Dan Burden)*

Trees and other landscaping elements can be added to raised medians as long as they do not restrict visibility. These elements can help change the character of a street and reduce speeds. Raised medians can also improve motorist safety when they replace two-way center turn lanes; however, desired turning movements need to be carefully studied and provided where necessary so that motorists are not forced to travel on inappropriate routes, such as residential streets, or make unsafe U-turns.

Raised landscaped median.
Source: Designing for Pedestrian Safety

Continuous raised medians are not always appropriate. In some cases, separating opposing traffic flow and eliminating left-turn friction can increase traffic speeds by decreasing the perceived friction of the roadway. Raised medians may also take up space that can be better used for wider sidewalks, bicycle lanes, landscaped buffer strips, or on-street parking, and may cause problems for emergency vehicles. In some environments, raised medians can be constructed in sections, creating an intermittent rather than continuous raised median. Another good alternative device for two-, three- or four-lane roads is the crossing island, which provides a crossing landing for pedestrians and, in some designs, aids in decreasing vehicle speeds.

Raised medians are most useful on high-volume, high-speed roads, and they should be designed to provide tactile cues for pedestrians with visual restrictions to indicate the border between the pedestrian refuge area and the motorized vehicle roadway. Examples of designs demonstrating a range of quality for raised median crossings can be found in Chapter 8 of Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide.[5]

Purpose

Raised medians separate opposing streams of traffic and restrict turning movements. They can facilitate pedestrian crossings, improve pedestrian visibility to motorists, slow motor vehicle speeds, and provide space for lighting and landscaping.

Considerations

• Ensure that there is enough room for wider sidewalks, bike lanes, and planting strips before proceeding with construction of raised medians.
• Landscaping in medians should not obstruct the visibility between pedestrians and approaching motorists.
• Median crossings at midblock and intersection locations must be fully accessible by means of ramps or cut-throughs, with detectable warnings.
• Fences, railings, and curbs can be added to raised medians to point pedestrians in the direction of oncoming traffic.
FHWA recommends particular consideration in areas with mixtures of significant pedestrian and vehicle traffic (more than 12,000 Average Daily Traffic) and intermediate or high travel speeds. They also recommend the medians be at least 4 feet wide (preferably 8 feet to accommodate pedestrian comfort and safety) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing.[9,10,11]

Estimated Cost

The cost for a raised median may vary widely, but is likely between $2,100 and $40,000 per intervention.

Case Studies

Grand Junction, CO
Tempe, AZ
University Place, WA
Tucson, AZ
Portland, OR
Sarasota, FL
New York, New York
Tampa, Florida
Detroit, Michigan

Raised Pedestrian Crossings

View Other At Crossing Locations Treatments

Raised crosswalks or raised intersections are ramped speed tables spanning the entire width of the roadway or intersection. Raised crosswalks are often placed at midblock crossing locations and only the width of a crosswalk. The crosswalk is demarcated with paint and/or special paving materials, and curb ramps are eliminated because the pedestrians cross the road the same level as the sidewalk. Raised crossings make the pedestrian more prominent in the driver's field of vision. Additionally, approach ramps may reduce vehicle speeds and improve motorist yielding. This countermeasure can reduce pedestrian crashes by 45%.

The crosswalk table is typically at least 10 feet wide and designed to allow the front and rear wheels of a passenger vehicle to be on top of the table at the same time. Detectable warnings (truncated domes) and curb ramps are installed at the street edge for pedestrians with impaired vision. In addition to their use on local and collector streets, raised crosswalks can be installed in campus settings, shopping centers, and pick-up/drop-off zones (e.g., airports, schools, transit centers). On one street in Cambridge, MA, motorists yielding to pedestrians crossing at the raised devices increased from approximately 10 percent before installation of the project to 55 percent after installation.[12]

This midblock raised pedestrian crossing features curb extensions and an in-street pedestrian crossing sign. *Pennsylvania Department of Transportation.*

Raised pedestrian crossing in Alexandria, Virginia. *Federal Highway Administration.*

Raised pedestrian crossing with curb extensions at a midblock location on a one-way street with a bike lane. *Pennsylvania Department of Transportation.*

Purpose

Local and collector roads with high speeds pose a significant challenge for pedestrians crossing the roadway. Motorist reaction time is reduced at higher speeds, and additional measures may be needed to improve motorist speed and yielding compliance. Raised pedestrian crossings and intersections reduce vehicle speeds, reduce the need for curb ramps (though truncated domes should still be included), and enhance the pedestrian crossing environment.

Considerations

- Typically installed on 2-lane or 3-lane roads with speed limits of 30 mph or less and annual average daily traffic (AADT) below about 9,000.
- May not be appropriate bus transit routes or primary emergency vehicle routes. These vehicles may experience issues with vertical deflection associated with raised crossings.
- Particular attention should be paid to impacts on drainage.
- May be inappropriate for crossings on curves or steep roadway grades.
- Snowplowing can be a concern for States with regular snowfall.
- Detectable warning strips at edges enable pedestrians with vision restrictions to detect the crossing.

Estimated Cost

The intersections and crossings can be built with a variety of materials, including asphalt, concrete, stamped concrete, or pavers. Raised crosswalks are approximately $7,110 to $30,880 each depending on drainage conditions and material used. The cost of a raised intersection is highly dependent on the size of the roads can range from $25,000 to $100,000.

Safety Effects

A summary of studies that have looked at the safety effects of raised pedestrian crossings can be found here.

Case Studies

Cambridge, MA
Grand Junction, CO

West Palm Beach, FL
Cambridge, MA
Bellevue, WA
Tucson, AZ

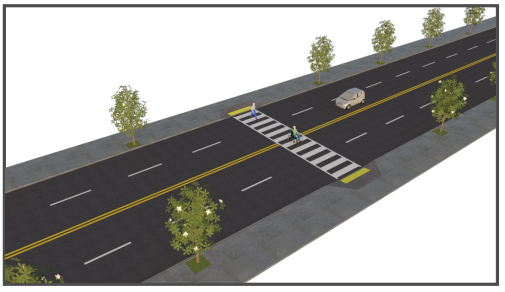
Lane Reduction (Road Diet)

View Other Roadway Design Treatments

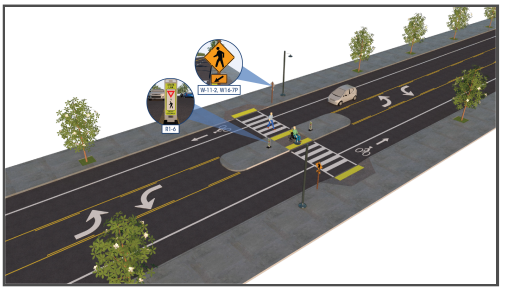
Lane reductions and road diets can decrease the lane crossing distance and reduce vehicle speeds. Multilane roads can take longer for pedestrians to cross and vehicle speeds may be high. A typical road diet converts an existing four-lane, undivided roadway to two through lanes and a center, two-way left turn lane (TWLTL). This design allows left-turning drivers to exit the traffic stream while waiting for a gap to complete their turn and frees up space that can be reallocated to other uses, including:

- Pedestrian refuge island
- Crosswalk visibility enhancements, such as curb extensions
- On-street parking, with parking restrictions on crosswalk approaches
- Widened sidewalks and landscaped buffers
- Bicycle lane and/or transit lanes

There are many other opportunities to perform road diets, particularly on roadways with wider cross sections, one-way streets (which may have excess capacity), and although not as common, where volumes are low a three-lane road (one lane in each direction with a TWLTL) can be converted to two. Road diets are often supplemented with painted, textured, or raised center islands.



This rendering shows a four-lane road with a midblock crosswalk before a road diet. *Federal Highway Administration.*



This rendering shows how a road diet on a street that was previously four lanes can create space for features like bicycle lanes and a pedestrian refuge island.
Federal Highway Administration.

"Before" picture from a typical four-lane to three-lane conversion.
Federal Highway Administration.

"After" picture from a typical four-lane to three-lane

Purpose

Lane reductions (i.e., road diets) optimize street space to benefit all users. Lane reductions help improve safety and comfort for pedestrian as well as bicyclists. Reducing the number of lanes on a multilane roadway can reduce crossing distance and exposure for pedestrians while also reducing vehicle speeds and the potential for rear-end collisions. Road diets also improve sight distances for left-turning vehicles.

Considerations

- Road diets may be uncommon in a community. Consider conducting an outreach effort to educate the public on the purpose and potential benefits.
- Four to three lane conversions should be considered for roadways with documented safety concerns, moderate volumes (less than 15,000 ADT, up to 25,000 ADT in special cases), and along priority bicycling and walking routes.
- FHWA's Road Diet Informational Guide recommends communities consider a range of factors including:

  - Vehicle speed
  - Level of Service (LOS)
  - Quality of Service
  - Vehicle volume (ADT)
  - The operation and volume of pedestrians, bicyclists, transit, and freight
  - Peak hour and peak direction traffic flow
  - Vehicle turning volumes and patterns
  - Frequency of stopping and slow-moving vehicles
  - Presence of parallel roadways

- Determine if and how alternative routes will be impacted by a lane reduction.
- Consider the importance a particular street plays in the pedestrian or bicycle network and the relationship between creating more livable streets and supporting economic development.
- Consider designs that incorporate raised medians and left-turn bays to help eliminate the potential for TWLTL to be used as acceleration lanes by some motorists.
- The common four-to-three-lane road diet is very compatible with single-lane roundabouts.

• Strongly consider conducting before-and-after studies of the conversion for safety and traffic flow conditions.[1,3,5,6,7,8]

conversion.
Federal Highway Administration.

Estimated Cost

The cost associated with a road diet can vary widely. The countermeasure can be a relatively low-cost safety solution if only pavement marking modifications are required to implement the reconfigured roadway design. Restriping costs for the three lanes plus bicycle lanes are estimated at $25,000 to $40,000 per mile, depending on the amount of lane lines that need to be repainted. However, work involving geometric features like extended sidewalks, curb extensions, a raised median, or refuge island can increase the cost to $100,000 or more per mile.

Side-by-side before and after pictures of a road diet with a pedestrian refuge island.
pedbikeimages.org - New York City DOT.

When planning in conjunction with reconstruction or overlay projects, the change in cross section may be completed without any additional cost. If a reconfiguration is done after repaving or with an overlay, and curbs do not need to be changed, there may be no additional costs for the reconfiguration or pavement markings. Reconstruction projects may also allow for curb lines to be moved to narrow the roadway.

Safety Effects

A summary of studies that have looked at the safety effects of road diets can be found here.

Case Studies

Oneonta, NY
West Palm Beach, FL
University Place, WA
Cleveland Heights, Ohio
El Cajon, California
New York, New York
Tampa, Florida
Seattle, Washington
Hendersonville, North Carolina
New York City, New York

Parking Restrictions (at Crossing Locations)

View Other At Crossing Locations Treatments

Parking restrictions help improve pedestrian and motorist sightlines through an intersection and can include the removal of parking space markings and/or installation of new “parking prohibition” pavement markings, curb paint, or signage. Removing a parking space on the approach into an intersection may help pedestrians to safely cross the street by providing them with a clearer view of oncoming vehicles. Removing a parking space also frees up roadway space for other uses.

Generally, vehicles should not be parked within at least 20 feet of an intersection and parking restrictions should consider adequate sightlines for motorists and pedestrians to be able to see and react to each other. The minimum setback is 20 feet in advance of the crosswalk where speeds are 25 mph or less, and 30 feet where speeds are between 26 and 35 mph.

However, it may also be important to provide physical roadway measures to prevent motorists from parking on the sidewalk or in areas intended for pedestrians to walk. Curb extensions improve sightlines and shorten the distance pedestrians need to cross a roadway.

Parking restrictions at intersections may provide help pedestrians to safely cross the street by providing them with a clearer view of oncoming vehicles. *Source: Peter Lagerwey.*

This rendering shows how the design of on-street parking can improve visibility at a midblock crosswalk. *Federal Highway Administration.*

Purpose

Sightlines of pedestrians and motorists are limited when vehicles are parked too close to pedestrian crossings, which increases risk for pedestrians who intend to cross the road.

Considerations

- Communicate with community stakeholders about parking space removal.
- Consistently enforce parking restrictions with signage, paint, and pavement markings.
- If curb extensions are out of the budget, vertical delineators can work to prevent motorists from parking vehicles too close to a crosswalk.

Estimated Cost

The cost of this countermeasure varies based on the required signs and pavement markings. Removing the striping of a parking space and/or adding paint is relatively inexpensive. However, the cost can increase substantially ($2,000 to $20,000) if curb extensions are added. Additionally, delineators cost approximately $50 to $100, and parking restriction signs cost approximately $200.

Case Studies

Hoboken, New Jersey
New York City, New York

Rectangular Rapid-Flashing Beacon (RRFB)

View Other Signals and Signs Treatments

RRFBs are pedestrian-actuated conspicuity enhancements used in combination with a pedestrian, school, or trail crossing warning sign to improve safety at uncontrolled, marked crosswalks. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated. The RRFB design differs from the standard flashing beacon by utilizing:

- A different shape
- A much faster rapid-pulsing flash rate.
- A brighter light intensity.

The RRFB is a treatment option at many types of established pedestrian crossings. RRFBs are particularly effective at multilane crossings with speed limits less than 40 mph. Consider the Pedestrian Hybrid Beacon (PHB) instead for roadways with higher speeds.

RRFBs are placed on both sides of a crosswalk below the pedestrian crossing sign and above the arrow indication pointing at the crossing. The flashing pattern can be activated with pushbuttons or automated (e.g., video or infrared) pedestrian detection, and should be unlit when not activated.

The Federal Highway Administration has issued interim approval for the use of the RRFB (IA-21). State and local agencies must request and receive permission to use this interim approval before they can use the RRFB.

A Rectangular Rapid-Flashing Beacon (RRFB) in Princeton, New Jersey. *Federal Highway Administration.*

A Rectangular Rapid-Flashing Beacon (RRFB).
Source: Carol Kachadoorian (2012)

Purpose

The RRFB is a device used in combination with pedestrian warning signs to provide a high-visibility strobe-like warning to drivers when pedestrians use a crosswalk.

Considerations

• RRFBs should not be used without the presence of a pedestrian crossing sign.
• A RRFB should be installed in the median rather than the far-side of the roadway if there is a pedestrian refuge or other type of median.
• Advance yield or stop pavement markings and signs may be used to supplement RRFBs.
• The crosswalk approach should not be controlled by a YIELD sign, STOP sign, traffic-control signal, or located at a roundabout.
• Solar-power panels can be used to eliminate the need for a power source.
• RRFB should be reserved for locations with significant pedestrian safety issues, as over-use of RRFB treatments may diminish their effectiveness.
• Other treatments may be more appropriate in locations with sight distance constraints.
• A high-intensity unit (SAE-1) should be used instead of a less intense unit.

Estimated Cost

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Flashing Beacon	RRFB	$14,160	$22,250	$4,520	$52,310	Each	3(4)

The cost to furnish and install a flashing beacon can vary widely depending on site conditions and the type of device that is used (from $4,500 to $52,000 each). The RRFB can be constructed using solar power to simplify installation. The installation may include an indication visible to pedestrians confirming that the device is activated and/or an audible message instructing pedestrians to wait until cars have stopped before crossing. The pushbutton and other components of the crosswalk must meet all other MUTCD accessibility requirements.

Safety Effects

The installation of RRFBs can reduce pedestrian crashes by 47%, see NCHRP Research Report 841: Development of Crash Modification Factors for uncontrolled Pedestrian Crossing Treatments.

Case Studies

San Francisco, California
St. Petersburg, Florida
Elmwood Park, New Jersey
Miami-Dade County, Florida

Right-Turn-on-Red Restrictions

View Other Signals and Signs Treatments

Prohibiting RTOR should be considered where exclusive pedestrian phases or high pedestrian volumes are present. The standard regulatory sign included in the MUTCD states NO TURN ON RED, but alternative sign options include a circular red icon or a larger 762-mm by 914-mm (30-in by 36-in) NO TURN ON RED sign, both of which improve conspicuity. For areas where a right-turn-on-red restriction is needed during certain times, time-of-day restrictions may be appropriate. A variable-message NO TURN ON RED sign is also an option.[10]

Example of RTOR restriction during certain times. *Source: Flickr - William Yurasko (2008)*

Purpose

A permissible Right Turn on Red (RTOR) was introduced in the 1970s as a fuel-saving measure and has sometimes had detrimental effects on pedestrians. While the law requires motorists to come to a full stop and yield to cross-street traffic and pedestrians prior to turning right on red, many motorists do not fully comply with the regulations, especially at intersections with wide turning radii. Motorists are so intent on looking for traffic approaching on their left that they may not be alert to pedestrians approaching on their right. In addition, motorists usually pull up into the crosswalk to wait for a gap in traffic, blocking pedestrian crossing movements. In some instances, motorists simply do not come to a full stop.

One concern that comes up when RTOR is prohibited is that this may lead to higher right-turn-on-green conflicts when there are concurrent signals. The use of the leading pedestrian interval (LPI) can usually best address this issue (see Pedestrian Signal Phasing). Where pedestrian volumes are very high, exclusive pedestrian signals should be considered.

Considerations

• Prohibiting RTOR is a simple, low-cost measure. Together with a leading pedestrian interval, the signal changes can benefit pedestrians with minimal impact on traffic.
• Part-time RTOR prohibitions during the busiest times of the day may be sufficient to address the problem.
• Signs should be clearly visible to right-turning motorists stopped in the curb lane at the crosswalk.
• RTOR restrictions are used at every intersection with crossing guards or with inadequate sight distances.
• RTOR restrictions should be used at school crossings.

Estimated Cost

The cost for a sign is approximately $200. Electronic signs are approximately $3,000 to install.

Case Studies

Signing

View Other Signals and Signs Treatments

Regulatory signs, such as STOP, YIELD, or turn restriction signs such as NO TURN ON RED require compliant driver actions and can be enforced. Warning signs can provide helpful information, especially to motorists and pedestrians unfamiliar with an area.

Advance pedestrian warning signs should be used where pedestrian crossings may not be expected by motorists, especially if there are many motorists who are unfamiliar with the area. A new fluorescent yellow/green color is approved for pedestrian, bicycle, and school warning signs (Section 2A.11 of the MUTCD).[1] This bright color attracts the attention of drivers because it is unique.

All signs should be periodically checked to make sure that they are in good condition, free from graffiti, retroreflective at night, and continue to serve the intended purpose. In unusual cases, signs may be used to prohibit pedestrian crossings at an undesirable location and re-route them to a safer crossing location, or warn pedestrians of unexpected driver maneuvers. It is preferable to create safe crossings where there are clear pedestrian destinations. If unexpected driving maneuvers occur at what is an otherwise legal pedestrian crossing, an evaluation should be done to find ways to remedy or prevent the unsafe motorist maneuvers.

An advance pedestrian warning sign located prior to a crosswalk. *Source: Toole Design Group*

Purpose

Signs can provide important information that can improve road safety. By letting people know what to expect, there is a greater chance that they will react and behave appropriately. For example, giving motorists advance warning of an upcoming pedestrian crossing or that they are entering a speed zone will alert them to the potential of pedestrians crossing the street and modify their speed. Sign use and movement should be done judiciously, as overuse may breed noncompliance and disrespect. Too many signs may also create visual clutter where their conspicuity is diminished.

Considerations

• Overuse of signs may breed noncompliance and disrespect. Too many signs can lead to visual clutter with the result that a driver may not amply heed directions or warnings.
• Traffic signs used on public property must comply with the Manual on Uniform Traffic Control Devices (MUTCD).
• Signs should be checked to assure adequate nighttime retroreflectivity.

Estimated Cost

Infrastructure	Description	Median	Average	Min. Low	Max. High	Cost Unit	# of Sources (Observations)
Sign	Stop/Yield Sign	$220	$300	$210	$560	Each	4(4)

Safety Effects

A summary of studies that have looked at the safety effects of different signs can be found here.

Case Studies

Arlington County, VA
Las Vegas, Nevada
Clemson, SC
Ithaca, New York
Portland, OR
Eureka, California
Seattle, Washington
Albemarle, Virginia
New York City, New York
San Francisco, California
Miami-Dade County, Florida

Phoenix, Arizona
Phoenix, Arizona

Crossing Islands

View Other At Crossing Locations Treatments

A crossing island is a median with a refuge area that is intended to help protect pedestrians crossing a multilane road. This countermeasure is sometimes referred to as a pedestrian refuge island. Crossing islands should be considered as a supplement to the crosswalk. They are appropriate at both uncontrolled locations (i.e., where no traffic signals or stop signs exist) and signalized crossings. When installed at a midblock crossing, the island should be supplemented with a marked, high-visibility crosswalk.

The presence of a pedestrian refuge island at a midblock location or intersection allows pedestrians to focus on one direction of traffic at a time as they cross and provides space to wait for an adequate gap in oncoming traffic before finishing the second phase of a crossing. Crossing islands are highly desirable for midblock pedestrian crossings on roads with four or more travel lanes, especially where speed limits are 35 mph or greater and/or where annual average daily traffic (AADT) is 9,000 or higher. They are also a candidate treatment option for uncontrolled pedestrian crossings on 3-lane or 2-lane roads that have high vehicle speeds or volumes.[9]

Center crossing islands allow pedestrians to deal with only one direction of traffic at a time, and can be constructed so that crossing pedestrians are forced to the right to view oncoming traffic as they are halfway through the crossing.
Source: pedbikeimages.org - Lyubov Zuyeva (2011)

The factors contributing to pedestrian safety include reduced conflicts, reduced vehicle speeds approaching the island (when the approach is designed to influence driver behavior), greater attention called to the pedestrian crossing, opportunities for additional signs in the middle of the road, and reduced exposure time for pedestrians.

Crossing islands can be located at intersections or midblock crossings to help protect crossing pedestrians from motor vehicles. hy and allows pedestrians to avoid conflicts with traffic at street level.
Source: Designing for Pedestrian Safety

Purpose

Crossing islands enhance the safety of pedestrian crossings and reduce vehicle speeds approaching pedestrian crossings. It can be difficult for pedestrians to cross high-volume roadways if the crossing is uncontrolled, if the existing pedestrian signal is short, and/or there is not a safe stopping place in the middle of the roadway. Pedestrians might get caught in the middle of the roadway if the traffic signal changes before they have finished crossing the roadway or motorists do not abide to the crossing.

Considerations

- The design must accommodate pedestrians with disabilities. Islands should be a minimum of 4 feet wide (preferably 8 feet) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing.
- The cut-through must include detectable warnings if the island width is at least 6 feet.
- Crossing islands at intersections or near driveways may affect left-turn access.
- Crossing islands at intersections or near driveways may affect left-turn access.
- If applicable, evaluate the impact of the island on bicycle facility design.
- Illuminate or highlight islands with street lights, signs, or reflectors to enhance visibility for motorists.
- Curb extensions may be built in conjunction with crossing islands where there is on-street parking.

Estimated Cost

The cost of a median island depends on its size and construction materials. The costs range from $2,140 to $41,170 per island depending on the design, site conditions, and whether the median can be added as part of a utility improvement or other street construction project. The average cost per square foot is approximately $10. The cost for an asphalt island or one without landscaping is less than the cost of installing a raised concrete pedestrian island with landscaping. Costs may be reduced if the island is incorporated into planned roadway improvements or utility work.[11]

Safety Effects

The installation of pedestrian refuge island can reduce pedestrian crashes by 32%, see NCHRP Research Report 841: Development of Crash Modification Factors for Uncontrolled Pedestrian Crossing Treatments.

Case Studies

Eureka, CA
Las Vegas, Nevada
Fort Pierce, FL
Phoenix, Arizona
Seattle, Washington
Tucson, AZ
Portland, OR
Portland, OR
Naples, FL
Queens, New York
Brooklyn, New York
Eureka, California
Montgomery County, Maryland
Shoreline, Washington
Washington, District of Columbia
Village of Great Neck Plaza, New York
San Francisco, California
Norfolk, Virginia
Phoenix, Arizona

Appendix D

Vertical Elements Policy

Town of Paradise Vertical Elements in the Roadway Policy

Policy

Vertical elements located within or that extend into the roadway are discouraged in future public works projects. Examples of vertical elements include, but are not limited to:

Bulb-Outs (aka Curb Extensions)	Bulb-outs are curb or sidewalk extensions that reduce the effective width of the roadway for traffic calming or pedestrian/bicyclist accommodations. Bulb outs can be implemented on roadways or at intersections.	
Raised Center Islands	Raised center islands, or medians, are used to physically separate opposing traffic movements. Raised islands can also be used as a mid-block pedestrian refuge.	
Splitter Islands	Splitter islands are often channelizing islands on the minor approach of an intersection to prevent or separate movements.	

The policy particularly pertains to arterial, collector and other roadways used as evacuation routes. These vertical elements are typically used to promote everyday safety and traffic calming but may be an impediment during an evacuation and prevent the entire roadway width from being used by evacuating vehicles or emergency response personnel.

Purpose

The need for this policy arose after the 2018 Camp Fire evacuation. Evacuating traffic was reportedly impeded by vertical elements in the roadway. In particular, the mid-block pedestrian crosswalk refuge center island on Skyway was identified as a hinderance during the 2018 Camp Fire evacuation since drivers were not able to use the full pavement width (i.e., the center turn lane as an additional evacuation lane). Public outreach efforts conducted during the Transportation Master Plan (*TMP)* process confirmed the public preference that roadways generally be clear of vertical elements. The everyday safety benefit of these elements was weighed against the potential evacuation implications. A recommendation was

brought forward to the Town Council on September 14, 2021, to remove the Skyway mid-block crossing at Town Hall and to establish a policy discouraging the use of vertical elements in future roadway projects.

The agenda item stated:

> ***Item 6b:*** *"Direct staff to include a policy in the Transportation Master Plan to discourage vertical elements in future public works projects such as bulb-outs, center islands and splitter islands on emergency access roadways."*

Exceptions

Exceptions may be granted if it is determined that the benefits of a particular vertical element outweigh the potential risks on a case-by-case basis. The policy is particularly geared toward arterial, collector and other roadways used as evacuation routes. Vertical elements may be considered at local roads as applicable.

Raised Mid-block Pedestrian Island outside of Paradise Town Hall was removed in 2021

Appendix E

Arterials Policy

Town of Paradise Arterial Roadway Policy

Policy Summary

Policy 1: New, reconstructed, and reconfigured arterial roadways should have exclusive left-turn lanes at all intersections with Collector, Minor Arterial, and Principal Arterial roadways. Policy 2: New on-street parking should not be implemented on arterial roadways.

Applicable Arterial Roadways in the Town of Paradise:

- Skyway
- Clark Road
- Pentz Road
- Wagstaff Road (Skyway to Pentz Road)
- Bille Road (Skyway to Pentz Road)
- Elliott Road (Skyway to east of Sawmill Road- existing, to Pentz Road- future)
- Pearson Road

Left-Turn Lanes on Skyway at Elliott Road in Paradise

Arterial Roadway Policy 1 – Left-Turn Lanes

Policy

New, reconstructed, and reconfigured arterial roadways should have exclusive left-turn lanes at all intersections with Collector, Minor Arterial, and Principal Arterial roadways.

Purpose

Left-turn lanes increase capacity and improve safety by removing left-turning vehicles from the through lanes. This reduces delay and prevents through-traveling vehicles from have to stop and wait for left-turning vehicles. This policy is consistent with national guidelines and many municipal policies. Both the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) have guidelines indicating that left turn lanes are desirable at intersections along arterials where left turns are permitted.

Many state and local standards set criteria for left-turn lane warrants based on a roadway's classification, speed, turning volume, crash history, etc. This policy is not intended to replace or override any standard, but provide the recommendation that left-turn lanes should be implemented as standard practice on arterial roadways given the capacity and safety benefits. This includes the use of two-way left-turn lanes along roadway segments that transition to left-turn lanes at intersections.

Exceptions

Justified exceptions may apply where:

- Left turns are prohibited

- Construction of left turn lanes is unfeasible and/or not beneficial, or
- An intersection will not be adversely impacted without left-turn lanes.

Arterial Roadway Policy 2 – On-Street Parking

Policy

New on-street parking generally should not be implemented on arterial roadways.

On-street Parking on Skyway in the Town of Paradise

Purpose

On-street parking along arterial roadways is not compatible with the goals of increased capacity and unimpeded flow. On-street parking along arterial roadways can reduce vehicle speeds and cause safety issues when slow vehicles enter/exit parking spaces conflicting with high-speed arterial vehicles. On-street parking can also negatively impact pedestrian safety by creating a sight obstruction between moving vehicles and pedestrians. Therefore, it is generally recommended that parking for land uses adjacent to arterial roadways be accommodated at locations other than the arterial roadway.

Exceptions

On-street parking can be appropriate for arterial roadways traversing downtown areas where speeds are lower, businesses are abundant and support economic vitality, and heavy pedestrian activity is expected. Noted exceptions for the Town of Paradise are downtown Skyway, between Elliott Road and Pearson Road, and Pearson Road between Skyway and Black Olive Drive.

Where on-street parking is allowed, the following guidelines are recommended:

- Parallel parking should be implemented
- Parking should be restricted within 30 feet of a crosswalk or intersection.

Appendix F

Project Descriptions

Skyway Capacity Improvements (Pearson to Elliott)
Part of on-system project scheduled for 2023

Project Limits: On Skyway, 1,000 feet south of Pearson to 1,000 feet north of Elliott

Description: This project will restripe the space between existing curb lines to provide increased evacuation capacity and long-term travel capacity. Skyway is the most significant evacuation route within the Town of Paradise. The project includes removing curb bulbs and street features where necessary to provide the increased evacuation width, repaving in select locations, and associated roadway revisions.

This project also includes property acquisition and construction of an approximately 40 space parking lot to replace parking which will be removed on Skyway between Pearson and Elliott.

Estimated Cost: $500,000 in addition to rehab project

Skyway/ Pentz Road and Adjacent Segments.

Project Limits: Skyway/Pentz Road Intersection and Adjacent Roadway Segments

Description: The project is planned to consist of either a signal or a roundabout at the intersection and widening on adjacent segments of Skyway and Pentz Road from two lanes to 3 lanes including a multiuse path.

Estimated Cost: $10,000,000

Black Olive/Foster Intersection Improvements

Project Limits: Black Olive/Foster Intersection and Approaches

Description: This project will realign Black Olive Drive both horizontally and vertically through the Foster Drive intersection, construct additional turn lanes, and revise the intersection controls. The project cost includes constructing either a traffic signal system or roundabout. The control type decision will be made during the engineering feasibility study (early phase) of the project. The project includes right-of-way acquisition in the intersection vicinity which will be required to realign the roadway in accordance with nationally recognized design guidelines.

Estimated Cost: $5,000,000

Pentz/Pearson Intersection Improvements

Project Limits: Pentz/Pearson Intersection and Approaches

Description: This project will construct additional turn lanes and a traffic signal system or a roundabout at the existing narrow, All-Way Stop Controlled intersection. The Pentz/Pearson intersection is a critical intersection in the evacuation route network. Additional capacity and large vehicle turning space is needed at this location for efficient emergency services. The control type decision will be made during the engineering feasibility study (early phase) of the project. The project includes right-of-way acquisition in the intersection vicinity which would be required to accommodate the larger intersection footprint.

Estimated Cost: $4,500,000

Honey Run Improvements

Project Limits: 1.9 miles from Skyway to the City limit

Description: Honey Run Road serves as a secondary evacuation route for the Town. If traffic backs up on Skyway at the south end of Town, vehicles can use Honey Run Road as an evacuation route down the hill. Currently, the roadway is too narrow to accommodate bi-directional traffic, has failing pavement, and doesn't have guardrails to protect motorists from running off the road and down the hill into Honey Run Creek. Widening the road and safety enhancements will improve evacuation along this route, eliminate vehicle throughput choke points due to narrow lanes. The scope includes include a 20-foot paved roadway with 2-foot shoulders, cut into the slope needing a retaining wall, and up to 3,000 linear feet of guardrail along the creek side of the roadway.

Estimated Cost: $6,100,000