Meeting of the Ad-Hoc Citizen Traffic Advisory Group
January 26, 2016

Lake Forest City Hall
25550 Commercentre Drive
Council Chambers
Lake Forest, California 92630

AGENDA ON THE INTERNET: The Agenda is available through the Internet at www.lakeforestca.gov**.** You can access the document on the Friday before the meeting on Tuesday.

AGENDA DOCUMENT REVIEW: The full Agenda including all back up information is available at City Hall, 25550 Commercentre Dr., Lake Forest, California, on the Friday prior to the Tuesday meeting.

AGENDA DESCRIPTION: The Agenda descriptions are intended to give notice to members of the public of a general summary of items of business to be transacted or discussed.

CALL TO ORDER: 7:00 p.m.

ROLL CALL:	Chair:	Scott Drapkin
	Vice Chair:	John Irish
	Members:	Mark Armando
		Grady Glover
		Tim Redwine
		Donald Stoll
		Derek Wieske
	Staff Liaison:	David Rogers, Traffic Engineering Manager

PUBLIC COMMENTS:

At this time, members of the public may address the Ad-Hoc Citizen Traffic Advisory Group regarding any items within the subject matter jurisdiction of the Group. No action may be taken on items not listed on the agenda unless authorized by law. Comments shall be limited to three minutes per person and an overall time limit of thirty minutes for the Public Comments portion of the agenda.

Any person wishing to address the Ad-Hoc Citizen Traffic Advisory Group on any matter, whether or not it appears on this agenda, is requested to complete a "Request to Speak" form available at the door. The completed form is to be submitted to City staff prior to an individual being heard by the Ad-Hoc Citizen Traffic Advisory Group.

CONSENT CALENDAR:

All matters listed under the Consent Calendar are considered routine and will be enacted by one vote. There will be no separate discussion of these items unless Members of the Group, the public, or staff request specific items be removed from the Consent Calendar for separate action.

1. APPROVAL OF MINUTES OF THE REGULAR MEETING OF THE CITIZEN TRAFFIC ADVISORY GROUP HELD ON December 22, 2015, submitted by Public Works staff.

   RECOMMENDED ACTION: Approve as submitted.

2. STATUS REPORT ON CTAG TRAFFIC CONCERNS LIST, submitted by Public Works staff.

   RECOMMENDED ACTION: Receive and File.

3. UPDATED WORK PLAN AND PRELIMINARY RECOMMENDATIONS LIST, submitted by Public Works staff.

   RECOMMENDED ACTION: Receive and File.

DISCUSSION/ACTION ITEMS:

The following matters are for Commission consideration/discussion/action. Members of the public may have the opportunity to address these items if they wish to do so. Please complete the "Request to Speak" form and give to the Public Works Management Aide.

4. PRESENTATION AND DISCUSSION REGARDING TRAFFIC ENGINEERING AND RELATED TOPICS, submitted by Public Works staff.

   RECOMMENDED ACTION:

   1. Receive a presentation from the Public Works Department regarding general municipal traffic engineering and other related traffic engineering topics; and

   2. Discuss and make findings and recommendations, as appropriate.

ADJOURNMENT:

In compliance with the Americans With Disabilities Act, if you need special assistance to participate in this Meeting, including auxiliary aids or services, you should contact the Public Works Management Aide at (949) 461-3493. Notification 48 hours prior to the Meeting will enable the City to make reasonable arrangements to assure accessibility to this meeting. The Ad-Hoc Citizen Traffic Advisory Group and agenda back-up materials can be obtained from Public Works Management Aide on the Friday prior to the Ad-Hoc Citizen Traffic Advisory Group meeting. Copies of all Agendas, Staff Reports and Supporting Materials can also be found on the City's website – www.lakeforestca.gov/services/agendas. Agenda and agenda packets, if requested, will be made available in an appropriate alternative format to persons with a disability as required by the Americans With Disabilities Act. Copies of the agenda are provided at no cost and agenda back-up materials are available at the per page copy cost. If you wish to be added to the mailing list to receive a copy of the agenda, request must be provided to staff in writing.

The City of Lake Forest mailing address is 25550 Commercentre Drive, Lake Forest, California 92630.
Phone: (949) 461-3400. FAX (949) 461-3511.

CERTIFICATION: I, Amber Haston, Public Works Management Aide, of the City of Lake Forest, California, hereby certify that the foregoing Ad-Hoc Citizens Traffic Advisory Group agenda was posted for public review on January 22, 2015, at 6:00 p.m.

MINUTES OF A SPECIAL MEETING OF THE LAKE FOREST
AD-HOC CITIZEN TRAFFIC ADVISORY GROUP

The meeting of the Lake Forest Ad-Hoc Citizen Traffic Advisory Group which was held December 22, 2015, at the Lake Forest City Council Chambers, 25550 Commercentre Drive, Lake Forest, California was called to order at 7:00 p.m.

ROLL CALL:	Chair:	Scott Drapkin (Absent)
	Vice-Chair:	John Irish
	Members:	Mark Armando
		Grady Glover (Arrived 7:13 p.m.)
		Tim Redwine
		Donald Stoll (Arrived 7:35 p.m.)
		Derek Wieske (Absent)

ALSO PRESENT: Tom Wheeler, Director of Public Works/City Engineer
Carlo Tomaino, Assistant to the City Manager
David Rogers, Traffic Engineering Manager
Amber Haston, Public Works Management Aide

PUBLIC COMMENTS:

There were no Public comments.

CONSENT CALENDAR:

ACTION: The Ad-Hoc Citizens Traffic Advisory Group approved the Consent Calendar Items 1 through 2.

Consent Calendar (Items 1-2)

1. APPROVAL OF MINUTES OF THE REGULAR MEETING OF THE CITIZEN TRAFFIC ADVISORY GROUP HELD ON November 24, 2015.

2. STATUS REPORT ON CTAG TRAFFIC CONCERNS LIST

DISCUSSION/ACTION ITEMS:

3. UPDATED WORK PROGRAM FOR REMAINING MEETINGS

   Dave Rogers, Traffic Engineering Manager, reviewed the updated work program with the Group Members.

A concern was expressed regarding the dedicated right turn lane for northbound Trabuco at Lake Forest Drive. Staff confirmed that this will be included with the January meeting on Traffic Engineering.

The Group discussed the limited amount of time the Ad-Hoc Citizens Traffic Advisory Group has to consider all of the traffic related services. The Group discussed the possibility of continuing the Ad-Hoc Citizens Traffic Advisory Group through to July. The Group Members also discussed the potential of the City Council extending the meetings a year with different members.

Discussion ensued about finalizing recommendations to City Council prior to the Budget Workshops. Staff advised the Group Members of staff's timeframe for preparing the budget recommendations for City Council. To mitigate budget constraints, the Group discussed switching the proposed schedule to allow for final recommendations in February, leave the March meeting open to discuss items previously requested by Group Members, and hold the Community Input discussion in April. Following this, the Group considered the various recommendations they had made to date with budgetary impact.

An alternative schedule was proposed to discuss the continuation of the CTAG during the Community Input discussion and to leave the proposed schedule as is, with the exception of potentially adding a meeting in April.

After further deliberation, the Group majority compromised with switching the proposed schedule to allow for an Initial Review of CTAG Recommendations in February, a Community Input discussion in March, the Finalization of Recommendations in April, and the potential to add a meeting in May, as necessary.

ACTION: The Ad-Hoc Citizens Traffic Advisory Group reviewed and discussed the Revised Work Plan for the remaining meetings and the Group majority directed staff to switch the proposed schedule to allow for an Initial Review of Recommendations in February, a Community Input discussion in March, a Finalization of Recommendations in April, and the potential to add a meeting in May, as necessary.

4. PRESENTATION AND DISCUSSION REGARDING TRAFFIC AND TRANSPORTATION RELATED CAPITAL PROJECTS

Dave Rogers, Traffic Engineering Manager, provided the Group Members with an overview of traffic and transportation related capital projects. He discussed the difference between a traffic project and a transportation project. Three steps were discussed with the Group on determining traffic and transportation projects and priorities: traffic modeling, City initiated projects and citizen initiated projects. Staff reviewed with the Group the various criteria taken into consideration when prioritizing projects, such as need, overall cost, conflicting projects, funding constraints and staff workload.

The Group Members reviewed a preliminary simulation visually depicting the optimization of the signal timing at the intersection of Bake Parkway and Trabuco Road. Staff explained to the Group the City of Irvine's project of synchronizing the traffic lights on Bake Parkway. The Group reached consensus on making an official recommendation for City Council to direct staff to look into the feasibility of adding a dedicated right turn lane and signal optimization at the intersection of Bake Parkway and Trabuco Road, with minimal impact to property owners.

Discussion ensued regarding Bake Parkway east of Trabuco; a concern listed on the CTAG Traffic Concerns List. While concern was expressed with not adding additional through lanes on this segment of Bake Parkway, staff explained to the Group Members how the roadway capacity would be maximized with a combination of the appropriate number of lanes and proper signal synchronization.

A question arose concerning the continuous development within the City of Lake Forest and if the model accounts for the growth, particularly on Bake Parkway. Staff explained that the model includes an assumption of a particular number of additional homes that accounts for both the demand and distribution of traffic along the roadways included in the model. Thus, staff could not recommend, at this time, the widening of Bake Parkway. The Group reached consensus on the recommended action to monitor and continue to check the model to ensure that there are not any additional potential enhancements to the arterial that the City Council may want to consider in the future that are not included.

The Group Members discussed the intersection at Bake Parkway and Toledo Way and the potential consideration of a second northbound left turn lane. Staff explained to the Group Members that the model projects that the single left turn lane is adequate.

Staff was commended for their efforts to successfully resolve many of the Groups traffic concerns and bring back studies for the Group's review.

ACTION: The Ad-Hoc Citizen Traffic Advisory Group received a presentation from the Public Works Department regarding traffic and transportation related capital projects and discussed this topic and recommended that the City Council consider 8 goals, with the inclusion of two additional goals related to two potential Capital Projects:

1) That the City continues to use the Two Year CIP as the planning tool for near term traffic and transportation projects.

2) That the City continues to use the 5 Year Strategic Plan to identify projects for future consideration.

3) That the LFTM continue to be updated at appropriate intervals to identify the timing of LFTM improvements and to identify other potential projects.

4) That the City continues to update both ADT counts and intersection counts in alternating years to provide data that can be reviewed to determine if additional traffic and transportation projects may be justified.

5) That the City continues to provide staff with adequate resources to review and evaluate traffic conditions that may result in recommendations for capital projects.

6) That the City limits the acquisition of right of way for capital projects until all other alternatives have been implemented and/or evaluated.

7) That the City Council direct staff to look into the feasibility of adding a dedicated right turn lane and signal optimization at the intersection of Bake Parkway and Trabuco Road, with minimal impact to property owners.

8) That the City continue to monitor and check the model to ensure that there are not any additional potential enhancements to the arterial street system that the City Council may want to consider in the future.

ADJOURNMENT:

The Ad-Hoc Citizen Traffic Advisory Group Adjourned the December 22 Ad-Hoc Citizen Traffic Advisory Group Meeting at 9:38 p.m.

Respectfully submitted:	APPROVED:
_____	_____
AMBER HASTON	DAVE ROGERS
PUBLIC WORKS MANAGEMENT AIDE	TRAFFIC ENGINEERING MANAGER

Ad-Hoc Citizen Traffic Advisory Group Agenda Report
Meeting Date: January 26, 2016
Department: Public Works

SUBJECT:

STATUS REPORT ON CTAG TRAFFIC CONCERNS LIST

RECOMMENDED ACTION(S):

Receive and File.

DISCUSSION:

At the August 25, 2015 CTAG meeting, the members provided staff with an initial list of traffic and transportation topics and issues to cover and address as part of future meetings. In subsequent meetings, the Group has added and deleted items from the list. The current list is attached. This will be a standing item for all future CTAG agendas.

The topics and issues range from concerns about traffic signal operations at individual intersections to broad topics such as the status of the gap closure for Portola Parkway between Lake Forest and Irvine. Some of the items have been referred to the City's contractors and consultants for review. Many have been reviewed and addressed in previous meetings. The remaining items will be discussed in one of the future meetings.

ATTACHMENTS:

CTAG Traffic Concerns List

Initiated By:	David Rogers, P.E., T.E., Traffic Engineering Manager
Reviewed By:	Carlo Tomaino, Assistant to the City Manager
Approved By:	Thomas E. Wheeler, P.E., Director of Public Works/City Engineer

CTAG TRAFFIC CONCERNS

UNDER REVIEW				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
6	EL TORO HIGH SCHOOL TRAFFIC –CONCERN ABOUT GENERAL SCHOOL TRAFFIC	STOLL	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016
7	PROTECTED/PERMISSIVE	WIESKE	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016
9	SB TOLEDO WAY AT SERRANO RD. (POSSIBLE USE OF PROTECTED PERMISSIVE)	WIESKE	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016
10	SHASTA LAKE RD. AT SERRANO RD. (STATUS)	WIESKE	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016
12	STERLING SIGHT DISTANCE	IRISH	UNDER REVIEW	STAFF IS REVIEWING CONDITIONS; SIGHT DISTANCE STANDARDS WILL BE DISCUSSED WITH THE TRAFFIC ENGINEERING PRESENTATION IN JANUARY 2016
16	ROUND ABOUTS	WIESKE	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016

CTAG TRAFFIC CONCERNS

UNDER REVIEW				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
19	ACCIDENT/SAFETY DATA INFORMATION	WIESKE/DRAPKIN	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2016
38	REVIEW SERRANO CREEK UNDERCROSSING ON TRABUCO FOR BIKERS AND HIKERS	WEISKE	UNDER REVIEW	WILL BE INCLUDED WITH TRAFFIC ENGINEERING DISCUSSION IN JANUARY 2015
40	ADD TRAFFIC DELINEATORS TO NB TRABUCO, NORTH OF EL TORO	ARMANDO	UNDER REVIEW	REVIEW TO BE COMPLETED BY MARCH 2016

CTAG TRAFFIC CONCERNS

COMPLETE				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
1	EB LAKE FOREST DR. INTO MIMI'S – SIGNAL TIMING EXCESSIVE DELAY	STOLL	COMPLETE	ADJUSTMENTS MADE ON SEPT 15
2	EB LAKE FOREST DR. TO 241 TOLL ROAD TRAFFIC SIGNAL ISSUE (LOOP DOES NOT DETECT MOTORCYCLE)		COMPLETE	FORWARDED TO CALTRANS FOR ADJUSTMENT
3	SB ALISO PARK, LEFT TURN TO GO EB ON EL TORO RD. TRAFFIC SIGNAL ISSUE (LOOP DOES NOT DETECT MOTORCYCLE)		COMPLETE	ADJUSTED MADE ON SEPT 15
4	EL TORO RD. WB AT TOLEDO WAY (NEEDS TO STAY GREEN LONGER)	REDWINE	COMPLETE	SIGNAL TIMING WAS ADJUSTED ON 9/8/15
5	EB EL TORO RD. ON SERRANO (SCHOOL TIME – DEMAND EXCEEDS THE LENGTH)		COMPLETE	SIGNAL TIMING WAS ADJUSTED ON 9/8/15
8	EB BAKE PKWY. AT TRABUCO RD.	STOLL	COMPLETE	CTAG RECOMMENDED 3 THRU LANES & DEDICATED RIGHT
11	NB TOLEDO WAY NEEDS DUAL LEFT ONTO WB BAKE PKWY.		COMPLETE	NO CHANGE RECOMMENDED
13	SADDLEBACK RANCH RD. – REVIEW BIKE SAFETY/PORKCHOPS/PARKING NEAR CONCOURSE PARK	GLOVER	COMPLETE	INFORMATION PROVIDED 11/24/15
14	SKYRIDGE DEVELOPMENT	GLOVER	COMPLETE	INFORMATION PROVIDED 11/24/15
15	BIKE SAFETY/TRAIL ALONG RAILROAD/MULTI MODAL STREETS	WIESKE/DRAPKIN	COMPLETE	INCLUDED WITH GENERAL PLAN DISCUSSION ON 10/27/15
17	PORTOLA GAP CLOSURE	WIESKE	COMPLETE	INFORMATION PROVIDED 11/24/15

CTAG TRAFFIC CONCERNS

COMPLETE				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
20	STRATEGIC PLAN BACKLOG PROJECTS		COMPLETE	INCLUDED WITH CAPITAL PROJECT DISCUSSION ON 12/22/15
21	GENERAL PLAN CIRCULATION ELEMENTS	DRAPKIN & WIESKE	COMPLETE	INFORMATION PROVIDED 10/27/15
22	MONITORING DEVELOPMENT IN ADJACENT CITIES	DRAPKIN	COMPLETE	INFORMATION WAS INCLUDED WITH TRAFFIC MODELING DISCUSSION IN NOVEMBER 2015
23	ALL TRAFFIC SIGNALS ESPECIALLY ON ARTERIALS – TOO LONG RED OR GREEN LIGHTS DURING NON-PEAK TRAFFIC PERIODS	GROUP VIA JIM RICHERT	COMPLETE	CYCLE LENGTHS ARE USUALLY REDUCED BUT GREEN LIGHTS WILL EXTEND WITH MINIMAL TRAFFIC
24	NORTHBOUND BAKE AT TRABUCO – RIGHT LANE ON BAKE HAS BOTH RIGHT TURN AND STRAIGHT AHEAD ABILITY – LARGE TRAFFIC BACKUP	GROUP VIA JIM RICHERT	COMPLETE	FUTURE CAPITAL PROJECT TO ADD DEDICATED RIGHT TURN LANE
25	SERRANO AND LAKE FOREST – WESTBOUND ON SERRANO CROSSING LAKE FOREST – LEFT TURN LIGHT ONTO LF IS ALWAYS GREEN EVEN WITH NO LEFT TURN TRAFFIC	GROUP VIA JIM RICHERT	CLOSED – PROJECT UNDER CONSTRUCTION	THIS IS CURRENTLY A SPLIT PHASE INTERSECTION FOR SERRANO. CITY IS MODIFYING TO INSTALL PROTECTED LEFTTURNS MARCH 2016

CTAG TRAFFIC CONCERNS

COMPLETE				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
26	WESTBOUND TOLEDO AT BAKE – RIGHT LANE BACKUP ON TOLEDO DUE TO NO RIGHT TURN LANE	GROUP VIA JIM RICHERT	COMPLETE	DEDICATED RIGHT NOT JUSTIFIED BASED ON TRAFFIC MODEL
27	SOUTHBOUND LAKE FOREST AT TRABUCO – RIGHT LANE BACKUP ON LAKE FOREST DUE TO NO RIGHT TURN LANE ONTO TRABUCO	GROUP VIA JIM RICHERT	COMPLETE	DEDICATED RIGHT NOT JUSTIFIED BASED ON TRAFFIC MODEL
28	HOME DEPOT ENTRANCE ON RANCHO PARKWAY IN FOOTHILL RANCH – LEFT TURN LIGHT ON RANCHO PARKWAY INTO HOME DEPOT IS NOT NEEDED DUE TO VERY LOW TRAFFIC VOLUME ON RANCHO PARKWAY	GROUP VIA JIM RICHERT	COMPLETE	PROTECTED LEFT IS JUSTIFIED
29	BAKE PARKWAY BETWEEN TRABUCO AND 241 – TRAFFIC CONGESTION ON BAKE – WILL BE EVEN WORSE WITH 4000 NEW HOMES	GROUP VIA JIM RICHERT	COMPLETE	SIGNAL COORDINATION PROJECT UNDERWAY. TRAFFIC MODEL DOES NOT CALL FOR ADDITIONAL MITIGATIONS/WIDENING
30	MUIRLANDS AND RIDGE ROUTE – AT RUSH HOUR, EASTBOUND TRAFFIC ON MUIRLANDS BACKS UP TO DYLAN	GROUP VIA JIM RICHERT	CLOSED – PROJECT UNDER CONSTRUCTION	TRAFFIC SIGNAL SYNCHRONIZATION PROJECT TO BE COMPLETED IN EARLY 2016
31	MUIRLANDS AND DYLAN – RED LIGHT FOR MUIRLANDS TRAFFIC AT DYLAN EVEN THOUGH NO CROSS TRAFFIC ON DYLAN	GROUP VIA JIM RICHERT	CLOSED – PROJECT UNDER CONSTRUCTION	TRAFFIC SIGNAL SYNCHRONIZATION PROJECT TO BE COMPLETED IN EARLY 2016
32	EL TORO AND ARBOR – GREEN LIGHT FOR ARBOR TRAFFIC IS VERY LONG – EL TORO ROAD TRAFFIC DELAYED NEEDLESSLY	GROUP VIA JIM RICHERT	COMPLETE	PEDESTRIANS ARE COMMON AT THIS

CTAG TRAFFIC CONCERNS

COMPLETE				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
				LOCATION. PEDESTRIANS REQUIRE EXTENDED TIMES TO CROSS THIS WIDE SECTION OF EL TORO. OVERALL GREEN IS AT MINIMAL NECESSARY
33	EL TORO AT BRIDGER – TRAFFIC BACKS UP ON EL TORO AS THERE IS NO DEDICATED RIGHT TURN LANE ONTO BRIDGER	GROUP VIA JIM RICHERT	COMPLETE	DEDICATED RIGHT NOT JUSTIFIED BASED ON TRAFFIC MODEL
34	CHINOOK AND SERRANO LIGHT COORDINATION – A REAL TRAFFIC MESS – CHINOOK AND SERRANO LIGHTS ALWAYS RED FOR LAKE FOREST TRAFFIC	GROUP VIA JIM RICHERT	CLOSED – PROJECT UNDER CONSTRUCTION	CONTRACTOR ORDERING EQUIPMENT; TO BE COMPLETED 3/2016
35	SUNFLOWER AND ALTON – SUNFLOWER GETS GREEN LIGHT EVEN WHEN THERE IS NO TRAFFIC EXITING SUNFLOWER ONTO ALTON	GROUP VIA JIM RICHERT	COMPLETE	BICYCLE LOOP SENSITIVITY ADJUSTED.
36	TRABUCO BETWEEN BAKE AND EL TORO – GREEN LIGHT DURATION ALONG TRABUCO IS WAY TOO LONG DURING PEAK VOLUME TIMES DUE TO NEW SYNCHRONIZATION PROGRAM	GROUP VIA JIM RICHERT	COMPLETE	LONGER GREEN TIMES FOR THRU MOVEMENT IS TYPICAL FOR COORDINATION
37	LAKE FOREST AT JERONIMO – LEFT TURN LIGHT FROM SOUTHBOUND LAKE FOREST ONTO EASTBOUND JERONIMO IS TOO SHORT	GROUP VIA JIM RICHERT	COMPLETE	BACKUP OCCURS ONLY DURING SCHOOL AM AND PM PEAKS. MAXIMUM TIME ALREADY ALLOTTED
39	WIDEN BAKE PARKWAY	GLOVER	COMPLETE	INCLUDED WITH CAPITAL PROJECT

CTAG TRAFFIC CONCERNS

COMPLETE				
NO.	TRAFFIC CONCERNS	CTAG MEMBER	STATUS	COMMENTS
				DISCUSSION ON 12/22/15
41	TRABUCO/VIA DEL RIO, SIGNAL CYCLING INCORRECTLY	REDWINE	COMPLETE	CYCLE LENGTH CHECKED & ADJUSTED PER SYNCHRONIZATION PLAN

Ad-Hoc Citizen Traffic Advisory Group Agenda Report
Meeting Date: January 26, 2016
Department: Public Works

SUBJECT:

UPDATED WORK PLAN AND PRELIMINARY RECOMMENDATIONS LIST

RECOMMENDED ACTION(S):

Receive and File.

DISCUSSION:

At the December 22, 2015 CTAG meeting, the group revised the Work Plan for the remaining meetings. The revised Work Plan is as follows:

February	-	An Initial Review of CTAG Recommendations
March	-	Community Input Discussion
April	-	Finalization of Recommendations
May	-	A placeholder meeting with topics (if any) to be determined

Although staff will be presenting a formal item at the February meeting on the recommendations, staff thought it might be helpful for the Members to have a list of the recommendations through the first 5 meetings to review in advance of the February meeting. The item in February will include all the recommendations from the attached list and the recommendations from the January (tonight's) meeting.

ATTACHMENT:

Preliminary Summary of Recommendations

Initiated By:	David Rogers, P.E., T.E., Traffic Engineering Manager
Reviewed By:	Carlo Tomaino, Assistant to the City Manager
Approved By:	Thomas E. Wheeler, P.E., Director of Public Works/City Engineer

CITY OF LAKE FOREST
CITIZENS TRAFFIC ADVISORY GROUP

SUMMARY OF RECOMMENDATIONS

RECOMMENDATIONS
MEETING 2: SEPTEMBER 22, 2015 (TRAFFIC SIGNAL OPERATIONS)
The CTAG recommended that the City Council direct staff to proceed forward with the following proposed goals:
1. Minimize issues with individual traffic signals so that signals are operating at optimum condition at all times.
2. Have all traffic signal equipment in the cabinets meet or exceed all current standards and be compatible with future technology.
3. Have all traffic signals connected to our master system to insure consistent communication.
4. Continue to update coordination timing.
5. Evaluate the City's needs and review a possible upgrade to Adaptive Signal Control (ASC) – Long-term Goal
6. Pursue supplemental funding opportunities.
7. Review the potential use of camera equipment for the sole purpose of monitoring and improving traffic flow.
MEETING 3: OCTOBER 27, 2015 (GENERAL PLAN)
8. The CTAG supported the City's efforts to revise the General Plan and the Circulation Element.
MEETING 4: NOVEMBER 24, 2015 (TRAFFIC MODELING)
The CTAG recommended that the City Council consider 6 goals:

SUMMARY OF RECOMMENDATIONS

RECOMMENDATIONS
MEETING 4: NOVEMBER 24, 2015 (TRAFFIC MODELING CONTINUED)
9. That the City continue to update the Lake Forest Traffic Model (LFTM), as appropriate, and continue to use the latest modeling processes and techniques to insure that the LFTM represents the most accurate depiction of the City's traffic condition.
10. That the City continue to review and monitor the LFTM and update the prioritization of the projects, as appropriate, every 2 years.
11. That the City consider conducting biennial peak hour traffic counts at the intersections in the LFTM and other select locations to help track and identify changing traffic conditions. This will assist in the project prioritization process in the years between the full LFTM updates (usually conducted once every 5 years).
12. That the City consider entering into a master funding and project implementation agreement with the City of Irvine to help expedite project delivery.
13. That the City review possible modifications to existing projects or substitute projects and improvements within the framework of the LFTM for projects that have a potential significant impact on residential properties.
14. That the City monitor potential traffic issues in the City of Irvine pertaining to the development in and around the Great Park.
MEETING 5: DECEMBER 22, 2015 (CAPITAL PROJECTS)
The CTAG recommended that the City Council consider 8 goals:
15. That the City continue to use the Two Year CIP as the planning tool for near term traffic and transportation projects.
16. That the City continue to use the 5 Year Strategic Plan to identify projects for future consideration.
17. That the LFTM continue to be updated at appropriate intervals to identify the timing of LFTM improvements and to identify other potential projects.

SUMMARY OF RECOMMENDATIONS

RECOMMENDATIONS
MEETING 5: DECEMBER 22, 2015 (CAPITAL PROJECTS CONTINUED)
18. That the City continue to update both average daily traffic (ADT) counts and intersection counts in alternating years to provide data that can be reviewed to determine if additional traffic and transportation projects may be justified.
19. That the City continue to provide staff with adequate resources to review and evaluate traffic conditions that may result in recommendations for capital projects.
20. That the City limit the acquisition of right of way for capital projects until all other alternatives have been implemented and/or evaluated.
21. That the City Council direct staff to look into the feasibility of adding a dedicated right turn lane and signal optimization at the intersection of Bake Parkway and Trabuco Road, with minimal impact to property owners.
22. That the City continue to monitor and check the model to ensure that there are not any additional potential enhancements to the arterial street system that the City Council may want to consider in the future.

Ad-Hoc Citizen Traffic Advisory Group Agenda Report
Meeting Date: January 26, 2016
Department: Public Works

SUBJECT:

PRESENTATION AND DISCUSSION REGARDING TRAFFIC ENGINEERING AND RELATED TOPICS

RECOMMENDED ACTION(S):

1. Receive a presentation from the Public Works Department regarding general municipal traffic engineering and other related traffic engineering topics; and
2. Discuss and make findings and recommendations, as appropriate.

DISCUSSION:

For purposes of this report, traffic engineering is defined as the type of on-going activities performed in the Traffic Engineering Division. These activities include conducting various studies and reviews and responding to requests for service. Some activities occur on a daily basis, while others occur less frequently and can be random or planned.

Daily activities can include the following:

Reviewing the Ask Lake Forest (ALF) System

This is the City's web based complaint management system. This can be used to inform the City of any traffic related issues, comment on traffic or transportation related issues (this was used extensively for Saddleback Ranch Road) or to ask questions. The City prides itself on timely responses to ALF requests and so we attempt to resolve traffic issue quickly, wherever possible. Responses can sometimes be made immediately with the information that is already available. Other responses require field reviews and/or the preparation of work orders and/or other work to fully and accurately respond.

Field Reviews

Traffic engineering requires field reviews for many issues. In addition to issue

specific field reviews, it is considered good engineering practice to spend some time in the field every day. Daily field reviews can help identify issues with signage, striping, traffic signal operations and other issues that can affect traffic safety and circulation.

Consultant/Contractor Activity

In addition to daily work by City staff, we have consultants and contractors performing work on behalf of the City on a daily basis. Our traffic signal monitoring consultants check our traffic signal master control system logs every day to see if there are any issues that need to reviewed or addressed. Many of the issues can be addressed remotely through this system. However, some require field modification and reviews, which can be performed by the consultant or staff or both. In addition, the City's traffic signal maintenance contractor is in the City on a daily basis performing monthly preventative maintenance on the City's 91 traffic signals and/or performing extra work as it arises, such as replacing burned out bulbs.

Development Reviews

Currently there is ongoing development activity in the Opportunities Study Area (OSA) and other more routine development activity in the rest of the City. New development and modifications to existing developments requires a review by the Traffic Engineering Division. Plans are reviewed to make sure sight distance is adequate, to insure that parking and street widths are appropriate and that appropriate traffic control is provided (signing, striping, new and/or modified traffic signals, street lighting, etc...).

Typical Requests

Typical requests from the public include, but are not limited to, the following:

Requests to install stop signs
Requests to install traffic signals
Requests to review sight distance
Requests for school crossing guards
Requests for permit parking

For nearly every type of request, the City (and most every other agency) uses standards established at the State and national level to determine if any changes to traffic controls should be considered. These standards incorporate decades of research, empirical data, driver behavioral information and other factors to help

agencies decide if and when to consider traffic controls. The goal of using these standards is to create consistency for drivers regardless of where they are driving and to create respect for and compliance with those traffic controls that are installed.

Some of the standards that the City uses include:

- The California Manual on Uniform Traffic Control Devices (CAMUTCD). This is a modified version of the national MUTCD.
- The Institute of Transportation Engineers (ITE) Traffic Engineering Manual
- California Department of Transportation (Caltrans) Design Manual

For many traffic control devices, such as stop signs and traffic signals, warrants (justifications) are used to see if minimum conditions exist to consider installing the devices. It is important to note that meeting one or more minimum warrants is not, in and of itself, justification to install a device. Usually other less restrictive measures are tried first and only if they do not address the issue should other devices be considered. In all cases engineering judgement also plays an important role as every condition is unique. The warrants usually involve quantifiable information such as traffic counts and/or pedestrian counts, traffic speeds and other similar information (see attached warrant information for traffic signals).

A common request is to ask for a traffic control device to address an issue that is not related directly to the purpose of the device. One of the most common ones is to install a stop sign as a speed control device. For these situations, the City needs to explain why the device is not appropriate and to suggest other ways to address the concern. Attached is an example of a public information handout that we use for stop signs.

Other On-Going Activities:

It is considered good engineering practice to conduct specific traffic engineering reviews on a regular basis. Some of the most important and useful ones are described below:

Traffic Collision Review

Reviewing traffic collision data is an especially effective method to help identify potential traffic safety issues. Generally, an annual review of the latest 12 month period for which data is available is the most effective, since it can help identify reasonably current trends and patterns that may require further review. For this

type of review, it is important to not only identify locations with the highest collision totals, but to also identify the locations with the highest collision rates. The collision rate takes into account traffic volume so you can compare locations equally (for intersections this is usually expressed as collisions per millions entering vehicles). The information is then compared to regional and local statistical baselines and other accepted comparison information to determine if additional reviews are justified.

Reviewing individual collision reports is also an important part of the collision review process. Currently, staff reviews the individual collision reports prepared by the Orange County Sheriff's Department as they become available throughout the year. This review process can provide information on specific conditions that may need to be reviewed such as when an involved party suggests that there may have been a burned out bulb or was unclear about what a particular sign meant. The reports also provide valuable information on the direction of travel of the involved vehicles; the specific violation type; the at-fault individual; and other relevant information, which helps to provide the full and compressive overview of collision history.

At this time the City of Lake Forest does not have an automated (traffic engineering centric) system in place to quickly and effectively review collision patterns or trends. Staff does use the information that is available to help analyze individual issues, but cannot realistically provide the more comprehensive citywide analysis.

Recommendations:

1. That the City Procure a Traffic Collision Analysis Program

Internet based traffic collision analysis programs are offered by several companies. The one that staff has used in the past is known as Crash Magic (see attached information). These programs allow for extensive and comprehensive reviews of traffic collision data. This tool not only helps to quickly and effectively identify traffic collision patterns and trends as part of an annual review, but can help in the review and analysis of individual traffic issues.

2. That the Orange County Sheriff's Department (OCSD) continue to take as many collision reports, as time and personnel permits, to provide the most complete data base possible for traffic engineering review and analysis.

Having as much data as possible for all type of collisions is essential to be able to conduct the most thorough and accurate analysis of traffic collision patterns

and trends. For example, if for some reason an agency decided to only take reports for injury collisions and not property damage collisions, this could leave half or more of the collision unreported. The difference between an injury collision and a non-injury collision can be as little as 1 mph, but both collisions may be an indicator of some larger issue.

3. That the City Maintain Individual Collison Records for a Period of Five Years

The information in individual collision reports provides important detail for collision analysis. Since 5 years is a typical collision history time frame for review, it is appropriate to maintain the individual collision reports for this period of time.

Annual School Review

Reviewing traffic conditions in and around schools is an important part of an overall traffic management and safety program. The City currently conducts these reviews on a biennial basis. Most of the schools in the City have been in operation for extended periods of time and therefore traffic patterns are fairly well established. Observing traffic in the morning and afternoon however can help to determine if patterns have changed and if any changes to traffic control may be appropriate. As an example, recent observations at Portola Hills Elementary School (opened 20+ years ago) indicated that some parents were dropping off their children in a “no stopping zone”. The zone was signed appropriately, but staff decided to change the area to red curb, since this is generally more effective near schools.

Recommendation:

Since traffic patterns can change over time, staff is recommending that the traffic conditions at all schools be reviewed on an annual basis. This would include staff reviews during peak periods and discussions with school personnel (Principal and/or District personnel).

Preparation of School Route Plans

Students that walk (either on their own at an appropriate age or with adult supervision) derive obvious health benefits associated with walking and also develop important life skills such as how to safely cross streets as a pedestrian, etc.…). In addition, more students walking, means fewer cars and less traffic congestion. Many of the school in Lake Forest are in compact neighborhoods and/or in relatively flat areas of the City that make walking a very viable

alternative to being driven to school. In order to promote walking, the CAMUTCD suggests that agencies consider preparing school route plans (formerly known as Suggested Route to School maps) to help guide and direct students and parents on the routes that take advantage of the traffic controls in the area (see attached). These maps are developed in coordination with school representatives and law enforcement and then distributed to the students (usually at the start of school).

Recommendation:

Staff is recommending that the City work with the SVUSD and OCSD to develop school route plans for each of the public schools in the City.

Traffic Signal Master Plan

The City regularly receives requests to review intersections for the possible installation of traffic signals. These requests often follow collisions that the individual believe could have been prevented by a traffic signal. At this time, the City will review the available data and respond appropriately. Usually this will resolve the issue, but occasionally the individuals are not satisfied and request (or want to appeal) this to someone else (the Director or in some cases the City Council).

Regularly reviewing intersections that may meet one or more traffic signal warrants can not only allow the City to monitor changing traffic conditions, but can assist the City is responding to these types of common requests. A formalized review consists of collecting traffic counts and reviewing the traffic collision analysis for each intersection in the study. This information is then used to determine if any warrants are met. Field observations are also conducted to assess the overall traffic conditions. Even if traffic signals are not recommended for installation, the process can sometimes identify other minor changes that can be made to improve overall traffic operations and/or improve traffic safety.

This ongoing process is also very helpful in responding to the individual request to install signals. In most cases, the intersections would be part of the study list of locations and therefore the City can indicate that it had been reviewed recently and is reviewed on a regular basis. If the intersection is not part of the list, it can be added to the list for future review. In either case, having a process in place allows the City to respond in a uniform and consistent manner to these requests.

Recommendation:

Staff is recommending that the City review select non-signalized intersections in the City once every 2-3 years to determine if any new traffic signals should be considered for installation.

Traffic Sign Reflectivity Reviews

In order for traffic control signs to be effective they must first be seen. Traffic control signs on the public streets are reflectorized so they can be seen at night and in some cases better in the day (with certain type of reflective sheeting). The CAMUTCD requires that the local agencies conduct periodic surveys to determine which signs no longer meet the minimum reflectivity standards (see attached). The City conducted the latest review in 2012 for all the major streets in the City. A group of signs was identified for replacement and the City is currently in the 3rd year of the replacement program. Based on the latest update to the CAMUTCD, the City should conduct a survey as necessary to maintain minimum reflectivity as outlined in the CAMUTCD. The City is currently seeking competitive proposals to provide street maintenance services with a new contract to be awarded for the beginning of fiscal year 16/17. The contract will require the contractor to conduct a new retro reflectivity study of all the signs in the City. This will then be the basis for additional funding requests to replace signs that do not meet the minimum requirements.

Recommendation:

Staff is recommending that the City continue to conduct traffic control sign retro reflectivity reviews as necessary to comply with applicable standard and that the City continue to provide funding to complete the sign replacements.

Specific CTAG Requests

As part of the first CTAG meeting, the members identified specific issues that they wanted to discuss. Several of the issues involve traffic engineering. These items are discussed below.

Protective Permissive Left Turn Phasing

Protected/permissive left turn phasing (PPLTP) allows left turning drivers to have a fully protected left turn movement typically followed by a permissive movement where left turning drivers may make left turns when there are appropriate gaps in opposing traffic. The CAMUTCD offers minimal guidance on when PPLTP might

be appropriate. However, other resources describe some of the advantages and disadvantages.

Advantages include:

A reduction in average delay per left-turn vehicle.
A reduction in fuel consumption and pollution.

Disadvantages include:

The permissive phase increases the potential for vehicle-vehicle and vehicle-pedestrian conflicts.
There is a limited ability to use lead-lag phase sequences (commonly used in coordination programing).
Driver confusion and resistance to change.

In the mid 1990's and early 2000's, cities in Orange County were beginning to consider the use of PPLTP. In some cases, PPLTP was installed, with many of them being conversions from fully protected. In order to provide some guidelines and to promote uniformity in the County, the Orange County Traffic Engineering Council (OCTEC) in 1995 prepared the Protected/Permissive Left Turn Phasing Design and Operational Guidelines. This document was last updated in 2001 (see attached). Generally, the document provides information on the types of traffic conditions where PPLTP could be considered and the design of the traffic signal indications.

Some of the conditions where PPLTP is discouraged include streets with speed limits of 45 mph or greater; streets where drivers would turn across 3 or more lanes; streets where there are inadequate gaps during peak hours and/or non-peak hours; and streets with dual left turns. This criteria would generally mean that most signalized intersections in the City of Lake Forest would not be considered good candidates for PPLTP.

The current Traffic Engineering Manager and the City's Traffic Engineering Consultant, Doug Anderson, have both been involved in projects in the past to convert traffic signals with protected left turns to PPLTP. In the mid-1990's, the City of Laguna Niguel converted about 6 traffic signals to PPLTP. Traffic collisions increased at the intersections and the City eventually removed all the PPLTP. The City of Tustin has a similar experience, but they did leave a couple locations with PPLTP.

In the case of Laguna Niguel, the City concluded that most residents had no experience with PPLTP and therefore did not understand the operation. Based on collision reports many drivers assumed that it was simply another form of fully protected left turns. If PPLTP had been in wide use in south Orange County prior to the City using PPLTP, then perhaps there would have been better understanding and acceptance.

Conclusion:

Based on staff's prior experience; the OCTEC guidelines that suggest that most locations in the City may not be good candidates; and the general lack of familiarity with PPLTP in South Orange County, staff would not recommend the use of PPLTP in Lake Forest. Modifications to traffic signal operations or timing can be used in place of PPLTP to partially address some of the concerns associated with fully protected left turn phasing, particularly at minor intersections.

Roundabouts/Traffic Circles

Roundabouts are one way circular intersections without traffic signals in which traffic flows around a center island. Generally roundabouts can be effective with one or two lane approaches. Modern roundabouts for larger streets require a substantial amount of space (significantly more than a traditional intersection) and are therefore best suited for new intersections. According to available information there are approximately 25 roundabouts in Orange County. Most of them are single lane approaches in residential areas. In the City of Lake Forest there is one at the intersection of Dimension and Monarch/Catalina in the new Shea Bake Ranch community and another one proposed for the new Irvine Ranch Water District (IRWD) development at the entrance to the new Civic Center.

The major benefits of roundabouts are that they generally have fewer and less severe collisions than traditional traffic signal controlled intersections and generally allow for constant movement of vehicles in all directions. A disadvantage is that they begin to lose operational efficiency with more than two approach lanes or when traffic volumes exceed certain thresholds. They are also difficult for pedestrians to navigate especially for visually impaired pedestrians.

Conclusion:

Modern roundabout can be effective and efficient in lower speed/lower volume environments, such as in residential areas. Roundabouts require significantly more right of way than traditional intersections and therefore are best suited for intersections in new developments where appropriate right of way can be allocated for construction.

Shasta Lake Road at Serrano Road

Group Member Wieske asked that this intersection be brought up for discussion. At the time of the writing of the report, staff had not been able to contact Member Wieske to get information on the specific concerns. As you can see on the attached aerial, this is a t-intersection in a residential area. Shasta Lake (a residential street) intersects Serrano (a 2 lane collector street) at the inside of a curve and therefore this can reduce sight distance. Currently there are t-Intersection warning signs in both directions on Serrano approaching Shasta Lake, as well as a curve warning sign for westbound Serrano. The eastbound t-intersection sign and the westbound curve warning sign are supplemented with a 35 mph advisory speed limit. In addition, there is a dedicated right turn lane for eastbound Serrano, which not only separates the right turning traffic from the through traffic, but also acts to guide vehicles closer to the centerline, thereby increasing sight distance. This is an example of the creative side of traffic engineering where a striping change can have more than one benefit. Overall the sight distance meets the minimum required and there is minimal collision history, which suggests that there are no unusual conditions at this intersection.

Conclusion:

Based on the information available at the time of the writing of this report, staff concluded that no additional traffic controls are justified at this time.

Lake Forest/Sterling

Group Member Irish asked that the sight distance be reviewed at this t-intersection. In this area, Lake Forest Drive is a 4 lane arterial roadway carrying about 24,000 vehicles per day. Sterling is a typical residential street. There is both horizontal and vertical curvature at this intersection, which limits sight distance. Staff completed several field observations and measurements and found that the sight distance for a properly positioned vehicle exiting Sterling meets the minimum required. There are also appropriately placed t-intersection warning signs in both directions on Lake Forest approaching Sterling. The traffic

collision history is minimal, which suggests that there are no unusual conditions. During one of the field reviews, staff did notice that a portion of the landscaping on the HOA owned and maintained slope east of Sterling could be trimmed to further enhance sight distance. Staff will contact the HOA and request that they trim and modify the landscaping.

Conclusion:

Sight distance does meet the minimum required for the current conditions. Staff will work with the HOA to see if sight distance in one direction can be enhanced by modifying landscaping on the slope east of Sterling.

Trabuco/El Toro

Group Member Armando asked that the City look at turn movements out of the shopping center on the northeast corner to see if the City should consider installing some type of delineators or other devices to prevent certain turns onto Trabuco. Staff reviewed the traffic conditions and found that both driveways on Trabuco are restricted to right turn only by painted or raised medians. Staff did note that there is limited signing and striping to help reinforce these restrictions for drivers exiting the center. Generally we like to use an incremental approach to traffic control, so staff will be contacting the management company for the center to ask them to install appropriate signing and/or striping to help inform drivers of the right turn only restrictions.

Conclusion:

Staff will be contacting the management company for the center to ask them to install appropriate signing and/or striping to help inform drivers of the right turn only restrictions.

El Toro High School

Group Member Stoll asked that a discussion item be added to review the overall traffic circulation in and around El Toro High School. Staff had previously worked with the City's traffic consultant to try and improve conditions at the two traffic signals on El Toro that are used to access the school. In addition, changes to the traffic controls near the school were made a few years ago when the stadium was expanded. As with any school there are unique traffic issues and travel patterns. High schools are unique in that you have students walking, driving and being dropped off/picked up.

Recommendation:

That the CTAG review and discuss any specific concerns on this issue and then direct staff to include a comprehensive review as part of the next annual school review process noted above.

Serrano Creek Trail Crossing at Trabuco

Member Wieske asked for a review of possible undercrossing for Serrano Creek Trail at Trabuco. Serrano Creek Trail begins near Bake/Toledo and continues all the way to Whiting Ranch beyond the 241 toll road and Portola Parkway. At both the 241 and Portola Parkway the trail goes under the roadways. At this time, trail users must cross Trabuco at-grade at the traffic signal at Peachwood (about 100 feet from the trail). The signal is set to provide a dedicated pedestrian/bike phase across the south leg of the intersection, which minimizes potential vehicle conflicts. Any type of undercrossing such as new bridge with a path or a tunnel would be a capital improvement project that would have to compete with other projects. At this time, this project is not included in the 2 year CIP or the 5 year Strategic Plan.

Recommendation:

At this time, this is not a listed capital project in either the 2 Year CIP or the 5 Year Strategic Plan. The CTAG should review and discuss this issue and decide if this project should be recommended for inclusion in either plan.

Trabuco/Lake Forest

At the December CTAG meeting, Group Member Irish brought up concerns about making right turns from northbound Trabuco to eastbound Lake Forest. He specifically mentioned making the right turn on red into the lane closest to the curb (the #3) lane often requires you to accelerate rapidly because the lane ends about 200 east of Trabuco. This #3 lane is actually the ending of the #3 through lane on Lake Forest and is not a right turn acceleration lane. Right turn acceleration lanes are typically 350 feet or more in length and do exist at some locations in the City including at Lake Forest/Rockfield and at Lake Forest/Muirlands.

Conclusion:

Because of the relatively rapid narrowing of eastbound Lake Forest east of Trabuco, it is not feasible to lengthen the lane. In this specific case, staff would

recommend that anyone that has concerns about making this right turn on red either wait until they can directly enter the #2 lane or wait for the green (as you are not required at any time to make a right turn on red).

Summary of Recommendations/Conclusions

The summary of recommendations and conclusions listed in the body of the report are as follows:

Recommendations

1. That the City procure a Traffic Collision Analysis Program.

2. That the Orange County Sheriff's Department (OCSD) continue to take as many collision reports, as time and personnel permits, to provide the most complete data base possible for traffic engineering review and analysis.

3. That the City maintain individual collision records for a period of five years

4. Since traffic patterns can change over time, staff is recommending that the traffic conditions at all schools be reviewed on an annual basis. This would include staff reviews during peak periods and discussions with school personnel (Principal and/or District personnel).

5. Staff is recommending that the City work with the SVUSD and OCSD to develop school route plans for each of the public schools in the City.

6. Staff is recommending that the City review select non-signalized intersections in the City once every 2-3 years to determine if any new traffic signals should be considered for installation.

7. Staff is recommending that the City continue to conduct traffic control sign retro reflectivity reviews as necessary to comply with applicable standard and that the City continue to provide funding to complete the sign replacements.

8. That the CTAG review and discuss any specific concerns about El Toro High School traffic patterns and circulation and then direct staff to include a comprehensive review as part of the next annual school review process.

9. At this time, a trail crossing under Trabuco Road is not a listed capital project in either the 2 Year CIP or the 5 Year Strategic Plan. The CTAG

should review and discuss this issue and decide if this project should be recommended for inclusion in either plan.

Conclusions

1. Based on staff's prior experience; the OCTEC guidelines that suggest that most locations in the City may not be good candidates; and the general lack of familiarity with PPLTP in South Orange County, staff would not recommend the use of PPLTP in Lake Forest. Modifications to traffic signal operations or timing can be used in place of PPLTP to partially address some of the concerns associated with fully protected left turn phasing, particularly at minor intersections.

2. Modern roundabout can be effective and efficient in lower speed/lower volume environments, such as in residential areas. Roundabouts require significantly more right of way than traditional intersections and therefore are best suited for intersections in new developments where appropriate right of way can be allocated for construction.

3. Based on the information available at the time of the writing of this report, staff concluded that no additional traffic controls are justified at Serrano/Shasta Lake at this time.

4. Sight distance at Lake Forest/Sterling does meet the minimum required for the current conditions. Staff will work with the HOA to see if sight distance in one direction can be enhanced by modifying landscaping on the slope east of Sterling.

5. Staff will be contacting the management company for the center on the northeast corner of El Toro/Trabuco to ask them to install appropriate signing and/or striping to help inform drivers of the right turn only restrictions.

6. Because of the relatively rapid narrowing of eastbound Lake Forest east of Trabuco, it is not feasible to lengthen the lane. In this specific case, staff would recommend that anyone that has concerns about making this right turn on red either wait until they can directly enter the #2 lane or wait for the green (as you are not required at any time to make a right turn on red).

ATTACHMENTS:

1. Traffic Signal Warrants - excerpts
2. Stop Sign Informational Handout
3. Crash Magic Information
4. School Route Map Information
5. Sign Retro reflectivity Information
6. OCTEC PPLTP Guidelines
7. Roundabout Information from ITE
8. Shasta Lake/Serrano – Aerial
9. Lake Forest/Sterling – Aerial
10. Trabuco/El Toro – Aerial
11. El Toro High School – Aerial
12. Trabuco/Serrano Creek Trail – Aerial
13. Lake Forest/Trabuco - Aerial

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Reviewed By:	Thomas E. Wheeler, Director of Public Works/City Engineer
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CHAPTER 4C. TRAFFIC CONTROL SIGNAL NEEDS STUDIES

Section 4C.01 Studies and Factors for Justifying Traffic Control Signals

Standard:

01 **An engineering study of traffic conditions, pedestrian characteristics, and physical characteristics of the location shall be performed to determine whether installation of a traffic control signal is justified at a particular location.**

01a **On State highways, the engineering study shall include consideration of a roundabout (yield control). If a roundabout is determined to provide a viable and practical solution, it shall be studied in lieu of, or in addition to a traffic control signal.**

Guidance:

01b *On local streets and highways, the engineering study should include consideration of a roundabout (yield control). If a roundabout is determined to provide a viable and practical solution, it should be studied in lieu of, or in addition to a traffic control signal.*

Support:

01c Refer to Caltrans' website (http://www.dot.ca.gov/hq/traffops/liaisons/ice.html) for more information on the Traffic Operations Policy Directive 13-02, Intersection Control Evaluation (ICE), and other resources for the evaluation of intersection traffic control strategies.

02 **The investigation of the need for a traffic control signal shall include an analysis of factors related to the existing operation and safety at the study location and the potential to improve these conditions, and the applicable factors contained in the following traffic signal warrants:**

Warrant 1, Eight-Hour Vehicular Volume
Warrant 2, Four-Hour Vehicular Volume
Warrant 3, Peak Hour
Warrant 4, Pedestrian Volume
Warrant 5, School Crossing
Warrant 6, Coordinated Signal System
Warrant 7, Crash Experience
Warrant 8, Roadway Network
Warrant 9, Intersection Near a Grade Crossing

03 **The satisfaction of a traffic signal warrant or warrants shall not in itself require the installation of a traffic control signal.**

Support:

04 Sections 8C.09 and 8C.10 contain information regarding the use of traffic control signals instead of gates and/ or flashing-light signals at highway-rail grade crossings and highway-light rail transit grade crossings, respectively.

Guidance:

05 *A traffic control signal should not be installed unless one or more of the factors described in this Chapter are met.*

06 *A traffic control signal should not be installed unless an engineering study indicates that installing a traffic control signal will improve the overall safety and/or operation of the intersection.*

07 *A traffic control signal should not be installed if it will seriously disrupt progressive traffic flow.*

08 *The study should consider the effects of the right-turn vehicles from the minor-street approaches. Engineering judgment should be used to determine what, if any, portion of the right-turn traffic is subtracted from the minor-street traffic count when evaluating the count against the signal warrants listed in Paragraph 2.*

09 *Engineering judgment should also be used in applying various traffic signal warrants to cases where approaches consist of one lane plus one left-turn or right-turn lane. The site-specific traffic characteristics should dictate whether an approach is considered as one lane or two lanes. For example, for an approach with one lane for through and right-turning traffic plus a left-turn lane, if engineering judgment indicates that it should be considered a one-lane approach because the traffic using the left-turn lane is minor, the total traffic volume approaching the intersection should be applied against the signal warrants as a one-lane approach. The*

approach should be considered two lanes if approximately half of the traffic on the approach turns left and the left-turn lane is of sufficient length to accommodate all left-turn vehicles.

10 *Similar engineering judgment and rationale should be applied to a street approach with one through/left-turn lane plus a right-turn lane. In this case, the degree of conflict of minor-street right-turn traffic with traffic on the major street should be considered. Thus, right-turn traffic should not be included in the minor-street volume if the movement enters the major street with minimal conflict. The approach should be evaluated as a one-lane approach with only the traffic volume in the through/left-turn lane considered.*

11 *At a location that is under development or construction and where it is not possible to obtain a traffic count that would represent future traffic conditions, hourly volumes should be estimated as part of an engineering study for comparison with traffic signal warrants. Except for locations where the engineering study uses the satisfaction of Warrant 8 to justify a signal, a traffic control signal installed under projected conditions should have an engineering study done within 1 year of putting the signal into stop-and-go operation to determine if the signal is justified. If not justified, the signal should be taken out of stop-and-go operation or removed.*

12 *For signal warrant analysis, a location with a wide median, even if the median width is greater than 30 feet, should be considered as one intersection.*

Option:

13 At an intersection with a high volume of left-turn traffic from the major street, the signal warrant analysis may be performed in a manner that considers the higher ~~of the major-street left-turn volumes as the "minor-street" volume and the corresponding single direction of opposing traffic on the major street as the "major-street" volume~~ volume of the major-street left-turn volumes plus the higher volume minor-street approach as the "minor street" volume and both approaches of the major street minus the higher of the major-street left-turn volume as "major street" volume.

14 For signal warrants requiring conditions to be present for a certain number of hours in order to be satisfied, any four sequential 15-minute periods may be considered as 1 hour if the separate 1-hour periods used in the warrant analysis do not overlap each other and both the major-street volume and the minor-street volume are for the same specific one-hour periods.

15 For signal warrant analysis, bicyclists may be counted as either vehicles or pedestrians.

Support:

16 When performing a signal warrant analysis, bicyclists riding in the street with other vehicular traffic are usually counted as vehicles and bicyclists who are clearly using pedestrian facilities are usually counted as pedestrians.

Option:

17 Engineering study data may include the following:

A. The number of vehicles entering the intersection in each hour from each approach during 12 hours of an average day. It is desirable that the hours selected contain the greatest percentage of the 24-hour traffic volume.
B. Vehicular volumes for each traffic movement from each approach, classified by vehicle type (heavy trucks, passenger cars and light trucks, public-transit vehicles, and, in some locations, bicycles), during each 15-minute period of the 2 hours in the morning and 2 hours in the afternoon during which total traffic entering the intersection is greatest.
C. Pedestrian volume counts on each crosswalk during the same periods as the vehicular counts in Item B and during hours of highest pedestrian volume. Where young, elderly, and/or persons with physical or visual disabilities need special consideration, the pedestrians and their crossing times may be classified by general observation.
D. Information about nearby facilities and activity centers that serve the young, elderly, and/or persons with disabilities, including requests from persons with disabilities for accessible crossing improvements at the location under study. These persons might not be adequately reflected in the pedestrian volume count if the absence of a signal restrains their mobility.
E. The posted or statutory speed limit or the 85th-percentile speed on the uncontrolled approaches to the location.
F. A condition diagram showing details of the physical layout, including such features as intersection geometrics, channelization, grades, sight-distance restrictions, transit stops and routes, parking conditions,

pavement markings, roadway lighting, driveways, nearby railroad crossings, distance to nearest traffic control signals, utility poles and fixtures, and adjacent land use.

G. A collision diagram showing crash experience by type, location, direction of movement, severity, weather, time of day, date, and day of week for at least 1 year.

18 The following data, which are desirable for a more precise understanding of the operation of the intersection, may be obtained during the periods described in Item B of Paragraph 17:

A. Vehicle-hours of stopped time delay determined separately for each approach.

B. The number and distribution of acceptable gaps in vehicular traffic on the major street for entrance from the minor street.

C. The posted or statutory speed limit or the 85th-percentile speed on controlled approaches at a point near to the intersection but unaffected by the control.

D. Pedestrian delay time for at least two 30-minute peak pedestrian delay periods of an average weekday or like periods of a Saturday or Sunday.

E. Queue length on stop-controlled approaches.

Standard:

19 **Delay, congestion, approach conditions, driver confusion, future land use or other evidence of the need for right of way assignment beyond that which could be provided by stop sign shall be demonstrated.**

Support:

20 Figure 4C–101(CA) and 4C-103(CA) are examples of warrant sheets.

Guidance:

21 *Figure 4C-103(CA) should be used only for new intersections or other locations where it is not reasonable to count actual traffic volumes.*

Section 4C.02 Warrant 1, Eight-Hour Vehicular Volume

Support:

01 The Minimum Vehicular Volume, Condition A, is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

02 The Interruption of Continuous Traffic, Condition B, is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street.

03 It is intended that Warrant 1 be treated as a single warrant. If Condition A is satisfied, then Warrant 1 is satisfied and analyses of Condition B and the combination of Conditions A and B are not needed. Similarly, if Condition B is satisfied, then Warrant 1 is satisfied and an analysis of the combination of Conditions A and B is not needed.

Standard:

04 **The need for a traffic control signal shall be considered if an engineering study finds that one of the following conditions exist for each of any 8 hours of an average day:**

A. The vehicles per hour given in both of the 100 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; or

B. The vehicles per hour given in both of the 100 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

In applying each condition the major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of these 8 hours.

Option:

05 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 70 percent columns in Table 4C-1 may be used in place of the 100 percent columns.

Guidance:

06 *The combination of Conditions A and B is intended for application at locations where Condition A is not satisfied and Condition B is not satisfied and should be applied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems.*

Standard:

07 **The need for a traffic control signal shall be considered if an engineering study finds that both of the following conditions exist for each of any 8 hours of an average day:**

A. The vehicles per hour given in both of the 80 percent columns of Condition A in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection; and

B. The vehicles per hour given in both of the 80 percent columns of Condition B in Table 4C-1 exist on the major-street and the higher-volume minor-street approaches, respectively, to the intersection.

These major-street and minor-street volumes shall be for the same 8 hours for each condition; however, the 8 hours satisfied in Condition A shall not be required to be the same 8 hours satisfied in Condition B. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Option:

08 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.03 Warrant 2, Four-Hour Vehicular Volume

Support:

01 The Four-Hour Vehicular Volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that, for each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) all fall above the applicable curve in Figure 4C-1 for the existing combination of approach lanes. On the minor street, the higher volume shall not be required to be on the same approach during each of these 4 hours.**

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-2 may be used in place of Figure 4C-1.

Section 4C.04 Warrant 3, Peak Hour

Support:

01 The Peak Hour signal warrant is intended for use at a location where traffic conditions are such that for a minimum of 1 hour of an average day, the minor-street traffic suffers undue delay when entering or crossing the major street.

Standard:

02 **This signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.**

03 **The need for a traffic control signal shall be considered if an engineering study finds that the criteria in either of the following two categories are met:**

A. If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:

1. The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach; and

2. The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes; and

3. The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.

B. The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

Option:

04 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-4 may be used in place of Figure 4C-3 to evaluate the criteria in the second category of the Standard.

05 If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal may be operated in the flashing mode during the hours that the volume criteria of this warrant are not met.

Guidance:

06 *If this warrant is the only warrant met and a traffic control signal is justified by an engineering study, the traffic control signal should be traffic-actuated.*

Section 4C.05 Warrant 4, Pedestrian Volume

Support:

01 The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Standard:

02 **The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that one of the following criteria is met:**

A. For each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure 4C-5; or

B. For 1 hour (any four consecutive 15-minute periods) of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) falls above the curve in Figure 4C-7.

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 35 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-6 may be used in place of Figure 4C-5 to evaluate Criterion A in Paragraph 2, and Figure 4C-8 may be used in place of Figure 4C-7 to evaluate Criterion B in Paragraph 2.

Standard:

04 **The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal or STOP sign controlling the street that pedestrians desire to cross is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.**

05 **If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads complying with the provisions set forth in Chapter 4E.**

Guidance:

06 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.

B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site

accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.

C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.

Option:

07 The criterion for the pedestrian volume crossing the major street may be reduced as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second.

08 A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street.

Section 4C.06 Warrant 5, School Crossing

Support:

01 The School Crossing signal warrant is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "schoolchildren" includes elementary through high school students.

Standard:

02 **The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of schoolchildren at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the schoolchildren are using the crossing is less than the number of minutes in the same period (see Section 7A.03) and there are a minimum of 20 schoolchildren during the highest crossing hour.**

03 **Before a decision is made to install a traffic control signal, consideration shall be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.**

04 **The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.**

Guidance:

05 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.

B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.

C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.

Section 4C.07 Warrant 6, Coordinated Signal System

Support:

01 Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that one of the following criteria is met:**

A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning.

B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation.

Guidance:

03 *The Coordinated Signal System signal warrant should not be applied where the resultant spacing of traffic control signals would be less than 1,000 feet.*

Section 4C.08 Warrant 7, Crash Experience

Support:

01 The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:**

A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and

B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and

C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (see Section 4C.02), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 40 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, the traffic volumes in the 56 percent columns in Table 4C-1 may be used in place of the 80 percent columns.

Section 4C.09 Warrant 8, Roadway Network

Support:

01 Installing a traffic control signal at some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that the common intersection of two or more major routes meets one or both of the following criteria:**

A. The intersection has a total existing, or immediately projected, entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and has 5-year projected traffic volumes, based on an engineering study, that meet one or more of Warrants 1, 2, and 3 during an average weekday; or

B. The intersection has a total existing or immediately projected entering volume of at least 1,000 vehicles per hour for each of any 5 hours of a non-normal business day (Saturday or Sunday).

03 **A major route as used in this signal warrant shall have at least one of the following characteristics:**

A. It is part of the street or highway system that serves as the principal roadway network for through traffic flow.

B. It includes rural or suburban highways outside, entering, or traversing a city.

C. It appears as a major route on an official plan, such as a major street plan in an urban area traffic and transportation study.

Section 4C.10 Warrant 9, Intersection Near a Grade Crossing

Support:

01 The Intersection Near a Grade Crossing signal warrant is intended for use at a location where none of the conditions described in the other eight traffic signal warrants are met, but the proximity to the intersection of a

grade crossing on an intersection approach controlled by a STOP or YIELD sign is the principal reason to consider installing a traffic control signal.

Guidance:

02 *This signal warrant should be applied only after adequate consideration has been given to other alternatives or after a trial of an alternative has failed to alleviate the safety concerns associated with the grade crossing. Among the alternatives that should be considered or tried are:*

A. Providing additional pavement that would enable vehicles to clear the track or that would provide space for an evasive maneuver, or

B. Reassigning the stop controls at the intersection to make the approach across the track a non-stopping approach.

Standard:

03 **The need for a traffic control signal shall be considered if an engineering study finds that both of the following criteria are met:**

A. A grade crossing exists on an approach controlled by a STOP or YIELD sign and the center of the track nearest to the intersection is within 140 feet of the stop line or yield line on the approach; and

B. During the highest traffic volume hour during which rail traffic uses the crossing, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the minor-street approach that crosses the track (one direction only, approaching the intersection) falls above the applicable curve in Figure 4C-9 or 4C-10 for the existing combination of approach lanes over the track and the distance D, which is the clear storage distance as defined in Section 1A.13.

Guidance:

04 *The following considerations apply when plotting the traffic volume data on Figure 4C-9 or 4C-10:*

A. Figure 4C-9 should be used if there is only one lane approaching the intersection at the track crossing location and Figure 4C-10 should be used if there are two or more lanes approaching the intersection at the track crossing location.

B. After determining the actual distance D, the curve for the distance D that is nearest to the actual distance D should be used. For example, if the actual distance D is 95 feet, the plotted point should be compared to the curve for D = 90 feet.

C. If the rail traffic arrival times are unknown, the highest traffic volume hour of the day should be used.

Option:

05 The minor-street approach volume may be multiplied by up to three adjustment factors as provided in Paragraphs 6 through 8.

06 Because the curves are based on an average of four occurrences of rail traffic per day, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-2 for the appropriate number of occurrences of rail traffic per day.

07 Because the curves are based on typical vehicle occupancy, if at least 2% of the vehicles crossing the track are buses carrying at least 20 people, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-3 for the appropriate percentage of high-occupancy buses.

08 Because the curves are based on tractor-trailer trucks comprising 10% of the vehicles crossing the track, the vehicles per hour on the minor-street approach may be multiplied by the adjustment factor shown in Table 4C-4 for the appropriate distance and percentage of tractor-trailer trucks.

Standard:

09 **If this warrant is met and a traffic control signal at the intersection is justified by an engineering study, then:**

A. The traffic control signal shall have actuation on the minor street;

B. Preemption control shall be provided in accordance with Sections 4D.27, 8C.09, and 8C.10; and

C. The grade crossing shall have flashing-light signals (see Chapter 8C).

Guidance:

10 *If this warrant is met and a traffic control signal at the intersection is justified by an engineering study, the grade crossing should have automatic gates (see Chapter 8C).*

Section 4C.101(CA) Criterion for School Crossing Traffic Signals

01 **Standard:**

A. The signal shall be designed for full-time operation.

B. Pedestrian signal faces of the International Symbol type shall be installed at all marked crosswalks at signalized intersections along the "Suggested Route to School."

C. If an intersection is signalized under this guideline for school pedestrians, the entire intersection shall be signalized.

D. School area traffic signals shall be traffic actuated type with push buttons or other detectors for pedestrians.

Option:

02 Non-intersection school pedestrian crosswalk locations may be signalized when justified.

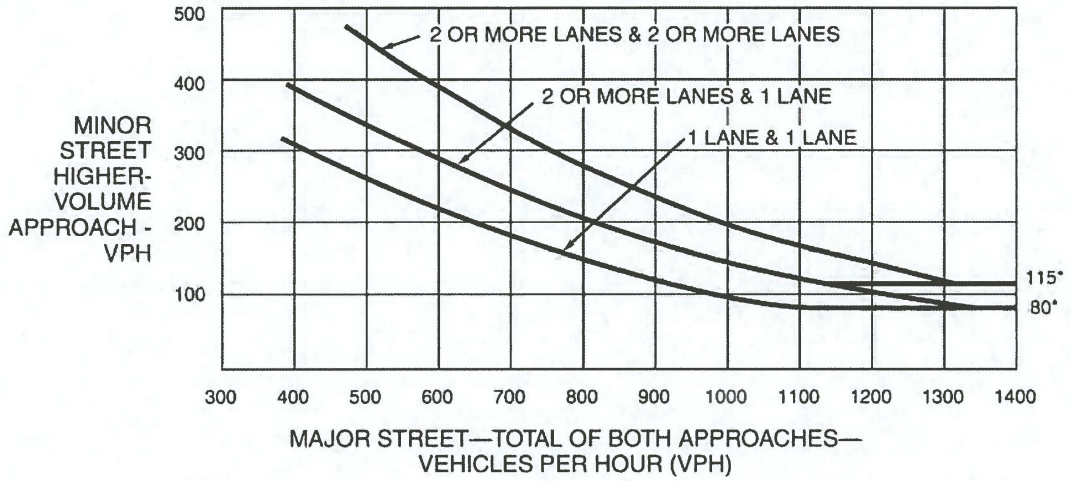
Section 4C.102(CA) Bicycle Signal Warrant

Guidance:

01 *A bicycle signal should be considered for use only when the volume and collision or volume and geometric warrants have been met:*

1. *Volume; When $W = B \times V$ and $W \geq 50{,}000$ and $B \geq 50$.*
   Where: W is the volume warrant. B is the number of bicycles at the peak hour entering the intersection. V is the number of vehicles at the peak hour entering the intersection. B and V shall use the same peak hour.
2. *Collision; When 2 or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.*
3. *Geometric;*
   (a) Where a separate bicycle/ multi use path intersects a roadway.
   (b) At other locations to facilitate a bicycle movement that is not permitted for a motor vehicle.

Figure 4C-1. Warrant 2, Four-Hour Vehicular Volume



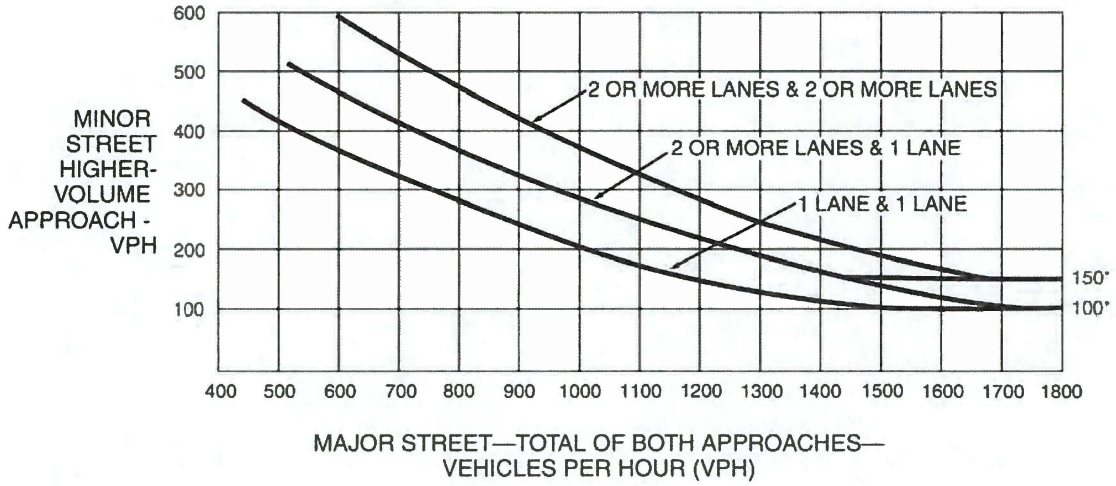
*Note: 115 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 80 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-2. Warrant 2, Four-Hour Vehicular Volume (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)

*Note: 80 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 60 vph applies as the lower threshold volume for a minor-street approach with one lane.

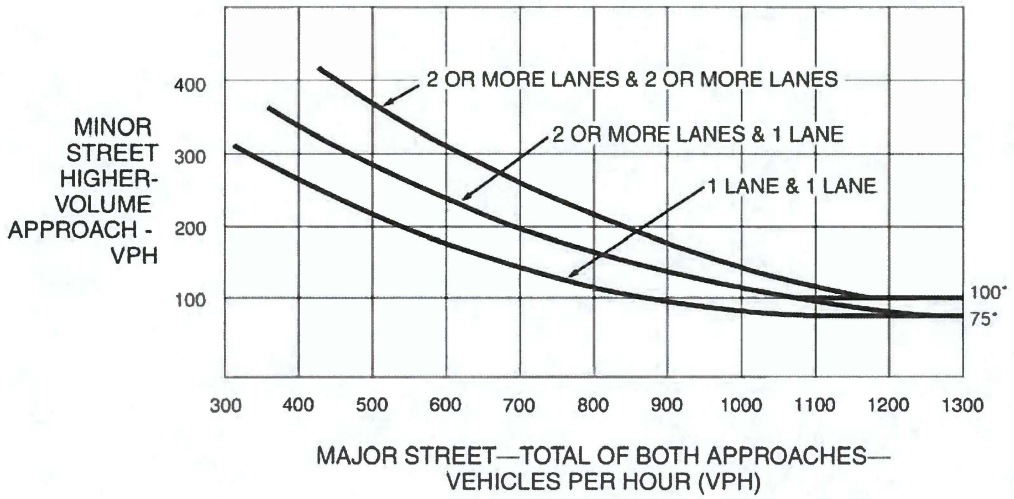
Figure 4C-3. Warrant 3, Peak Hour



*Note: 150 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 100 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-4. Warrant 3, Peak Hour (70% Factor)

(COMMUNITY LESS THAN 10,000 POPULATION OR ABOVE 40 MPH ON MAJOR STREET)

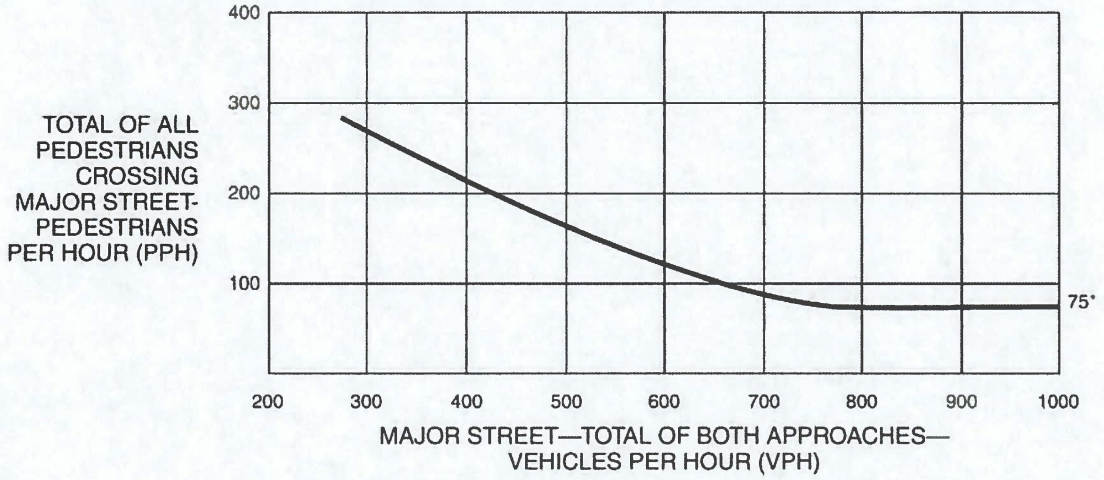


*Note: 100 vph applies as the lower threshold volume for a minor-street approach with two or more lanes and 75 vph applies as the lower threshold volume for a minor-street approach with one lane.

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume

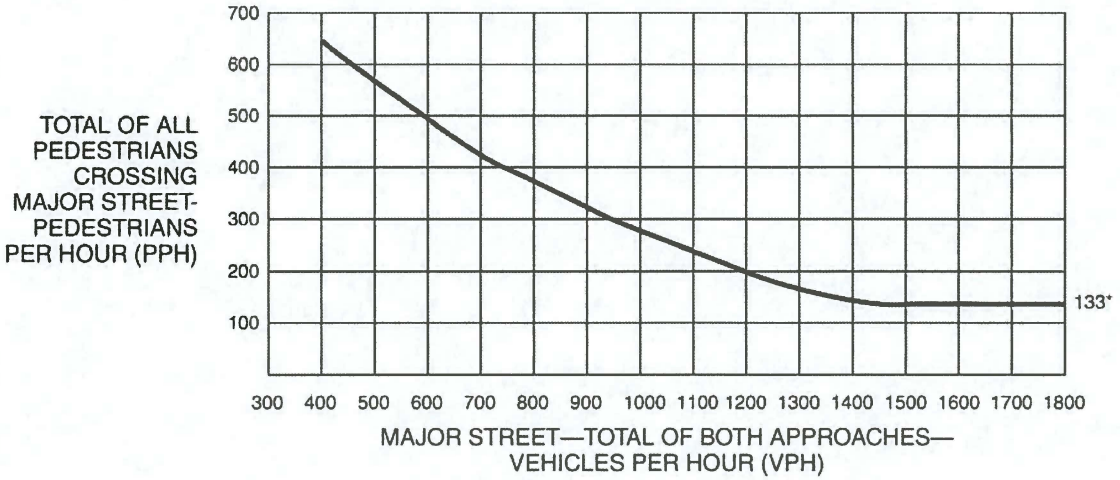
*Note: 107 pph applies as the lower threshold volume.

Figure 4C-6. Warrant 4, Pedestrian Four-Hour Volume (70% Factor)



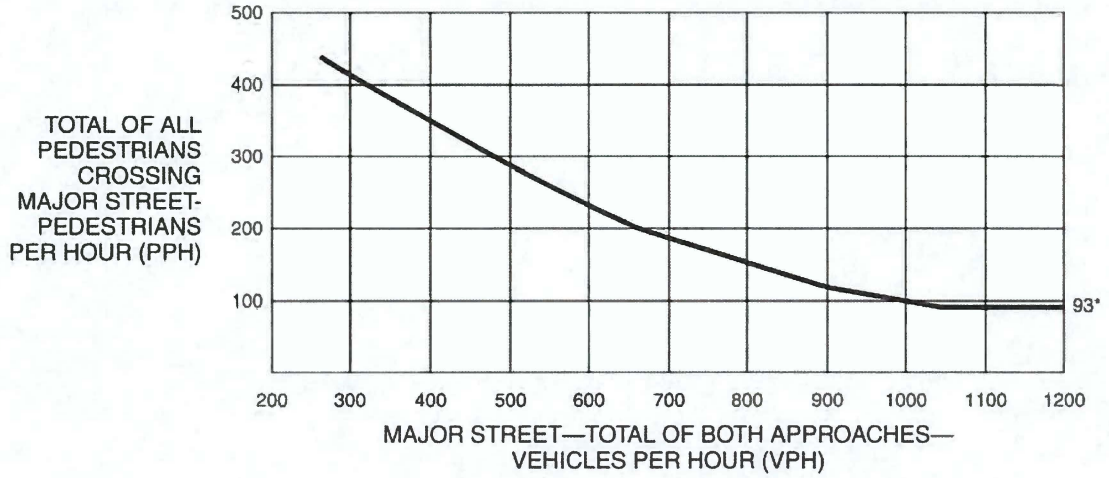
*Note: 75 pph applies as the lower threshold volume.

Figure 4C-7. Warrant 4, Pedestrian Peak Hour



*Note: 133 pph applies as the lower threshold volume.

Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)



*Note: 93 pph applies as the lower threshold volume.

STOP SIGNS

WHY DON'T THEY PUT IN MORE STOP SIGNS?

A stop sign is one of our most valuable and effective control devices when used at the right place and under the right conditions. It is intended to help drivers and pedestrians at an intersection decide who has the right of way.

One common misuse of stop signs is to arbitrarily interrupt through traffic, either by causing it to stop or by causing such an inconvenience as to force the traffic to use other routes. Where stop signs are installed as "nuisances" or "speed breakers", there is a high incidence of intentional violation. In those locations where vehicles do stop, the speed reduction is effective only in the immediate vicinity of the stop sign, and frequently speeds are actually higher between intersections. For these reasons, it should not be used as a speed control device.

A school crossing may appear unsafe for children to use, causing parents to demand a stop sign to halt traffic. Now a vehicle which had been a concern for three seconds while approaching and passing the intersection becomes a concern for a much longer period. A situation of indecision is created as to when to cross as a pedestrian or when to start as a motorist. Normal gaps in traffic through which crossings could be made safely no longer exist. An intersection which previously was not busy now looks like a major intersection. It really isn't – it just looks like it. It doesn't even look safer and it usually isn't.

Most drivers are reasonable and prudent with no intention of maliciously violating traffic regulations; however, when an unreasonable restriction is imposed, it may result in flagrant violations. In such cases, the stop sign can create a false sense of security in a pedestrian and an attitude of contempt in a motorist. These two attitudes can and often do conflict and may increase the chance of collisions.

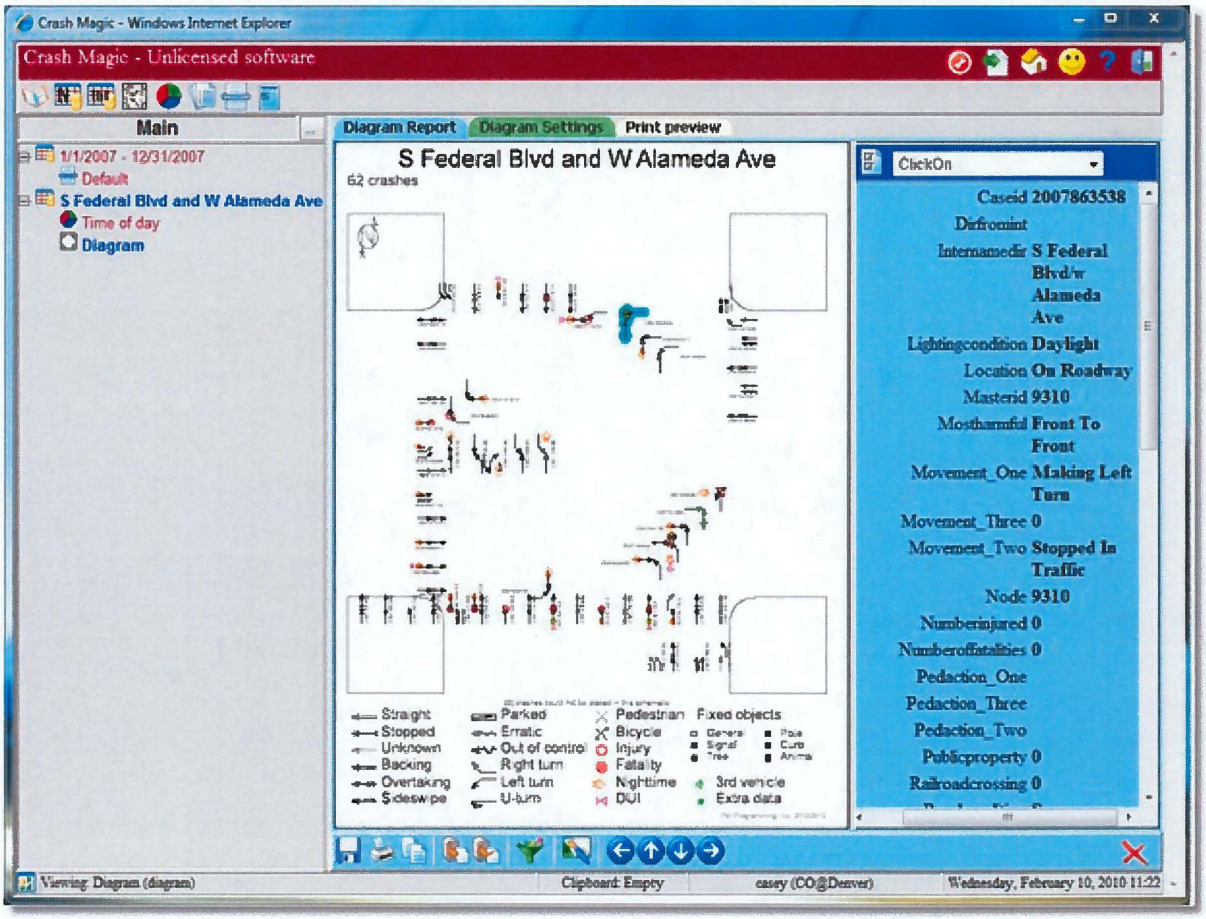
Well-developed, nationally recognized guidelines help to indicate when such controls become necessary. These guidelines take into consideration, among other things, the probability of vehicles arriving at an intersection at the same time, the length of time traffic must wait to enter, and the availability of safe crossing opportunities.

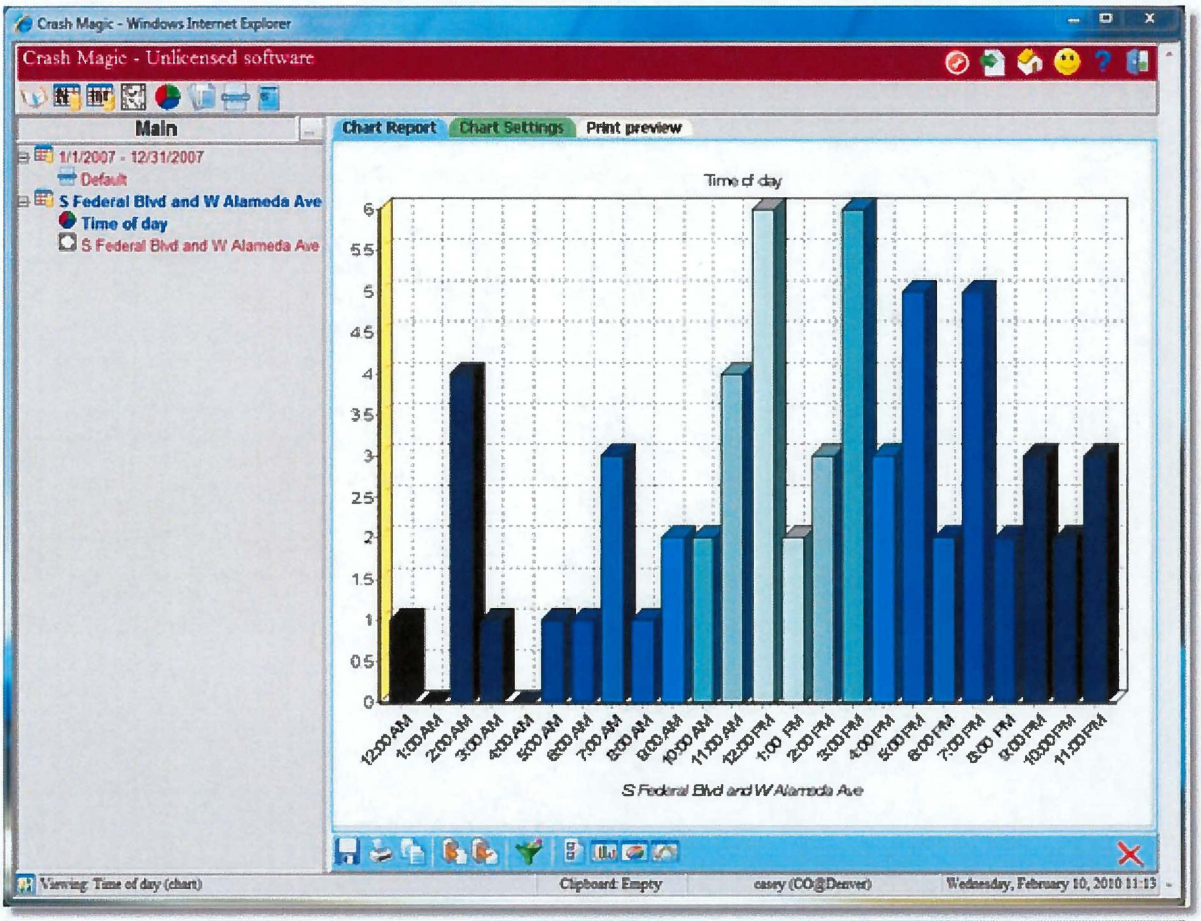
Crash Magic - Screen Shots

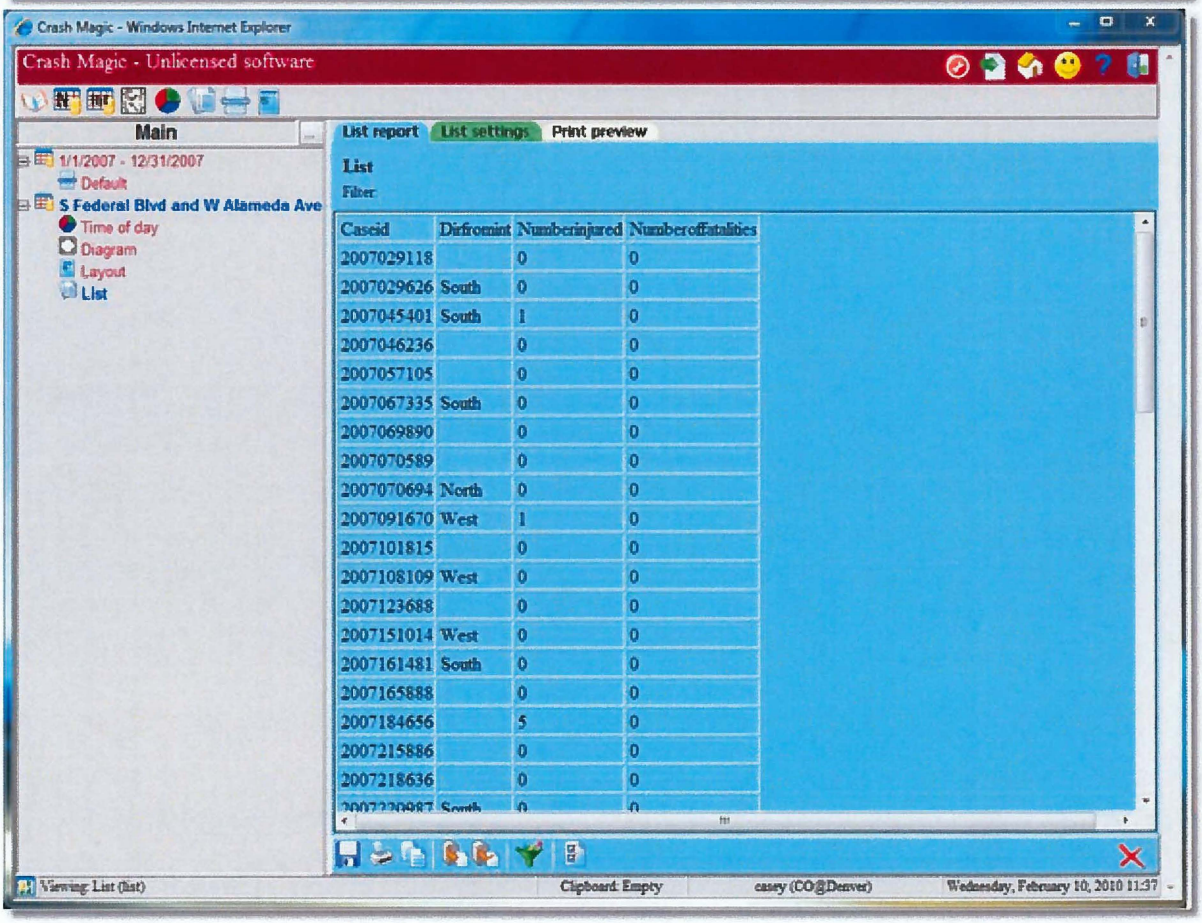
Crash Magic™ - Online Safety Management System

Technical requirements / specifications

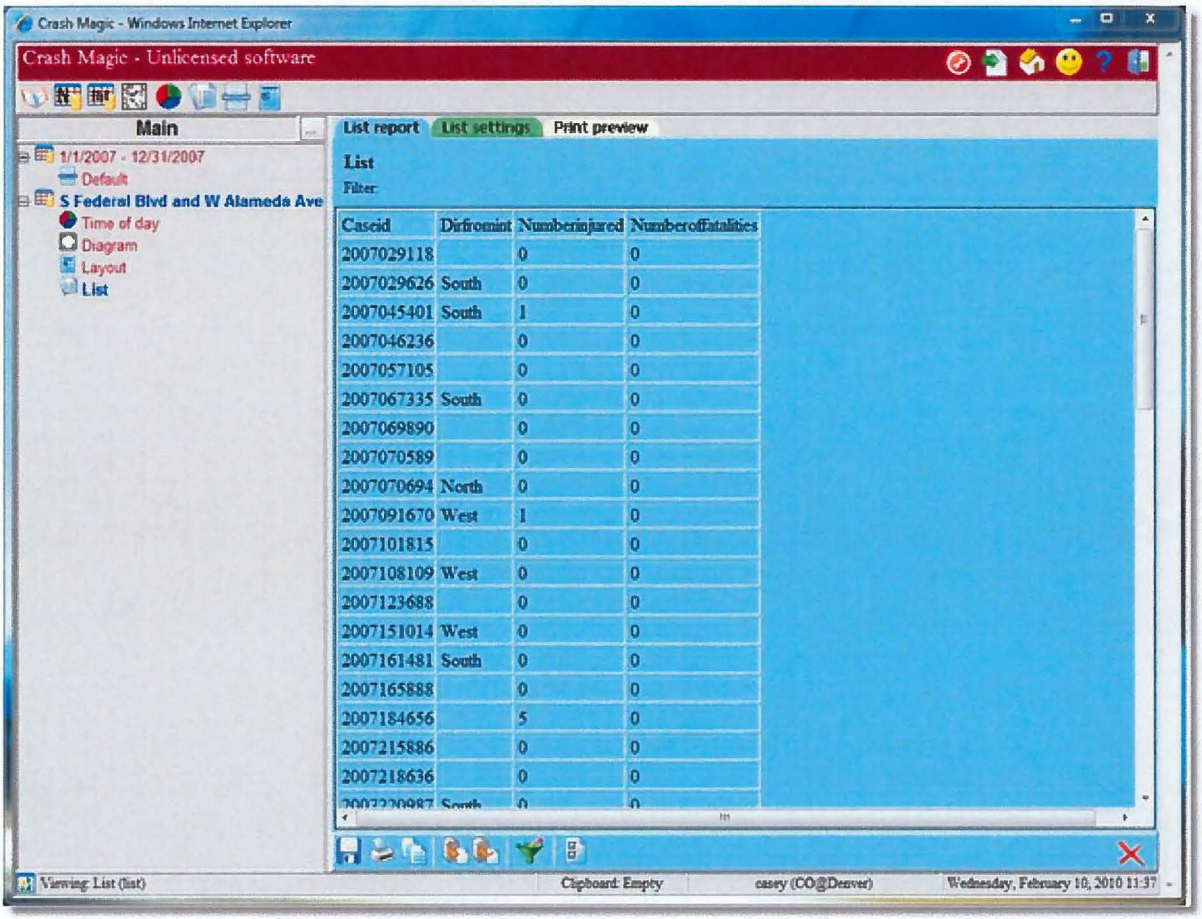
Product information pages coming soon. For now, here are some screen dumps from the system.







Caseid	Dirfromint	Numberinjured	Numberoffatalities
2007029118		0	0
2007029626	South	0	0
2007045401	South	1	0
2007046236		0	0
2007057105		0	0
2007067335	South	0	0
2007069890		0	0
2007070589		0	0
2007070694	North	0	0
2007091670	West	1	0
2007101815		0	0
2007108109	West	0	0
2007123688		0	0
2007151014	West	0	0
2007161481	South	0	0
2007165888		0	0
2007184656		5	0
2007215886		0	0
2007218636		0	0
2007220987	South	0	0



Caseid	Dirfromint	Numberinjured	Numberoffatalities
2007029118		0	0
2007029626	South	0	0
2007045401	South	1	0
2007046236		0	0
2007057105		0	0
2007067335	South	0	0
2007069890		0	0
2007070589		0	0
2007070694	North	0	0
2007091670	West	1	0
2007101815		0	0
2007108109	West	0	0
2007123688		0	0
2007151014	West	0	0
2007161481	South	0	0
2007165888		0	0
2007184656		5	0
2007215886		0	0
2007218636		0	0
2007220987	South	0	0

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Pd' Programming, Inc.
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(303) 666-7896

QUOTE

Quote Date:	Quote #:
1/13/2016	2016-14
Quote valid for 30 days	

Quote prepared for:
City of Lake Forest, CA Dave Rogers PE, TE
On behalf of (if different):

ITEM	DESCRIPTION	COST	QTY	TOTAL
Hosted	Crash Magic Online hosted software annual fee. Provides one year of access to Crash Magic running on the GovernmentTools server. Includes all upgrades, support and overall system administration. Does not include User Group Administration. Includes configuration, project and data backups up to 100MB. February 1, 2016 - Jan 31, 2017	3,420.00		3,420.00
SWITRS Std ...	California SWITRS Standard Configuration One-time fee for use of existing configuration specific to California agencies using the SWITRS data extracts. Hosted or Installed. Any modifications to the existing configuration cause it to become a "Custom Configuration" which carries a different cost. Acquisition and import of initial SWITRS data is included in the cost.	500.00		500.00
Onsite CM trai...	Onsite Training and/or installation of Crash Magic software - Daily Rate	1,000.00	2	2,000.00
Onsite Trainin...	Training Expenses (assumes arrangements made 30 days in advance)	1,000.00		1,000.00

Please contact us if you have any questions regarding the software or this quote. **(303) 666-7896**	**TOTAL** $6,920.00

All amounts in US dollars.

Pd' Programming Inc. Federal ID# : 84-1294809

PART 7
TRAFFIC CONTROL FOR SCHOOL AREAS

CHAPTER 7A. GENERAL

Section 7A.01 Need for Standards

Support:

01 Regardless of the school location, the best way to achieve effective traffic control is through the uniform application of realistic policies, practices, and standards developed through engineering judgment or studies.

02 Pedestrian safety depends upon public understanding of accepted methods for efficient traffic control. This principle is especially important in the control of pedestrians, bicycles, and other vehicles in the vicinity of schools. Neither pedestrians on their way to or from school nor other road users can be expected to move safely in school areas unless they understand both the need for traffic controls and how these controls function for their benefit.

03 Procedures and devices that are not uniform might cause confusion among pedestrians and other road users, prompt wrong decisions, and contribute to crashes. To achieve uniformity of traffic control in school areas, comparable traffic situations need to be treated in a consistent manner. Each traffic control device and control method described in Part 7 fulfills a specific function related to specific traffic conditions.

04 A uniform approach to school area traffic controls assures the use of similar controls for similar situations, which promotes appropriate and uniform behavior on the part of motorists, pedestrians, and bicyclists.

05 A school traffic control plan permits the orderly review of school area traffic control needs, and the coordination of school/pedestrian safety education and engineering measures. Engineering measures alone do not always result in the intended change in student and road user behavior.

Guidance:

06 *A school route plan for each school serving elementary to high school students should be prepared in order to develop uniformity in the use of school area traffic controls and to serve as the basis for a school traffic control plan for each school.*

07 *The school route plan, developed in a systematic manner by the school, law enforcement, and traffic officials responsible for school pedestrian safety, should consist of a map (see Figure 7A-1) showing streets, the school, existing traffic controls, established school walk routes, and established school crossings.*

08 *The type(s) of school area traffic control devices used, either warning or regulatory, should be related to the volume and speed of vehicular traffic, street width, and the number and age of the students using the crossing.*

09 *School area traffic control devices should be included in a school traffic control plan.*

Support:

10 Reduced speed limit signs for school areas and crossings are included in this Manual solely for the purpose of standardizing signing for these zones and not as an endorsement of mandatory reduced speed zones.

11 "School" and "school zone" are defined in Section 1A.13.

12 Parents, school administrators, traffic officials, civic leaders, and vehicle drivers share the responsibility of educating school pedestrians on the use of traffic control devices. Programs in the home and school to train the child as a responsible pedestrian are an important factor in improving their understanding of traffic control devices.

13 The words "School Pedestrians", "Children", and "Students" are used interchangeably and could include student bicyclists for the purpose of determining appropriate cross protection measures.

Section 7A.02 School Routes and Established School Crossings

Support:

01 To establish a safer route to and from school for schoolchildren, the application of planning criterion for school walk routes might make it necessary for children to walk an indirect route to an established school

crossing located where there is existing traffic control and to avoid the use of a direct crossing where there is no existing traffic control.

Guidance:

02 *School walk routes should be planned to take advantage of existing traffic controls.*

03 *The following factors should be considered when determining the feasibility of requiring children to walk a longer distance to a crossing with existing traffic control:*

A. The availability of adequate sidewalks or other pedestrian walkways to and from the location with existing control,

B. The number of students using the crossing,

C. The age levels of the students using the crossing, and

D. The total extra walking distance.

Support:

04 There is a need in each school district to establish an organization concerned with students enroute to and from school. Through such an organization, the school district can be responsibly involved in processing requests for traffic safety controls and for safety programs and can coordinate activities within and between the community and public agencies.

In order to provide a responsible administrative structure for the school area, each school district is encouraged to:

A. Assign student pedestrian responsibilities to a competent staff member and/or

B. Organize a school student pedestrian advisory committee to serve the needs of each public and private school.

Guidance:

05 *When the advisory committee structure is used, the committee should include governmental and school district staff who has the responsibility and authority to initiate and provide programs and projects.*

06 *Representatives from the city and/or county superintendent of schools office should be the official members. Advisors should include representatives of the local area Safety Council, traffic engineers, police authorities, the Parent-Teachers Association, Automobile Clubs (AAA), local Bicycle or Pedestrian Advisory Committee, plus others as needed.*

Staff and Committee Responsibility:

07 *The duties of staff members and/or each committee should be to guide and coordinate all activities connected with the school traffic safety program, such as:*

A. Establish traffic safety policies and procedures.

B. Recommend priorities for proposed improvement projects.

C. Notify the responsible agencies of school-pedestrian-traffic related issues.

D. Review and approve the various phases of the school student traffic safety program.

E. Review and process requests and complaints.

F. Promote good public relations.

08 *The County Superintendent of School's office should coordinate all student pedestrian committees' actions in establishing and promoting uniform practices for school pedestrian safety throughout the county.*

School Responsibility:

09 *Traffic related issues about school pedestrians on the approaches to the school should be referred to the school district or local school principal for review and transmission to the appropriate staff person or to the school student pedestrian advisory committee.*

Support:

10 Refer to CVC 21373 for school board request for traffic control devices.

Government Traffic Agency Responsibility:

Standard:

11 **Upon request of the local school district, responsible traffic authorities shall investigate all locations along the school route and recommend appropriate traffic control measures. Refer to CVC 21373.**

Support:

12 The following references from the California Vehicle Code relate to traffic controls for school areas:

A. Section 377 – Limit Line.

B. Section 627 – Engineering and Traffic Survey.

C. Section 21102 – Local Authority to Close Streets.

D. Section 21368 – Crosswalks Near Schools.

E. Section 21372 – Guidelines for Traffic Control Devices Near Schools.

F. Section 21373 – School Board Request for Traffic Control Devices.
G. Section 21458 – Curb Markings.
H. Section 21949 through 21971 – Pedestrians' Rights and Duties.
I. Section 22350 – Basic Speed Law.
J. Section 22352 – Prima Facie Speed Limits.
K. Section 22358.4 – Decrease of Local Limits Near Schools or Senior Centers.
L. Section 22504 – Unincorporated Area Parking; School Bus Stops.
M. Section 40802 – Speed Traps.
N. Section 42200 – Disposition by Cities and Other Local Entities.
O. Section 42201 – Disposition by County.

Section 7A.03 School Crossing Control Criteria

Support:

01 The frequency of gaps in the traffic stream that are sufficient for student crossing is different at each crossing location. When the delay between the occurrences of adequate gaps becomes excessive, students might become impatient and endanger themselves by attempting to cross the street during an inadequate gap. In these instances, the creation of sufficient gaps needs to be considered to accommodate the crossing demand.

02 A recommended method for determining the frequency and adequacy of gaps in the traffic stream is given in the "Traffic Control Devices Handbook" (see Section 1A.11).

03 Engineering and traffic studies will determine the appropriate measures to be developed at school crossings. The devices and treatments described herein are for use in school zones and do not preclude use of other devices and treatments described elsewhere in this document. Types of school pedestrian measures that can be considered can include:

A. Warning signs and markings.
B. School speed limits.
C. Intersection stop signs.
D. Flashing yellow beacons.
E. Traffic signals.
F. Pedestrian Hybrid Beacons.
G. Remove visibility obstructions.
H. School Safety Patrol.
I. Adult Crossing Guard.
J. Pedestrian separation structures.
K. Pedestrian walkways along the roadway.
L. Pedestrian walkways separated from the roadway.
M. Parking controls and curb-use zones.

Section 7A.04 Scope

Standard:

01 **Part 7 sets forth basic principles and prescribes standards that shall be followed in the design, application, installation, and maintenance of all traffic control devices (including signs, signals, and markings) and other controls (including adult crossing guards) required for the special pedestrian conditions in school areas.**

Support:

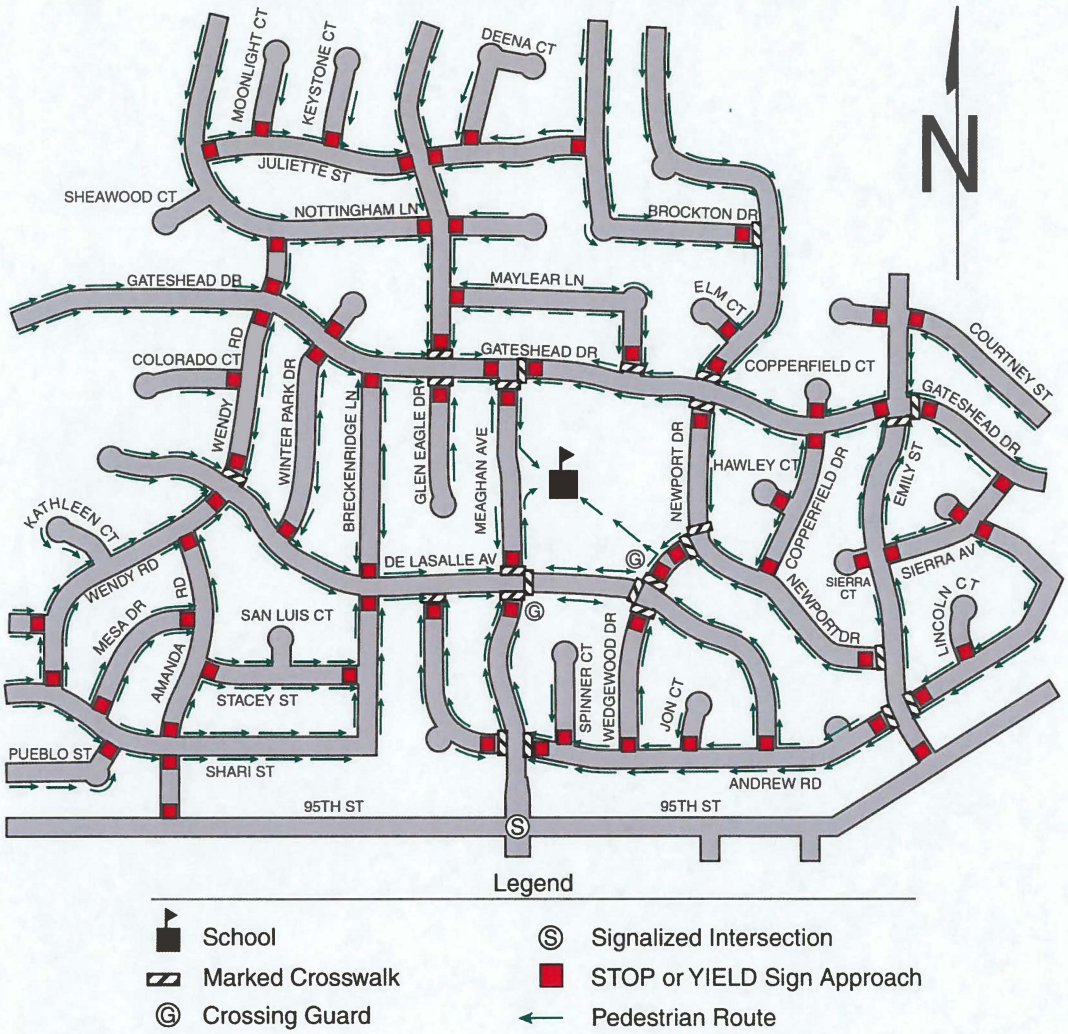
02 Sections 1A.01 and 1A.08 contain information regarding unauthorized devices and messages. Sections 1A.02 and 1A.07 contain information regarding the application of standards. Section 1A.05 contains information regarding the maintenance of traffic control devices. Section 1A.08 contains information regarding placement authority for traffic control devices. Section 1A.09 contains information regarding engineering studies and the assistance that is available to jurisdictions that do not have engineers on their staffs who are trained and/or experienced in traffic control devices.

03 Provisions contained in Chapter 2A and Section 2B.06 are applicable in school areas.

04 Part 3 contains provisions regarding pavement markings that are applicable in school areas.

05 Part 4 contains provisions regarding highway traffic signals that are applicable in school areas. The School Crossing signal warrant is described in Section 4C.06.

Figure 7A-1. Example of School Route Plan Map



Guidance:

15 *Unless otherwise provided in this Manual for a specific sign, and except as provided in Paragraph 16, telephone numbers of more than four characters should not be displayed on any sign, supplemental plaque, sign panel (including logo sign panels on specific service signs), or changeable message sign.*

Option:

16 Internet addresses, e-mail addresses, or telephone numbers with more than four characters may be displayed on signs, supplemental plaques, sign panels, and changeable message signs that are intended for viewing only by pedestrians, bicyclists, occupants of parked vehicles, or drivers of vehicles on low-speed roadways where engineering judgment indicates that an area is available for drivers to stop out of the traffic flow to read the message.

Standard:

17 **Pictographs (see definition in Section 1A.13) shall not be displayed on signs except as specifically provided in this Manual. Pictographs shall be simple, dignified, and devoid of any advertising. When used to represent a political jurisdiction (such as a State, county, or municipal corporation) the pictograph shall be the official designation adopted by the jurisdiction. When used to represent a college or university, the pictograph shall be the official seal adopted by the institution. Pictorial representations of university or college programs shall not be permitted to be displayed on a sign.**

Section 2A.07 Retroreflectivity and Illumination

Support:

01 There are many materials currently available for retroreflection and various methods currently available for the illumination of signs and object markers. New materials and methods continue to emerge. New materials and methods can be used as long as the signs and object markers meet the standard requirements for color, both by day and by night.

Standard:

02 **Regulatory, warning, and guide signs and object markers shall be retroreflective (see Section 2A.08) or illuminated to show the same shape and similar color by both day and night, unless otherwise provided in the text discussion in this Manual for a particular sign or group of signs.**

03 **The requirements for sign illumination shall not be considered to be satisfied by street or highway lighting.**

Option:

04 Sign elements may be illuminated by the means shown in Table 2A-1.

05 Retroreflection of sign elements may be accomplished by the means shown in Table 2A-2.

06 ~~Light Emitting Diode (LED) units may be used individually within the legend or symbol of a sign and in the border of a sign, except for changeable message signs, to improve the conspicuity, increase the legibility of sign legends and borders, or provide a changeable message.~~

06a Light Emitting Diode (LED) units may be used in the border of regulatory or warning signs, except for Changeable Message Signs, to improve the conspicuity of signs.

Standard:

07 **Except as provided in Paragraphs 11 and 12, neither individual LEDs nor groups of LEDs shall be placed within the background area of a sign.**

08 **If used, the LEDs shall have a maximum diameter of 1/4 inch and shall be the following colors based on the type of sign:**

A. ~~White or~~ Red, if used with STOP, DO NOT ENTER, or WRONG WAY signs. ~~or YIELD signs~~.

B. White, if used with regulatory signs including ~~other than STOP or~~ YIELD signs.

C. ~~White or~~ Yellow, if used with warning signs.

~~D. White, if used with guide signs.~~

E. ~~White, yellow, or~~ Amber, if used with temporary traffic control signs of warning type.

~~F. White or yellow, if used with school area signs.~~

09 **If flashed, all LED units shall flash simultaneously at a rate of more than 50 and less than 60 times per minute.**

10 **The uniformity of the sign design shall be maintained without any decrease in visibility, legibility, or driver comprehension during either daytime or nighttime conditions.**

Option:

11 For STOP and YIELD signs, LEDs may be placed within the border or within one border width within the background of the sign.

12 For STOP/SLOW paddles (see Section 6E.03) used by flaggers and the STOP paddles (see Section 7D.05) used by adult crossing guards, individual LEDs or groups of LEDs may be used.

Support:

13 Other methods of enhancing the conspicuity of standard signs are described in Section 2A.15.

14 Information regarding the use of retroreflective material on the sign support is contained in Section 2A.21.

Section 2A.08 Maintaining Minimum Retroreflectivity

Support:

01 Retroreflectivity is one of several factors associated with maintaining nighttime sign visibility (see Section 2A.22).

Standard:

02 **Public agencies or officials having jurisdiction shall use an assessment or management method that is designed to maintain sign retroreflectivity at or above the minimum levels in Table 2A-3.**

Support:

03 Compliance with the Standard in Paragraph 2 is achieved by having a method in place and using the method to maintain the minimum levels established in Table 2A-3. Provided that an assessment or management method is being used, an agency or official having jurisdiction would be in compliance with the Standard in Paragraph 2 even if there are some individual signs that do not meet the minimum retroreflectivity levels at a particular point in time.

Guidance:

04 *Except for those signs specifically identified in Paragraph 6, one or more of the following assessment or management methods should be used to maintain sign retroreflectivity:*

A. *Visual Nighttime Inspection—The retroreflectivity of an existing sign is assessed by a trained sign inspector conducting a visual inspection from a moving vehicle during nighttime conditions. Signs that are visually identified by the inspector to have retroreflectivity below the minimum levels should be replaced.*
B. *Measured Sign Retroreflectivity—Sign retroreflectivity is measured using a retroreflectometer. Signs with retroreflectivity below the minimum levels should be replaced.*
C. *Expected Sign Life—When signs are installed, the installation date is labeled or recorded so that the age of a sign is known. The age of the sign is compared to the expected sign life. The expected sign life is based on the experience of sign retroreflectivity degradation in a geographic area compared to the minimum levels. Signs older than the expected life should be replaced.*
D. *Blanket Replacement—All signs in an area/corridor, or of a given type, should be replaced at specified intervals. This eliminates the need to assess retroreflectivity or track the life of individual signs. The replacement interval is based on the expected sign life, compared to the minimum levels, for the shortest-life material used on the affected signs.*
E. *Control Signs—Replacement of signs in the field is based on the performance of a sample of control signs. The control signs might be a small sample located in a maintenance yard or a sample of signs in the field. The control signs are monitored to determine the end of retroreflective life for the associated signs. All field signs represented by the control sample should be replaced before the retroreflectivity levels of the control sample reach the minimum levels.*
F. *Other Methods—Other methods developed based on engineering studies can be used.*

Support:

05 Additional information about these methods is contained in the 2007 Edition of FHWA's "Maintaining Traffic Sign Retroreflectivity" (see Section 1A.11).

Informational Report:

Protected/Permissive Left-turn Phasing
Design and Operational Guidelines (Updated)

Prepared by:

Orange County Traffic Engineering Council
Protected/Permissive Left-Turn Phasing Update Committee

Draft Report, May 2001

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B. The "Trap" Explanation
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D. Recommended Signal Head Locations
E. Visibility Considerations

REPORT CONTEXT

This Protected/Permissive Left-Turn (P/PLT) Guidelines Report has been prepared for use as a tool for traffic engineers. Recommendations contained herein are based on national and local (Orange County) agency experience regarding design and installation of P/PLT traffic signals.

This report is based on the work of a prior committee that in 1995 published OCTEC's original PPLT guidelines. The focus of the prior committee was to establish guidelines for P/PLT signal design in order to promote uniformity, which is believed to be a key to successful operation; and public outreach/education, in order to promote better understanding among drivers. The focus of this Update Committee was to:

- Update the Guidelines to conform to best current practices.
- Provide sight distance criteria in keeping with new national standards.
- Provide guidance for selecting left-turn phasing type.

This updated report is intended to stand alone; all relevant information from the prior report has been carried over.

The recommendations and guidelines contained in this report represent the majority judgments of the Update Committee as of May 2001. The Committee recognizes that as new research findings and experience are gathered, the opinions expressed in this report may be modified.

The opinions expressed are not intended to establish usage standards, but to provide the best current, collective opinions and experiences that the Committee majority can formulate. The Guidelines are not intended as a substitute for engineering knowledge, experience or judgment; each user must use his/her own judgment and experience in applying the information contained in this report. The guidelines do not necessarily represent the opinions of all OCTEC members, OCTEC officers, Committee members, and/or their employers. The information in these Guidelines shall be considered in addition to, rather than in lieu of other pertinent and generally accepted manuals. Additionally, such information is intended to serve as an aid in the solution of various traffic situations but it is not intended that any standard of conduct or duty toward the public shall be created or imposed by these Guidelines.

NOTE: Complete OCTEC Protected/Permissive Left Turn Phasing Report is available separately.

Informational Report:

Protected/Permissive Left-turn Phasing
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Protected/Permissive Left-Turn Phasing Update Committee

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I. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

This is an overview of the Report's "bottom lines." This brief summary only highlights the various issues that the Committee considered and, therefore, the entire document must be considered to fully understand the various detailed conclusions and recommendations.

A. Conclusions

- While the use of protected/permissive left-turn (P/PLT) traffic signal phasing can significantly reduce overall intersection vehicle delays, fuel consumption, and emissions, the technique is not a panacea in traffic signal phasing and may result in the following:
  - A reduction in "green band width" for system operation.
  - Initial misunderstanding by a portion of the area's drivers.
  - Potential increase in left-turn collisions.
- Improved driver education on "turning left on a green ball" is a challenge that is believed to be the most important step toward effective utilization of the more sophisticated P/PLT traffic signal phasing. This phasing has been used in Orange County since the 1960's, but recently has been gaining more widespread use.
- Uniformity of the traffic signal displays by local agencies is expected to help the driver comprehend and understand the P/PLT phasing and better facilitate the education process.
- Conversely, differentiation of traffic signal displays by type is important to helping drivers understand their differences. A major goal of this report is to help new P/PLT installations to look less like protected-only and more like permissive-only, thereby reducing the chance that a driver may mistakenly interpret the green ball as a protected left-turn indication.
- The traffic engineering profession should be actively involved in the public education process, not just the technical aspects, of P/PLT. To this end, OCTEC has previously:
  - Communicated to the California DMV our recommendations for changes in the "California Driver Handbook" concerning traffic signals (and pedestrian signals).
  - Designed color public information "handouts" on traffic and pedestrian signal operations that can be used as a model by local agencies.

- Developed a draft script for a public service video that will feature a celebrity. If produced, this video could be furnished to local agencies as a part of their educational efforts.

- Traffic engineers and their support staff need to be aware of the various aspects of P/PLT, in order to safely and effectively apply this tool.

B. Recommendations

- Signal displays throughout Orange County should be uniform so that there will be no confusion as to the intended operation. Protected-permissive installations should look similar to each other and should look different from protected-only. The latter goal is accomplished by positioning the five-section "cluster" or "doghouse" head to the right of the barrier line.

- Continue to use the "cluster" five-section signal head mounted on the mast arm and the stacked five-section signal head at the far-left corner as the standard signal displays for P/PLT operations. To accentuate the permissive element of the operation, it is recommended that the cluster head be mounted eight feet (±3') to the right of the barrier line separating the left-turn lane from the adjacent through lane. No additional three-section mast-arm indications are required, but one may be provided on very wide approaches.

- If desired, an R73-7 (Left Turn Yield on green ball) sign may be mounted on the mast arm adjacent to the cluster head.

- Additional considerations:

  - Sufficient sight distance should be provided for drivers turning left on the green ball.
  - Avoid the "trap" situation (see Appendix B).
  - In some system situations, lead/lag full-time left-turn phasing may be more efficient than using lead/lead P/PLT.
  - As the number of approach lanes and the volume and speed of opposing through vehicles increase, the task of selecting a safe gap in oncoming traffic while turning left on a green ball is made more difficult. This factor should be evaluated when considering the suitability of P/PLT.
  - The use of queue detection may be appropriate to minimize the display of the green arrow when the left-turn volume (during a particular cycle) can be adequately served with the green ball only.

- The number of left-turn collisions (that cannot be corrected by sight distance or other operational improvements) warranting use of only full-time left-turn phasing should be determined by each local agency. This determination will require engineering evaluation and will consider the agency's desired balance between minimizing overall traffic delay and collisions.

Overall, the Committee has recognized that the successful technical aspects of traffic signal operations are closely related to the driving public's knowledge of our methods to increase the degree of mobility.

II. INTRODUCTION

The use of protected/permissive left-turn (P/PLT) traffic signal operation has, over recent years, proliferated throughout California and the United States. The P/PLT traffic signal operation provides a dual function where an exclusive left-turn movement, under the arrow display, is followed by a permissive left-turn movement on a green ball (under the leading protected left turn scenario). The green ball indication allows drivers to continue making left turns, as a permissive movement, depending on suitable gaps in approaching traffic. The benefit of this P/PLT type of signal operation is a reduction in stops and delays, which reduces driver frustration, fuel consumption, and pollution.

In 1995, OCTEC published its original P/PLT Guidelines. New research and practitioner's experience since 1995 have indicated a need to update the Guidelines. The program for the January 27, 2000, OCTEC meeting, presented by Mr. Hank Mohle, and Mr. Dave Royer was "Protected/Permissive Signals: Lessons Learned." This presentation summarized the current state of the art in P/PLT implementation, especially with regard to sight distance and signal head positioning. Following the meeting, the OCTEC officers and membership chose to initiate a volunteer effort to update the OCTEC P/PLT Guidelines to reflect current best practices. A Committee was formed consisting of representatives from various Orange County municipalities and consulting firms with a wide variety of professional experience.

The membership of the update committee was as follows:

John Kerenyi,	Kimley-Horn and Associates,	Chair
Mark Esposito,	Hartzog & Crabill	
Jose Alire,	City of Fountain Valley	
Mike Evans,	City of Mission Viejo	
Mark Lewis,	City of Fountain Valley	
Hank Mohle,	Rick Engineering	
Carlos Ortiz,	Robert Bein, William Frost & Associates	
Jim Otterson,	Otterson & Associates	
David Royer,	U.C. Berkeley Institute of Transportation Studies	
Bob Stachelski,	City of Huntington Beach	
Monica Suter,	City of Santa Ana	

The members of this committee would like to continue to recognize the efforts of the previous committee that originally authored this document. Much of this document is the result of their efforts and remains an integral part of the these guidelines. The members of the original committee, along with contact information for the Update Committee members, are listed in Appendix "A."

A. Orange County Protected/Permissive Usage

For years, various P/PLT configurations have been used in Orange County. The City of Santa Ana had an installation on 17th Street and Main Street in the early 1960's that displayed a leading left-turn arrow followed by a green ball for eastbound left turns. This operation allowed the heavier eastbound left-turn movement to start early as a protected phase, followed by permissive movements. Caltrans had a similar operation for the southbound on-ramp signal at Red Hill Avenue and the I-5 Freeway. These displays used four-section heads and a blank amber (i.e. "dark yellow") operation. In the 1970's, the City of Tustin installed P/PLT signals at various locations on Irvine Avenue, Newport Avenue, and McFadden Avenue. The installations used four-section, mast-arm-mounted signal heads with the lower section being a dual-color (yellow, green) arrow display that was switched electronically. This allowed for a yellow arrow clearance interval. The dual-color signal indication was phased out of production, which led to using stacked and cluster five-section heads for mast-arm mountings. Five-section heads are generally considered to be a requirement for P/PLT operation. In the 1980's, the County of Orange installed several P/PLT signals in the Mission Viejo and North Tustin areas; however, most of the installations were designed for ease of conversion to full protected by placing the P/PLT mast-arm head where a future full protected head would be located. The conversion to fully protected operation was ultimately made at most locations. Cities such as Anaheim, Fountain Valley, and Tustin presently have progressive programs for the installation of P/PLT signals. All three agencies, along with installing new P/PLT signals, have converted existing signals (including protected left-turn locations) to P/PLT.

Besides the various signal head display configurations used in Orange County, we also have various placement of the signal heads. As with a fully protected operation, mast-arm and far-left display locations are used; however, both are five-section heads. The existing mast-arm-mounted locations vary from a position in the center of the left lane to somewhere in the number one lane. Actual placement of the P/PLT mast-arm head has typically been determined by the local agency.

B. Previous Study Review

The study of P/PLT has been occurring for decades throughout the United States. Various studies have reviewed signal head displays, lane orientation, operation, warrants, and collision information. Public surveys have been taken to evaluate drivers' perception of P/PLT signal displays and operation. The vast amount of information has become somewhat redundant. Therefore, for the purpose of this

Report, information was selected that either involves the Southern California area or applies to the focus of the OCTEC Committee.

The following is a list of recent articles pertaining to P/PLT that were used by the Committee as references and as general background information. A brief overview of each document is provided. The information is for research only and does not imply endorsement by the OCTEC Committee in general.

1. Fisher, John (LADOT), "Toward Uniform Left-Turn Guidelines," ITE Journal, December 1998. This article proposes a warrant system for selecting left-turn phasing type. Criteria include collisions (including time of day criteria), geometry, gaps, capacity, delay, lane blockage, transit reliability, progression, and livable neighborhoods. The article recommends an incremental approach to providing left-turn phasing; that is, generally providing permissive left-turn phasing by default, then protected-permissive if necessary, then protected left turn phasing only if PPLT is not satisfactory.

2. Signals Technical Committee of the NCUTCD, "MUTCD Requirements for Signal Displays to Left-Turning Drivers," ITE Journal, September 1992. This article summarized the requirements of the 1988 version of the MUTCD with respect to various forms of left-turn phasing, including PPLT. The traffic signal indications are clearly specified, but lateral position of the mast arm-mounted five-section head is not specified. (The recommendations of the OCTEC committee were also double-checked against the new Millennium Edition of the MUTCD.)

3. Shebeeb, Ousama (U.T. Austin + City of Hurst, TX), "Safety and Efficiency for Exclusive Left-Turn Lanes at Signalized Intersections," ITE Journal, July 1995. This article quantitatively examined collision history at 54 intersections with different forms of left-turn phasing located in Texas and Louisiana. The analysts found a correlation between safety and efficiency. Permissive left-turn phasing was most efficient (in terms of left-turn stopped delay) but had the highest left-turn collision rate. Conversely, protected left-turn phasing had the highest left-turn stopped delay but the lowest left-turn collision rate. PPLT phasing was generally intermediate in both categories.

4. Poston, Jim (Reno Transportation Commission), "Flashing Yellow Arrow: Novelty or Nascency?" 1999 ITE International Meeting Compendium of Technical Papers. This paper presented a unique four-section display that allows selection of protected-only or PPLT by time of day, and allows for lead-lag PPLT operation without causing the yellow trap. The paper is an example of novel left-turn phasing techniques that Orange County agencies may wish to consider.

5. Agent, Kenneth (University of Kentucky), "Guidelines for the Use of Protected/Permissive Left-Turn Phasing," ITE Journal, July 1987. The study results reviewed previous recommendations and collision history of P/PLT installations in Kentucky. It was recommended that P/PLT be used as a time-

saving operation, rather than protected-only. However, P/PLT is not recommended for installation when any of the following conditions exist:

- Speed limit exceeds 45 MPH.
- Current signal operation is protected-only and speed limit is more than 35 MPH.
- Left-turn movement crosses three or more lanes of opposing traffic.
- Intersection geometrics require that the left-turn lane have a separate signal head.
- Double (or more) left-turn-only lanes on the approach.
- A left-turn collision problem exists (four or more left-turn collisions in one year or six or more in two years on an approach).
- A potential left-turn collision problem exists as documented by a traffic conflicts study.
- Sight distance limitations.

When P/PLT is used, the following recommendations are made for installation purposes:

- The signal head for P/PLT should be located so that the left-turning traffic does not have a separate signal head (this article recommended positioning the indication over the barrier line; that is, the line separating the left-turn lane from the through lane).
- The five-section cluster head should be used.
- No regulatory sign is necessary.

III. GUIDELINES

A. Use Guidelines

Caltrans Traffic Manual and other studies and reports indicate in their guidelines for left-turn phasing that when left-turn phasing is justified, P/PLT operation should be considered when implementing protected left-turn operation. These guidelines should be used to determine the need for left-turn phasing including the use of P/PLT.

Several additional factors should be considered in order to determine whether P/PLT should or should not be implemented if left-turn phasing is justified. Figure 1 presents a flow chart for reviewing basic traffic signal phasing alternatives including P/PLT. The following is a list of factors that should be reviewed when considering P/PLT:

1. Sight distance restrictions for drivers desiring to turn left should be analyzed in all locations where P/PLT is being considered. Sight restrictions for the left-turning driver are potential collision generators for non-protected left-turn operation, and if no modification of the intersection is possible to provide sufficient sight distance, fully protected left-turn operation is recommended. (See Design section.) Information contained in the NCHRP 383 provides standards for minimum sight distance for left-turning vehicles.

2. The designer should consider the number of acceptable gaps in the opposing traffic stream that are available for permissive left-turns during both the peak and off-peak conditions. Without acceptable gaps in traffic, the successful use of the permissive portion of the protected/permissive operation may be limited and may require different implementation strategies. Without sufficient gaps in traffic, significant delays to left turns are likely to occur and motorists may be more inclined to risk turning during gaps of insufficient size. System modifications may help to improve the availability of gaps by improving vehicle platoons. However, it is important that the gaps occur during periods when a permissive left-turn is allowed. Modification of "termination by gap" programming may be needed to allow vehicles the opportunity to use available gaps. The NCHRP Report 383 identifies appropriate gap size for various roadway conditions.

3. A high-speed approach (45 MPH or greater) of opposing through movement traffic makes it more difficult to identify an adequate gap for the driver attempting to turn left during the permissive portion of the green phase. Experience indicates that, as the approach speed of the opposing through traffic increases, the ability to determine an adequate gap for making a permissive left turn is reduced. The speed of opposing approach traffic should be considered along with the availability of gaps in determining the suitability of P/PLT application and the type of operation that should be implemented.

4. The number of opposing through lanes affects the ability of motorists to identify suitable gaps in traffic. The more opposing through lanes that are present, the more difficult it is to identify a suitable gap and the larger the gap must be. The number of opposing through lanes should be considered in combination with the availability of appropriate gaps and vehicle speeds in determining the suitability of P/PLT application and the type of operation that should be implemented. In general, motorists generally start to have more difficulty identifying gaps when more than two opposing through lanes exist. However, P/PLT operations have been successful with more than two opposing through lanes. Vehicle platooning and lower traffic volumes can make P/PLT an acceptable alternative with three opposing through lanes.

5. Left-turn collisions in one direction may indicate conditions that P/PLT cannot address. If it is determined that the collisions are the result of visibility restrictions or other factors that cannot be corrected by changing the configuration of the approaches, then exclusive protected left-turn operation is recommended. (See Design section.)

6. Two or more left-turn lanes in one direction introduces potential confusion and may affect the judgment of drivers attempting to complete a permissive left turn. Permissive dual left-turns may also impact pedestrian safety. Multiple turn lanes across a permitted pedestrian movement can restrict motorist views of pedestrians in crosswalks. Use of P/PLT is not recommended to serve two or more left-turn lanes in one direction unless pedestrians are simultaneously restricted.

7. The location of advance vehicle detection loops may affect the success of the operation of P/PLT at an intersection. One significant assumption of P/PLT is that two to three motorists will complete a left turn during the change interval (amber indication). The placement of advance detection can affect the number of motorists that me be "trapped" in the "dilemma zone." The actions of these motorists may be difficult to predict or discern by motorists making a permissive left turn during the amber indication. Advance loop detection locations and timing adjustments should be carefully evaluated and incorporated into the design of the P/PLT operation.

8. Geometric conditions or traffic signal coordination may restrict left-turn operations to lead/lag phasing. When this is a requirement at an intersection and it appears that protected/permissive left-turn phasing would be beneficial, the use of the "Dallas" style of designing and implementing P/PLT should be considered. This operation allows for the use of lead/lag operations while eliminating the potential for the "left-turn trap" situation.

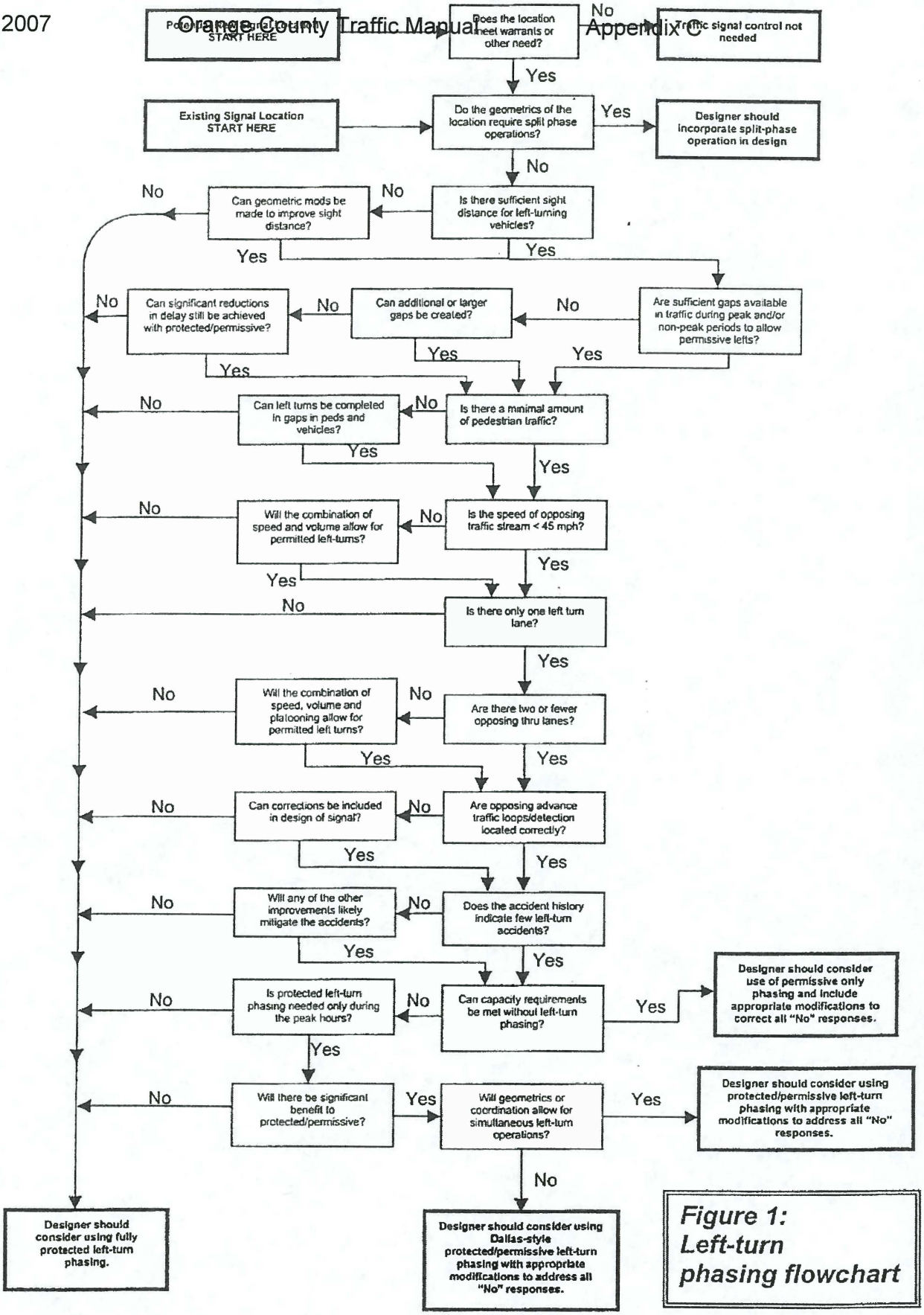


Figure 1: Left-turn phasing flowchart

B. Additional Factors to Consider

1. If there are few or no gaps in the peak hour for the safe movement of a permissive left turn, is there significant gain in reducing overall delay to justify using P/PLT?

2. Is there any way to provide protected left turns in the peak and P/PLT in the off-peaks, and will it be economically feasible? Would this operation introduce a liability factor into the operation?

3. If a signal is operating free and fully actuated and fully flexible in its ability to terminate greens and respond to left-turn demand, is P/PLT effective in reducing delays?

4. Is there a need for P/PLT operation at some level below fully protected left-turn warrant satisfaction?

5. **Implementation of P/PLT must include a guaranteed red interval for through traffic prior to the showing of the protected portion of the left-turn phase, under all conditions, in order to eliminate the possibility of a "trap" situation.** This can either be a secondary phase green or an all-red interval if there is no demand on any secondary phase. A more complete description the "trap" situation is provided in Appendix B.

IV. OPERATIONS

A. Why Use Protected/Permissive Left-Turn Phasing?

From an operational standpoint, the purpose of using P/PLT phasing operation is generally to **reduce delay.** It is an especially effective remedy for reducing left-turn vehicle delay when operating a coordinated fixed-cycle-length timing plan at an intersection. By providing the ability for left-turn vehicles to turn left during permissive gaps in the through phase, required left-turn green phase time can be reduced, therefore reducing minimum required cycle length for the intersection, and hence reducing delay for all vehicles in all non-sync phase movements.

Along with travel time savings, other associated benefits of reduced delay include reduction in fuel consumption and vehicle pollution, thus improving air quality. The Committee also recognizes that motorists sometimes become frustrated at fully protected locations during off-peak hours and illegally turn in spite of the red arrow. This is one safety consideration related to fully protected operations, and motorists can develop an indirect disrespect for traffic control devices in general, as their frustration level increases.

Other factors may cause agencies to consider P/PLT. Intersections operating with protected left-turn phasing under unwarranted conditions may realize improved operations with P/PLT. Another use of P/PLT may be as a solution for left-turn capacity constraints when right of way is not available for a second left-turn lane. However, caution should be taken when operating P/PLT under high capacity levels as discussed later.

B. The "Trap" and Real World Considerations

When operating P/PLT, the protected portion of the left-turn movement may be either simultaneous **leading** or **lagging**. Leading left turns are the most common, as they are generally more operationally efficient. Combination lead/lag operation may be a desirable use at an intersection to promote arterial progression, since through greens are not constrained to start simultaneously. **However, lead/lag operations can incur "trap" situations** (see Appendix B for the "trap" explanation). Lagging left turns may be an effective way to clear left-turn queues at intersections, although for P/PLT they should begin simultaneously.

An important operational factor to consider with P/PLT is the impact on arterial progression. Many agencies take advantage of lead/lag left turns to maximize green bandwidth. But under P/PLT operation, agencies may not want to design around the "trap" scenario. With the standard P/PLT indications **no lead/lag operation is possible without the "trap" scenario unless it is a "T" intersection**. However, the "Dallas style" P/PLT operation enables a lead-lag operation while effectively addressing the "trap" situation, as may other custom solutions.

C. Queue Detection

With continual advancements in controllers and signal systems, possibilities exist to operate P/PLT under certain times of day. An operation commonly used that is similar to a "combined" phasing is to fully take advantage of P/PLT operation during off-peak hours by not bringing up the protected left-turn arrow unless there is a predetermined threshold of vehicles in the left-turn lane. This operation requires special left-turn queue detection.

The utilization of a queue detector system, usually located 50 to 80 feet from the limit line in the left-turn lane, provides a logic mechanism to display the green arrow only when there is a queue so long that the left-turning volume cannot be served by the "green ball" only on that particular phase. With only the "green ball" under many situations of opposing Through traffic, the left turners will find an adequate gap in the opposing Through traffic and/or they will be able to make their left turn during the "yellow ball" clearance period. The exact distance back of the limit line to set the queue detector depends on the designer's judgment on the number of vehicles in the queue that warrants "bringing up" the green arrow at the predetermined time in the particular signal cycle. Some agencies, such as Los Angeles, consider bus activity in placing queue detectors.

In many installations, if the queue detector is occupied at the time in the cycle for the left arrow phase to begin, the left-turn lane will be displayed a green arrow. After the start of the left-turn arrow, the timing of the arrow is transferred to the "up close" loops in the left-turn lane for green arrow gap timing with a predetermined maximum time.

It is recognized that there is much to be learned in operating the most efficient queue detection system, including the prediction of the number of adequate gaps that will be available in the opposing through traffic so that the number of vehicles that could turn left in the gaps can be estimated. In most situations, two cars can make a left turn during the clearance interval (amber display). This means that if the intersection is operating on an 80-second cycle length, there would be 45 cycles per hour or 90 cars per hour turning left **without** the need to take time away from the opposing through traffic phase to serve the left turners. In addition to these "yellow clearance" left turners, under many conditions during the day, the left-turn demand can be satisfied by the gaps in the opposing through traffic, thereby increasing the capacity of the left-turn lane without the need for the green arrow.

D. All-Red Considerations

Intersections near major event generators can be good candidates for P/PLT operation. This would occur at an intersection with nominal cross-street traffic volumes most of the time, but with heavy directional flow on the cross street during events. An agency can operate the cross street under P/PLT and change the phase sequencing to run opposed (or "split") phasing on the cross street during event periods.

Agencies operating P/PLT may consider increasing "all red" time following through greens and yellows for permissive left-turn vehicle movements during the clearance interval (i.e., sneakers). However, experience indicates that once motorists become aware of the "all red," they begin to utilize it similar to a yellow clearance interval.

E. Switching between PPLT and Other Modes

It may be desirable to turn off P/PLT during unfavorable gap acceptance periods (i.e., peak). This operation, however, would require a custom application such as:

- A six-section head with a red arrow display for exclusive protected left-turn control.
- The system recommended by Jim Poston (see the "Previous Study Review" section for a reference).

To our knowledge, no Orange County agency has implemented a system that switches between PPLT and another form of left-turn phasing by time of day.

F. Survey of Orange County Agencies

The prior committee's survey of Orange County agencies revealed a desire for regional uniformity. Region-wide consistency on head design (cluster vs. vertical), head placement on the mast arm, and possible use of supplemental signing are most desirable. Agencies that have implemented many P/PLT signals have found that the operation works best when implemented on a corridor- or area-wide basis.

V. DESIGN

A. Introduction

The design element of this report is not intended to be used as a standard of practice for the design of P/PLT phasing. It is, however, intended to add uniformity and consistency in the design of traffic signals utilizing P/PLT phasing. Its use as a reference guideline could be extremely beneficial for traffic design professionals to facilitate design of different scenarios facing today's designer, ranging from a "T" intersection to a fully actuated eight-phase major arterial intersection.

The Update Committee has endeavored to incorporate the most recent hardware and software advances, as well as leading-edge operational practices and philosophies.

These design guidelines attempt to dispel long-standing myths associated with P/PLT phasing and address technical questions concerning operation, design, timing, peak-hour use, and indication placement. Its advantages and disadvantages, geometric constraints, and design characteristics are discussed in detail to allow the designer to be more informed and to make intelligent design decisions.

Being consistent in the design of P/PLT signal phasing is a two-fold proposition: first of all, it will help driver initiation, recognition, and acceptance of this particular form of phasing; and second, it will assist the governing agency to operate, program, and maintain this phasing system.

B. Description of Operation

The particular types of left-turn signal phasing possibilities are as follows: lead/lead, lag/lag, lead/lag, and lag/lead. It seems that for as many different intersection configurations that exist today, there are an equal number of available operating possibilities and phase sequences. The four conditions mentioned previously are the four sequences specifically analyzed for these guidelines.

C. Design Characteristics

This section has been compiled to point out many of the pros and cons the P/PLT designer might encounter (see Appendix C for summary). Review of the pros and cons will assist the designer in determining whether or not it is appropriate to implement this particular type of left-turn phasing at any given location. Also, for determining mounting and signing locations at new, modified, or retrofitted intersections, please review the technical diagrams in Appendix D for desired head placement, sign placement, and indication type considerations.

D. Recommended Design Characteristics and Equipment

This section provides the engineer/designer a brief overview of the recommended equipment and design characteristics for P/PLT phasing.

For further explanation or clarification on any of the recommendations outlined below, please refer to Appendix D at the end of this report.

The recommendations are as follows:

1. Use a five-section cluster head for mast arm mounting only.
2. The five-section cluster head should be placed as follows:
   a. For intersections with one approach lane and a separate left-turn lane, a cluster head should be mounted over the center of the through lane, along with a pole-mounted three-section head for through traffic.
   b. For intersections with two or more approach lanes and a separate left-turn lane, a cluster head should be mounted eight feet (±3') to the right of the barrier line, along with a pole-mounted three-section head.
3. Far-left indications should be a five-section stack head type. All configurations shall have a far-left indication.
4. Use left-turn pocket detector switching or back-up protection to avoid the "trap" situation.
5. Use queue detectors to call protected periods (see Operations section).
6. No sign is required; however, if one is desired by a particular agency, then an R73-7 "Left Turn Yield on 'green ball'" may be used.
7. A four-section stack head type is recommended for use at "T" intersections or one-way streets with lagging left turns. Clearance time is during the yellow ball.
8. A supplemental three-section head on the mast arm is not required but may be provided on very wide approaches.
9. Queue detection should be considered as a part of any P/PLT installation. Many methods exist to implement this design feature, which allows greater signal efficiency. See the Operations section for discussion on the operational parameters.

In order to modify a traditional left-turn phasing intersection into a P/PLT phasing intersection and to reuse existing equipment or hardware, the designer should consider all relevant modifications.

E. Geometric Constraints

The provisions listed in this geometric constraints section is a partial check-list of unfavorable geometric conditions that may exist at certain locations and to help determine if the proposed location is adaptable to P/PLT phasing.

- Horizontal curves creating sight distance problems (see discussion on sight distance problems in the Guidelines section and in Appendix E).
- Vertical curves creating sight distance problems (see discussion on sight distance problems in the Guidelines section and in Appendix E).
- Wide medians could obstruct sight distance (see sight distance considerations in Appendix E).

F. Sight Distance

The terms "gap" and "sight distance" are used to explain and clarify two important aspects in relation to protected/permissive left-turn phasing signal operation. Both of these terms have a direct relationship and importance for the left-turning motorist making a left turn on a "green ball" signal (permissive period).

When a motorist makes a "protected" left turn on a "green arrow," the left turner has the right-of-way and is given an unrestricted pathway for making the left turn. This left-turning motorist will logically assume that all conflicting pedestrian and vehicular movements are not allowed to conflict with the left turner's left-turn movement. Under normal circumstances, the left turner's attention is primarily focused on the "green arrow" signal, and secondarily on possible obstructions in the left-turner's pathway.

When the left turner is making a left turn on a "green ball" (permissive left turn), the situation is significantly different.

The typical "permissive" left-turn operation (left turn on green ball) in full execution involves the following generalized incremental steps by the motorist making the left turn:

1. Left-turning motorist observes oncoming (opposing) vehicles as he/she drives the vehicle into the street intersection area.

2. Left-turning motorist evaluates the available openings, or "gaps," in the opposing traffic stream and conflicting pedestrian movements. The "gaps" are the clear distances between approaching vehicles.

3. Left-turning motorist makes the left turn if the motorist's evaluation of the "gap" in the opposing traffic results in the conclusion that an adequate "gap" is available so that the left turn can be safely completed.

4. If the left-turning motorist's evaluation of the available "gaps" (spaces) in the oncoming (opposing) traffic stream results in the conclusion that there is not an adequate "gap," the left-turning motorist will normally (and should) wait in the intersection until he/she sees the yellow ball signal *and* observes that the

opposing vehicles are slowing and will be stopping for the red signal; after which the left turn is completed on the yellow signal, at the end of the yellow signal, or during the red clearance interval.

In cases when there are not enough adequate "gaps" in the opposing traffic stream, and there is a heavy demand for left turns, the particular signal control for the left-turn movement may incorporate a "queue detector" which changes the operation from "permissive" to "protected." That is, when the number of cars waiting at the signal in the left-turn lane equals or exceeds approximately three or more, the signal has the capability of detecting this queue length and provides that the left-turning vehicles will be given a green arrow.

Protected left-turn operations can also be triggered using "first car detection." With this operation, the protected left turn is triggered whenever any car is present in the left-turn pocket at the point in the cycle when a left-turn arrow can be provided.

For the left-turning motorist making a left turn on a green ball, the availability and determination of an adequate "gap" is important to the safe operation of this type of left turn. It is important to recognize that the "gap" in the opposing approaching traffic stream can be created in the following two ways:

- Density of the opposing traffic stream determines the number of seconds or distance between the opposing vehicles.
- Platooning of approaching vehicles due to an upstream traffic signal operation.

Sometimes roadway alignment conditions may limit the left-turning motorists' ability to observe the "gaps" in the approaching traffic stream in adequate time to make the permitted left turn. Standards for sight distance of approaching vehicles are discussed below.

"Gap" Standards

Prior to the publication of NCHRP Report 383 titled "Intersection Sight Distance," by the Transportation Research Board of the National Research Council in 1996, the standard for sight-distance evaluation was based on stopping sight distance. This means that the opposing through-movement vehicle was expected to have adequate distance to stop for the left-turning vehicle assuming that the left-turning vehicle stopped or was in the direct line of the opposing through-movement vehicle. The new standard now relates to having adequate "gaps" in the flow of traffic along the major road opposing the left-turn movement so that it is now the left turner who has adequate "gaps" in the opposing stream. While the new standard is given in "seconds," the "gap" distance can be determined as the product of "gap" in seconds and the vehicle speed in feet per second. Table 1 titled "Recommended Travel Times for Determining Sight Distance for Left Turns from the Major Road Across Opposing Traffic Lanes," as shown on page 81 of NCHRP Report 383, provides the current acceptance standard for "gap" spacing or sight distance wherever left turns are made from the major road across opposing traffic lanes.

Table 1 (Table 37 from page 81 of NCHRP Report 383) and its accompanying note are shown below.

TABLE 1:
Recommended Travel Times for Determining Sight Distance for Left Turns from the Major Road Across Opposing Traffic Lanes (Gap Acceptance)

Vehicle type	Travel time (sec) at design speed of major road
Passenger car	5.5
Single-unit truck	6.5
Combination truck	7.5

Note: For left turns that must cross more than one opposing lane, add 0.5 sec per additional lane for passenger cars, and 0.7 sec per additional lane for trucks.

As noted in the above table, the travel times or "gaps" shown in the table (for instance, 5.5 seconds for passenger cars) are for left turners crossing just one opposing lane of traffic. If there are two opposing lanes of traffic to be crossed by the left-turning motorist, the table indicates that an additional one-half second should be added to the 5.5 seconds, thereby providing a total required "gap" of 6 seconds for left turners crossing two opposing through lanes of traffic.

While Table 1 shows the "gaps" in terms of seconds, the distance requirement between vehicles, or from the intersection to the nearest sight obstruction, can be converted to distance in feet by multiplying the travel time in seconds required for the particular speed in feet per second. The required minimum "gap" establishes the sight-distance requirement. The previously used standard using "stopping sight distance" (in feet) did not relate to the left turner but referred to the vehicle opposing the left turner.

Determining the "Design Speed"

It is recommended that in those instances where the particular agency does not have a "design speed" designated for the particular street segment, one of the following two alternative procedures be used to determine the "design speed" for the approaches to the particular intersection.

The alternatives are as follows:

AASHTO Procedure

Using Figure II-22, *Relation of Average Running Speed and Volume Conditions* (p. 70 of "A Policy on Geometric Design of Highways and Streets," 1994), and the average speed recorded for the particular street approach to the intersection, the "design speed" can be estimated using the appropriate traffic volume curve. A copy of Figure II-22 is included in Appendix F for reference.

Procedure Based on 85th Percentile Speed

To determine the design speed from the 85th percentile speed, the following procedure is recommended:

- If the 85th percentile speed is at a 5 MPH increment, the design speed would be assumed to be 5 MPH higher (e.g. 45 MPH 85th percentile, 50 MPH design speed).
- If the 85th percentile speed is not at a 5 MPH increment, the design speed would be assumed to be 5 MPH higher than the next highest 5 MPH increment (e.g. 46 MPH 85th percentile, 55 MPH design speed).

Other examples include:

85th Percentile	5 MPH Increment	Design Speed
40 MPH	40 MPH	45 MPH
43 MPH	45 MPH	50 MPH
52 MPH	55 MPH	60 MPH
39 MPH	40 MPH	45 MPH

Based on this procedure, the design speed will range from 5 to 9 MPH above the 85th percentile speed.

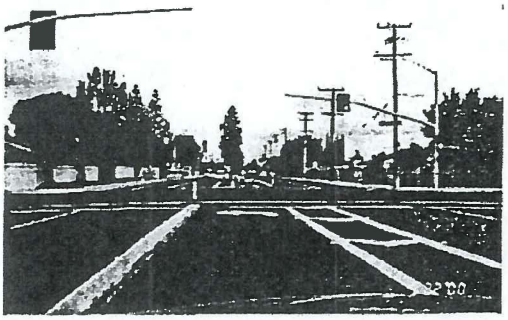
Positive Offset Left-Turn Lanes

In some cases, the policy in implementing protected/permissive left-turn phasing involves the offsetting of the left-turn lanes so that left-turning vehicles have a clear sight line of opposing through traffic which is not restricted by vehicles in the opposing left-turn lane.

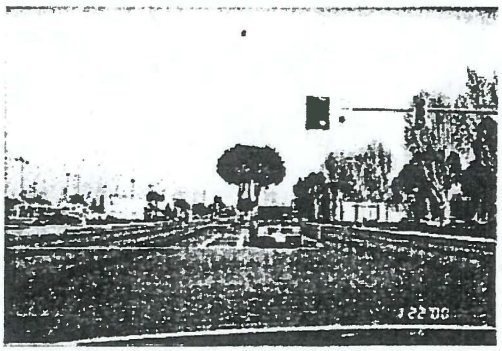
Figure 2, titled *Examples of "Positive Offset" Left-Turn Lanes at Signalized Intersections*, shows some examples of left-turn lane geometrics designed so that the driver in the left-turn lane can see approaching through traffic (i.e., past the vehicles in the opposing left-turn lane).

Appendix E illustrates examples of positive and negative offset.

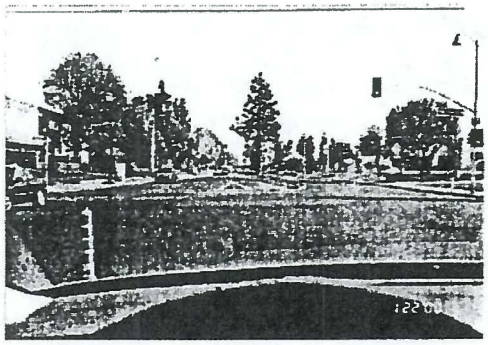
Left turn "positive offset"



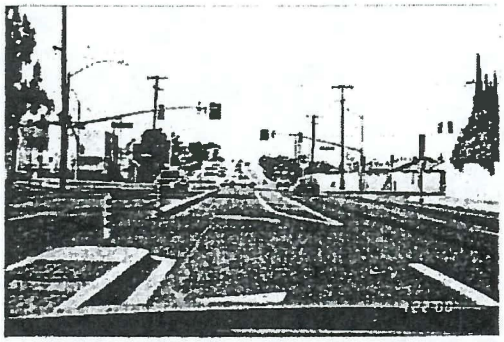
Example of left turn lane
to create "positive offset" for
visibility of opposing thru vehicles



Shows how "positive offset"
allows good view of on-coming
thru vehicles for permitted
left turn driver



Example of a "positive offset"
at a two phase signal



Shows narrowing of median
nose to create "positive offset"

Photos taken in Fountain Valley

HMA	Examples of "positive offset" left turn lanes at signalized intersections	FIGURE 2

G. Signal Indications

As the variety of signal displays for similar movements by agencies increases, so does driver confusion. There is a need for the driver to be able to associate (identify) specific indications for specific movements. These design guidelines will help resolve some of the problems with conflicting displays.

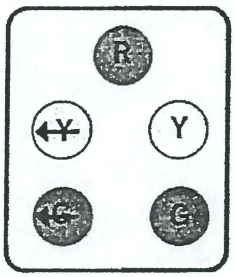
To aid drivers in movement identification, the following recommendations for protected/permissive signalized intersections are made:

1. The cluster head be used exclusively for left-turn displays on mast arm mount.
2. Three-section vertical heads only (on the mast arms) for Through movements (for two or more approach lanes and a separate left-turn lane).
3. Five-section stack heads should be used for far-left indication.

A graphic display of the signal heads, their uses, and their functions are discussed as follows:

Common Name:

Cluster Head (aka "Doghouse")



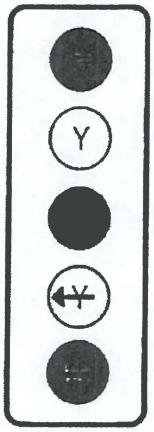
Uses:	Mast-arm mounting. PPLT phasing.
Sign: (if used)	R73-7 "Left-Turn Yield on 'green ball' (others possible)
Advantages:	Distinctive indication arrangement, which alerts drivers to the P/PLT operation. Consistent with heads already in use.
Disadvantages:	May be confusing to first-time users.

Note: Due to the distinctive shape of the cluster head and the Committee's desire to distinguish P/PLT operations, it was determined that this head should be used only for P/PLT operation (for the mast arm indications).

DRAFT

Common Name:

Five-Section Stack



Uses: Far-left mounting. P/PLT phasing.

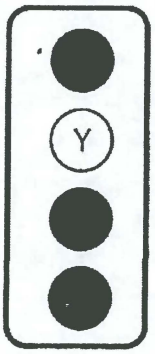
Sign: (if used) R73-7 "Left-Turn Yield on 'green ball'."

Advantages: More consistent with traditional displays. Consistent with existing installations. (TV-1-T mounting recommended.)

Disadvantages: Not as compact as the cluster head. May not be identified by drivers as a P/PLT operation.

Common Name:

Four-Section Stack



Uses: Far-left and mast-arm mounting. P/PLT phasing at "T" intersections and where lagging left turns are used.

Signs: (if used) R73-7 "Left-Turn Yield on 'green ball'."

Advantages: Compact size and ease to recognize. (TV-1-T mounting recommended.)

Disadvantages: No yellow arrow display.

Note: Numerous other signal head configurations are in use today that cannot be listed separately here. Only commonly used configurations are illustrated in this section.

H. Summary

Use of the P/PLT phasing sequence is a viable operational parameter during non-saturated traffic flow condition. Through the use of accepted updated traffic signal equipment, the installation, operation, and maintenance of these systems is an acceptable alternative to conventional left-turn design. Most people would prefer not to remain at a signalized intersection any longer than possible. At the same time, P/PLT saves the commuter time and increases the efficiency of the signal systems, which translates into fuel efficiency and less driver frustration.

It is always a good idea to remember that many locations are not well suited for this form of operation, such as arterials with high approach speed, multiple left-turn lanes, vertical and horizontal alignment problems, and high left-turn collision history. Therefore, extra care should be taken when designing a new P/PLT phasing intersection or in the modification of an existing conventional left-turn phasing intersection.

The benefit of using the protected/permissive operation is clearly in time savings and pollution reduction. This is a trend that has far-reaching impacts. Most public agencies using this system have reduced stop delay, fuel consumption, and citizen complaints.

The Committee acknowledges this operation is not ideal for every situation, but recommends considering this type of left-turn phasing at locations that could benefit from P/PLT phasing.

VI. PUBLIC AWARENESS AND EDUCATION

A. Summary of Prior Efforts

The previous PPLT Committee organized a major public education campaign with the following features:L

- Revisions to the State of California Department of Motor Vehicles (DMV) Driver Handbook to educate drivers about PPLT.
- Preparation of public information bulletins and hand-outs, also to educate drivers about PPLT.
- Preparation of a script for a Public Service Announcement video.

The current committee's efforts were focused on updating the guidelines to conform to best current practices, in part to reduce the need for public education. Therefore, no additional public education campaign was undertaken.

Appendix A:

Members of the Update Committee

and the

Original PPLT Committee

The PPLT Update Committee Membership

John A. Kerenyi, P.E. (Chair)	Kimley-Horn & Associates	(714) 939-1030
Mark Esposito	Hartzog & Crabill	(714) 731-9455
Jose Alire, P.E.	City of Fountain Valley	(714) 593-4517
Mike Evans	City of Mission Viejo	(949) 470-3039
Mark Lewis, P.E.	City of Fountain Valley	(714) 593-4435
Hank Mohle, P.E.	Rick Engineering	(714) 939-1440
Carlos Ortiz, P.E.	Robert Bein, William Frost & Associates	(949) 472-3505
Jim Otterson, P.E.	Otterson & Associates	(714) 960-5620
David Royer, P.E.	U.C. Berkeley Institute of Transportation Studies	(661) 255-6556
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The Original PPLT Committee Membership

Cory A. Bersch, P.E.

H. William Dickson, P.E.

Gary P. Foxen

R. Paul Grimm, P.E.

Tram Hartzog

R. Henry Mohle, P.E.

Ignacio G. Ochoa, P.E.

James D. Otterson, P.E.

James M. Paral, P.E.

Steven S. Sasaki, P.E.

Dennis Schmitz

James J. Sommers

Bernard J. Vokoun, P.E.

Appendix B:

The "Trap" situation explained

Appendix B: The "Trap" Explanation

This appendix contains diagrams to explain the "trap" situation which shall not be permitted when protected/permissive left-turn phasing is used.

The "trap" occurs when a person turning left on a "yellow ball" crosses in front of opposing thru traffic that continues to be controlled by a "green ball."

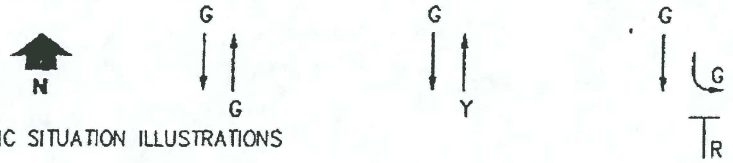
A basic driving assumption is that when a driver is turning left on a "yellow ball," the opposing thru traffic is also observing a "yellow ball" and, therefore, the opposing thru traffic will be stopping on the "red ball" following the "yellow ball." The driver turning left on the "yellow ball" must be assured that this basic assumption is true.

The diagrams were furnished by Brian Gallagher, P.E., Transportation Engineer, Signal Systems and Research Section, Department of Transportation, City of Los Angeles. Brian's valuable contribution to the original PPLT Committee's work is hereby acknowledged with sincere appreciation.

THE "TRAP" ILLUSTRATED

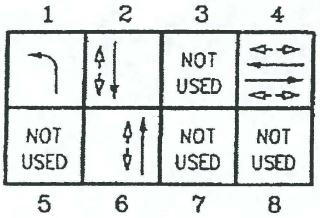
1) QUESTION – What is a "left turn trap" ?

2) ANSWER – This is a "trap" for Northbound & Westbound left turns. The left turns are permissive.



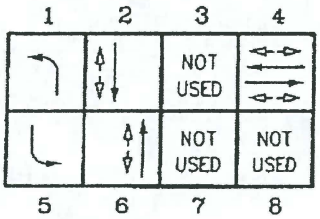
3) SPECIFIC SITUATION ILLUSTRATIONS

A)



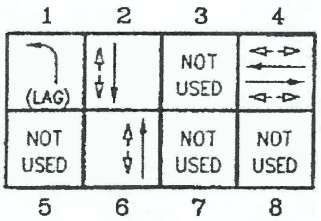
Trap for S/B Left–Turn if ø4 not on recall or ø1 does not place a call to ø4.
ø1 can be either Protected–Only or Protected/Permissive.

B)



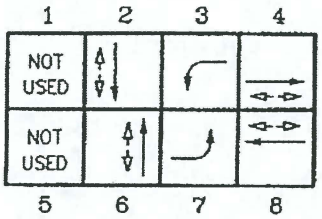
Trap for either N/B Left–Turn or S/B Left–Turn if there is no ø4 call and both Left–Turn Phases do not come up simultaneously.
Only applies if ø1 and ø5 are Protected/Permissive Left–Turn.

C)



You can Not have a Lagging Permissive/Protected Left–Turn when the cross street is 2–way.
This would be acceptable (and preferred) if the East–West street shown was One Way Westbound.

D)



As long as ø2 and ø6 are on recall, this is O.K. for Protected only or Protected/Permissive Left–Turn in either ø3, ø7 or both.
See note "C" regarding Lagging Permissive/Protected.

RULES:
1. If Left–turn phase for only 1 of 2 directions, use call to phase or min. recall for side street.
2. Don't use Lagging Permissive/Protected left–turn phases when a one–way street or T–intersections is Not Involved.
3. Even a 2–phase intersections a left–turn trap can occur during preemptions – BE CAREFUL.

Page 1 of 1
JULY 22, 1994

Appendix C:

Pros and Cons of PPLT

Appendix C:

Pros and Cons of Protected/Permissive Left-Turn Phasing

Pros:

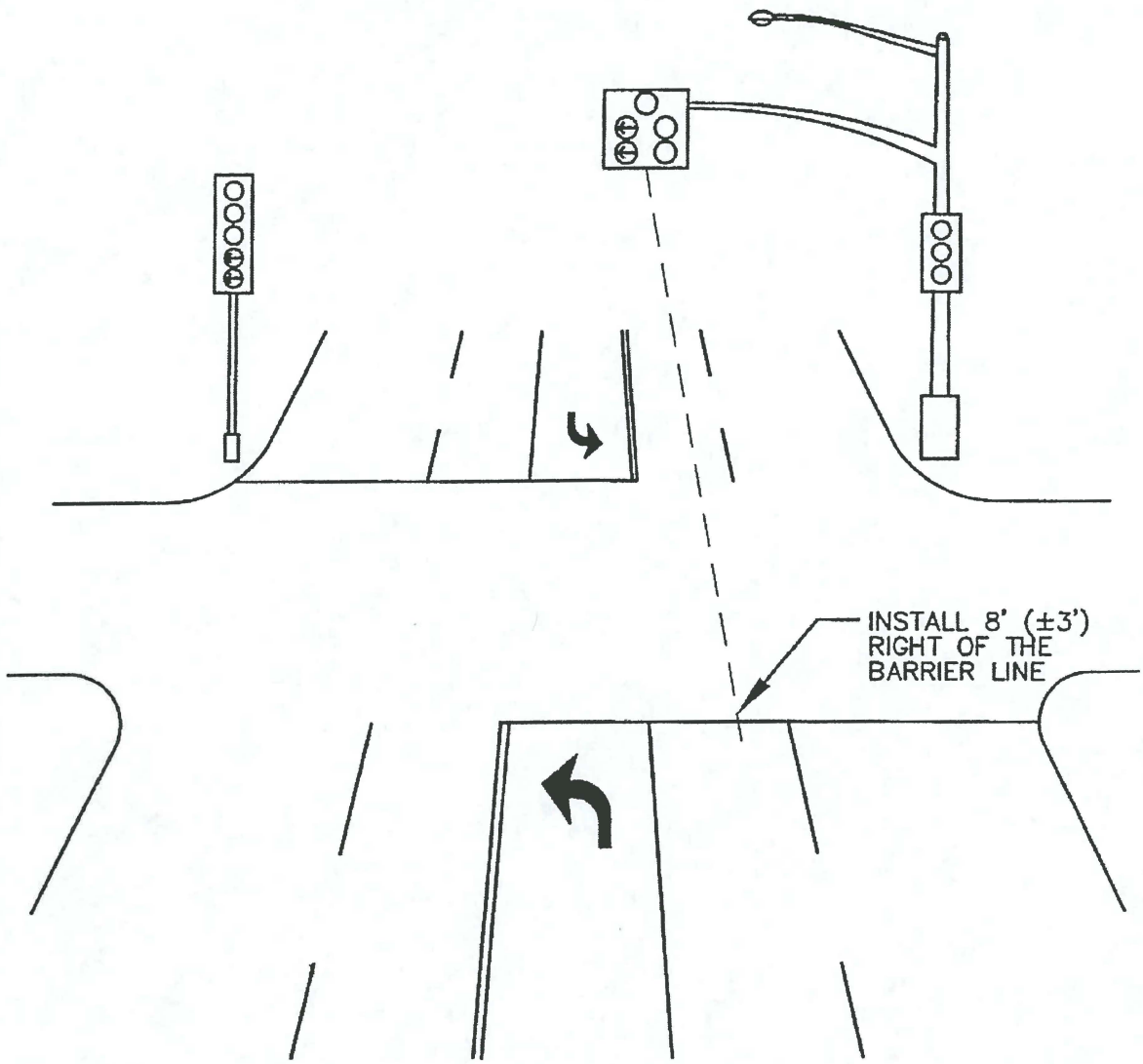
- Reduces delays and stopped time on coordinated systems.
- Allows for selective use of shorter cycle lengths at each intersection.
- Reduces fuel consumption.
- Reduces pollution.
- Provides high signal system efficiency (slightly less than only permissive in the worst case and as good in the best case) because it allows for all left-turn phasing combinations (with special equipment), thus producing the best fit into the green band, while still providing protected left turns. This benefit is high both during peak travel periods, when protected lef-turn phasing has the greatest effect; and off-peak, when the larger number of acceptable gaps in through traffic allow left turners to proceed without waiting for the green arrow.
- Fewer right-angle accidents may occur than under permissive-only operation, due to the presence of the protected lef-turn phase.

Cons:

- Lost time due to various measures required to prevent left-turn trap phasing situations.
- Driver confusion and resistance to acceptance.
- More right-angle accidents may occur when compared to protected-only.
- Signal head configuration and placement not uniform throughout the area.
- Arterial system timing is difficult to use with protected/permissive operation.

Appendix D:

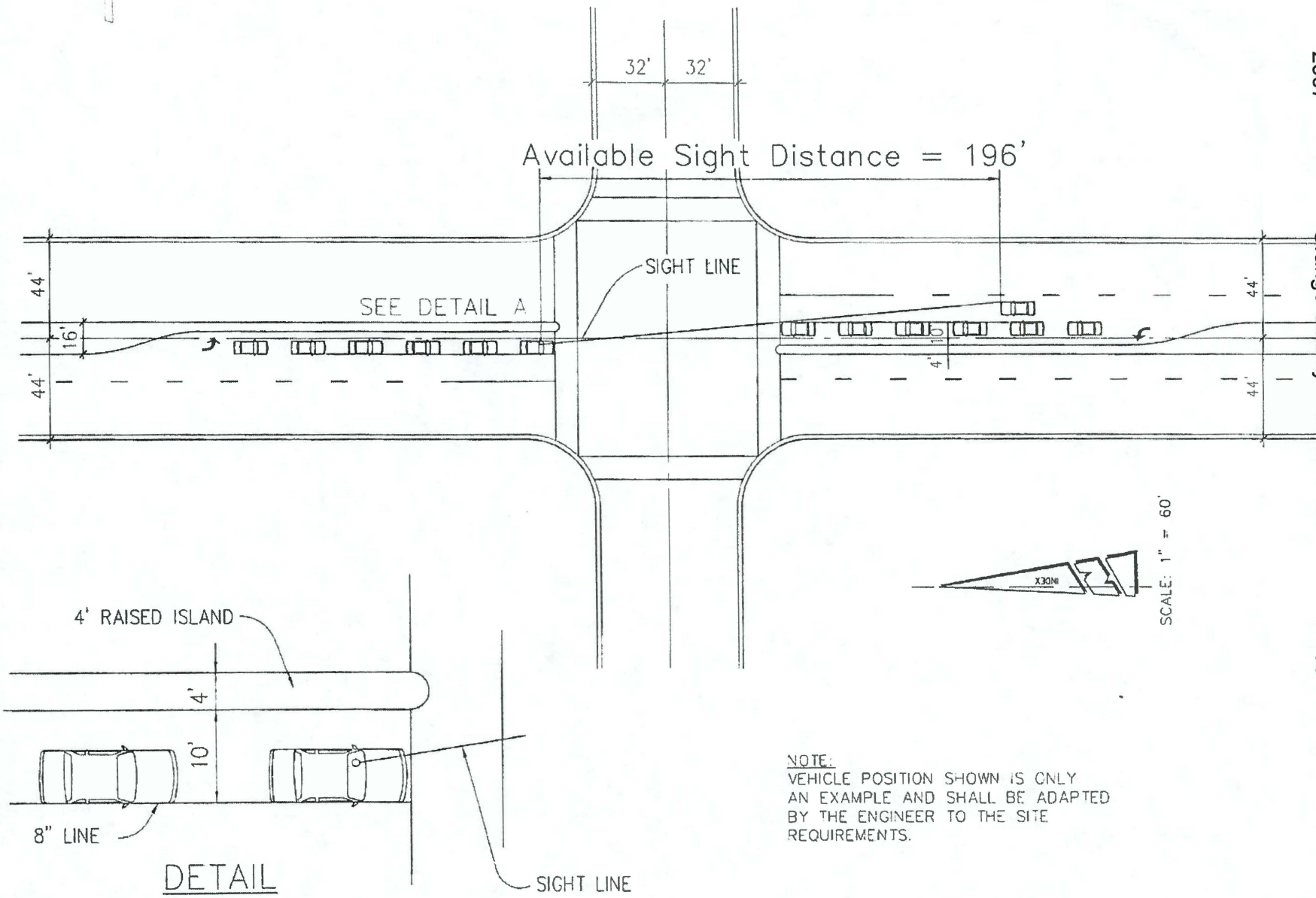
Recommended Signal Head Locations



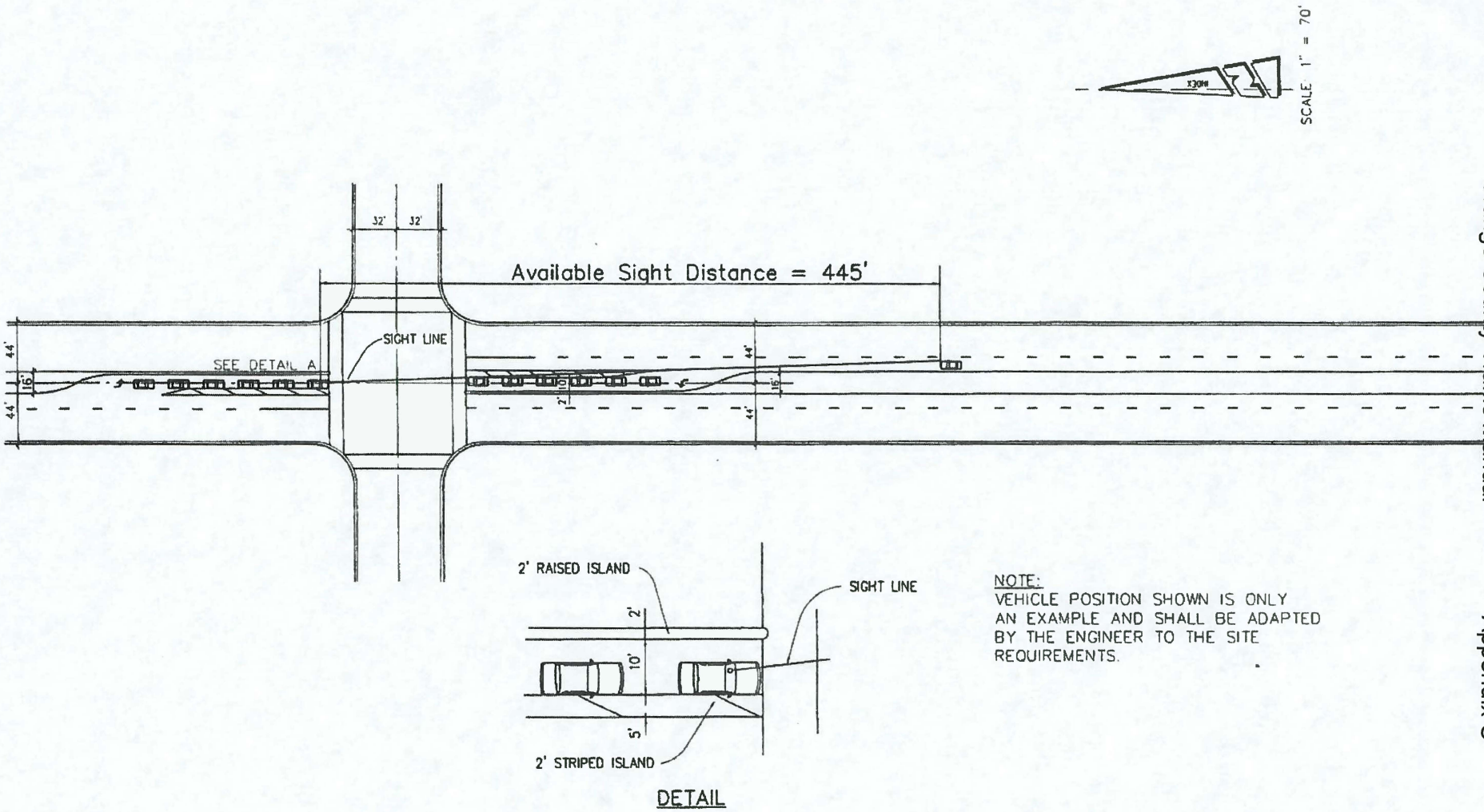
Appendix D:
Recommended Signal Head Locations

Appendix E:

Visibility Considerations

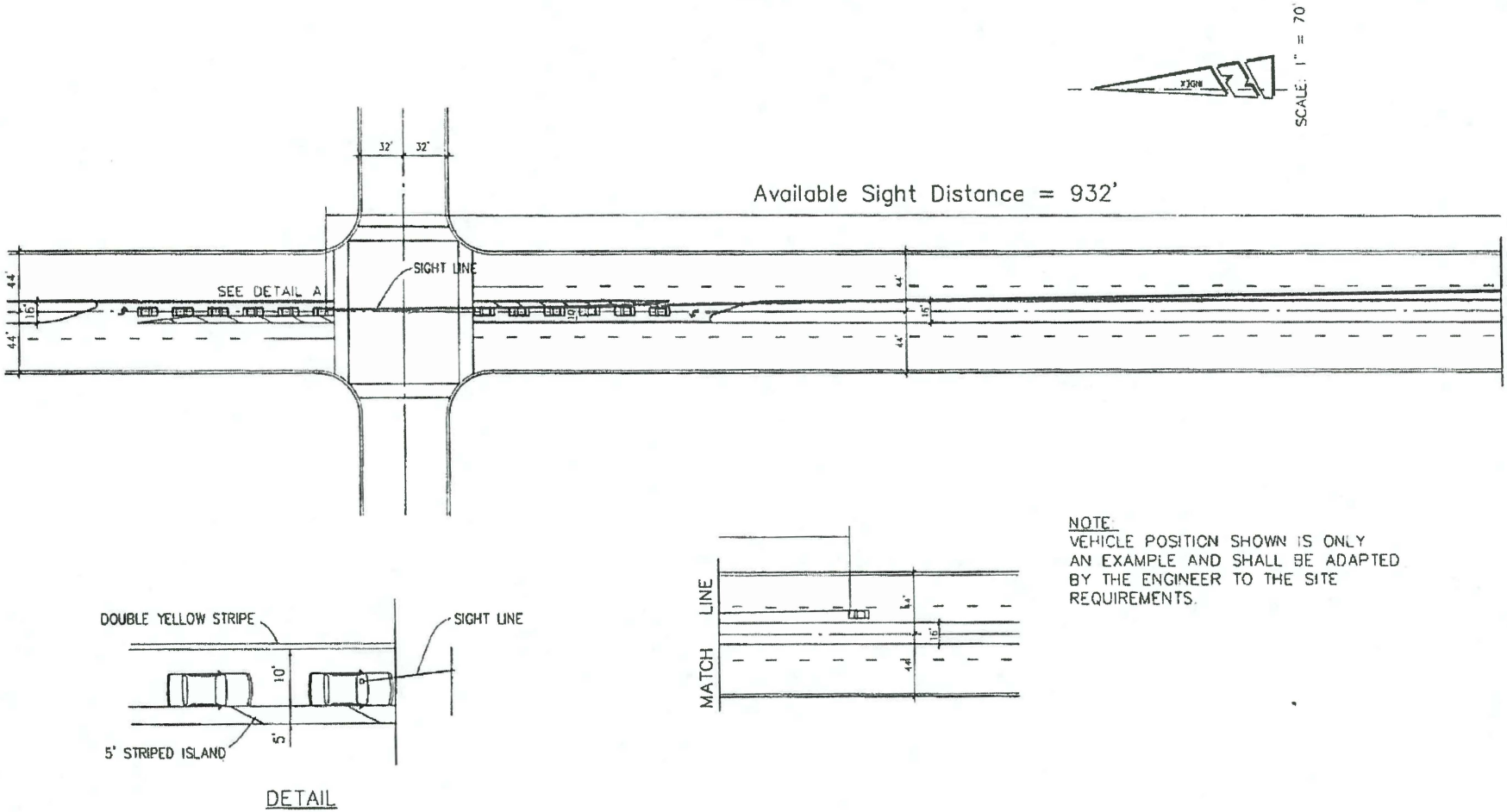


OCTEC	Visibility Consideration for Left Turning Vehicles– Straight Roadway with Standard Islands	FIGURE E–1



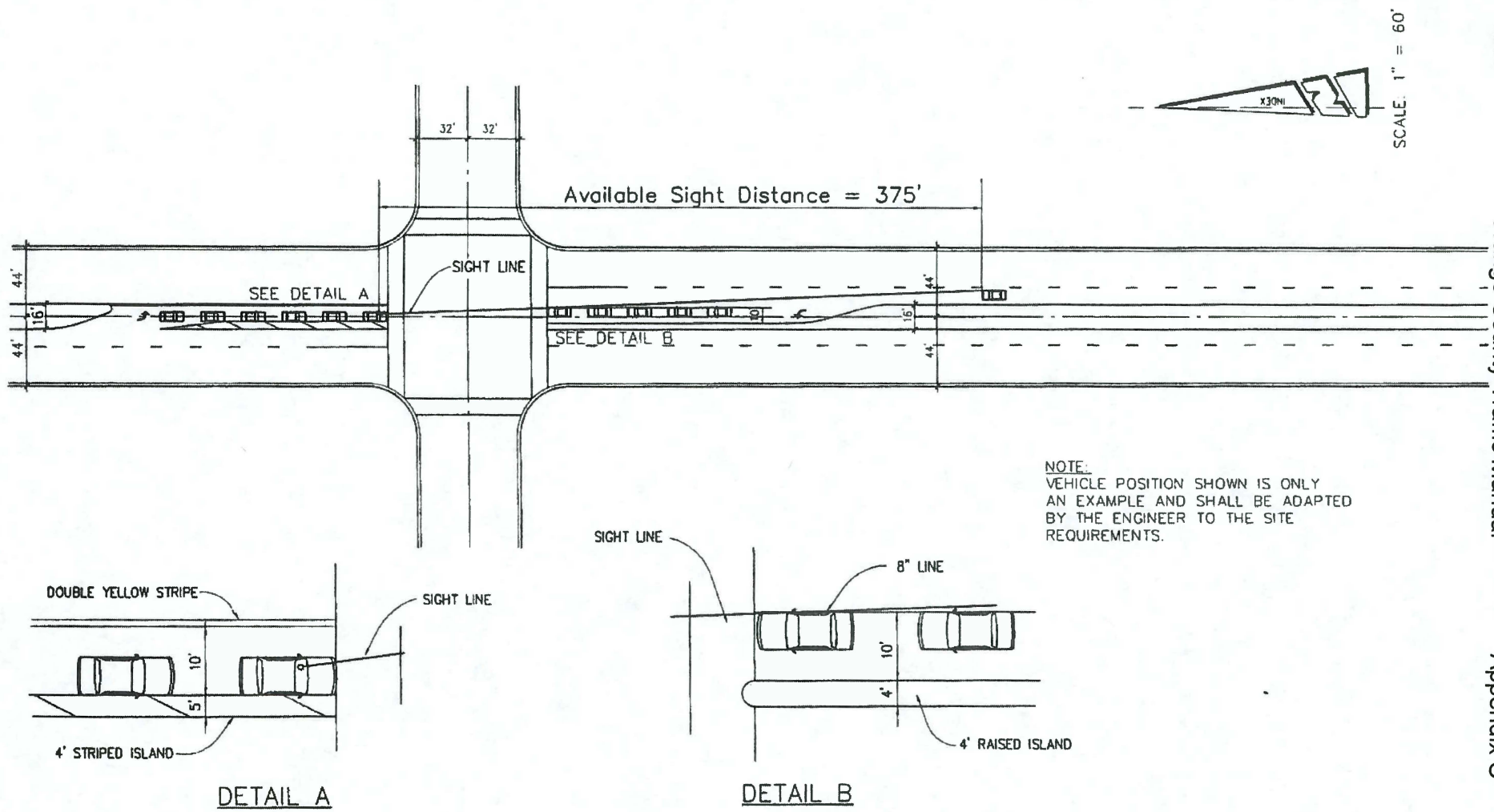
NOTE:
VEHICLE POSITION SHOWN IS ONLY AN EXAMPLE AND SHALL BE ADAPTED BY THE ENGINEER TO THE SITE REQUIREMENTS.

OCTEC	Visibility Consideration for Left Turning Vehicles– Straight Roadway with 2–Foot Noses	FIGURE E–2



NOTE
VEHICLE POSITION SHOWN IS ONLY AN EXAMPLE AND SHALL BE ADAPTED BY THE ENGINEER TO THE SITE REQUIREMENTS.

OCTEC	Visibility Consideration for Left Turning Vehicles– Straight Roadway with Double–Yellow Lines	FIGURE E–3



OCTEC	Visibility Consideration for Left Turning Vehicles– Straight Roadway with Double–Yellow Line and Opposing Standard Island	FIGURE E–4

4.2.3 Protected-Permissive Left-Turn phasing

A combination of protected and permissive left-turn phasing is referred to as protected-permissive left-turn (PPLT) operation. This phasing pattern is illustrated in figure 28. A typical signal head and associated signing arrangement that implements protected-permissive phasing is shown in figure 29; refer to the MUTCD for other configurations.

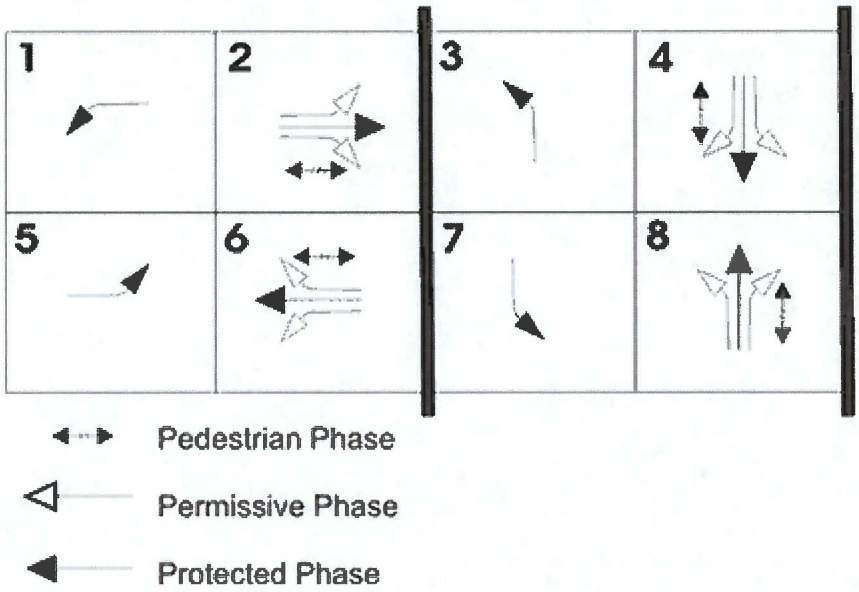
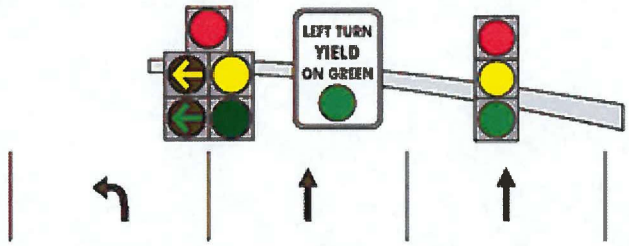
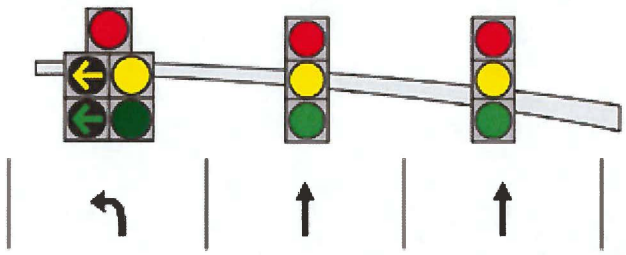


Figure 28. Typical phasing diagram for protected-permissive left-turn phasing.



(a) Protected-permissive left-turn phasing using a five-section head located directly above the lane line that separates the exclusive through and exclusive left-turn lane, along with an accompanying sign.



(b) Protected-permissive left-turn phasing using a five-section signal head located directly above the exclusive left-turn lane.

Figure 29. Possible signal head and signing arrangement for protected-permissive left-turn phasing.

Observed improvements in signal progression and efficiency combined with driver acceptance have led to expanded usage of PPLT over the years. PPLT signals offer numerous advantages when compared to "protected-only" operation. These advantages are associated with both protected-permissive and lead-lag operation. They include the following (adapted with additions by the authors):[48]

- Average delay per left-turn vehicle is reduced.
- Protected green arrow time is reduced.
- There is potential to omit a protected left-turn phase.
- Arterial progression can be improved, particularly when special signal head treatments are used to allow lead-lag phasing.

Some disadvantages include the following:

- The permissive phase increases the potential for vehicle-vehicle and vehicle-pedestrian conflicts.
- There is a limited ability to use lead-lag phase sequences unless special signal head treatments are used (see below).

The controller phasing for protected-permissive mode is the most complicated phasing because of the safety implications created by the potential of what is known as the "yellow trap." In a permissive-mode operation, the left-turning driver must obey the green display for the adjacent through movement, which also gives permission for the permissive left turn. When the yellow display for the adjacent through movement appears, the left-turning driver ordinarily expects the opposing through display to be yellow as well. The driver may now mistakenly believe that the left turn can be completed on the yellow display or immediately thereafter when the opposing through display will be red.

For ordinary lead-lead operation where both protected left-turn phases precede the permissive phases, this is not a concern, as both permissive phases end concurrently. However, this problem can occur when a permissive left turn is opposed by a lagging protected left turn. In this type of operation (known as lag-permissive), the yellow display seen by a left-turning driver is not indicative of the display seen by the opposing through driver. The opposing through display may be yellow or may remain green. A driver who turns left believing that the opposing driver has a yellow or red display when the opposing driver has a green display may be making an unsafe movement. This yellow trap is illustrated in figure 30.

Drivers who encounter this trap are those that attempt to make a permissive left-turn after a protected leading left-turn phase. Typically they have entered the intersection on a permissive green waiting to make a left turn when sufficient gaps occur in opposing through traffic. If the absence of gaps in opposing through traffic requires them to make their turn during the left-turn clearance interval, they may be "stranded" in the intersection because of the absence of gaps and because the opposing through movement remains green. More importantly, they may incorrectly presume that the opposing through traffic is being cleared at the same time that the adjacent through movement is being terminated. Therefore, they may complete their turn believing that opposing vehicles are slowing to a stop when in fact the opposing vehicles are proceeding into the intersection with a green ball signal indication.

There are two ways to eliminate the yellow trap. First, the phase sequence at the intersection can be restricted to simultaneous leading (lead-lead) or lagging (lag-lag) left-turn phasing. Second, the signal display can be altered to allow the left-turn signal head to display a permissive left turn independently of the adjacent through movements, which allows the through movements to terminate but allow a permissive left turn to continue during the opposite approach's lagging protected left-turn phase. Some agencies have experimented with signal displays (e.g., "Dallas Display," flashing circular red, flashing red arrow, flashing circular yellow, and flashing yellow arrow) that allow this type of operation. Of these, the "Dallas Display" optically restricts the visibility of the permissive movement using louvers; it is fully compliant with the MUTCD and is shown in figure 31.

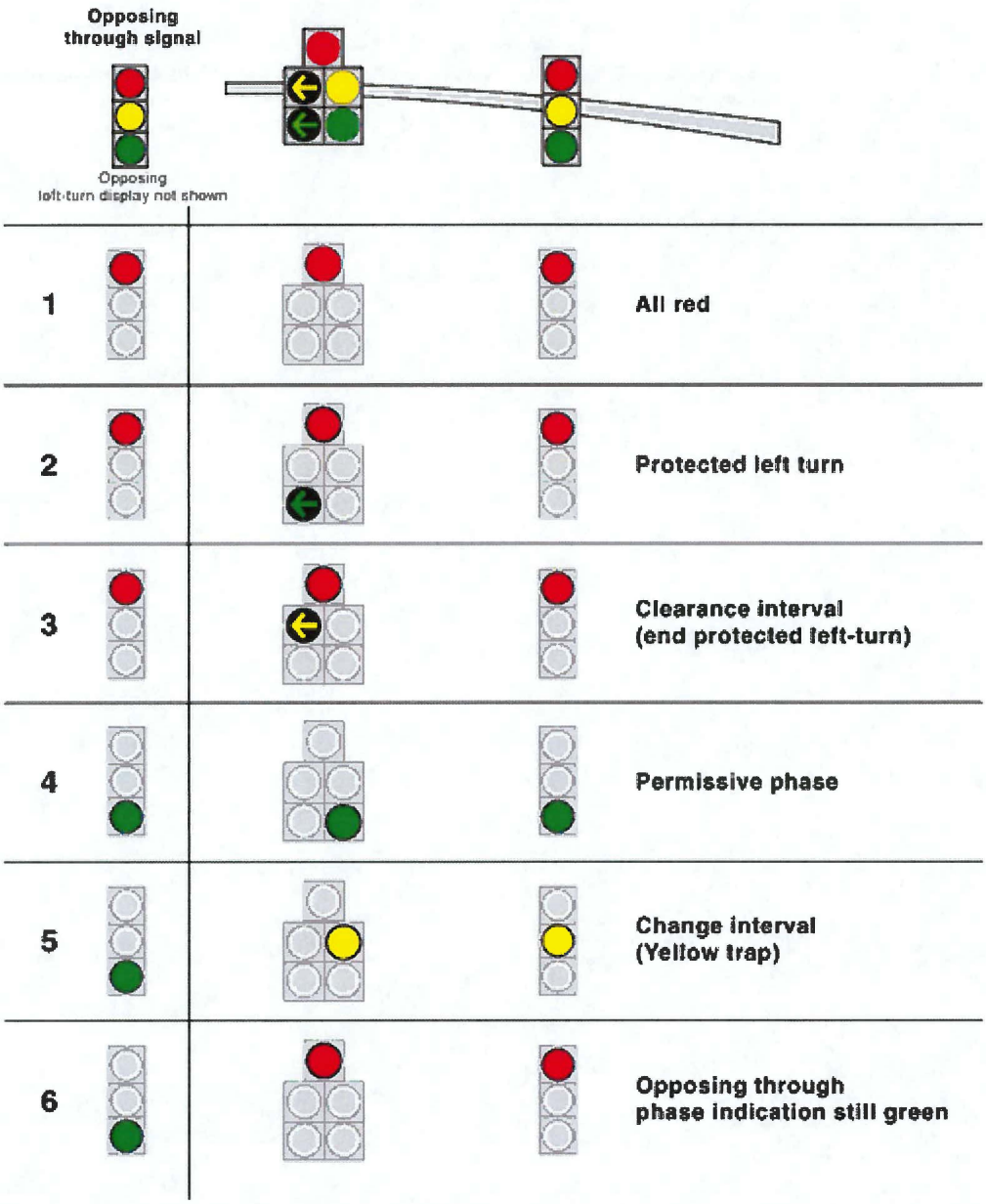


Figure 30. Illustration of the yellow trap.[3]

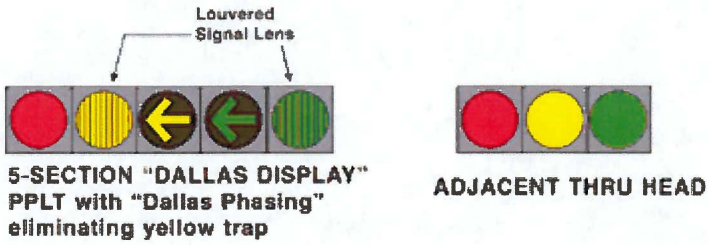


Figure 31. The protected-permissive left-turn display known as "Dallas display" uses louvers to restrict

visibility of the left-turn display to adjacent lanes.[49]

A national NCHRP study, has examined the operational advantages and safety aspects of various PPLT control devices and signal arrangements. The study determined that a flashing yellow arrow PPLT display was consistently found to be equal or superior to existing PPLT displays both in a laboratory environment and in cities where the display was experimentally implemented in the field.[49] The flashing yellow arrow display for PPLT is still considered experimental by the MUTCD and is undergoing further field testing.

14 ISSUE BRIEFS

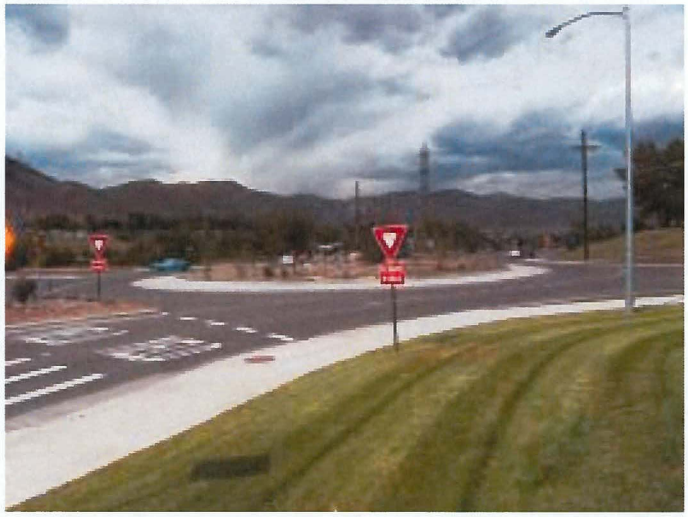
Roundabouts

A proven safety solution that reduces the number and severity of intersection crashes.

History of Roundabouts

The "modern roundabout" is commonly confused with older-style traffic circles and rotaries. Traffic circles have been around almost a century, with the first documented one being built in 1905 on the southwest corner of Central Park in New York City and named after Christopher Columbus. From the start, traffic circles provided the ability for a city to tie a number of intersecting streets together and make a landscaped central circle that had aesthetic value to the community. Many large circles or rotaries were built in the United States until the 1950s when they fell out of favor. The older-style rotaries enabled high-speed merging and weaving of vehicles that led to a high crash experience.

The modern roundabout was developed in the United Kingdom to rectify problems associated with these traffic circles. In 1966, the United Kingdom adopted a mandatory "give-way" rule at all circular intersections, which required entering traffic to give way, or yield, to circulating traffic. This rule prevented circular intersections from locking up by not allowing vehicles to enter the intersection until there were sufficient gaps in circulating traffic.



What is a Modern Roundabout?

A modern roundabout is a one-way circular intersection without traffic signals in which traffic flows around a center island. Roundabouts feature yield control for all entering traffic, channelized approaches and appropriate geometric curvature to ensure that travel speeds on the circulatory roadway are typically less than 30 mph. Roundabouts must be designed to meet the needs of all users—drivers, pedestrians, pedestrians with disabilities and bicyclists. When designing roundabouts, special considerations must be given to the needs of pedestrians with visual disabilities who are unable to judge adequate gaps in traffic at roundabouts. Proper site selection and pedestrian channelization are essential to making roundabouts accessible to all users. Roundabouts can also be designed for trucks and larger vehicles and in geographic areas where significant snowfall is the norm during the winter.

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Features of Modern Roundabouts

The design and traffic control features of roundabouts are as follows:

- **Yield control** is used on all entries.
- The **circulatory roadway** has no traffic control. Circulating vehicles have the right-of-way. All vehicles circulate counter-clockwise and pass to the right of the central island.
- **Central island.** Once within the circulatory roadway, vehicles' paths are further deflected by the central island.
- **Pedestrian access** is allowed only across the legs of the roundabout, behind the yield line to the circulatory roadway. Pedestrian crossings are located at least one vehicle length upstream of the yield point.
- **Splitter island.** A splitter island is a raised or painted area on an approach used to separate entering from exiting traffic, deflect and slow entering traffic and provide storage space for pedestrians crossing the road in two stages.
- **Yield line** is a pavement marking used to mark the point of entry from an approach into the circulatory roadway. This is generally marked along the inscribed circle. Entering vehicles must yield to any circulating traffic coming from the left before crossing this line into the circulatory roadway.
- **Landscaping buffer** Landscaping buffers are provided at most roundabouts to separate vehicular and pedestrian traffic and to encourage pedestrians to cross only at the designated crossing locations. Landscaping buffers can also significantly improve the aesthetics of the intersection.
- **Accessible pedestrian crossings.** Accessible pedestrian crossings should be provided at all roundabouts. The crossing location is set back from the yield line and the splitter island is cut to allow pedestrians, wheelchairs, strollers and bicycles to pass through. Tactile surfaces should be used to warn pedestrians with visual disabilities that they are about to enter the roadway.

Roundabout Safety

Research indicates that well-designed roundabouts can be safer and more efficient than conventional intersections. Safety benefits of roundabouts include:

- Roundabouts have fewer conflict points in comparison to conventional intersections. The potential for hazardous conflicts, such as right-angle and left-turn head-on crashes is eliminated with roundabout use. Single-lane approach roundabouts produce greater safety benefits than multilane approaches because of fewer potential conflicts between road users and because pedestrian crossing distances are shorter;
- Low absolute speeds associated with roundabouts allow drivers more time to react to potential conflicts, also helping to improve the safety performance of roundabouts;
- Since most road users travel at similar speeds through roundabouts, i.e., have low relative speeds, crash severity can be reduced compared to some traditionally controlled intersections;
- Roundabouts have fewer annual injury crashes than rural two-way stop-controlled intersections, and the total number of crashes at roundabouts is relatively insensitive to minor street demand volumes; and
- Roundabouts have fewer injury accidents per year than signalized intersections, particularly in rural areas. At volumes greater than 50,000 average daily traffic (ADT), urban roundabout safety may be comparable to that of urban signalized intersections.

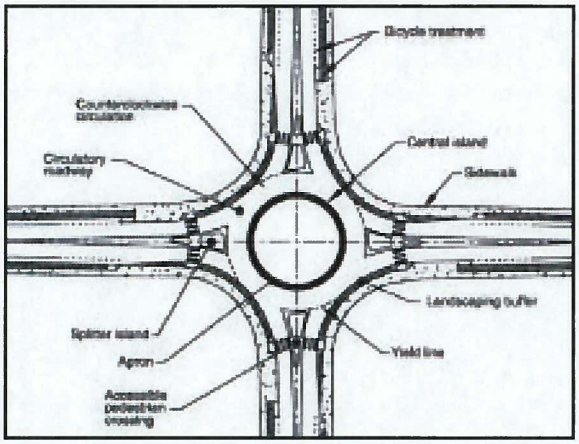
Table 1 shows the crash frequencies (average annual crashes per roundabout) experienced at 11 intersections in the United States that were converted to roundabouts. As the exhibit shows, both types of roundabouts showed a reduction in both injury and property-damage crashes after installation of a roundabout.

A December 2002 report by the Maryland Highway Administration indicates that 15 single-lane roundabouts have greatly improved intersection safety in the state. The analysis shows that there has been a 100 percent decrease in the fatal crash rate; a 60 percent decrease in the total crash rate; an 82 percent reduction in the injury crash rate; and a 27 percent reduction in the property damage only accident rate.

Table 1

		Before Roundabout			Roundabout			Percent Change 5		
Type of Roundabout	Sites	Total	Inj.[3]	PDO[4]	Total	Inj.	PDO	Total	Inj.	PDO
Small/Moderate[1]	8	4.8	2.0	2.4	2.4	0.5	1.6	-51%	73%	-32%
Large[2]	3	21.5	5.8	15.7	15.3	4.0	11.3	-29%	31%	-10%
Total	11	9.3	3.0	6.0	5.9	1.5	4.2	-37%	51%	-29%

Notes:
1. Mostly single-lane roundabouts with inscribed circle diameter of 100 ft. to 115 ft.
2. Multilane roundabouts with an inscribed circle diameter greater than 165 ft.
3. Inj. = Injury crashes
4. PDO = Property Damage Only crashes
5. Only injury crash reductions for small/moderate roundabouts were statistically significant. Source: Jacquemart, G. Synthesis of Highway Practice 264: *Modern Roundabout Practice in the United States.* National Cooperative Highway Research Program. Washington, DC: National Academy Press, 1998.



Safety Problems Susceptible to Correction by Roundabouts

The decision to install a roundabout as a safety improvement should be based on a demonstrated safety problem of the type susceptible to correction by a roundabout. A review of crash reports and the type of accidents occurring is essential.

Examples of safety problems include:

- High rates of crashes involving conflicts that would tend to be resolved by a roundabout (right-angle, head-on, left/through, U-turns, etc.);
- High-crash severity that could be reduced by the slower speeds associated with roundabouts;
- Site visibility problems that reduce the effectiveness of STOP sign control (in this case, landscaping of the roundabout needs to be carefully considered); and
- Inadequate separation of movements, especially on single-lane approaches.

Issues to Review When Considering Roundabout Design Alternatives

During the planning and alternatives development stage of a project, the following issues should be considered prior to making the decision to implement a roundabout design:

- **Context.** What are the regional policy constraints that must be addressed? Are there site-specific and community impact reasons why a roundabout of any particular size would not be a good choice?
- **Space feasibility.** Is there enough right-of-way to build the roundabout? Is right-of-way acquisition required? If "yes," this introduces administrative complications that some agencies might want to avoid.
- **Physical or geometric complications** such as right-of-way limitations, utility conflicts, drainage problems and unfavorable topography that may limit visibility or complicate construction.
- **Proximity of generators** of significant traffic that might have difficulty negotiating the roundabout, such as high volumes of oversized trucks.
- **Proximity of traffic control devices** that would require preemption, such as railroad tracks or drawbridges.
- **Traffic congestion** that would cause routine back-ups into the roundabout, such as over-capacity signals or freeway entrance ramps. The successful operation of a roundabout depends on unimpeded flow on the circulatory roadway.
- **Intersections of a major arterial and a minor arterial or local road** where an unacceptable delay to the major road could be created. Roundabouts delay and deflect all traffic entering the intersection and could introduce excessive delay or speed inconsistencies to flow on the major arterial.
- **Heavy pedestrian or bicycle movements** in conflict with high traffic volumes. (These conflicts pose a problem for all types of traffic control.)
- **Coordinated signal system.** Intersections located on arterial streets within a coordinated signal network. In these situations, the level of service on the arterial might be better with a signalized intersection incorporated into the system.

The existence of one or more of these conditions does not necessarily preclude the installation of a roundabout. Roundabouts have, in fact, been built at locations that exhibit nearly all of the conditions listed above. They may be resolved through coordination with and support from other agencies and implementation of specific mitigation actions.

Resources

1. FHWA has published a comprehensive guide called *Roundabouts: An Informational Guide*. The information supplied in this document is based on established international and U.S. practices and is supplemented by recent research. Call 202-366-5915 to order Publication No. FHWA-RD-00-067, or download this guide from the Internet at http://www.tfhrc.gov/safety/00068.htm

2. Florida Department of Transportation. *Florida Roundabout Guide*. Florida Department of Transportation, March 1996.

3. Garder, P. *The Modern Roundabouts: The Sensible Alternative for Maine*. Maine Department of Transportation, Bureau of Planning, Research and Community Services, Transportation Research Division, 1998.

4. Jacquemart, G. Synthesis of Highway Practice 264: *Modern Roundabout Practice in the United States*. National Cooperative Highway Research Program. Washington, DC: National Academy Press, 1998.

14 ISSUE BRIEFS

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ROUNDABOUTS **April 2004**

Appendix B Example Roundabout Designs

The purpose of this Appendix is to provide examples for each of the six roundabout categories. Exhibit B-1 lists typical inscribed circle diameter ranges for each roundabout category. Note that the flared-entry roundabout uses the same range of inscribed circle diameters as the double-lane roundabouts. Note that the dimensions of roundabouts may vary considerably within each category, depending on site-specific characteristics, including number of legs, approach angles, design vehicle requirements, and so on. Refer to Chapter 6 for more discussion of specific dimensions.

Exhibit B-1. Typical inscribed circle diameter ranges by roundabout category.

Site Category	Inscribed Circle Diameter Range
Mini-roundabout	13–25 m (45–80 ft)
Urban compact	25–30 m (80–100 ft)
Urban single lane	30–40 m (100–130 ft)
Urban double lane	45–55 m (150–180 ft)
Rural single lane	35–40 m (115–130 ft)
Rural double lane	55–60 m (180–200 ft)

The following pages show examples for each of the roundabout categories:

- Exhibit B-2: Typical mini-roundabout.
- Exhibit B-3: Typical urban compact roundabout.
- Exhibit B-4: Typical urban single-lane roundabout.
- Exhibit B-5: Typical urban double-lane roundabout.
- Exhibit B-6: Typical flared-entry roundabout.
- Exhibit B-7: Typical rural single-lane roundabout.
- Exhibit B-8: Typical rural double-lane roundabout.

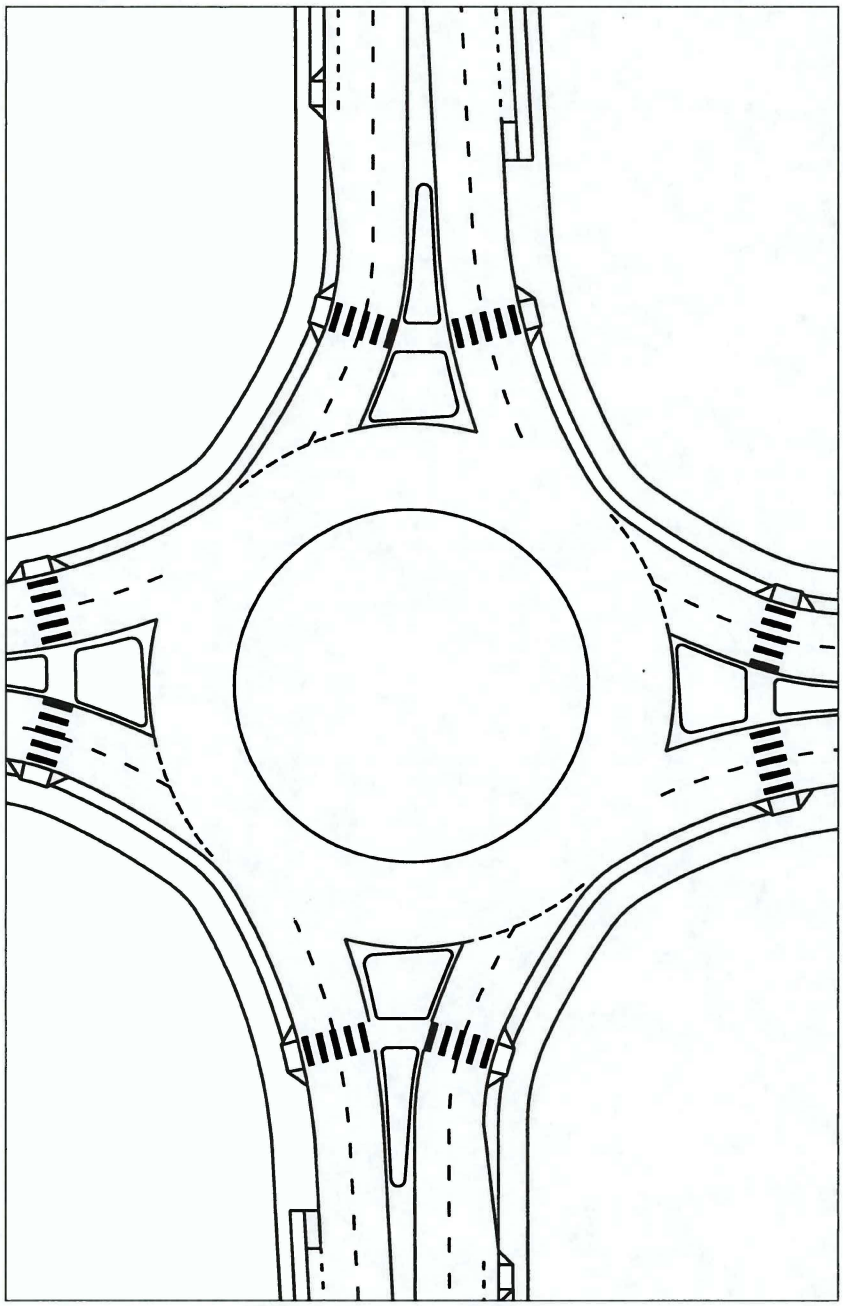
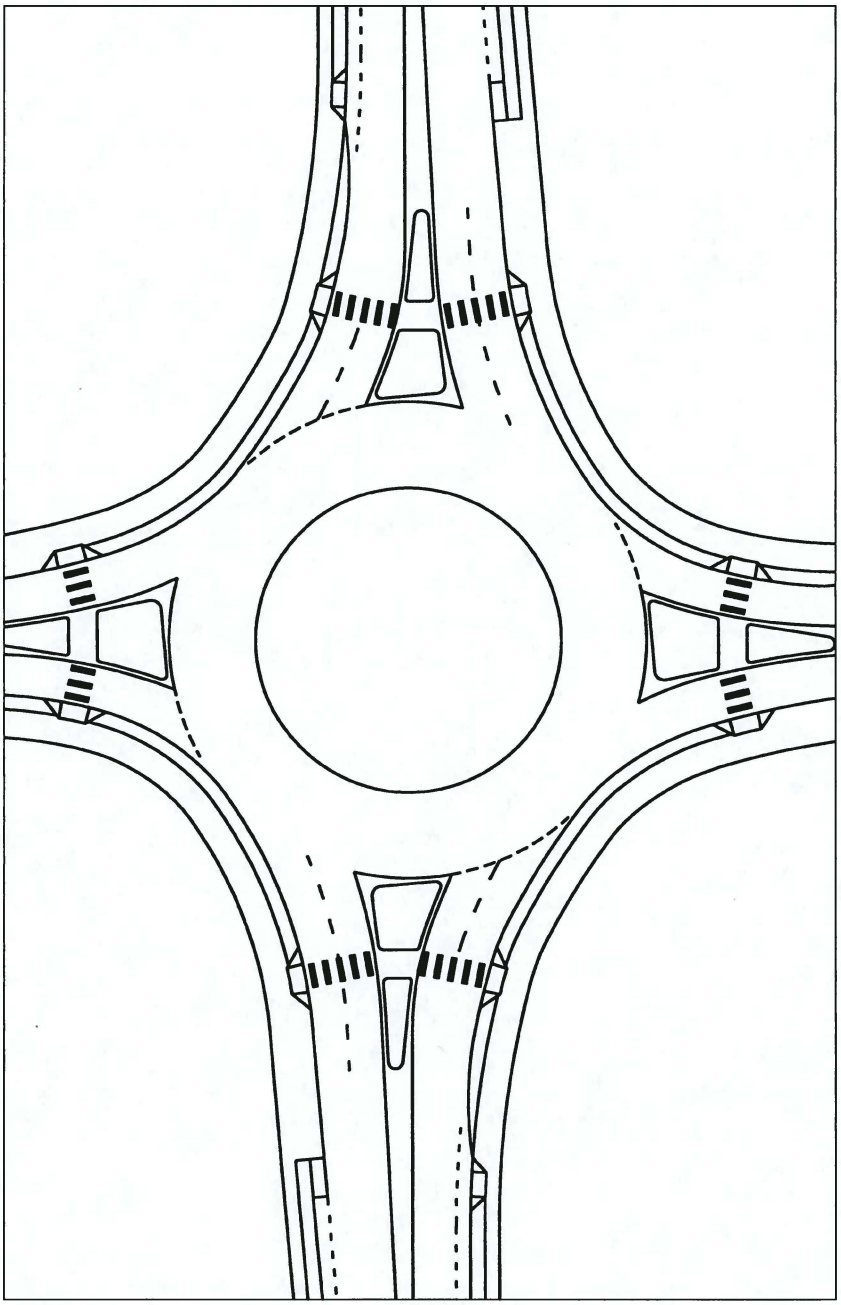
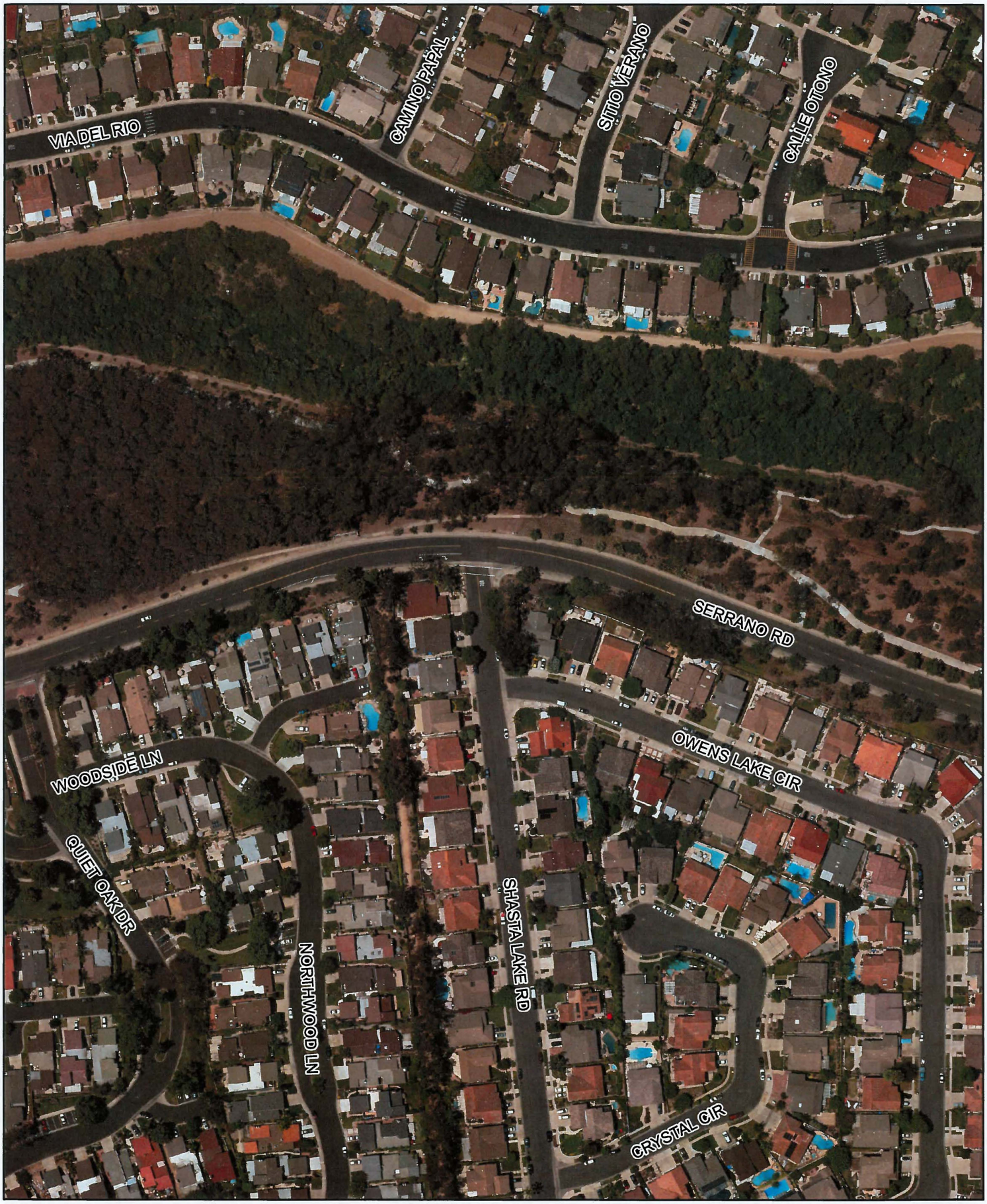


Exhibit B-5. Example of a typical urban double-lane roundabout.

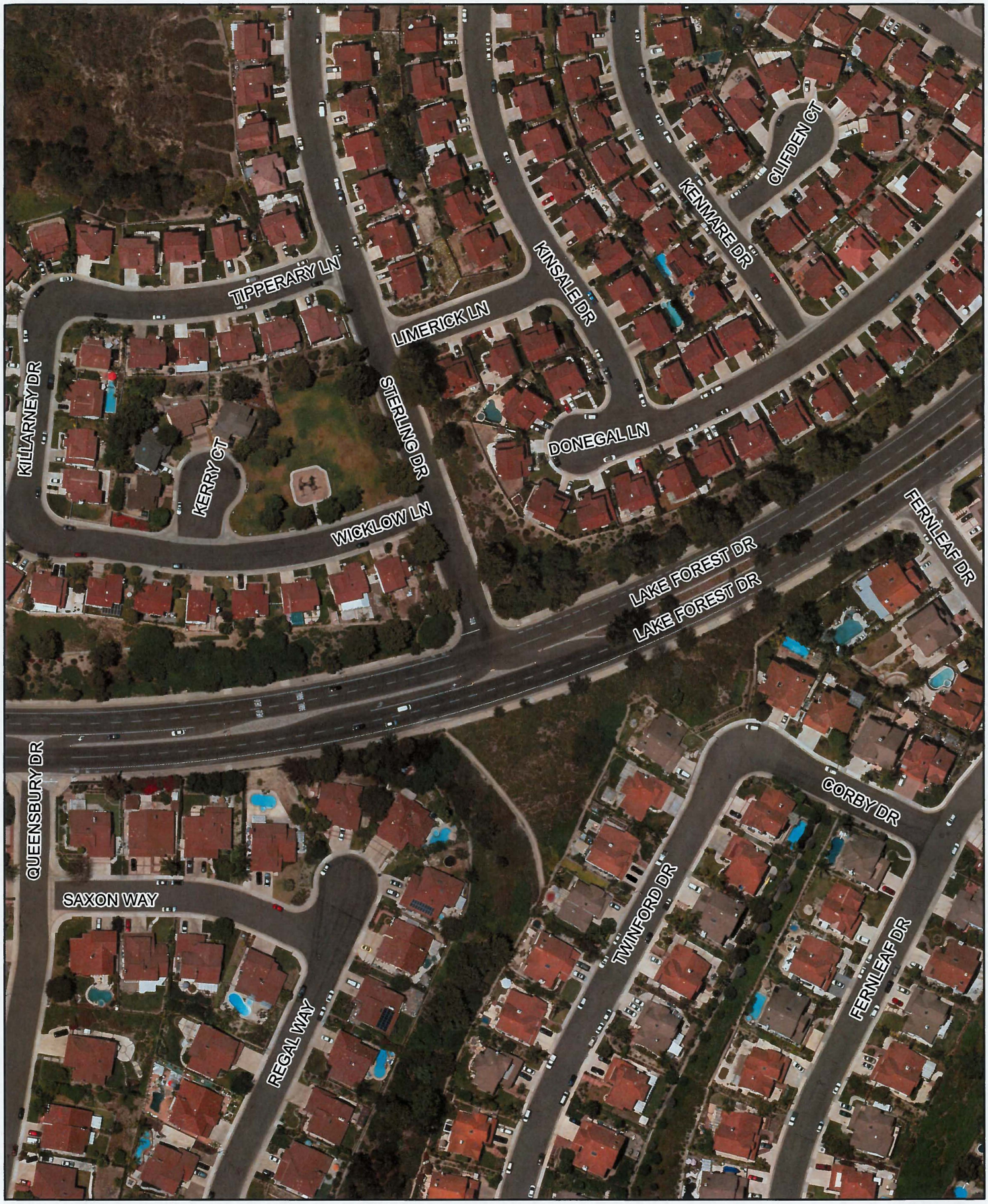
Exhibit B-6. Example of a typical flared-entry roundabout.





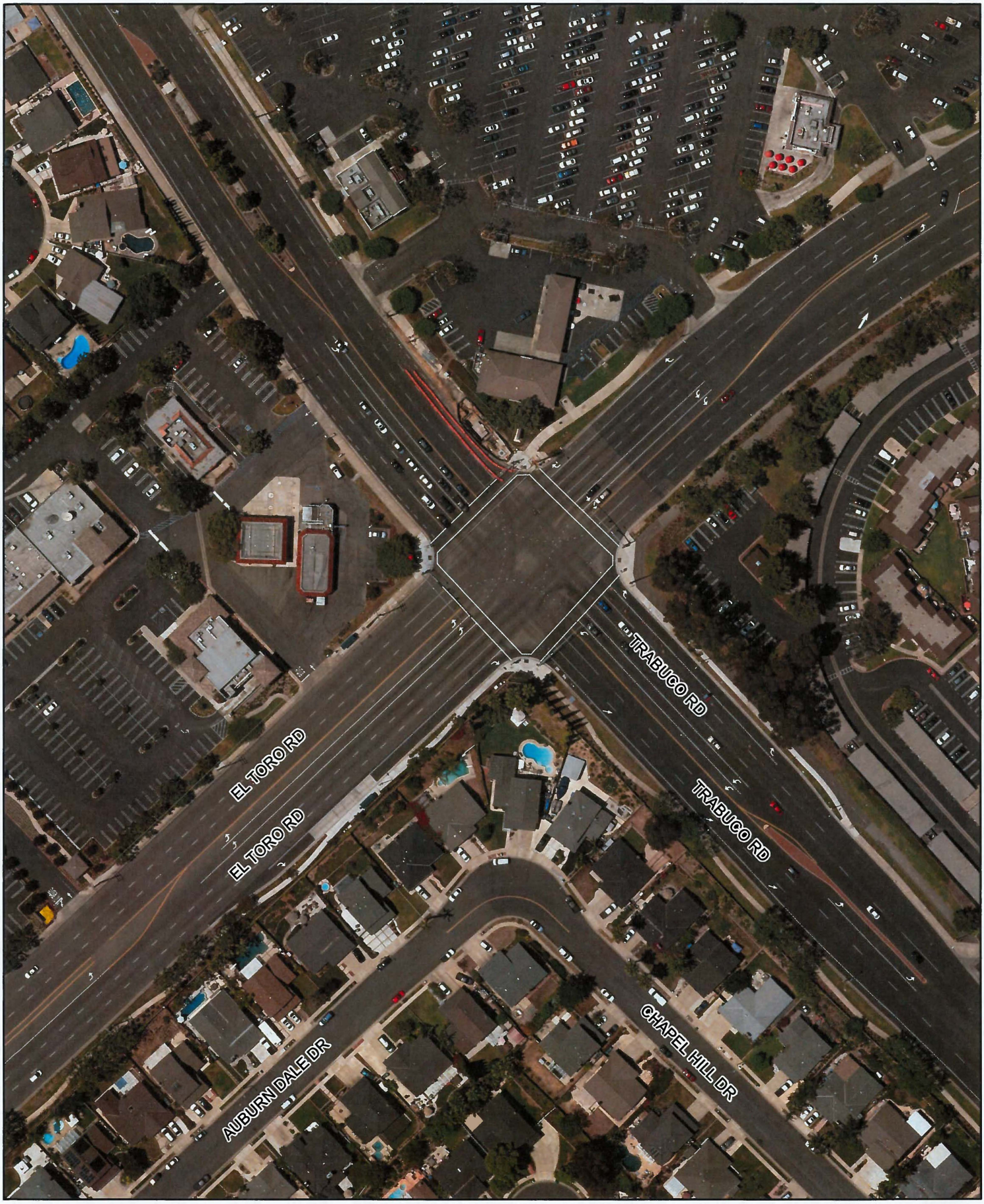
Clty of Lake Forest

Shasta Lake Road & Serrano Road



Clty of Lake Forest

Sterling Drive & Lake Forest Drive



Clty of Lake Forest

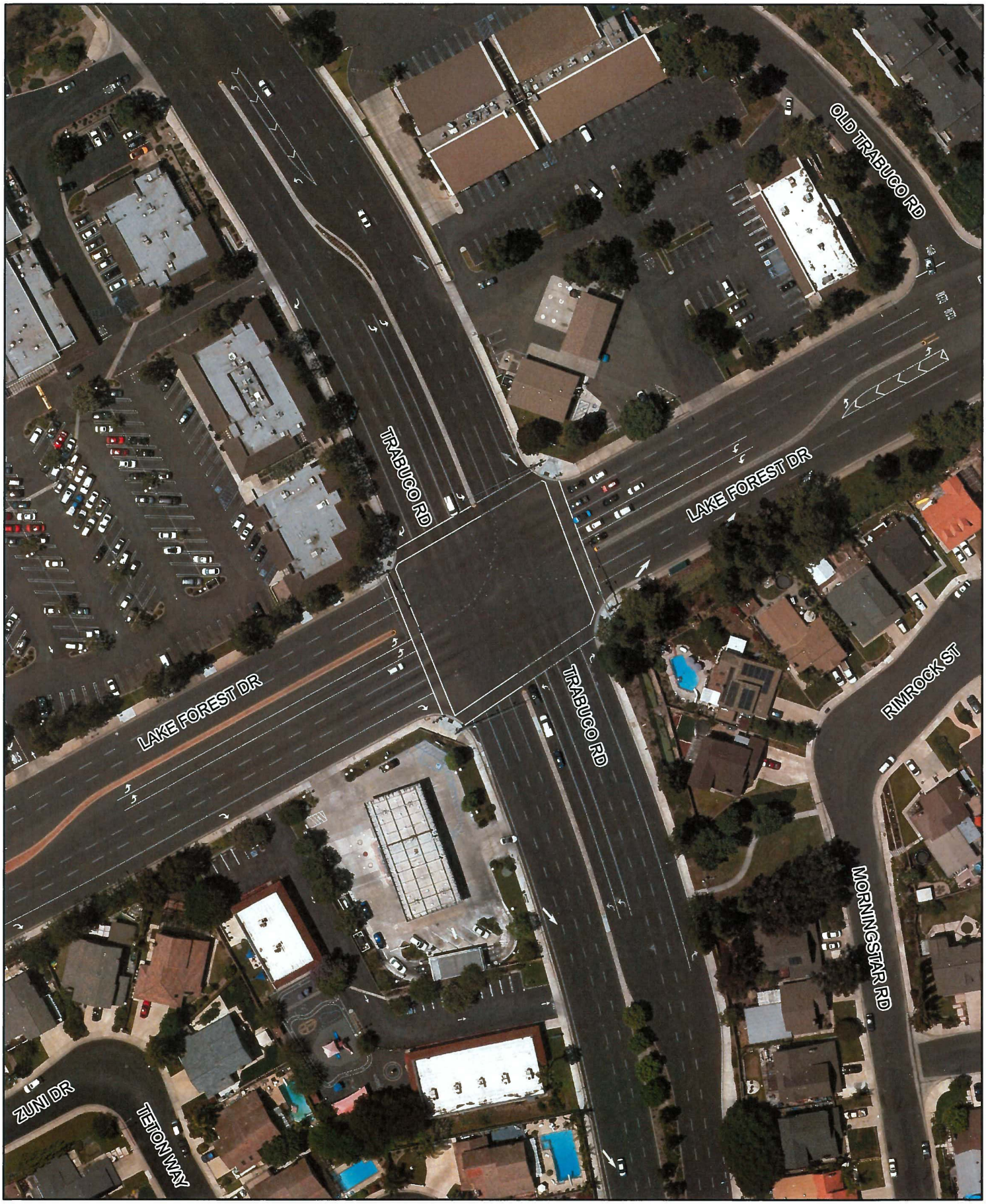
Trabuco Road & El Toro Road

Clty of Lake Forest

El Toro High School

CIty of Lake Forest

Trabuco Road and Serrano Creek Trail



Clty of Lake Forest

Trabuco Road and Lake Forest Drive