October 31, 2000

Mr. Mark Lewis, P.E.
City of Fountain Valley
10200 Slater Avenue
Fountain Valley, CA 92708-4736

Subject: Illuminated Crosswalks: An Evaluation Study and Policy Recommendations in the City of Fountain Valley

Dear Mr. Lewis:

Katz, Okitsu & Associates has completed a study of Illuminated Crosswalks: An Evaluation Study and Policy Recommendations in the City of Fountain Valley. The study evaluates the current use of illuminated crosswalks, the various illuminated crosswalk systems available and the performance of the crosswalk systems. The final report illustrates the project methodologies and findings and presents recommendations for the City's consideration.

It has been a pleasure to provide this study for you and the City of Fountain Valley. Please contact me if you require any additional information, or if you have any questions.

Sincerely,

Rock E. Miller, P.E.
Principal

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City of Fountain Valley

Illuminated Crosswalks
An Evaluation Study and
Policy Recommendations

Prepared for

City of Fountain Valley

10200 Slater Avenue

Fountain Valley, CA 92708-4736

Prepared by:

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October, 2000

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Executive Summary

The City of Fountain Valley is evaluating the use of a new type of traffic warning device for uncontrolled marked crosswalks. The device is known by many terms, including “Illuminated Crosswalk”, however the most commonly known device of this type is generally referred to as an “in-pavement flasher system”. These devices are normally dark, but they initiate a flashing yellow light while the pedestrian crossing is in use.

Katz, Okitsu & Associates was retained by the City to review the state-of-the-art for Illuminated Crosswalks. The results of the review are included in this study. The study includes results of a survey of existing users to obtain their experiences and opinions. The report also reviews product information from the manufacturers of in-pavement flashers, summarizes the material, and provides a comparison of the products.

There are only about 35 agencies using in-pavement flasher systems, and there are about 100 installations, mostly in the states of California and Washington. However, the number of in-pavement flasher systems is increasing monthly.

A questionnaire was sent to all known agencies that have installed in-pavement flashers, including all agencies with installations more than one year old. Telephone follow-ups were made with selected agencies with the most relevant installations.

There is a high level of satisfaction reported among the user agencies, and they report high satisfaction by the public. However, support is not 100%, and it is weakest among agencies that have experienced accidents following implementation. Also, support for the devices is generally weaker among agencies who have not utilized the devices, although agencies that do not have experience with these devices were not formally surveyed for this project. From the User’s Survey, most of the in-pavement flasher systems in California have been installed for 3 years or less. LightGuard Systems has been the vendor for most of the systems.

Passive pedestrian detector systems accounted for most of the objections with the systems, as reported by user agencies. These are systems that automatically sense the presence of pedestrians via motion, microwave, video, etc., and initiate flashing. Most agencies that have a passive pedestrian detection system would not recommend its use in future installations, unless improvements are made.

Human factor studies suggest that in-pavement flasher systems are more effective at night than during the day. However, the systems also have a measurable positive effect during daylight hours. The percentage of drivers yielding to pedestrians has increased after installation of the systems.

Warrant criteria used by several agencies was reviewed. A proposed warrant for the City of Fountain Valley is included in this study. The locations identified by the City were reviewed and those locations that satisfied the warrant criteria were prioritized.

There have been two reported pedestrian accidents among the locations surveyed in this study since the installation of in-pavement flashers. With over 427 million vehicle crossings, the number of reported accidents is about 80% less than might be expected from uncontrolled marked crosswalks with "average" crosswalk treatments. There have been concerns over increases in rear-end accidents at locations with in-pavement flashers, but this concern was not quantifiable. This study presents the first actual evidence that pedestrian safety at uncontrolled marked crosswalks is better at locations with In-Pavement Flashers than at comparable marked crosswalks with average signing and striping treatments. However, no locations with in-pavement flashers have existed long enough to determine whether this effect in permanent and long lasting.

Marked School Crosswalks in Fountain Valley were also evaluated. Their accident experience was compared with "average" locations. The experience at the City's marked crosswalks is also better than average crosswalk treatments and is comparable to the record at locations with in-pavement flasher systems. This is possibly attributed to the presence of an advanced limit line that is located about 50 feet in front of the crosswalk. Some crosswalk safety "experts" have postulated that this treatment may be very effective at improving pedestrian safety at uncontrolled crosswalks. The Fountain Valley experience supports this theory.

Other striping and marking techniques may be equally effective at reducing pedestrian accidents at marked crosswalks, including advanced limit lines and actuated overhead flashers. However passive treatments such as advanced limit lines may not be as effective in producing greater motorist compliance with pedestrian right-of-way. This is probably the key element in actuated flash systems that may distinguish them from passive treatments.

Final Recommendations

- Katz, Okitsu & Associates has recommended the use of in-pavement flasher systems as a tool to agencies that have established high goals for pedestrian mobility while preserving or enhancing pedestrian safety. We have concluded that the devices can greatly improve pedestrian safety at certain types of marked crosswalks beyond conventional treatments. We could recommend consideration of this device to the City of Fountain Valley or to any interested community that has appropriate locations for its use. However, all of the agencies we have counseled understand that the technology is new, under continuing improvement, and liable to change in the future. They have agreed to participate in use of the devices as experimenters or early innovators, knowing that current City goals will be met, but that changes, difficulties, or surprises may emerge at a later date.
- The locations in Fountain Valley have unique treatments for the pedestrian crosswalks. These treatments are working as effectively as Illuminated Crosswalks.
- The study suggests a warrant and priority system to determine the need for Illuminated Crosswalks. The warrant system is based upon pedestrian activity levels and other factors. The City should review the proposed warrant system and adopt it or modify it to better suit Fountain Valley needs and goals. The current warrant system indicates that one location (Newhope/Primrose) could satisfy the warrants for an in-pavement flasher system.
- Katz, Okitsu & Associates recommends that pedestrian crossings during hours when school-crossing guard are present should be excluded from the measurements of pedestrian volumes or calculation of priority scores.
- If devices are implemented, Katz, Okitsu & Associates recommends that light trip-beam passive actuation systems should be used, where practical. Although they are currently less reliable, the detection technology is improving and there are considerable traffic benefits. We believe that the use of passive actuation will become the standard approach after it is perfected for this usage.

1.0 Introduction

The purpose of this study is to assist the City of Fountain Valley in evaluating the potential installation of illuminated warning devices at uncontrolled crosswalks to enhance pedestrian safety. Most of the candidate locations are school crossings that are not located near signalized intersections along major and minor arterial streets.

Several new applications have been developed to facilitate travel by pedestrians across busy arterials. These include most notably systems of in-pavement actuated flashers, as well as overhead actuated flashers. These devices offer promise of improved safety and better compliance by motorists for pedestrian's legal right-of-way at permitted crossings.

There are several types of illuminated crosswalks and crosswalk activation. Three vendors now provide different variations of in-pavement flashers. The flashing lights can be unidirectional or bi-directional. The most common color used for the lights is yellow or amber, consistent with standard overhead flashing beacons that provide advance warning to drivers. The light fixtures vary in shape from square to round. The illuminated crosswalks can be activated by push buttons, ultrasonic detectors, video imaging, or bollards with infrared beams. Additionally, there are different approaches to illuminating the crosswalks, e.g. lighting both sides of the crosswalk or just the approach side.

All of these pedestrian crossing systems rely upon the principle that motorists quickly tune out conventional flashing beacons that are operated continuously. Motorists are far more apt to notice a flashing beacon or similar device that is normally not flashing. The same principle applies to freeway changeable message signs that are largely ignored when blank.

The City of Fountain Valley has received requests to install illuminated crosswalks. Since this technology is relatively new, the City has some concerns in regard to the use of the illuminated crosswalks. These concerns include reliability, installation, maintenance, weather conditions, cost, liability, and effectiveness. City staff would like to gain a better understanding of how pedestrians interact with illuminated crosswalks, and whether the technology is appropriate for the City.

This report provides a summary of the state-of-the-art for available technologies and the practice for the use of illuminated crosswalks. The report also addresses the relevant environmental issues potentially associated with illuminated crosswalks. The discussion then focuses on the effectiveness of in-pavement flashers and the available installation guidelines and warrants. After an assessment of the existing school crossings in Fountain Valley, as well as a crossing used by senior citizens, sections on policy recommendations, installation warrants, and site-specific recommendations are provided to guide the City in its future course of action with respect to illuminated crosswalks or in-pavement flashers.

2.0 Current Technologies

Illuminated crosswalks are known by many names, including in-pavement flashers, in-pavement flashing lights, pedestrian crosswalk warning system, pedestrian crosswalk lights, crosswalk pavement lights (CPLs), in-roadway warning system, in-roadway lights, in-roadway warning lights, *SMART Crosswalk*, intelligent road studs (IRS), flashing crosswalks, lighted crosswalks, and "Santa Rosa lights," among others. For the purposes of this report, illuminated crosswalks are referred to as in-pavement flashers.

Previously, the California Department of Transportation (Caltrans) required local agencies to send in a letter requesting approval for the experimental installation of in-pavement flashers. As of this writing, the California Traffic Control Devices Committee (CTCDC) has given local agencies a blanket authority allowing them to install in-pavement flashers without having to secure permission for experimental installation. The CTCDC now only requires local agencies to inform the Committee about their upcoming installations. A copy of the CTCDC information is included in Appendix D of this report. Caltrans, through its Traffic Operations Program, has released *Interim Guidelines for Experimental Crosswalk Pavement Lights* to guide installations prior to the establishment of statewide standards.

To date, three commercial vendors supply in-pavement flashers that are compliant with the CTCDC and Caltrans guidelines. They include the following:

- LightGuard Systems, Inc. (LGS), Santa Rosa, CA (*LightGuard System*)
- Traffic Safety Corporation (TSC), Sacramento, CA
- Astucia UK LTD, England (*Intelligent Road Studs (IRS)*)

Samples of the vendors' product brochures are included in *Appendix A*.

2.1 LightGuard System

The *LightGuard System* has been referred to as the "Pedestrian Crosswalk System" or *SMART Crosswalk*. Introduced in the market in 1994, this product has been installed in most of the locations surveyed as part of this project. All of the documented testing for pedestrian crosswalk applications in the U.S. has involved versions of the *LightGuard System*. According to the manufacturer, this system is now operational in about 115 sites located in about 60 cities within the U.S.

According to the vendor's product brochure, the *LightGuard System* is comprised of the following major components:

- High output, amber LEDs housed in the in-roadway warning signals
- Flashing in-roadway warning signals that are installed less than ½ inch above pavement that can be viewed from about 1,000 to 1,500 feet from the crosswalk
- Pedestrian manual push-button system and/or automatic activation system (Solar cell battery power for activation is also available where electrical power is not readily available.)
- One roadside NEMA-approved cabinet to contain all electronics
- An optional diamond-shaped pedestrian warning sign facing automobile traffic with a row of four flashing amber LEDs built into the sign that also flash when the in-pavement flashing lights warning system is active

Nearby locations include one installation in unincorporated Orange County (El Modena: Hewes Street at Center Street), two locations on Pacific Coast Highway in Laguna Beach, and about eight installations in cities in Los Angeles County and Ventura County.

2.2 TRAFFIC SAFETY CORP. (FLIGHT LIGHT, INC)

Traffic Safety Corp. (TSC), a company owned by Flight Light, Inc., produces crosswalk lighting systems that are also referred to as "In-pavement Pedestrian Crosswalk Fixtures" or "Crosswalk Warning Systems." The manufacturer introduced this product in the market in early 1997. According to the manufacturer, the product is now operational at about 100 sites located in about 80 cities in the U.S.

TSC manufactures a line of in-pavement lights that may be used for various applications requiring lights for guidance. The vendor recommends the use of in-pavement lights where overhead clearance is restricted or suspension of overhead light would be too expensive. Applications include crosswalks, school zone warning system, urban intersections and interchanges, heavy fog areas, lane control for bridges and tunnels, vehicle inspection, wrong way warning systems, toll booths/tollway lead-on lights, and other lighting needs. Their product appears to be adapted from their lines of airport runway lights, however it has been modified for street usage. This would imply that there would be fewer maintenance problems with these devices.

According to the vendor's product brochure, the Crosswalk Warning System has the following key features:

- High intensity, bi-directional in-pavement lights activated by push-button and or microwave sensor at either end of the crosswalk
- Lights emitting a rapidly bright, flashing yellow light in both traffic directions
- Light fixtures installed to protrude only ½ inch above the roadway
- Light fixtures made of spheroidal graphite iron or high tensile aluminum alloy
- Light fixtures 8" in diameter, rated for 40,000 lb, and impervious to salt and snowplows

No agency responding to our survey reported using this product. Some of these devices have recently been installed in West Hollywood, CA.

2.3 ASTUCIA INTELLIGENT ROAD STUDS (IRS)

Astucia, a company from the United Kingdom, has worldwide patents for *Intelligent Road Studs (IRS)*, marketed as the "next generation reflective roadstuds with on-board microprocessor technology." IRS, also referred to as *Hazlight*, are described by the vendor as maintenance free, solar rechargeable road studs designed to improve road safety for nighttime driving, foggy weather, ice condition, surface or standing water on roadways, road construction work, disabled vehicle emergencies, and other potentially hazardous roadway conditions.

According to the vendor's product brochures, the basic IRS detects and communicates to drivers the existence of hazardous conditions. The units within the IRS system can also communicate between themselves, hence they are capable of transmitting and receiving information and acting upon the information received.

The City of Santa Ana recently implemented a flashing crosswalk system for a crosswalk across Lyon Street at Mark and Brian Way. Astucia equipment has been installed at this location. The City of Orange also has three sites with this system: Chapman Ave. at Cypress St., Glassell St. at Quincy Ave. and Prospect St. at Maple Ave. The vendor describes the in-pavement crosswalk system to have the following main features:

- Ultra bright high intensity amber LEDs which are fitted into an Intelligent Flush Pavement Marker
- Hardwired markers which are installed across the road along the crosswalk
- Pedestrian sensors installed at the crosswalk
- Marker emitting a flashing light visible up to one kilometer at night

Table 1 provides a comparison of some of the features that differentiate these systems.

2.4 COMPARISON OF AVAILABLE PRODUCTS

A broad comparison of the three commercial products for in-pavement flashers that are currently available in the market is shown in Table 1 below.

Table 1 - Comparison of Vendor Products

	Vendors		
Criteria	**LightGuard System**	**Traffic Safety Corp.**	**Astucia IRS**
Light fixture	LED, unidirectional	Halogen bulb, bi-directional	LED, unidirectional or bi-directional
Actuation/detection	Push button, bolllards with infrared beams	Push button, microwave sensors (requests can be accommodated)	Microwave detectors (push button optional)
Visibility of lights	1000 - 1500 ft from crosswalk	600 ft or more from crosswalk	900 ft from crosswalk
Power source	110, 120 volts AC or solar cell battery	110, 120 volts AC (solar power optional)	Solar panel (110W) with rechargeable batteries (AC/DC power optional)
In-street voltage	12.5 DC volt system	Series lighting circuit of 7 volts/lamp	5 volts/lamp
Height from the ground	Less than 0.50 "	0.39 - 0.50 "	Less than 0.75 "
Depth into pavement	Flush, 1" depression	Excavate for base can of 4.5 or 7.5 "	Flush or excavate for base can of 4 "
Sawcutting requirement	1.50 - 1.75 " for in-road electrical installation	Conduit recommended (sawcutting optional)	1.0 " or more for in-road electrical installation
Cost of equipment per site*	$20,000 -25,000	$10,000 - 12,000	$17,000 - 22,000
Cost of installation per site**	$8,000 - 12,000	$10,000 - 12,000	$5,000 - $7,000
Time for installation	1 - 1.5 days	3 - 5 days	2 days
Short-term maintenance	Virtually maintenance-free	Low maintenance, cleaning lights	Virtually maintenance-free
Long-term maintenance	Potential removal to accommodate pavement overlay	Base cans of varying depth facilitate pavement overlay	Undetermined
Product warranty	1 year	90 days (options available	1 year

* Assumed for a five- to seven-lane roadway cross section

** Reflects Southern California labor estimate

All cost estimates are preliminary only and are subject to direct negotiation with the vendors.

2.5 PASSIVE VS ACTIVE ACTUATION

There are two means of activating the in-pavement flashers: Passive and Push Button. Each method has its advantages and disadvantages. These are summarized in the following table

Table 2 - Activation Devices

Method	*Advantages*	*Disadvantages*
Passive	• Less disruptive to traffic • Easier for pedestrians to use	• More expensive to install • More difficult to maintain • Produces more false calls
Push Button	• Less expensive to install • Easier to maintain • Has less false calls	• More disruptive to traffic • More problems with providing sufficient time for pedestrians to cross

The Passive Detection involves use of microwave or light curtain. There have been several complaints from maintaining agencies that the microwave detection is difficult to get to operate properly. They produce false calls in inclement weather and at other times. They also provide more complicated systems requiring maintenance that is different from the requirements of traffic signals.

When working properly, passive detection is less disruptive to traffic, as pedestrians typically wait until there is a natural gap in traffic before walking off the curb and activating the device. The most recent installations with bollards and a light barrier appear to have fewer problems than the earlier microwave detectors. The few agencies reporting the use of bollards with light trip-beams appear to be more satisfied than the users of other detection types.

Push button detection is generally more reliable and simple to maintain than passive detection. However the lights will begin to flash as soon as the button is pushed, regardless of the level of traffic at the time. Aggressive motorists may be unwilling to yield to pedestrians at first, even though the lights are flashing. Motorists driving within coordinated signal systems may also be more unwilling to yield while driving within platoons created by upstream traffic signals. As a result, it is common for the pre-set flash timer to time out before pedestrians can fully cross the street.

2.6 OTHER TREATMENTS

There are several other crosswalk warning systems, however they are generating less publicity and current interest than the in-pavement flasher systems. Also there is less information available on the effectiveness of other crosswalk treatments. The City of Los Angeles has tested the use of overhead actuated flashing beacons using microwave detection. They report similar behavioral changes at test locations and plan to use this technology instead of In-Pavement Flashers. Various Puget Sound communities in Washington State used a system of overhead flashing beacons that used a “wig-wag” alternating beacon on each side of a pedestrian crossing sign, actuated by a push button. The system was believed to be effective however few remain today. The reason for their decline is not known.

A practicing Orange County, CA traffic engineering consultant has implemented “key activated” overhead flashing beacons at school crossings in the cities of Orange and Yorba Linda. He reports great satisfaction in the devices and plans to install more. He is considering pedestrian push buttons activation during non-school hours, but has not implemented this.

3.0 Results of Users' Survey

Katz, Okitsu & Associates developed a survey questionnaire designed for agencies and institutions with deployed illuminated crosswalks to determine their experiences with such devices. The survey questionnaire included the following items, which have been prescribed in the City's RFP for this project:

- Feedback from the general public
- Feedback from organizations for the disabled
- Feedback from school crossing guards
- Accident history (3 years where available)
- Experience with installation contractors
- Liability issues

A copy of the users' survey questionnaire is included in *Appendix B.*

Katz, Okitsu & Associates contacted a total of 31 agencies/institutions with deployed illuminated crosswalks. Lists of existing sites in the U.S. that have in-roadway warning systems are included in *Appendix B.* All known agencies and institutions in California were contacted. Agencies and institutions outside of California with in-pavement installations older than one year were also contacted. It should be noted that new devices are being installed monthly.

A summary of the participation responses from the users' survey is shown in Table 2. Of the 31 agencies and institutions contacted, 15 completed the survey questionnaire. Three agencies offered their insight over the phone, and one offered information on available evaluation studies. Information from one agency (Santa Monica) was based on current work by Katz, Okitsu & Associates. This translates to about a 65% response rate for the overall survey. The detailed responses to the survey questionnaire are summarized in tabular form and included in Table 3

Table 2 - Summary of Responses from Users' Survey

State	*City/County/Institution*	*Response*
CA	Anaheim	Completed questionnaire
CA	Antioch	No response
CA	Danville	Completed questionnaire
CA	Fort Bragg	Completed questionnaire
CA	Glendale	Completed questionnaire
CA	Lafayette	Completed questionnaire
CA	Menlo Park	Completed questionnaire
CA	Orange, City of	Gave comments by phone
CA	Orange County	Completed questionnaire
CA	Orinda/JFK University	Completed questionnaire
CA	Petaluma	Completed questionnaire
CA	San Francisco/Urban School	Completed questionnaire
CA	San Pablo	Completed questionnaire
CA	Santa Barbara	Completed questionnaire
CA	Santa Monica	Based on current KOA studies
CA	Santa Rosa	Gave comments by phone
CA	Sonoma	No response
CA	Suisun City	Completed questionnaire
CA	Thousand Oaks	Completed questionnaire
CA	Visalia	No response
CA	Walnut Creek	Gave comments by phone
CA	Willits	Completed questionnaire
FL	Lakeland	No response
FL	Orlando	No response
GA	Savannah	No response
NV	Washoe County	No response
WA	Kirkland	Completed questionnaire
WA	Lynnwood	No response
WA	Mercer Island	Completed questionnaire
WA	Washington State	Sent information on evaluation study
WA	Seattle University	No response
WA	University Place	No response

Table 3 - Summary of Installation of Illuminated Crosswalks

3.1 Installation Descriptions from the Users' Survey

The users' survey conducted for this study included questions on the physical installation of in-pavement flashers. A summary of the reported physical features of the installations is shown in Table 3.

The surveyed sample of crossing locations with in-pavement flashers has the following main physical and operating features:

- The average daily traffic (ADT) on the main roadway ranges from 2,500 to 23,100 vehicles per day.
- The number of lanes of the roadway to be crossed ranges from two to five lanes.
- About 82 % of the roadway cross-sections do not have a median.
- About 65% of the roadway cross-sections have a left-turn lane.
- About 71% of the sites have parking on street.
- About 76% of the roadway cross-sections do not have bike lanes.
- About 19% of the crossings are school crossings.
- About 59% of the installed in-pavement flashers are activated by push-button.

Most of the areas responding to the Users' Survey have used the *LightGuard System*.

In general, most agencies have had favorable reaction to the use of In-Pavement Flashers. There is dissatisfaction with the current passive detection systems reported by agencies that have used passive detection. One agency (Santa Rosa) is shifting from in-pavement flashing to overhead flashers.

The following two sections present the most significant insight gained from the users' survey regarding the installation, operation, and maintenance of existing in-pavement flashers. The anecdotal accounts are presented below in the order of longest experience (in years) with the product. "Older" installations are over one year, while "newer" ones are one year or less.

3.2 OLDER INSTALLATIONS

The City of **Santa Rosa** in Sonoma County, CA was one of the national demonstration test cases for in-pavement technology and first installed such devices in the fall of 1994 through the spring of 1995. The City declined to submit a written survey, however they responded to a telephone inquiry. Santa Rosa did indicate that it is in the process of removing the three existing in-pavement flasher installations and substituting them with overhead devices. Two of the locations are for school areas, and one is for a commercial/park area. Santa Rosa staff indicated that overhead devices are more effective for both pedestrians and motorists in managing potential conflicts. The overhead devices consist of a PED XING sign with actuated flashers and an extinguishable "Crosswalk In Use" sign, all suspended over the center of the street above the crosswalks. The treatment also features a voice synthesized message "You have actuated the crosswalk warning system. Please cross with care." The City is proceeding with the use of these overhead devices and will not use in-pavement flashers in the future. A pedestrian accident occurred at one of their locations following implementation.

The City of **Fort Bragg** in Mendocino County, CA installed in-pavement flashers in one location on a State Highway in its central business district in the fall of 1996 (one of the first prototypes installed) and recently installed a second one. Generally satisfied with their in-pavement flashers, Fort Bragg thinks that the product has performed very well at one location and has enhanced driver awareness to pedestrians. The in-pavement flashers are very visible at night and during heavy storms. The City has received feedback from residents who feel that the system is very effective in alerting motorists and creating safer conditions. Negative reactions have focused on the push button sticking periodically, concerns with delays due to high pedestrian use of the push button, and the confusion caused by the intermittent non-operation of the flashers. As Fort Bragg is a small city with minimal requirements for such devices, the City does not anticipate installing more in-pavement flashers in the future.

The City of **Lafayette** in Contra Costa County, CA installed in-pavement flashers in two locations: one at an intersection and one mid-block in the winter of 1997. Generally they are not satisfied with their in-pavement flashers. The City has received little feedback from residents and only during times that the system is malfunctioning. So far, the City feels that the system is very high maintenance and needs a design standard for the installation of the system. Also, the City believes that the in-pavement flashers give the pedestrian a false confidence in the ability of the system to stop motorists once the system is activated. At this time, the City of Lafayette does not anticipate installing more in-pavement flashers in the future. An evaluation report for this system noted that the Lafayette locations were on high-speed multi-lane roadways and had very low pedestrian use. Also a pedestrian accident occurred at one of the locations shortly after the in-pavement flashers were installed.

The City of **Petaluma** in Sonoma County, CA installed in-pavement flashers with passive video detection in one mid-block location in its downtown area in early 1997. Petaluma is satisfied with the product and expects to install more in-pavement flashers at other locations in its downtown. The City does not have warrants for the installation of in-pavement flashers and has expressed a need for them. Feedback from the general public has been positive. Petaluma thinks the in-pavement flashers are good in areas with poor visibility and lighting conditions. The early type of the product was one-inch high and was damaged by the street sweeping machine. The City recommends the installation of in-pavement flashers under a design-build procurement process. They also strongly do not recommend video detection due to cost, maintenance and false call problems.

The City of **Willits** in Mendocino County, CA is another site for the early testing of in-pavement flashers. In the winter of 1997, Willits installed push-button type in-pavement flashers at one school crossing in its commercial district. The City is satisfied with the product and expects to install more in-pavement flashers at uncontrolled crosswalks in the future. City staff expressed the need for installation warrants. A key maintenance issue is the need for the complete removal and replacement of the flashers whenever the street is re-paved. The manufacturer has continued to improve the product, hence eliminating many of the problems of earlier versions. Once the general public understood the purpose of the warning system, public feedback has been positive. Before- and after-studies conducted by the City showed that drivers responded to the system by braking sooner and driving slower. Staff feels that the flashers have a much more significant effect during adverse weather conditions, such as darkness, fog, and rain.

The City of **Kirkland**, WA has installed in-pavement flashers with push-button detection at 22 sites since the fall of 1997. Kirkland is very satisfied with the technology and expects to install more in-pavement flashers in the future. In fact, the City has installation warrants for in-pavement flashers to guide them in future installations. These warrants are available in their web-site (www.ci.kirkland.wa.us) and are also described later in this report. The City has found the older models of in-pavement flashers to break down more, but finds the newer models to perform better. The public has been very supportive of the City's effort to enhance pedestrian safety through the flashers. The City has also found the in-pavement flashers to function best at night. However, some pedestrians have complained about motorists' compliance with stopping at crossings with in-pavement flashers, feeling perhaps that more needs to be done to increase stopping compliance.

The City of **Orinda** in Contra Costa County, CA required JFK University to install in-pavement flashers at a pedestrian crossing connecting the school's main facilities with leased parking facility across the street, as part of the school's expansion program. Installed in time for the fall semester in 1997, the flashers were deemed by the City as necessary because of visibility issues associated with the rolling topography of the area and nighttime lighting condition. Before the expansion of the school's facilities, the pedestrian crossing was not heavily used. The university has not measured the effectiveness of the in-pavement flashers, and could not comment on the effectiveness of the product. The maintenance staff at the school has not received any feedback, positive or negative, on the in-pavement flashers since they have been installed.

The City of **Thousand Oaks** in Ventura County, CA has one site with in-pavement flashers, which are actuated by a light-trip beam set in bollards. Installed in the summer of 1998, the flashers are located along a collector in an industrial area of the City. Thousand Oaks is pleased with the product and expects to "cautiously" install more in-pavement flashers in the future. The City has no installation warrants for the flashers, but has expressed a need for them. A maintenance issue cited is the lack of spare controllers. The City has received no complaints regarding the flashers, receiving only positive feedback from the general public. City staff has observed drivers yielding more to pedestrians since the installation. However, staff is concerned about using the flashers on multi-lane streets and in residential areas. The flashers are seen by City staff as more effective than pedestrian signals in reducing delay along arterials.

The City of **Suisun City** in Solano County, CA has one installation on a mid-block crossing that connects a senior center and a shopping center along an arterial. Installed in the fall of 1998, the flashers' main operational problem involves passive actuation through the use of infrared or photocell technologies. The passive actuation has been a "source of grief" since rain causes a lot of false calls. Suisun City recommends the manual push button detection and considers this product type as reliable. In-pavement flashers are particularly effective during foggy weather in this area. The City is installing the flashers at a second location within the next few months, this one with push button actuation. Feedback from senior citizens and those with disabilities has been very positive.

3.3 NEWER INSTALLATIONS

The City of **San Pablo** in Contra Costa County, CA has two locations with in-pavement flashers with passive actuation, which were installed in the summer of 1999. The locations are mid-block crossings along arterial streets in a commercial area. The City is satisfied with the product, but is not sure about future installations of in-pavement flashers. San Pablo has indicated no need for installation warrants. City staff had no issues working the with manufacturer, but found the contractor "difficult to work with." The key maintenance issue for the City is how to preserve the flashers when the streets get a pavement overlay. Feedback from the general public has been positive. City staff observes that in spite of the in-pavement flashers, drivers still tend to go faster than they should and some fail to yield to pedestrians on these arterials.

The City of **Mercer Island** in King County, WA installed push-button type in-pavement flashers at one mid-block school crossing on a secondary arterial street. There is a school crossing guard at the location before and after school. Installed in the summer of 1999 in a single-family residential area, the flashers are accompanied by an illuminated crossing sign. Satisfied with the product, the City anticipates more installations of the in-pavement flashers depending on funding availability. Feedback from the general public, as well as the crossing guards, has been positive. City staff has cited concerns regarding the continued operation of the power box and breakers, product warranty and upgrades, and potential malfunctioning of the lights and push button.

Orange County, CA**,** has installed in-pavement flashers, actuated by push button, at the intersection of Hewes Street and Center Street in the East Orange area. The County expressed satisfaction with the flashers, which were installed in the fall of 1999. Although no new installations are programmed currently, the County identified its need for installation warrants to help evaluate requests from the public for such pedestrian crossing devices. The contractor has done a "clean job," and no major maintenance issues have surfaced, except for some lights going out. Feedback from the public has been generally positive. The flashers have operated well under various weather conditions. Drivers have been observed to react to the presence of the in-pavement flashers on the roadway. The County will evaluate the product after a full year of operation.

The City of **Menlo Park** in San Mateo County, CA installed in-pavement flashers with bollard actuation at one site in a residential area at a mid-block crossing connecting a senior home and a hospital across the street. This first installation (LightGuard System) was completed in the fall of 1999, and a second one is currently underway for a busier street and using a different vendor (Traffic Safety Corp.). The City feels satisfied with the product. The flashers have received high approval from the elderly. City staff cites that it has made the elderly pedestrians feel safer. The general public reaction to the flashers has also been one of satisfaction; no reports of annoyance to the product have been received. A maintenance issue involves having an electrical short in one of the lights. The City expressed no need for installation warrants for in-pavement flashers.

The City of **Santa Barbara,** CA has two locations with in-pavement flashers, one installed in the early part of this year and the other currently under construction using two different contractors. Both locations are along arterial streets in the City's commercial area. The flashers have push button detection and are accompanied by voice messaging special feature. The City staff expressed dissatisfaction with the product because of problems it has had. Some lights have failed. Feedback from the general public is mixed. Apparently some people do not understand the function of the device. Drivers have complained about having trouble understanding the device.

Still, the City anticipates installing in-pavement flashers at more locations and would like to have installation warrants to support decisions on where to place them.

The City of **Walnut Creek** in Contra Costa County, CA has installed in-pavement flashers at three locations along major arterial streets in its downtown area since the beginning of this year. Manufactured by TSC, the flashers are of the low voltage type and are activated by push button. City staff is satisfied with the system and expects to install more in the future without the need for installation warrants. Walnut Creek likes the flashers because they highlight the presence of pedestrians and complement the traditional warning devices already available. The City has received positive feedback from both motorists and pedestrians. However, staff feels that the system is still too new to identify any major disadvantages of the system. From the driver's perspective, some motorists are still trying to get used to the device.

The Town of **Danville** in Contra Costa County, CA installed in-pavement flashers (with passive detection) at one mid-block school crossing on a neighborhood collector street in the spring of this year. The crosswalk has brick pavers and concrete bands on each side. The private Catholic school being served does not use crossing guards. Danville feels that the product is effective overall, although its short experience with the flashers does not allow for a thorough and complete evaluation. The Town expects to install in-pavement flashers at more locations and could benefit from having installation warrants. The staff feels that the flashers are not as effective during daytime (because of sun glare) as they are at nighttime. Town staff also expressed concerns about the product's lack of official recognition from the State or the MUTCD.

The Urban School, a private school in **San Francisco**, CA has in-pavement flashers (with passive detection) at a mid-block crossing along a residential City street. The School paid for the installation of the flashers and two handicap ramps, and turned over the maintenance to the City of San Francisco. Crossing guards are not present at this location. Satisfied with the product, the School feels that the lights have made the crosswalk more visible. The flashing lights are particularly effective at night and on overcast or rainy days. The School highly recommends the use of in-pavement flashers for school crosswalks because the flashing lights clearly have made it safer for students and faculty to cross the street.

The City of **San Francisco**, CA has been aggressively tackling its pedestrian problem for the last two years. The National Highway Traffic Safety Administration reported about five years ago that San Francisco had the highest percentage of pedestrian fatalities in California and the third highest in the U.S. As a result of a recent summit on pedestrian safety sponsored by the City's Board of Supervisors, the City has now embarked on a multi-pronged approach to enhance pedestrian safety in the City. The strategy includes in-pavement flashers, additional signage at crosswalks, extending walk phases at signalized intersections, cameras for red-light violators, and more police enforcement. At the ribbon cutting ceremony at the Urban School, the Mayor of San Francisco articulated the need for illuminated crosswalks at every school in the City and the need to find ways of funding them. [4]

The City of **Anaheim**, in Orange County, CA installed in-pavement flashers on a secondary arterial street at a tram crossing near Disneyland. The flashers are red and operate in conjunction with a traffic signal that is used for a tram crossing. They were installed when motorists were found to run the red lights excessively. Installed in the late spring of this year, the flashers have detection wired into the signal controller. Satisfied with the product, the City thinks that the in-pavement flashers have worked well to date. Drivers have been observed to stopping in advance of the stop bar. Anaheim is open to future installations of the flashers and expressed need for installation warrants. As the installation is new, no feedback has been received nor maintenance issues revealed.

The City of **Santa Monica** has installed in-pavement flashers at five locations along suburban commercial corridors as part of its comprehensive enhanced pedestrian crossings program. Installed in the late spring of this year, the in-pavement flashers are solar-powered and activated by push button. The City anticipates installing the system in five more locations within the next two years. Santa Monica is satisfied with the system and feels that the in-pavement flashers are a vital and visible aspect of their pedestrian program. Staff has raised concerns regarding the disruption to traffic flow and the termination of the flashing lights prior to the complete crossing of the pedestrians. The City Council has adopted a goal to make the City more pedestrian friendly, including a desire to increase the use of marked crosswalks, where safe. Katz, Okitsu & Associates has advised the City and assisted in its pedestrian enhancement project. Flashers are being used for multi-lane streets, where on-street parking is essential and other treatments are not appropriate. They use a toolbox approach for pedestrian crossings, including curb extensions, median refuges, pedestrian traffic signals, and enhanced markings as appropriate for specific locations.

The City of **Glendale**, CA just very recently installed push-button type in-pavement flashers at two locations—both uncontrolled crossings on major arterials in business areas. The City is not able to comment on the effectiveness of the product or its satisfaction with the product because the installation is too new.

Caltrans District 12 just very recently installed push-button type in-pavement flashers at two locations in the City of **Laguna Beach**—both uncontrolled crossings on Pacific Coast Highway in the central business areas. The locations were selected due to congestion and pedestrian accident history. Caltrans and the City are not able to comment on the effectiveness of the product or its satisfaction with the product because the installation is too new. Caltrans plans to do a "before and after" study when the flashers have been in operation for 6 months.

Katz, Okitsu & Associates inspected the Caltrans sites and formed impressions. The locations would not be consistent with our recommended guidelines, because the traffic level on Pacific Coast Highway is much higher than the recommended maximum value, and the flasher systems are also nearer to the nearest traffic signal controlled intersection. These factors may combine with the use of push button actuation to be disruptive to traffic platoons. However, there is very heavy pedestrian demand for both locations, and the use of the technology is probably appropriate for testing at these locations.

3.4 Operation within Coordinated Signal Systems

Some agencies have desired to operate in-pavement flasher systems in conjunction with coordinated signal systems. The systems are not designed or intended to operate in this manner, and it may not be practical to do so. The pedestrian is not aware that the flasher actuation has actually initiated activity, since the flashing is not readily visible to the pedestrian. They will thus not know to wait for the signal coordination system. Consideration of full pedestrian signals may be a more appropriate alternative than in-pavement flashers.

Katz, Okitsu & Associates believes that systems with "passive actuation" are less disruptive to signal coordination, because pedestrians will usually wait for a gap in traffic before entering the roadway. If push-button actuation is employed, the flashing operation begins immediately,maximizing potential interference with traffic. However, passive detection technology is more complicated and less reliable at this time.

4.0 History and Effectiveness of In-Pavement Flashers

This section recounts the history of the evaluation of the experimental versions of in-pavement flashers and features the "Findings" from the latest national evaluation report. Environmental issues related to illuminated crosswalks are then discussed. Finally, results from the users' survey for this project are presented to explore the potential impacts of in-pavement flashers on the reduction of pedestrian accidents at uncontrolled crosswalks.

4.1 TESTING OF EXPERIMENTAL SYSTEMS

The experimentation with in-pavement flashing lights or crosswalk warning systems began in Santa Rosa, CA in 1993. After a fatal pedestrian accident involving a friend, a private citizen went before the City of Santa Rosa with the idea for a flashing device to be installed on the pavement surface along the crosswalk lines and facing traffic. This citizen invented the pedestrian crosswalk warning system, now known as the *LightGuard System*, and founded the company of the same name in 1994.

The California Traffic Control Devices Committee (CTCDC) permitted the City of Santa Rosa to test the new experimental device at three locations. The California Office of Traffic Safety (OTS) granted funds to the City for the evaluation of the device's effectiveness. The Santa Rosa test sites were evaluated by the team of transportation consultants, W-Trans and TJKM. The findings were presented in a July 1995 report entitled *Analysis of an Experimental Pedestrian Crosswalk Device.*

The CTCDC endorsed the testing of the experimental pedestrian warning system in additional California cities to determine the need for standardization statewide. The California OTS provided funding for the evaluation of in-pavement flashing lights crosswalk warning systems in the Cities of Fort Bragg, Lafayette, Petaluma, Willits, West Hollywood, and Santa Rosa. The results of this study were presented by W-Trans in a July 1997 report entitled *Evaluation of an Experimental Crosswalk Warning System*.

The California OTS and the Federal Highway Administration, through the *Pedestrian Facilities Program*, provided funding for a study to update the July 1997 report to include the additional experiences in the Cities of Orinda in California and Kirkland in Washington. Conducted by the University of North Carolina Highway Safety Research Center and distributed by W-Trans, the study is documented in an April 1998 report entitled *An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights*.

The "Findings" from the Executive Summary of the April 1998 evaluation report are quoted below for easy reference of Fountain Valley City staff, Citizen Traffic Committee, and elected officials. [1]

- The concept of flashing amber lights embedded in the pavement at uncontrolled crosswalks clearly has a positive effect in enhancing a driver's awareness of crosswalks and modifying driving habits to be more favorable to pedestrians.

- The In-Pavement Flashing Lights Crosswalk Warning System has a much more significant effect in enhancing a driver's awareness of crosswalks during adverse weather conditions such as darkness, fog, and rain.

- Over the long term, the affect of the crosswalk warning system will degrade slightly during daytime conditions from initial implementation of the system. However, the resulting long term conditions still represent improved vehicle reaction characteristics compared with conditions before installation.

- The In-Pavement Flashing Lights Crosswalk Warning System has the potential to be an effective traffic control device since it fulfills a need, commands attention, conveys a clear meaning, commands respect of road users, and give adequate time for proper response.

- An automatic detection system is more appropriate than a push button system and can result in less confusion for the pedestrian.

- A recently demonstrated "bollard gateway system" which utilizes two parallel modulated visible red beams seems to be the most promising automatic activation technology.

- The warning system seems to be particularly effective at locations where there is at least a moderate flow of pedestrians (100 pedestrian crossing per day).

- At speeds less than 35 mph, drivers seem to be able to respond properly if at least 400 feet of sight distance is provided to the warning system.

- At speeds greater than 40 mph, drivers seem to have difficulty stopping safely if less than 600 feet of sight distance is available prior to the warning lights.

- The presence of a lighting device at the other edge of the travel lane may be a hazard to some bicyclists.

- Each successive prototype of the light devices which has been tested has been superior in terms of their physical durability. Further improvements to its durability are still warranted. However, the desires of the market will dictate further physical evolution of the device.

4.2 ENVIRONMENTAL ISSUES

The City of Fountain Valley requested research on environmental issues associated with illuminated crosswalks to include the following items:

- Annoyance to the average pedestrian or resident
- Effectiveness during various weather conditions in the City
- Driver reaction

The April 1998 report entitled *An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights* (W-Trans, UNC) provides the most thorough evaluation of the above issues as they relate to in-pavement flashers. The sections that follow highlight the main findings of the April 1998 study, supplemented by anecdotal accounts from the users' survey conducted for this project.

Annoyance to Pedestrians

The W-Trans/UNC study included the conduct of pedestrian reaction surveys for the study location in downtown Petaluma, CA. The location has in-pavement flashers with automatic activation and a fairly constant stream of pedestrians. After crossing, the pedestrians surveyed were asked the following questions: [1]

- In terms of your level of safety, do you feel comfortable crossing at this location?
- Were you aware of the flashing lights in the pavement?
- (If yes) Do you rely upon the lights to cause the driver to stop and give you the right of way?

As quoted from the report, the analysis of the resulting data from the pedestrian reaction surveys conducted under "before" and "after" conditions yielded the following observations: [1]

- The number of pedestrians crossing in the crosswalk did not substantially change with the addition of the lights.

- The locations that the pedestrians entered the street did not substantially change with the addition of the lights.

- The number of times that a pedestrian looked at oncoming traffic while crossing did not substantially change with the addition of lights.

- Of those interviewed, 80 percent were aware of the flashing lights.

- Of the 80 percent who were aware of the flashing lights, 23 percent said they relied on the lights to cause the driver to stop and give them the right of way.

From the users' survey conducted for this project, over three quarters of the respondents indicated no reports of annoyance from pedestrians or residents. A few respondents identified some annoyance feedback. The following comments were obtained from the city traffic engineer or maintenance manager regarding the type of annoyance that the average pedestrian or resident has expressed with respect to the in-pavement flashers:

- People see nothing flashing in the street and they don't know what is working and what is not.
- Some people don't understand the device.
- The devices are not stopping traffic enough.

Effectiveness during Various Weather Conditions

The users' survey conducted for this project included a question on the type of feedback that local agencies have received regarding the effectiveness of in-pavement flashers during various weather conditions.

The comments received regarding the performance of in-pavement flashers under various weather conditions include the following:

- Not as effective during daytime (with sun glare) as they are at nighttime
- Very visible at night and during heavy storm
- Operated OK under various weather conditions
- Good in poor visibility and lighting conditions
- Particularly effective at night and on overcast rainy days
- No impact
- False calls in bad weather (fog, overcast, rain)
- Much more significant effect during adverse weather conditions such as darkness, fog, and rain
- Best at night

About half of the survey respondents did not offer any feedback regarding the effectiveness of in-pavement flashers under various weather conditions.

Driver Reaction [1]

The W-Trans/UNC study measured the reaction of the driver to in-pavement flashers under two conditions:

- Staged pedestrian looking at oncoming traffic
- Staged pedestrian stepping out into the travelway

The W-Trans/UNC study collected the following information, which were identified as the most critical factors obtained in the behavioral/conflict sampling:

- Braking distance (i.e. distance away from the crosswalk that vehicles begin to brake) in feet

- Driver reaction (e.g. yielded to the pedestrian, reacted but did not yield, and did not yield to the pedestrian) as a percentage of drivers that yielded to pedestrians

The W-Trans/UNC study team recognized these two factors as the most critical in terms of determining whether the experimental system of in-pavement flashers enhances crossing conditions for the pedestrian. The results of these two factors under both "before" and "after" conditions for the study locations in the City of Kirkland in Washington and the Cities of Fort Bragg, Lafayette, Petaluma, Willits, Orinda, and Santa Rosa in California are summarized in Table 3.

Taking the average for the study locations in the sample shown in Table 3, the following observations can be made regarding the impact of in-pavement flashers on driver reaction:

- Under daytime conditions, the braking distance used by drivers increased by an estimated 26 feet (or about 17% increase) after the installation.

- Under nighttime conditions, the braking distance used by drivers increased by an estimated 76 feet (or about 53% increase) after the installation.

- Under daytime conditions, the percentage of drivers yielding to pedestrians increased by an estimated 26% after the installation.

- Under nighttime conditions, the percentage of drivers yielding to pedestrians increased by an estimated 49% after the installation.

A separate data collection process for the W-Trans/UNC study involved the interview of drivers after they had driven through the subject crosswalk. Before and after the installation of the in-pavement flashers, the following questions were asked, as quoted in the report:

- Did you notice the crosswalk which you passed within the last block? (yes/no)
- Did you notice any pedestrians in or near that crosswalk? (yes/no)
- If you did notice a pedestrian, where was the pedestrian? (in the crosswalk/stepping out from the curb/waiting on the sidewalk)

Table 4 - "Before" and "After" Studies of In-Pavement Flashers [1]

Daytime Conditions

			Braking Distance (ft)			% Drivers Yield to Peds		
City	*Location*	*Heading*	*Before*	*After*	*Increase*	*Before*	*After*	*Increase*
Kirkland, WA	Central Wy.	East	200	278	78	62	92	30
		West	192	244	52	59	94	35
Kirkland, WA	NE 124th St.	East	209	214	5	46	85	39
		West	271	312	41	55	92	37
Fort Bragg, CA	Main St./Laurel St.	North	99	129	30	45	76	31
		South	106	154	48	51	92	41
Lafayette. CA	Mt. Diablo Bl.	East	110	116	6	3	15	12
		West	145	138	-7	9	27	18
Lafayette. CA	Pleasant Hill Rd.	North	170	205	35	6	30	24
		South	196	215	19	7	34	27
Petaluma, CA	So. Petaluma Bl.	North	91	106	15	73	83	10
		South	108	133	25	64	90	26
Willits, CA	Main St./Hazel St.	North	168	196	28	33	61	28
		South	172	190	18	20	62	42
Orinda, CA	JFK University	East	107	50	-57	17	39	22
		West	124	158	34	19	8	-11
Santa Rosa, CA	Sommerfiled Rd.	North	151	220	69	25	62	37
		Average:	154	180	26	35	61	26

Nighttime Conditions

			Braking Distance (ft)			% Drivers Yield to Peds		
City	*Location*	*Heading*	*Before*	*After*	*Increase*	*Before*	*After*	*Increase*
Kirkland, WA	Central Wy.	East	115	238	123	16	100	84
		West	175	270	95	27	98	71
Kirkland, WA	NE 124th St.	East	204	244	40	65	93	28
		West	266	304	38	48	97	49
Fort Bragg, CA	Main St./Laurel St.	North	84	178	94	22	92	70
		South	97	253	156	15	93	78
Lafayette. CA	Mt. Diablo Bl.	East	125	167	42	0	59	59
		West	63	180	117	0	46	46
Lafayette. CA	Pleasant Hill Rd.	North	150	346	196	4	33	29
		South	254	289	35	0	45	45
Petaluma, CA	So. Petaluma Bl.	North	97	116	19	60	85	25
		South	98	130	32	52	80	28
Willits, CA	Main St./Hazel St.	North	124	222	98	4	67	63
		South	157	233	76	8	64	56
Orinda, CA	JFK University	East	114	54	-60	17	42	25
		West	131	238	107	15	21	6
Santa Rosa, CA	Sommerfiled Rd.	No./So.	185	268	83	20	87	67
		Average:	143	219	76	22	71	49

After the installation of the in-pavement flashers, the following questions were also asked of the drivers, as quoted from the report:

- Did you or have you previously noticed the flashing lights at the crosswalk? (yes/no)
- Have the lights been effective in changing your driving habits at the crosswalk? (yer/no)
- Do you rely on the lights to indicate that there is a pedestrian in the crosswalk? (yes/no)

Taking the average for the study locations in the sample for the driver interviews (including Fort Bragg, Lafayette, Petaluma, Willits, and West Hollywood in CA), the following observations can be made regarding the impact of in-pavement flashers on driver reaction:

- The percent of drivers that saw the crosswalk increased from 82% to 93% after the installation.

- The percent of drivers that saw a pedestrian increased from 67% to 84% after the installation.

- The percent of drivers that stated the position of pedestrian accurately increased from 48% to 66% after the installation.

- The percent of drivers that saw the flashing lights was estimated at 77%.

- The percent of drivers that feel that the flashing lights have changed their driving habits was estimated at 62%.

- The percent of drivers that rely on the flashing lights to inform them when a pedestrian is present was estimated at 6%.

4.3 ACCIDENT ANALYSIS FROM THE USERS' SURVEY

Accidents are considered to be infrequent events and defy prediction. Pedestrian accidents are even more infrequent than other accidents. Accident rates for individual locations are generally not usable. Locations with accidents will have very high accident rates, while locations without accidents will have "zero" accident rates. A concept known as "regression to the mean" is one statistical anomaly that makes this form of analysis difficult. It is thus very difficult to evaluate the effectiveness of a safety device based upon the performance of a limited number of individual locations.

Statistical Analysis Tools

Combining statistics for similar locations to produce aggregate accident rates can develop meaningful accident rates; however, locations must be combined carefully to insure that important factors are not overlooked. Combining of locations with different characteristics can potentially distort or mask significant findings, because an attribute of a sub-group can be improperly applied to the entire sample.

Relationship to Daily Traffic Volume

Katz, Okitsu & Associates conducted a large pedestrian safety study for the City of Santa Ana in 1998. This study analyzed various relationships between pedestrian accidents at marked crosswalks and other criteria. This study found a strong relationship between pedestrian accidents and vehicle traffic volumes (million vehicles per accident). Table 5 shows the relationship. The accident rates presented in the final two columns are stable for all volume ranges. Katz, Okitsu & Associates has subsequently calculated similar rates for other communities and found comparable results.

Table 5 - Accidents and Traffic Volume Ranges

ADT Range	*Number of Locations*	*Number of Accidents*	*Accidents Per Year per 100 locations*	*Accidents Per Million Vehicles*	*Million Vehicles per Accident*
0-2,700	71	2	0.94	.019	52
2,701-10,000	54	7	4.32	.021	47
10,001-20,000	34	15	14.71	.029	35
20,001-up	25	23	30.67	.028	35

The Santa Ana study also found a strong relationship between accidents and roadway cross section and concluded that four-lane divided is an "average" cross section. Finally the study found a very weak relationship between pedestrian volume and pedestrian accidents. The risk at locations with low pedestrian activity is about the same as at similar locations with high pedestrian activity.

The data from Santa Ana was compared to information from the 1970 San Diego Marked Crosswalk Study and found to compare well. As a result, an accident rate of one pedestrian accident per 35 million vehicles is considered to be representative of the expected record for a typical marked crosswalk on a high volume multi-lane street. This is thus the expected rate for typical locations.

Accident Analysis of Illuminated Crosswalks

Based on the data obtained from the users' survey conducted for this project, the accident analysis of pedestrian crossings with illuminated crosswalks is summarized in Table 6. Most agencies responding to the survey indicated no accidents at the crossings with in-pavement flashers since the installation of such devices. According to news reports, there has been one accident reported in Santa Rosa at one of its locations with in-pavement flashers. Lafayette also reported one pedestrian accident that occurred just after installation of the in-pavement flashers.

In the aggregate, the traffic volume that has passed through all locations is estimated at 428 million vehicles. Typically, we could expect one accident per 35 million vehicles under average conditions.

At this average accident rate, we would expect about 12.2 accidents for the sample of crossing locations with in-pavement flashers, based upon the proposed "average" accident rate. However, only 2 accidents have been reported. From the information available, it is estimated that the illuminated crosswalks have reduced the expected accidents by 80% at the locations where they have been installed.

Of the two reported accidents, one involved a right-turning vehicle that could not see the flashers from their approach. The other accident occurred when the sun was low and shining directly into the driver's eyes. Both of these accidents may be "exceptions", however they clearly illustrate that the systems are not 100% effective.

Table 6 - Accident Analysis of Pedestrian Crossings with Illuminated Crosswalks

Location	Years Installed	ADT	Vehicle Volume Since Installation (million vehicles)	Number of Lanes
Danville	0.5	3600	0.66	2
Fort Bragg	4	23100	33.73	3
Glendale	0.1	20000	0.73	5
Glendale	0.1	20000	0.73	5
Lafayette Site 1	3	19500	21.35	4
Lafayette Site 2	3	18000	19.71	4
Menlo Park	1	2500	0.91	2 w parking
Mercer Island, WA	1	11000	4.02	2 w median
Orange County	1	5000	1.83	4
Orinda	3	2000 (est)	2.19	2
Petaluma	3.5	16000	20.44	4 w parking
San Francisco	0.33	3000	0.36	2 w parking
San Pablo Site 1	1	11000	4.02	4
San Pablo Site 2	1	11000	4.02	3
Santa Barbara Site 1	0.5	20000	3.65	5
Santa Barbara Site 2	0.5	15000	2.74	5
Santa Rosa Site 1	4	15000 [e]	21.90	4
Santa Rosa Site 2	4	25000 [e]	36.50	5
Santa Rosa Site 3	4	15000 [e]	21.90	
Suisun City	1.75		0.00	
Willits	3.5	22000	28.11	5
Kirkland, WA Site 1	3	25000	27.38	5
Kirkland, WA Site 2	2.5	25000	22.81	5
Kirkland, WA Site 3	2.5	12000	10.95	3
Kirkland, WA Site 4	3	21000	23.00	5
Kirkland, WA Site 5	2.5	15000	13.69	3
Kirkland, WA Site 6	2.5	15000	13.69	3
Kirkland, WA Site 7	2.5	19000	17.34	3
Kirkland, WA Site 8	2.5	25000	22.81	5
Kirkland, WA Site 9	2.5	25000	22.81	5
Kirkland, WA Site 10	2.5	17000	15.51	3
Kirkland, WA Site 11	2.5	9000		2
Total			427.67	
Accidents Reported			2	

Notes: ADT is average daily traffic

e= estimated. City did not provide data

5.0 Installation Guidelines and Warrants

The following sections feature the installation guidelines for in-pavement flashers that are currently available and those that are expected to be available in the near future.

5.1 "RECOMMENDATIONS" FROM THE 1998 EVALUATION REPORT

The "Recommendations" from the Executive Summary of the April 1998 evaluation report entitled *An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights* (W-Trans, UNC) are quoted below for easy reference of Fountain Valley City staff, Citizen Traffic Committee, and elected officials. [1]

- Since the concept of flashing amber lights embedded in the pavement at uncontrolled crosswalks clearly has merit in modifying driving habits to be more favorable to pedestrians, further use of this concept should be pursued at appropriate locations.

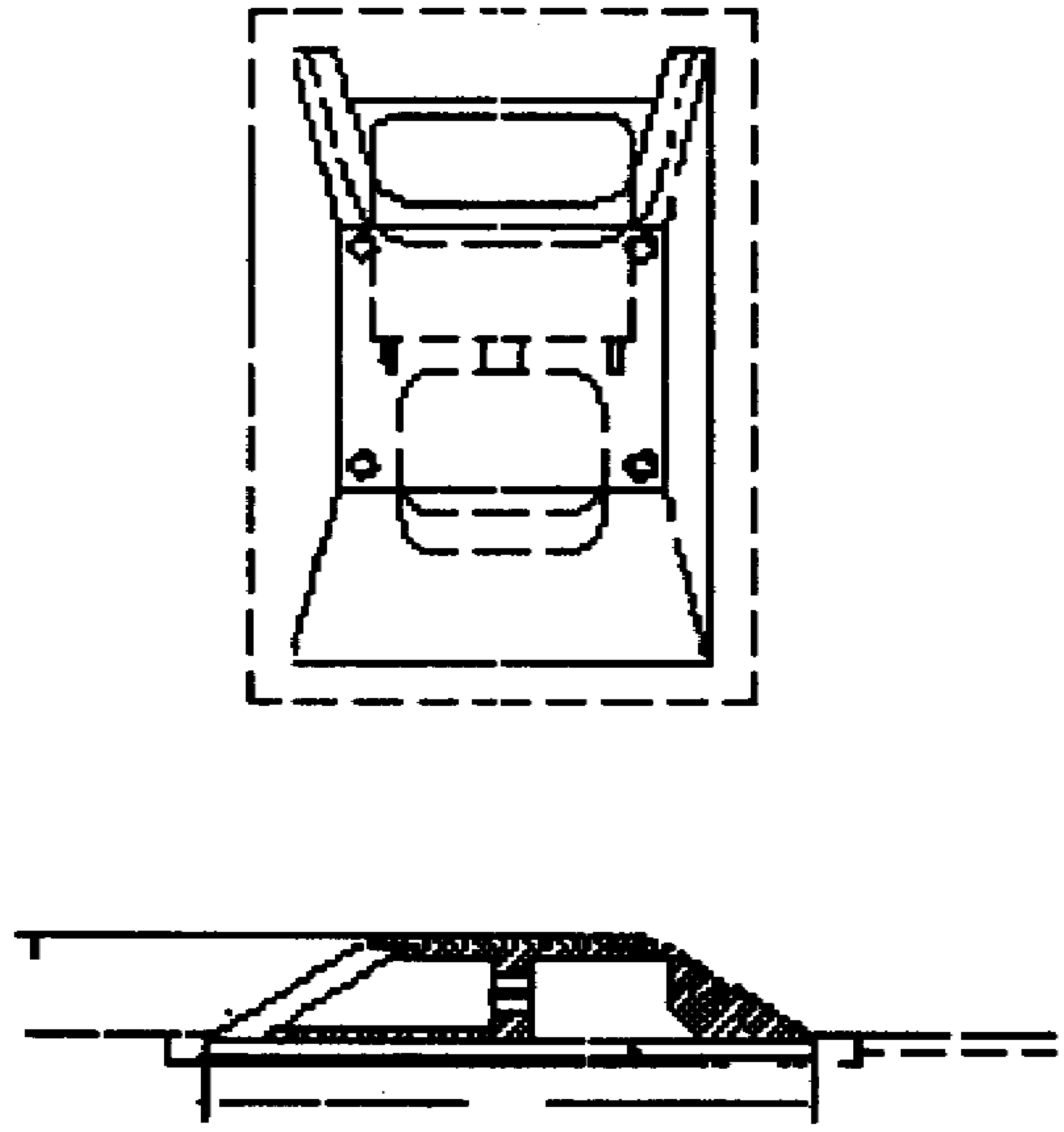
- The current installation pattern should be maintained as a standard. *[See Figure 1.]* However, the outermost device should be placed to avoid the path of bicyclists to the extent possible.

- The device should be no higher than ¾ -inch which is the maximum height of a standard lane delineator button.

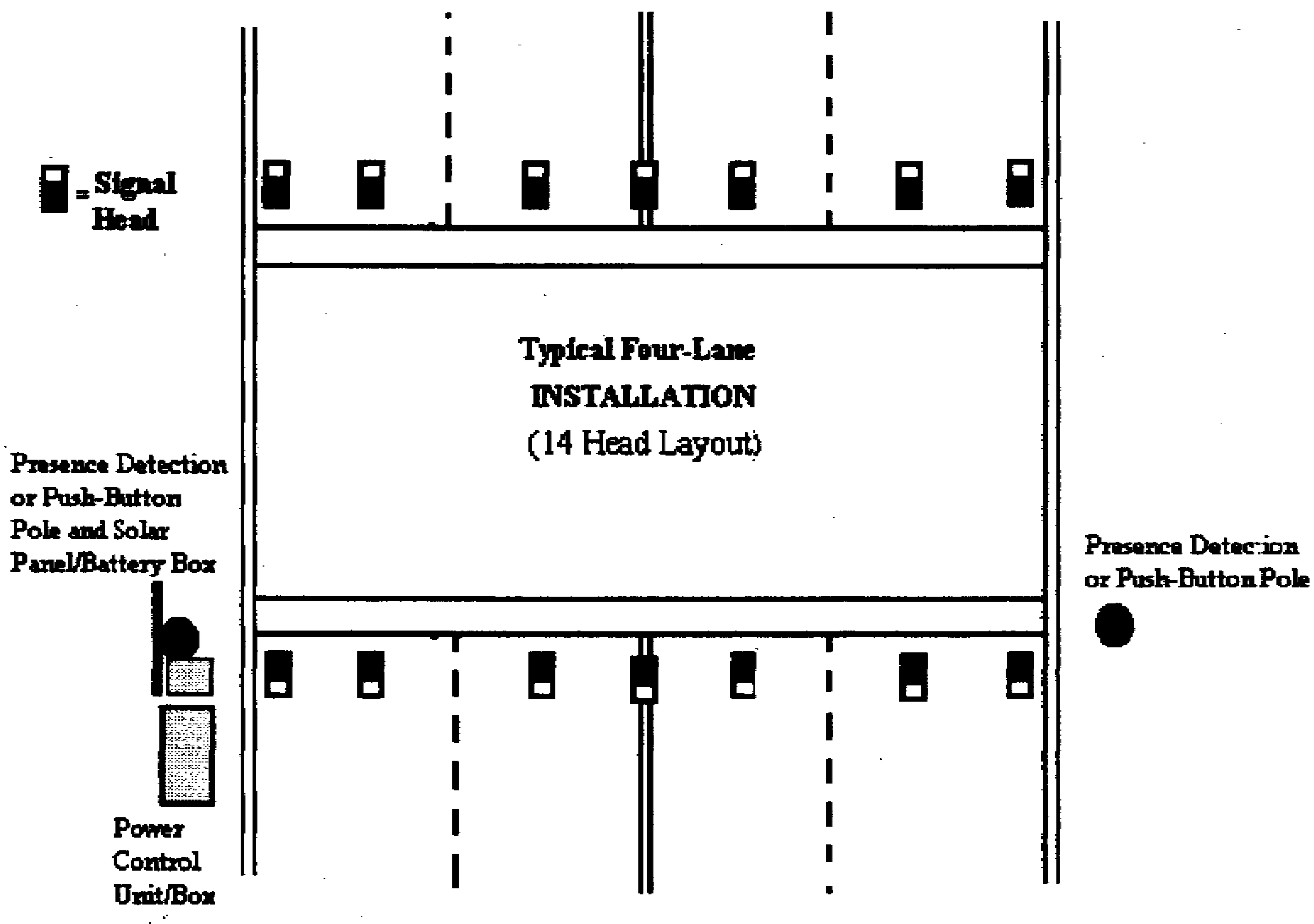
- Amber flashing lights seem to be the most appropriate color based on vehicle laws and considering a person's visual capabilities.

- In the long run, an automatic pedestrian activation system seems to be more appropriate than a pedestrian push button. This allows the pedestrian to cross with caution and at their own discretion. The most promising technology to date has been a "bollard gateway system."

- Appropriate street lighting should be considered at crosswalks where the system is applied. Street lighting will allow the pedestrian to be more visible at night and wash out the glow of the lighting devices so they do not distract the pedestrian.



Device Design



Experimental System Installation Pattern

Source: LightGuard Systems, Inc.

Figure 1 Experimental System

In-Pavement Flashing Lights Crosswalk Warning System Evaluation

Whitlock & Weinberger Transportation Inc.

XWK001.DRW 4/98

- Federal standardization through the Manual on Uniform Traffic Control Devices (MUTCD) and consistency with crosswalk laws in states other than California should be investigated. An organization such as the Institute of Transportation Engineers would be an appropriate organization to pursue this course of action.

- Based on the experience of the initial test sites, it is recommended that the following guidelines to be met for installation of the In-Pavement Flashing Lights Crosswalk Warning System. The development of guidelines will be important in focusing use of the device where it will be most effective and maintaining its effectiveness through limiting the number of locations where it is present.

  - The Crosswalk Warning System should be used only at uncontrolled crosswalks.

  - Main street average vehicular approach speeds should be 45 mph or less.

  - Main street traffic volumes should be between 5,000 and 30,000 vehicles per day. (It should be noted that the City of West Hollywood will be testing the device on Sunset Boulevard which has 55,000 vehicles per day.)

  - At speeds less than 35 mph, the approaching motorist should have visibility of the lighting devices at least 400 feet in advance of the crosswalk (measured from 3.5-foot eye height of the driver to 1-inch height at the edge of the crosswalk line). At speeds greater than 35 mph, appropriate additional sight distance to the warning lights should be provided.

  - There should be no other crosswalks or traffic control devices at least 250 feet in advance or following the crosswalk location.

  - A minimum pedestrian volume of 100 pedestrians per day is suggested for application of the system.

- Agencies which install the system should ensure that the public is educated on the proper use of the device by both the driver and the pedestrian.

5.2 CALTRANS INTERIM GUIDELINES

In response to a recommendation from the California Traffic Control Devices Committee (CTCDC), the California Department of Transportation (Caltrans) has made plans to adopt standards and specifications for pedestrian crosswalk lights pursuant to the California Vehicle Code (Section 21400). Section 21400 requires Caltrans, after consultation with local agencies and public hearings, to adopt rules and regulations prescribing uniform standards and specifications for all official traffic control devices placed pursuant to this code. A copy of Caltrans information is included in Appendix C.

In the spring of 1998, Caltrans, through its Traffic Operations Program, released the following *Interim Guidelines for Experimental Crosswalk Pavement Lights* to guide experimental installations prior to the establishment of statewide standards: [5]

1. Crosswalk Pavement Lights (CPLs) shall be amber and shall not exceed more than 20 mm (3/4 in.) above the pavement.

2. When activated, CPLs may either operate in a continuous or flashing mode. The flash rate should conform to Section 8.3.3 of the National Electrical Manufacturers Association Standards Publication No. TS-1, “Traffic Control Systems.” The luminance of CPLs should be a minimum of 2250 cd/m^2 when tested according to California Test 606. The lights should be clearly visible up to 61m (200 ft.) by approaching traffic.

3. Under normal conditions, the minimum pedestrian crossing time shall be based on a walking rate of four feet per second.

4. CPLs, as a minimum, should be placed in each lane. They should be located on the outside and on each side of the crosswalk. Either unidirectional or bidirectional CPLs may be used. Unidirectional CPLs shall face away from the crosswalk. Special consideration should be given to bike lanes. Any alternative placement of CPLs, greater than the minimum, should be reviewed and approved by the government authority with responsibility for installation.

5. CPLs may be manually or automatically activated. Special consideration should be given for handicapped and the visually impaired.

6. CPLs shall not be installed where vehicular traffic is controlled by a STOP sign or traffic signal.

7. Caution should be exercised to locate CPLs where they do not create confusion with other traffic control devices including traffic signals.

8. The vehicular approach speed should be 45 mph or less. Stopping sight distance should be provided in accordance with current engineering standards.

9. CPLs are not intended to be a substitute for standard STOP signs or traffic signals.

10. Advance pedestrian crosswalk warning signs should be considered where appropriate.

11. The CPL surface should be the same color as the crosswalk lines.

12. Public education for motorists and pedestrians is advised.

5.3 UPCOMING NATIONAL GUIDELINES

In January of 1999, the National Committee on Uniform Traffic Control Devices (NCUTCD), through its Marking and Signals Committees, heard an overview of the technology for in-pavement flashing lights at crosswalks, the test site results, and recommended amendments to the current *Manual on Uniform Traffic Control Devices* (MUTCD). In June of 1999, the NCUTCD voted in favor of those recommendations and forwarded the recommended language to the Federal Highway Administration (FHWA). The FHWA has proposed new sections on in-roadway warning lights for inclusion into the Federal Register, with the public comment period lasting through June 30, 2000. The FHWA is expected to make the final decision on the recommended language for inclusion of in-pavement flashing lights at crosswalks in the upcoming MUTCD, expected in early 2001. [3]

The following section, quoted from the FHWA web-site, summarizes the proposed amendments (subject to change) to the MUTCD that relate to in-roadway lights or in-pavement flashers: [6]

> 29. The FHWA proposes to add a new Section 4L, In-Roadway Lights, to the MUTCD. In-Roadway Lights are special types of highway traffic signals. They consist of a series of flashing light units embedded across the roadway to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent and might require the road users to slow down and possibly come to a stop.

These conditions include, but are not limited to, marked crosswalks that are not controlled by STOP signs, YIELD signs, or traffic control signals.

30. The proposed new Sections 4L.1 and 4L.2 would provide STANDARDS and GUIDANCE for the design and operation of In-Roadway Lights (if used) installations. The STANDARDS, among other things, would provide:
(1) For the installation of In-Roadway Lights parallel to the edge of the crosswalk,
(2) For the operation to be initiated based on pedestrian actuation (active or passive)
(3) For the operation to cease at a predetermined time after the actuation or with passive detection when the pedestrian clears the crosswalk,
(4) For the installation at marked crosswalks only with applicable warning signs, and
(5) For the height of the In-Roadway Lights not exceed a height of 20 mm (3/4 in.).

4L IN-ROADWAY LIGHTS

4L.1 Application of In-Roadway Lights

Support:

In-Roadway Lights are special types of highway traffic signals installed in the roadway surface to warn road users that they are approaching a condition on or adjacent to the roadway that might not be readily apparent and might require the road users to slow down and possibly come to a stop. This includes, but is not necessarily limited to, situations warming of marked school crosswalks, marked mid-block crosswalks, marked crosswalks on uncontrolled approaches, and other roadway situations involving pedestrian crossings.

Standard:

In-Roadway Lights shall not exceed a height of 20 millimeters (3/4 inches) above the roadway surface.

Option: The flash rate for In-Roadway Light may be different than the flash rate of standard beacons.

4L.2 In-Roadway Warning Lights at Crosswalks

Standard:

In-Roadway Warning Lights at crosswalks shall be installed only at marked crosswalks with applicable warning signs. They shall not be used at crosswalks controlled by YIELD signs, STOP signs or traffic control signals.

In-Roadway Warning Lights at crosswalks shall be installed along both sides of the crosswalk and shall span its entire length.

In-Roadway Warning Lights at crosswalks shall initiate operation based on pedestrian actuation and shall cease operation at a predetermined time after the pedestrian actuation or with passive detection after the pedestrian clears the crosswalk.

In-Roadway Warning Lights at crosswalks shall display a flashing yellow indication when actuated. The flash rate for In-Roadway Warning Lights at crosswalks shall be at least 50 flash periods per minute. The flash rate shall be between 5-30 flashes per second to avoid frequencies that might cause seizures.

For one-lane, one-way roadways, a minimum of two In-Roadway Warning Lights shall be installed on the approach side of the crosswalk. For two-lane roadways, a minimum of three In-Roadway Warning Lights shall be installed along both sides of the crosswalk. For roadways with more than two lanes, a minimum of one In-Roadway Warning Light per lane shall be installed along both sides of the crosswalk.

In-Roadway Warning Lights at crosswalks shall be installed within 3 meters (10 feet) of the outside edge of the crosswalk. In-Roadway Warning Lights shall face away from the crosswalk if uni-directional, or shall face away from and across the crosswalk if bi-directional.

Guidance:

The period of operation of In-Roadway Warning Lights following each actuation should be sufficient to allow a pedestrian crossing in the crosswalk to start crossing the traveled way and travel at a normal walking speed of 1.2 meters (4 feet) per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait. Where significant numbers of pedestrians who walk slower than normal routinely use the crosswalk, a walking speed of less than 1.2 m (4 feet) per second should be considered in determining the period of operation.

Where the period of operation is sufficient only for crossing from a curb or shoulder to a median of sufficient width for pedestrians to wait, additional measures should be considered, such as median-mounted pedestrian actuators.

The location of the In-Roadway Warning Lights within the lanes should be based on engineering judgment.

Option: On one-way streets, In-Roadway Warning Lights may be omitted on the departure side of the crosswalk.

Based on engineering judgment, the In-Roadway Warning Lights on the departure side of the crosswalk on the left side of a median may be omitted.

In-Roadway Warning Lights may be installed in the center of each travel lane, at the centerline of the roadway, at each edge of the roadway or parking lanes, or at other suitable locations.

Unidirectional In-Roadway Warning Lights installed at crosswalk locations may have a yellow light indication in each unit that is visible to pedestrians in the crosswalk. These lights may flash with and at the same flash rate as the light head in which each is installed.

5.4 INSTALLATION CRITERIA FROM KIRKLAND, WA

The City of Kirkland in Washington developed a system of selecting and prioritizing locations for in-pavement flashers, through a similar citizen participation process used for developing the system of ranking other Capital Improvement Projects. The philosophy ultimately adopted said that "flashing crosswalks at locations already benefiting from improvements should be delayed with improvements coming at less developed locations first." The ultimate criteria approved for the City of Kirkland are shown in Table 7. [2]

Table 7 - Criteria for Locating Flashing Crosswalks in Kirkland, WA

I. Threshold criteria:

Location must have a marked crosswalk and stopping sight distance must be adequate for approach speed.

II. Engineering (30 points max)

Approach speed 85th percentile (MPH)

Speed	*Points*
<20 or >45	0
20-29 or 41-45	4
30-35	8
36-40	12

ADT (000)

Volume	*Points*
<5 or >30	0
>5-<15 or >25-<30	8
>15-<25	16

Cost
(Above standard costs)

Cost	*Points*
Other	0
Small or no additional cost	2

III. **Connections (35 points max)**

Distance in feet to nearest crosswalk

Distance	*Points*
<500	0
>500-<1000	4
>1000-<1500	6
>1500	9

Table 7- Criteria for Locating Flashing Crosswalks in Kirkland, WA (Cont.)

What type of facilities does the crosswalk cross and/or continue?

(Priority 1 and 2 Pedestrian facilities are defined in the Non-Motorized Plan.)

Continues/Crosses	*P1*	*P2*	*Other*
P1	8	6	4
P2	6	4	2
Other	4	2	0

Is the crosswalk on school Walk Route?

Yes	6

Is the crosswalk near schools, community facilities, etc.?

	Distance to Center	
Activity Ctr.	*< 1/4 mi*	*<1/2 mi*
School	3 pts	2 pts
Com. Facility	2 pts	1 pt
Business Dist	2 pts	1 pt
Transit/HOV	1-2 pts	0.5-1 pt
Regional Ctr	1 pt	0.5 pt
Connect w/in Business Dist		1 pt

IV. Safety (35 points maximum)

Does the crosswalk serve a vulnerable population?

Yes	13

What is the accident history at the crosswalk?

Experience	*Points*
Less than Average	0
Average	6
More than Average	12

What improvements exist?

Improvements	*Points*
Striped crosswalk	10
Striped+Median or +O'head sign	6
Striped+O'head+Median	2

6.0 Existing Conditions: School Crossings in Fountain Valley

The City of Fountain Valley has identified nine school crossing locations and one other location used by senior citizens for potential installation of in-pavement flashers. Spread throughout the City, the nine school crossing locations are along major or minor arterial streets. These locations are listed in Table 8. All the school crossings are uncontrolled with marked crosswalks, while all side streets are stop-controlled. The tenth location is unmarked and is at an intersection of an arterial street and a shopping center driveway. There is a senior citizen center nearby.

6.1 ROADWAY GEOMETRIES

Eight of the nine school crossing locations have five-lane cross-sections (two lanes in each direction with a left-turn lane) with striped bike lanes in both directions. One of these eight locations, Talbert / St Cecilia, has a raised median island. The ninth location has a seven-lane cross-section (three lanes in each direction with a left-turn lane) with a median island but no striped bike lane. This ninth location, Warner at Greenleaf, has the only overhead flashing beacons among all the crossings. The tenth location, Magnolia south of Warner, is on a four-lane divided roadway with a raised landscaped median and left turn pockets. A senior housing development is located across from a neighborhood shopping center at this site. None of the locations have on-street parking allowed.

All the nine school crossings have advance stop lines that are set back from the crosswalk at a distance of at least 50 feet and striped with the text "WAIT HERE." This is a unique distinguishing feature of the Fountain Valley locations. All the crossings are signed according to California school crossing standards.

There are no signs or markings related to pedestrians at the tenth site.

6.2 Accident History at Crossings

Fountain Valley has had very good experience with the use of its existing striping treatment that includes the use of set back stop lines. As shown on Table 8, the nine school crossing crosswalks have been in use for three years and have over 195 million vehicle crossings. This could have resulted in 6 pedestrian accidents, based on experience at other crosswalks cited earlier in this report. The City of Fountain Valley has had no reported accidents at any of the locations. This would indicate that the advanced stop lines and related signs and the presence of school-crossing guards are a very good safety measure by themselves.

Some persons might be tempted to conclude that the crossing guards alone were responsible for the good safety record. However, Katz Okitsu & Associates' study in Santa Ana determined that accidents should be expected at school crossing during low use periods when crossing guards are not present just as frequently as at locations that are not school crossings, regardless of use level during these hours. For this reason, we attribute the excellent safety record to a combination of the crossing guard and the striping treatment.

Table 8 - Accident Analysis of School Crossings in Fountain Valley

Location	*Years Installed*	*ADT*	*Vehicle Volume Since Installation (million vehicles)*	*Number of Lanes*
Bushard/Honeysuckle	3	12,400	13.58	5
Bushard/Robin	3	15,200	16.64	5
Ellis/Hawthorn	3	23,300	25.51	5
Ellis/Las Flores	3	21,900	23.98	5
Ellis/Santa Andrea	3	17,300	18.94	5
Talbert/Santa Cecilia	3	20,400	18.94	5
Warner/Greenleaf	3	34,200	37.45	7
Newhope/Sandstone	3	17,700	19.38	5
Newhope/Primrose	3	18,900	20.70	5
Total			**195.13**	
Reported Accidents			None	

Note: ADT is average daily traffic

The other location has experienced three pedestrian related accidents since 1997. Two accidents, with one fatality, involved pedestrians crossing Magnolia Street while the other involved a pedestrian being hit while standing on the sidewalk by a vehicle that had been hit by another vehicle. This results in an accident rate of one pedestrian accident per 21 million vehicle crossings. This rate is higher than the “expected” rate of one pedestrian accident per 35 million vehicle crossings discussed earlier in this study. The three pedestrians were all over age 70. The fatality involved an 84 year old woman.

Pedestrian Volumes

Pedestrian volumes were obtained from the City of Fountain Valley for the school crossings during school hours. They are shown on Table 9. These volumes exclude pedestrian activity during other hours, but are representative of peak activity at the locations

Table 9 Pedestrian Volumes at School Crossings

Location	AM Peak	PM Peak
Bushard/Honeysuckle	44	39
Bushard/Robin	10	8
Ellis/Hawthorn	25	30
Ellis/Las Flores	25	59
Ellis/Santa Andrea	7	12
Talbert/Santa Cecilia	8	16
Warner/Greenleaf	15	21
Newhope/Sandstone	17	18
Newhope/Primrose	28	30

A review of the volumes indicates that several locations would not likely satisfy requirement of 100 pedestrian crossings per day, even if crossings when a school crossing guard is present are included. These locations are Bushard/Robin, Ellis/Santa Andrea, Talbert/Santa Cecilia, Warner/Greenleaf and Newhope/Sandstone. The remaining school crossing locations, along with the Magnolia Street location were counted for 2 hours to obtain a better indication of total usage. One hour was during school activity (2-3 PM) while the other hour was during a normal non-school use hour (1-2 PM) These are shown on Table 10.

Table 10 Pedestrian Volumes

Location	1:00 PM to 2:00 PM	2:00 PM to 3:00 PM
Bushard/Honeysuckle	0	60
Ellis/Hawthorn	0	16
Ellis/Las Flores	5	25
Newhope/Primrose	22	80
Magnolia/Driveway	3	0

Katz, Okitsu & Associates has developed a procedure for estimating daily pedestrian volumes at locations with school related activity, based on the above two hours of data. The formula is :

Daily Volume is equal to:

7*(volume, 1PM to 2PM) + 4*(highest hourly volume from 1PM to 3PM)

The first term is the non-school volume, while the second term accounts for heavy school volume. The pedestrian counts were used to estimate the daily school hours and non-school hours as indicated in Table 9. Using that formula, only Newhope/Primrose would meet the requirement for 100 crossings per day, during hours when a school crossing guard is not present.

7.0 Recommendations for an Installation Policy and Applicable Warrants

The City of Fountain Valley needs to decide whether the in-pavement flashers are appropriate for use within the City. The devices are generally new, and they are being used primarily by agencies with significant pedestrian issues and pedestrian goals. Katz, Okitsu & Associates has recommended them to cities that have expressed interest in being innovators and that have established high goals for pedestrian mobility while maintaining safety. These Cities understand that the devices are new and undergoing refinements based upon the experience of the early users. They also understand that there is a possibility that these demonstrations may result in major changes to the technology, approach, or guidelines for usage.

If the City determines that the devices are appropriate, the following criteria can be used in evaluating locations.

School Crossing Usage

In-Pavement Flashing systems have not been installed frequently at school crossings with crossing guards. Most applications are in commercial districts or other locations where pedestrian traffic is heavy for many hours. Also, school-crossing guards provide a high level of crossing protection compared with other treatments. While In-Pavement Flashers can assist school-crossing guards, they may be more appropriate for locations with steady pedestrian traffic throughout the day. Nevertheless, the safety record of school crossings during non-school hours should not be discounted. Many Santa Ana pedestrian accidents occurred at school crossings during nighttime hours.

The City of Fountain Valley should determine whether to include or exclude pedestrian use during hours when crossing guards are present. Pedestrian counts are not available for non-school hours. However, most of the locations will probably not meet the pedestrian use criteria if crossings assisted by a school crossing guard are excluded.

In developing a priority system, Katz, Okitsu & Associates does not believe that crossings made during hours with school crossing guards should be considered. However school-crossing usage should certainly be considered at locations where crossing guards are not present.

In determining the locations that should be considered for installation of illuminated crosswalks, Katz, Okitsu & Associates considered the following roadway and operational characteristics, which have been prescribed by the City:

a.) Number of Approaches
b.) Width of Crossing
c.) Pedestrian Usage
d.) Proximity to Schools, transit centers, and pedestrian generators
e.) Signage
f.) Sight distance requirements (include on street parking)

7.1 PROPOSED INSTALLATION WARRANT

In addition to the above items, Katz, Okitsu & Associates reviewed all the parameters used in currently available installation guidelines and recommendations from other studies, which have been described in earlier sections of this report. Our proposed installation warrant consists of a streamlined list of criteria as shown in Table 11.

Instead of a numeric or point system, the proposed installation warrant uses simple binary decision-making, i.e. determining whether a necessary condition is met or not. The eight criteria in the proposed warrant are a composite of all the installation guidelines and criteria from other local, state, and federal sources. The warrant also reflects the state-of-the practice in the use of in-pavement flashers as revealed in the users' survey conducted for this project.

We recommend that the City of Fountain Valley adopt the installation warrant, as shown in Table 11, to screen the nine crossing locations that have been identified for potential installation of in-pavement flashers.

Table 11- Proposed Installation Warrant for In-Pavement Flashers

Criteria	Yes or No
1. Type of Pedestrian Crossing The crosswalk must be uncontrolled, marked, and accompanied by applicable warning signs. (The crosswalk cannot be controlled by STOP signs, YIELD signs, or traffic signals.)	______
2. Speed on the Main Street The vehicular approach speed (85th percentile) on the main street to be crossed must be 45 mph or less.	______
3. Average Daily Traffic (ADT) The traffic volume or ADT on the main street to be crossed must be between 5,000 and 30,000 vehicles per day.	______
4. Safe Stopping Distance If the vehicular approach speed on the main street is less than 35 mph, the stopping sight distance must be at least 400 feet prior to the crosswalk. If the vehicular approach speed on the main street is between 35 mph and 40 mph, the stopping sight distance must be at least 500 feet prior to the crosswalk. If the vehicular approach speed on the main street is between 40 mph and 45 mph, the stopping sight distance must be at least 600 feet prior to the crosswalk.	______
5. Pedestrian Volume The crossing must be used by at least 100 pedestrians per day.	______
6. Adjacent Crosswalks or Traffic Control There must be <u>no</u> marked crosswalks or controlled intersections within 300 feet in advance of or following the crosswalk.	______
7. Roadway Cross Section The cross section of the main street to be crossed must be a minimum of three lanes.	______
8. Other Treatments Considered Other treatments for facilitating pedestrians have been considered and the use of in-pavement flashers is most appropriate for site conditions.	______

The installation warrant is satisfied if the requirements for all criteria are met, i.e. all answers are "Yes."

The proposed installation warrant for in-pavement flashers at crosswalks has requirements that must be met for the following criteria:

- Type of Pedestrian Crossing
- Speed on the Main Street
- Average Daily Traffic (ADT)
- Safe Stopping Distance
- Pedestrian Volume
- Adjacent Crosswalks or Traffic Control
- Roadway Cross Section
- Other Treatments Considered

A candidate location passes the installation warrant for in-pavement flashers by satisfying all the requirements for the eight criteria. The final criteria acknowledge that in-pavement flashers may not necessarily be the optimum treatment for crossing situations. They should be considered for implementation only after the other criteria are met, and a site specific study determines that they are the most appropriate device for the location.

7.2 Results and Prioritization of Candidate Locations

After crosswalk locations have been screened through the installation warrant from Table 9, they can be ranked using the following procedure:

PCI = ADT * APDT * NL * VPF

Where: PCI: Pedestrian Crossing Intensity
ADT: Average Daily Traffic (in 1,000 vehicles/day (vpd))
APDT: Average Pedestrian Daily Traffic (in 100 pedestrians/day)
NL: Number of Lanes (to be crossed on the main street)
VPF Vulnerable Population Factor
= 1.00 *for general population*
= 1.25 *for low percentage of school kids/senior citizens*
= 1.50 *for moderate percentage of school kids/senior citizens*
= 1.75 *for high percentage of school kids/senior citizens*
= 2.00 *for very high percentage of school kids/senior citizens*

The proposed Pedestrian Crossing Intensity parameter is a measure of the magnitude of the conflict between vehicles and pedestrians and the vulnerability of the population group using the crosswalk.

We recommend that the City of Fountain Valley adopt the parameter Pedestrian Crossing Intensity, as shown in Section 7.2, to prioritize crossing locations that have been screened for potential installation of in-pavement flashers.

7.3 SITE-SPECIFIC RECOMMENDATIONS

Table 12 shows the results warrant analysis for the nine school crossings. Only one of the nine locations meets the proposed criteria. The primary reason for not meeting the criteria was having less than 100 pedestrian crossings per day, if usage when crossing guards are present is excluded. The only location that would meet the warrant is Newhope at Primrose.

The City also asked that the location on Magnolia Street south of Warner Avenue be analyzed. This location has a senior citizen complex on the west side of Magnolia Street and a shopping center on the east side. Magnolia Street has an traffic volume of 33,000 vehicles per day (vpd). This is higher than the maximum recommended criteria for an illuminated crosswalk. The are available pedestrian volumes at this location indicate that there are approximately 20 pedestrians per day using that location. The accident records show 2 pedestrian accidents within the street and a third accident on the sidewalk at this location in the last 3.6 years. Based on the criteria established earlier in this report, this location does not warrant in-pavement flashers. However, due to the accident history, some form of treatment may be advised.

Median refuges are frequently identified as devices that meet the needs of pedestrians who are having difficulty crossing wide multi-lane roadways. They provide a raised standing area within the raised median separating the two travel directions. This allows a safe and comfortable half-way place for pedestrians to wait until traffic clears to continue their crossing. It also improves visibility to motorists and increases the likelihood that a courteous motorist will slow for the pedestrian waiting in the median refuge. Some median refuges have been designed to require pedestrians to zig-zag within the median to face oncoming traffic, improving pedestrians awareness of current traffic conditions.

A median refuge would appear to be an appropriate treatment for the Magnolia location, however the median needs to be at least six feet wide and preferably much wider. At the subject location, it would be most desirable to provide a median refuge with an improved standing area and wheelchair access that is at least as wide as the raised median in its landscaped areas, 14 feet. This would require reconstruction of the median to eliminate the left turn lane. The most logical location to eliminate the median is on the south side of the crossing point, where it would only interfere with drivers who intend to turn left into the senior housing complex. Spot traffic counts taken during the hours when pedestrians were observed suggest that the volume of motorists who turn left at the location is about equal to the number of pedestrians who cross at the location. The trade off is thus between 3-4 pedestrians per hour and 3-4 motorists per hour. If the northbound left-turn lane is eliminated, then each left-turning motorist will have to travel about 150 feet further north and make a U-turn at the next driveway opening.

Katz, Okitsu & Associates would recommend a median refuge as the most appropriate improvement to enhance pedestrian mobility and safety for this location. We would not recommend a marked crosswalk, due to safety concerns that apply to the use of crosswalk markings at locations with high traffic volume and low pedestrian volume. However, if the City found a crosswalk to be an appropriate device, we would recommend consideration of a pedestrian signal flasher or other warning system to be included in the implementation plan. A crosswalk alone would likely continue to experience an unsatisfactory safety record, and motorists would also be unwilling to yield to pedestrians at this particular location due to traffic volumes and speeds.

Table12- Warrants Analysis for Fountain Valley School Crossings

Criteria	*Location* Bushard/ Honeysuckle	Bushard/ Robin	Ellis/ Hawthorn	Ellis/ Las Flores	Ellis/ Sta Andrea	Talbert/ Sta Cecilia	Warner/ Greenleaf	Newhope/ Sandstone	Newhope/ Primrose
1. Type of Crossing (uncontrolled, marked, & signed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Speed on main street (45 mph or less)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. ADT (between 5,000 - 30,000 vpd)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
4. Safe Stopping Distance (based on speed)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Pedestrian Volume (at least 100 peds/day)	No	No	No	No	No	No	No	No	Yes
6. No Adjacent Crosswalks or Traffic Control Devices	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Vulnerable Population Served	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Roadway Cross Section (3 lanes min.; over 5 lanes w/ median)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Is installation warrant satisfied?	No	No	No	No	No	No	No	No	Yes

8.0 Summary of Findings

From the User's Survey, most of the in-pavement flasher systems in California have been installed for 3 years or less. LightGuard Systems has been the vendor for most of the systems.

There is a high level of satisfaction reported among the user agencies and they report high satisfaction by the public. However, support is not 100% and it is weakest among agencies that have experienced accidents.

Users and human-factor studies suggest that in-pavement flasher systems are more effective at night than during the day. However, there is a positive effect of the systems during daylight hours. The percentage of drivers yielding to pedestrians has increased after installation of the systems.

Passive pedestrian detectors accounted for most of the problems with the systems, as reported by using agencies. Most agencies having passive pedestrian detection would not recommend their use in future installations. However, agencies using the newest trip beam bollard systems appear to be satisfied with this method of actuation.

There have been two reported accidents at locations with in-pavement flashers. With over 427 million vehicle crossings, this is about 80% less than might be expected from untreated marked crosswalk locations with "average" applications.

Current school crossings in Fountain Valley report significantly better safety records than comparable crosswalks elsewhere. This is attributed to the separation between the advanced limit line and the crosswalks by 50 feet or more. Some crosswalk safety "experts" have postulated that this treatment may be very effective at improving pedestrian safety at uncontrolled crosswalks. The Fountain Valley experience supports this theory.

There is good evidence that pedestrian safety is higher at multi-lane locations with in-pavement flashers. Preliminary information from this study suggests an improvement by up to 80% over typical untreated marked crosswalks. However, no locations have existed long enough to determine whether this effect in permanent.

Other striping and marking techniques may be equally as effective, including advanced limit lines and actuated overhead flashers. However passive treatments such as advanced limit lines may not be as effective in producing greater motorist compliance with pedestrian right-of-way. This is probably the key element that distinguishes actuated flash systems from passive treatments.

Final Recommendations

- Katz, Okitsu & Associates has recommended the use of in-pavement flasher systems as a tool to agencies that have established high goals for pedestrian mobility while preserving or enhancing pedestrian safety. We have concluded that the devices can greatly improve pedestrian safety at certain types of marked crosswalks beyond conventional treatments. We could recommend consideration of this device to the City of Fountain Valley or to any interested community that has appropriate locations for its use. However, all of the agencies we have counseled understand that the technology is new, under continuing improvement, and liable to change in the future. They have agreed to participate in use of the devices as experimenters or early innovators, knowing that current City goals will be met, but that changes, difficulties, or surprises may emerge at a later date.
- The locations in Fountain Valley have unique treatments for the pedestrian crosswalks. These treatments are working as effectively as Illuminated Crosswalks.
- The study suggests a warrant and priority system to determine the need for Illuminated Crosswalks. The warrant system is based upon pedestrian activity levels and other factors. The City should review the proposed warrant system and adopt it or modify it to better suit Fountain Valley needs and goals. The current warrant system indicates that one location (Newhope/Primrose) could satisfy the warrants for an in-pavement flasher system.

- Katz, Okitsu & Associates recommends that pedestrian crossings during hours when school-crossing guard are present should be excluded from the measurements of pedestrian volumes or calculation of priority scores.
- If devices are implemented, Katz, Okitsu & Associates recommends that light trip-beam passive actuation systems should be used, where practical. Although they are currently less reliable, the detection technology is improving and there are considerable traffic benefits. We believe that the use of passive actuation will become the standard approach after it is perfected for this usage.

References

1. Whitlock & Weinberger Transportation Inc, *An Evaluation of a Crosswalk Warning System Utilizing In-Pavement Flashing Lights*, April, 1998

2. Godfrey, David and Tony Mazella, *Kirkland's Experience with In-Pavement Flashing Lights at Crosswalks*, ITE/MSA Annual Meeting, February 8, 1999, Lynnwood, WA

3. Institute of Transportation Engineers, *In-Pavement Flashing Lights at Crosswalks Information Report*, ITE Committee TENC-98-03, February 18, 2000.

4. Lelchuk, Ilene, *City Installs Lighted Safety Crosswalk*, San Francisco Examiner, April 19, 2000.

5. California Department of Transportation, Traffic Operations Program, *Interim Guidelines for Experimental Crosswalk Pavement Lights*, Revised March 22, 1999

6. Federal Highway Administration; 23 CFR Part 655; Revision of the Manual on Uniform Traffic Control Devices; General Provisions, Markings, and Signals; From the Federal Register Online via GPO Access [wais.access.gpo.gove]

APPENDIX A
Vendor Product Brochures

APPENDIX B

- **Users' Survey Questionnaire**
- **Tables of Existing Sites of In-Roadway Warning Systems**

Katz, Okitsu & Associates
Traffic Engineers and Transportation Planners

City of Fountain Valley

Illuminated Crosswalks: Users' Survey

Information Needed	***Information Provided***	***Comments/Notes***
Name of City/County		Phone:
Name of Contact		Fax:
# of Locations Installed		
# of Years since Turn-On		
Date of Installation		
ADT		
Crossing Type		
Pedestrian Volume		
Road Type/Street Function		
Cross Section (# of Lanes)		
Median Island	YES or NO	
Left-Turn Pockets	YES or NO	
Street-Parking (plus Type)	YES or NO	
Bike Lanes	YES or NO	
Land Use		
Speed Limit		
Safety Record/# of Accidents		
Detection Type (Push-button or Passive)		
Special Features		
Brand Name/Manufacturer		

Katz, Okitsu & Associates
Traffic Engineers and Transportation Planners

Illuminated Crosswalks: Users' Survey

Comments/Thoughts		***Additional Space for Notes***
Are you **satisfied** with the product?	YES or NO	
Will you **install more** in the future?	YES or NO	
Do you **have** installation **warrants**? If yes, request copy of warrants.	YES or NO	.
If no, do you have **need** for installation **warrants**?	YES or NO	
What **maintenance issues** for this product might you have?		
What issues might you have with the **manufacturer or installation contractors**?		
What feedback have you received from the **general public**?		
What feedback have you received from the **organizations for the disabled**?		
What feedback have you received from the **school crossing guards**?		
What type of **annoyance** from the average pedestrian or resident have you received?		
What feedback have you received on effectiveness during **various weather condition**s?		
What feedback have you received on **driver reaction** to the product?		
What **liability issues** might you find caused by this product?		
What are your **final thoughts** on this product?		

EXISTING US SITES of IN-ROADWAY WARNING SYSTEMS (Outside CA)

CITY	STATE	NO. SITES	CONTACT	STREET / LOCATION	CROSSING TYPE	STREET FUNCTION	ADJACENT LAND USE	INSTALLED
GOODYEAR	AZ	2	CHUCK HYDEMAN 706-613-3440	SAN MIGUEL @ PORTER DRIVE LITCHFIELD RD. @ WESTERN AVE.	MIDBLOCK	CITY ARTERIAL	RESIDENTIAL / SCHOOL COMMERCIAL	Sep-99
GAINESVILLE	FL	1	ALLEN REID 407-628-1965	UNIVERSITY OF FLORIDA CAMPUS	SCHOOL XING	CAMPUS	UNIVERSITY	Aug-99
DISNEY WORLD		2	KATHERYN KOLBO 407-828-2250	HOTEL PLAZA BLVD. @ HILTON HOTEL	MIDBLOCK	CITY ARTERIAL	HOTEL	Aug-99
LAKELAND		3	BRUCE O'DONOGHUE 407-628-1965	1 - CRESAP STREET EAST OF S. LAKESHORE AVENUE 2 - JENKINS ARENA / THEATER	MIDBLOCK	CITY COLLECTOR PARKING LOT	SENIOR HOMES THEATER PARKING LOT	Summer-99
ORLANDO		1	JOHN SUSSI 407-246-2617	DOWNTOWN LIVINGSTON ST. @ CENTROPLEX	MIDBLOCK	CITY COLLECTOR	HOTEL / SPORTS ARENA	Mar-97
UNIVERSAL STUDIOS		1	DARRELL HOSMER 407-252-3324	UNIVERSAL STUDIO GROUNDS	MIDBLOCK	PRIVATE LOCATION	THEME PARK	May-98
ATHENS	GA	3	DAVID CLARK 706-613-3440	2 - LUMPKIN STREET 1 - CONFERENCE CENTER	SCHOOL XING / COMMERCIAL	CAMPUS / CITY	UNIVERSITY	Oct-99
SAVANNAH		1	DOYLE SAXON 912-651-6600	HISTORIC DISTRICT BAY STREET @ DAYS INN	MIDBLOCK	CITY ARTERIAL	HOTEL / TOURIST	Apr-99
OUAHU	HI	1	TOM HAMM 808-637-9703	PALI HIGHWAY @ JACK LANE	INTERSECTION	STATE HIGHWAY	RESIDENTIAL	Mar-00
BOISE	ID	1	MIKE SNELLGROVE 425-222-3653	BEHIND CITY OFFICES	MIDBLOCK	CITY ARTERIAL	SCHOOL	Nov-99
BIRMINGHAM	MI	1	BRAD CASE (248) 477-8700	DOUNTOWN BUSINESS DISTRICT	MIDBLOCK (snow plow)	CITY ARTERIAL	DOWNTOWN	Apr-00
RENO	NV	4	DAVID LAZO 775-328-6458	3 - RENO / TAHOE INT'L AIRPORT 1 RENO COSTCO	PASSENGER CROSSING PARKING LOT	PASSENGER DROP-OFF PARKING LOT	AIRPORT TERMINAL SHOPPING CENTER	Jul-98 - Jan-99
ALVIN	TX	1	TOM WILKS 281-388-4281	MUSTANG RD @ ALVIN COMMUNITY COLLEGE	MIDBLOCK	CITY ARTERIAL	COLLEGE	
AUSTIN		1	BEN AVILA 512-499-7223	BARTON SPRINGS ROAD NEAR CITY HALL	MIDBLOCK	CITY ARTERIAL	COMMERCIAL	Aug-99
KIRKLAND	WA	22	DAVE GODFREY 425-828-1214	VARIOUS	VARIOUS	CITY ARTERIAL	VARIOUS	TO DATE
LYNNWOOD		2	DALE LYDIN 425-775-1971	168TH STREET SW @ 58TH STREET	CROSSWALK	CITY ARTERIAL	SCHOOL	Summer-99
MERCER ISLAND		1	NANCY FAIRCHILD 206-236-5300	ISLAND CREST WAY @ ISLAND PK. ELEMENTARY SCHOOL	MIDBLOCK SCHOOL XING	CITY COLLECTOR	SCHOOL	Jun-99
OLYMPIA COUNTRY & GOLF CLUB		1	STEVE LIND 360-753-6538	COOPERS POINT ROAD @ OLYMPIA COUNTRY & GOLF CLUB	MIDBLOCK	COUNTY ROAD	GOLF COURSE	Oct-98
SEATTLE UNIVERSITY		1	JOAN WEISER 206-441-4509	EAST JAMES WAY @ SEATTLE UNIVERSITY	MIDBLOCK	CITY ARTERIAL	UNIVERSITY	Mar-99
SNOHOMISH COUNTY		1	BILL CURTIS 425-388-6420	LARCH RD. @ MARTHA LAKE ELEMETARY SCHOOL	CROSSWALK	CITY COLLECTOR	SCHOOL	Mar-00
UNIVERSITY PLACE		2	STEVE SUGG 253-566-5656	BRIDGEPORT WAY WEST	MIDBLOCK	CITY ARTERIAL	COMMERCIAL / SHOPPING	Oct-98
VANCOUVER		2	BONNIE MARTIN 360-696-8290	FOURTH PLAIN BLVD. @ NE 87TH AVENUE MILL PLAIN BLVD. @ 39TH STREET	MIDBLOCK	CITY ARTERIAL	COMMERCIAL	Nov-99
CNMI-SAIPAN	GUAM	4	JOSE CASTRO 670-233-6021	COMMONWEALTH CENTER @ MIHA HOUSING UNITED GARMENT FACTORY TICK TOCK @ CHALAN KANOA	MIDBLOCK	CITY ARTERIAL	COMMERCIAL	Aug-97

59 TOTAL SITES

* ONE WAY STREET

APPENDIX C
Caltrans Criteria

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS PROGRAM

INTERIM GUIDELINES FOR EXPERIMENTAL CROSSWALK PAVEMENT LIGHTS

1. Crosswalk Pavement Lights (CPL's) shall be amber and shall not extend more than 20 mm (3/4 in.) above the pavement.

2. When activated, CPL's may either operate in a continuous or flashing mode. The flash rate should conform to Section 8.3.3 of the National Electrical Manufacturers Association Standards Publication No. TS-1, "Traffic Control Systems." The luminance of CPL's should be a minimum of 2250 cd/m2 when tested according to California Test 606. The lights should be clearly visible up to 61 m (200 ft.) by approaching traffic.

3. Under normal conditions, the minimum pedestrian crossing time shall be based on a walking rate of four feet per second.

4. CPL's, as a minimum, should be placed in each lane. They should be located on the outside and on each side of the crosswalk. Either unidirectional or bi-directional CPL's may be used. Unidirectional CPL's shall face away from the crosswalk. Special consideration should be given to bike lanes. Any alternative placement of CPL's, greater than the minimum, should be reviewed and approved by the government authority with responsibility for installation.

5. CPL's may be manually or automatically activated. Special consideration should be given for handicapped and the visually impaired.

6. CPL's shall not be installed where vehicular traffic is controlled by a STOP sign or traffic signal.

7. Caution should be exercised to locate CPL's where they do not create confusion with other traffic control devices including traffic signals.

8. The vehicular approach speed should be 45 mph or less. Stopping sight distance should be provided in accordance with current engineering standards.

9. CPL's are not intended to be a substitute for standard STOP signs or traffic signals.

10. Advance pedestrian crosswalk warning signs should be considered where appropriate.

11. The CPL surface should be the same color as the crosswalk lines.

12. Public education for motorists and pedestrians is advised.

Revised 3-22-99

June 24, 1998

CALIFORNIA DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS PROGRAM

CROSSWALK PAVEMENT LIGHTS EXPERIMENTAL INSTALLATION EVALUATION

(To be filled out after one year of operation.)

Date ____________________

Your Agency ____________________

Agency Address ____________________

____

Contact Person ____________________

Contact Person's Phone Number ____________________

Test Site Location ____________________

____

____

Date Installation Became Operational ____________________

Reason This Particular Location Was Selected ____________________

____

____

____

Are the Crosswalk Pavement Lights (CPLs) Operational 24 Hours per Day, 7 Days per Week?

Yes ☐ No ☐

If No, Please Describe ____________________

Mode of Operation

Flashing ☐ Continuous ☐

Other ____________________

Type of CPL

Incandescent ☐ LED ☐ Other ____________________

Type of CPL Activation

Automatic ☐ Manual ☐ Other ____________________

CPL Manufacturer (Optional) ____________________

Describe Other Traffic Control Devices in the Vicinity ____________________

____

____

____

June 24, 1998

Describe Any Unusual Geometric Conditions ______________________________

____

____

____

Describe Any Accommodations for Handicapped or Visually Impaired Pedestrians

____

____

____

Describe CPL Public Education and It's Effectiveness (Optional)

____

____

____

Summarize Public Comments

____

____

____

Vehicular Traffic Volume (Two-way)

ADT ____________________________

AM Peak Hour ________________ PM Peak Hour ________________

Prevailing Vehicular Approach Speed __________ Posted Speed __________

Pedestrian Traffic Volume

Average Day ____________________________

AM Peak Hour ________________ PM Peak Hour ________________

Prior Accident History (3 yrs.) Within 250 Feet of the Crosswalk

Year			
Total Veh. Accidents			
Veh./Ped. Accidents			
Veh. Rear End Accidents			

Post Accident History (1 yr.) Within 250 Feet of the Crosswalk

Year	
Total Veh. Accidents	
Veh./Ped. Accidents	
Veh. Rear End Accidents	

Cost of Installation (Optional) ______________________________

Description of Any Maintenance Problems ______________________________

____

____

____

Annual Cost of Operations, Including Maintenance Costs (Optional)

Year			
Annual Cost			

Features You Would Recommend to be Included or Excluded in a California Standard for CPLs

____

____

____

Explain How the Installation Benefited the Public ______________________________

____

____

Other Comments ______________________________

____

____

Attach a sketch showing the geometrics of the location, other traffic control devices in the vicinity, and CPL layout. Please send sketch and evaluation to:

California Department of Transportation
Traffic Operations Program
Office of Signs and Delineation MS 36
1120 N Street
P.O. Box 942874
Sacramento, CA 94274-0001

City of
Cupertino

City Hall
10300 Torre Avenue
Cupertino, CA 95014-3255
Telephone: (408) 777-3354
FAX: (408) 777-3333

DEPARTMENT OF PUBLIC WORKS
File No. 74,001.22

August 10, 1999

Gerry Meis, Chief
Office of Signs, Delineation and
Technical Support
California Department of Transportation
1120 N Street, MS 36
Sacramento, California 95814

SUBJECT: EXPERIMENTAL CROSSWALK PAVEMENT LIGHTS

Dear Mr. Meis:

The City of Cupertino is requesting your approval to install experimental crosswalk pavement lights. As a professional civil engineer, I will oversee the installations

We are proposing to install them at three locations (see figures):

- McClellan Road, two-lane minor collector, near Lincoln Elementary School
- McClellan Road, two-lane minor collector, near Monta Vista High School
- Stevens Creek Boulevard, two-lane major collector, near Cupertino Post Office

We will evaluate the experimental crosswalk pavement lights for a one-year period of operation. We will submit the results to you.

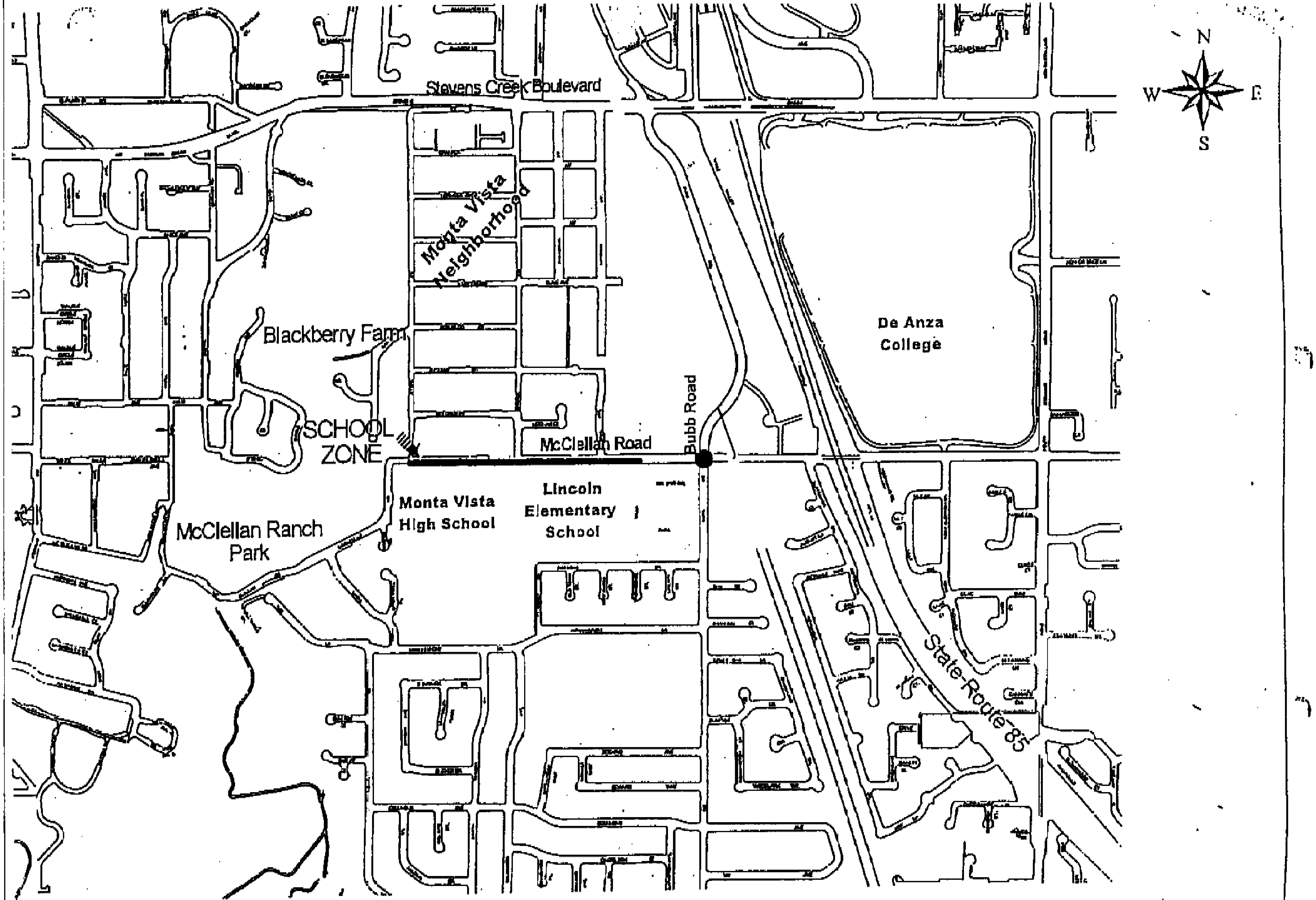
If you have any questions, please call me at (408) 777-3240.

Sincerely,

Bert J. Viskovich
Director of Public Works

Raymond D. Chong, P.E.
City Traffic Engineer

RDC/cs
cc: Vicki Guapo
Diane Arrants



CITY OF CUPERTINO
MC CLELLAN ROAD SCHOOL ZONE
PEDESTRIAN SAFETY IMPROVEMENTS PROJECT
MAP


U.S.
Post Office
Stevens Creek Boulevard
PROJECT
Pasadena Avenue
State
Route
85
N

STATE OF CALIFORNIA-BUSINESS, TRANSPORTATION AND HOUSING AGENCY GRAY DAVIS, Governor

DEPARTMENT OF TRANSPORTATION
TRAFFIC OPERATIONS
1120 N STREET, MAIL STATION 36
P.O. BOX 942873
SACRAMENTO, CA 94273-0001
PHONE (916) 654-4551
FAX (916) 653-3055

August 18, 1999

Mr. Bert J. Viskovich
Director of Public Works
City of Cupertino
10300 Torre Avenue
Cupertino, CA 95014-3255

Attention: Mr. Raymond D. Chong

Dear Mr. Viskovich:

I am responding to your letter to me dated August 10, 1999, requesting approval to install experimental crosswalk pavements lights (CPLs) at three locations. Two locations are on McClellan Road near Lincoln Elementary School and near Monta Vista High School, and the third location is on Stevens Creek Boulevard near the Cupertino Post Office. I am pleased to let you know that your request is approved. Before installing the lights in a public roadway, I suggest the installation plans be approved by an Engineer registered in California.

Enclosed for your use are the interim guidelines for experimental installations. Also enclosed is a three-page evaluation form.

To assist the California Department of Transportation with the development of standards and specifications for CPLs, we ask that you complete the evaluation form and return it to us after one year of operation of each installation.

If you have any questions, please call me at (916) 654-4551.

Sincerely,

Original Signed By

GERRY MEIS, Chief
Office of Signs and Delineation

Enclosure

bc: HBenouar
AHaq
GMeis
JMcCrank, DDC, Ops-D4
RMellon, Chairman CTCDC
MSchmitz, FHWA
PJang
Traffic Ops files

APPENDIX D
Acknowledgements

ACKNOWLEDGEMENTS

The City of Fountain Valley and Katz, Okitsu & Associates express our sincere appreciation for the participation of the following people in the *Users' Survey* for this project:

City/County/Institution	*State*	*Contact Person*
Anaheim	CA	Taher Jalai
Danville	CA	Nazanin Shakerin
Fort Bragg	CA	Dave Goble
Glendale	CA	Wayne Ko
Menlo Park	CA	Rich Angulo
Orange County	CA	Mauricio Diaz
Orange, City of	CA	Hamid Bahadori
Orinda/JFK University	CA	Matt Patterson
Petaluma	CA	Allan Tilton
San Francisco/Urban School	CA	Susan Munn
San Pablo	CA	Adele Ho
Santa Barbara	CA	Rob Eaton
Santa Rosa	CA	Gene Benton
Suisun City	CA	Vince Hale
Thousand Oaks	CA	James Mashiko
Walnut Creek	CA	Rafat Raie
Willits	CA	Dave Madrigal
Kirkland	WA	Dave Godfrey
Mercer Island	WA	Nancy Fairchild
Traffic Safety Commission	WA	Steve Lind

We would also like to express our appreciation to the following vendors who have shared with us information on their products:

LightGuard Systems, Inc.	Peter Floodman
Traffic Safety Corp.	Bill Streeter
Astucia / NexTech	Janna McKhann