

# TRANSPORTATION PLANNING AND TRAFFIC ENGINEERING CONSULTANTS

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# **MEMORANDUM**

Date: November 18, 2011

TO: Rob Brueck, Hauge Brueck Associates

FROM: Gordon Shaw and Jason Briedis, LSC

RE: Dollar Creek Trail – SR 28 Crossing Options

The route of the North Tahoe Dollar Creek Shared Use Trail ("Dollar Creek Trail") is proposed from the eastern terminus of the existing multiuse trail at the top of Dollar Hill to a location near the end of Fulton Crescent Drive (approximately 2.3 miles). A key issue in the evaluation of the project is the crossing of State Route 28 (SR 28) at the southern end of the trail at its connection to the existing TCPUD shared use trail along the south side of the highway. This memo presents our evaluation of potential highway crossing options.

#### **Study Area Characteristics**

The Dollar Creek Trail is proposed to cross SR 28 near the top of Dollar Hill. SR 28 at this location has two travels lanes (one for each direction of travel), a striped left-turn lane for turns onto Dollar Drive, and a two-way left-turn lane (TWLTL) for left-turns into the 7-11 parking lot as well as a two-stage outbound left-turn from Dollar Drive. Three locations have been considered for the trail crossing: one across the eastern leg of the SR 28/Dollar Drive intersection, a second approximately 370 feet to the east (the location of the widest portion of the painted median that forms the taper for the left-turn lane) of the 28/Dollar Drive intersection, and a third location roughly half way between the Dollar Drive intersection and the access for the 7-11. The pavement width is consistent at the former two of these locations at approximately 35 feet and the pavement width at the latter location is approximately 55 feet.

This section of SR 28 has a posted speed limit of 45 mph. A speed survey was performed at the proposed crossing location (in accordance with Caltrans standards for such studies) to determine the actual speed of free-flowing traffic. Traffic engineers typically focus on the 85<sup>th</sup> percentile speed in assessing speed conditions (the speed which is exceeded by 15 percent of all drivers). The 85<sup>th</sup> percentile speed was observed to be 45 mph for westbound traffic and 48 mph for eastbound traffic.

Traffic counts were conducted along SR 28 over the 2011Labor Day weekend. The average daily traffic volumes over the Friday through Monday count period was 11,900. The peak month ADT as reported by Caltrans is 13,700 for 2010.

#### **Potential Crossing Demand**

The potential crossing demand for the Dollar Creek Trail at its southern point is estimated in the *Dollar Creek Trail Use Memorandum*, (LSC Transportation Consultants, Inc., October 2011). As provided in the memo, the peak hour trail crossing volume is 45 bicycles/pedestrians per hour (total of both directions). The preferred crossing location is located approximately 100 feet from bus stops for both directions of travel. It is likely that once constructed, the crossing location will be used by transit riders, therefore increasing the crossing demand.

#### **Sight Distance Considerations**

Stopping sight distance and crossing sight distance are important design criteria at pedestrian crossing locations. Adequate stopping sight distance is important both to provide drivers with adequate time to react to the presence of a pedestrian/cyclist in the crosswalk and come to a safe stop. Adequate crossing sight distance is important to provide pedestrians/cyclists with an adequate opportunity to choose a gap in oncoming traffic. The Caltrans <u>Highway Design Manual</u> provides the pertinent stopping sight distance criteria. As is standard practice, a design speed 5 mph over the posted speed is assumed for this analysis. With a posted speed limit of 45 mph, the design speed for sight distance consideration is 50 mph. The base stopping sight distances for a roadway with a 50 mph design speed is 430 feet.

Crossing sight distance is the minimum distance for which a pedestrian waiting to the cross the roadway should be able to see an approaching vehicle and have enough time to safely cross the roadway at walking speed without the vehicle needing to reduce its speed. The ideal safe crossing sight distance is calculated as the distance traveled by a vehicle at the design speed for the amount of time that it takes a pedestrian to cross the roadway. Based on a pedestrian crossing speed of 3.5 feet per second, approximately 900 feet of crossing sight distance should be provided.

This section of SR 28 is characterized by both horizontal and vertical curvature. Sight distance at the proposed crossing locations is restricted for westbound traffic approaching the proposed crossing location by the crest of the vertical curve and vegetation located within the horizontal curve. This limitation in sight distance for westbound vehicles is less at the preferred crossing location versus the locations considered to the east. Sight distance for eastbound traffic approaching the proposed crossing location is adequate for both drivers to slow down for a pedestrian crossing and for pedestrians waiting for an adequate gap in which to cross. As the proposed crossing location is near the top of a hill, sight distance criteria do not need to be reduced for downhill grades.

#### **Potential Trail Crossing Treatments**

There are several treatments available to make an at-grade trail crossing location safer and more efficient for trail users. This memo provides a discussion of the following pedestrian/bicycle crossing options and their applicability to the Dollar Creek Trail crossing of SR 28 near Dollar Drive:

- Standard crosswalk striping with signage
- Crosswalk with the addition of a pedestrian refuge island
- Additional warning beacons/signage/lighting

- Pedestrian Hybrid Beacon
- Full pedestrian/bicycle activated midblock traffic signal
- Full signal at SR 28 / Dollar Drive with pedestrian crosswalk

There have been many studies conducted to assess the safety and efficiency of various treatments for midblock or non-intersection and uncontrolled-intersection pedestrian crossing locations. National Cooperative Highway Research Project (NCHRP) Report 562 (herein referred to as the NCHRP Report) provides a discussion and statistical analysis of many different types of crossing treatments. The study discusses the effectiveness of crossing treatments in terms of the percentage of drivers that yield to pedestrians or comply with the treatment. The following presents a discussion of pedestrian crossing options that may be considered for SR 28 at the proposed Dollar Creek Trail Crossing.

#### Standard Crosswalk with Striping and Signage

A marked crosswalk provides a defined path for pedestrians to cross a roadway. Marked crosswalks can serve several purposes including channelizing pedestrians to cross the road in a single specific location, and making drivers aware of encountering a pedestrian crossing location. There have been several studies conducted to determine the effects that marked crosswalks have on pedestrian safety. The studies conclude that the addition of marked crosswalks does not increase pedestrian safety versus locations with unmarked crosswalks. In many cases, especially in the case of roadways with multiple travel lanes in one direction and/or high-speed roadways (travel speeds greater than 40 mph), the addition of a marked crosswalk can actually decrease pedestrian safety. The recommendations of these studies state that a combination of crossing treatments in addition to a marked crosswalk are preferred for increased pedestrian safety and efficiency.

The <u>California Manual on Uniform Traffic Control Devices</u> (Caltrans, 2010, based on Federal Highway Administration MUTCD, 2003) (California MUTCD) does not specify minimum pedestrian crossing volume warrants for the installation of marked crosswalks at midblock locations. However, <u>Pedestrian and Bicycle Facilities in California: A Technical Reference and Technology Transfer Synthesis for Caltrans Planners and Engineers</u> (prepared for Caltrans by Alta Planning + Design in July 2005) states that "*It is recommended that a minimum of 20 pedestrian crossing per peak hour (or 15 or more elderly and/or child pedestrians) exist at a location before placing a high priority on the installation of a marked crosswalk alone." Comparing this figure with the estimated use levels discussed above, a crosswalk is a potential option in this study area.* 

Providing an uncontrolled at-grade crossing on a high-speed highway is generally not a recommended practice. Therefore, it is not recommended that a marked crosswalk be installed anywhere along SR 28 in the study area without also installing an adequate series of advance warning devices to alert approaching drivers to the presence of the trail crossing location. The standard striping and signing configurations for crossing locations are found in California MUTCD Sections 2B.11, 2C.41 and Figure 3B.15.These standards include the provision of Yield pavement markings, a "Yield Here for Pedestrians" sign (R1-5a), signage marking the location of the crosswalk (sign W11-2 with supplemental plaque W16-7p), and an advance warning sign. The "Yield Here for Pedestrians" signs and pavement markings should be placed 20 feet in advance of the crosswalk for both directions of travel; the pedestrian warning signs (W11-2) should be placed approximately 300 feet in advance of the crosswalk location in both directions.

This treatment should be included with the implementation of any unsignalized crosswalk options discussed in this memo.

## Marked Crosswalks with Pedestrian Refuge Islands

Crosswalks may be enhanced by the addition of a median or pedestrian refuge island. The presence of the pedestrian refuge island provides pedestrians with a two-stage crossing, allowing pedestrians to wait for a separate gap in traffic for crossing each direction of traffic. In addition, the use of pedestrian refuge islands shortens the crossing distance and pedestrians' exposure to vehicle traffic. Providing a two-stage crossing also has the advantage of shortening the necessary safe crossing sight distance. With a two-stage crossing of SR 28 for the Dollar Creek Trail, pedestrians/bicyclists would only have to cross one lane of traffic at a time as opposed to three; therefore, the minimum safe crossing sight distance would be approximately 315 feet with a two-stage crossing as opposed to 900 feet without a two-stage crossing. This distance is less than the required stopping sight distance for vehicles and is provided along SR 28 in both directions of travel at the proposed crossing location.

The NCHRP Report states a very wide range of vehicle yielding rates for crosswalks with a pedestrian refuge island. Vehicle yielding rates vary from approximately 5 percent to 75 percent, with an average of 35 percent of drivers yielding to pedestrians at crosswalks with refuge islands. The report found a high correlation between driver yielding rates and speed limits for refuge islands. Roadways with a 25 mph speed limit had a driver compliance rate of 75 percent, while roadways with a 35 mph speed limit had an average compliance rate 15 percent. These data suggest that on moderate to high-speed roadways, pedestrian refuge islands are beneficial, but alone are an insufficient treatment to supplement crosswalks. However, despite the low compliance rate of vehicles yielding to pedestrians in a crosswalk supplemented with refuge islands, refuge islands have the great benefit of reducing crossing distance, as discussed above, and allowing pedestrians to wait for an acceptable gap in only one direction at a time.

A pedestrian island does not necessarily have to be a permanent raised concrete structure. The California MUTCD specifies in section 3G.01 that "An island may be designated pavement markings, channelizing devices, curbs, pavement edges, or other devices." In order to facilitate snow removal during the winter months, it is necessary to design a pedestrian refuge island to be temporary and removable. It is acknowledged that providing a pedestrian refuge in the existing TWLTL between Dollar Drive and the 7-11 access will shorten the available deceleration and storage for vehicles turning left into 7-11. However, adequate storage for four to five vehicles turning left into 7-11 would be maintained. Additionally, adequate TWLTL length would be maintained for the two-stage left-turns exiting Dollar Drive. Therefore it is recommended that a pedestrian refuge island be provided at the Dollar Creek Trail crossing of SR 28 using removable flexible delineators in a portion of the existing TWLTL. Examples and specifications for flexible delineator use are provided in the California MUTCD in Section 3D-101(CA). Five to seven delineator posts arranged in an isosceles triangle (roughly 10 feet wide and 20 feet long) on either side of the crosswalk would be adequate. A keep right symbol sign (R4-7) should be affixed to the post on the point of the triangles. These posts would need to be affixed to the pavement each year, through bolts or using a metal sleeve.

## Warning Beacons

The use of warning beacons at crosswalk locations is common throughout the United States. Crosswalk warning beacons consist of a single or series of flashing yellow signals. They can be implemented in numerous configurations (e.g. overhead, side of roadway, with signs, single flasher, alternating flashers, in advance of crossing location, etc.) to address issues specific to the locations where they are being used. Some pedestrian crossing warning beacons operate continuously, while others are pedestrian actuated. Warning beacons at crosswalk locations are most effective if they operate only when a pedestrian is present, as warning beacons that flash continuously quickly become routine and are subconsciously ignored by drivers. Therefore, an active (push-button activated) or passive (no action required by the pedestrian) pedestrian detection system should be used with the warning beacon.

Vehicle yielding rates are generally higher for pedestrian crossing warning beacons with active detection than beacons with passive detection. This is due to imperfections in the passive detection technology, which tend on occasion to produce "false calls." For pedestrian warning beacons with active (push-button) detection, it is important to provide conspicuous and straightforward signage that provides pedestrians instructions on the proper procedures for use of the warning beacon. The flashing sequence should begin immediately when the device is activated and remain flashing for enough time for vehicles to yield and for the pedestrian to finish his/her crossing maneuver.

Vehicle yielding rates for overhead warning beacons at crosswalks on four-lane roadways were between 30 and 75 percent for push-button activated beacons. The NCHRP Report only conducted studies of pedestrian warning beacons at locations with speed limits of 30 and 35 mph. There was limited statistical correlation between driver compliance rates and speed limits for pedestrian warning beacons. Based on the data it would be difficult to estimate the driver yielding rate at a beacon controlled crosswalk location on a roadway with the higher posted speed of 45 mph present on SR 28 over Dollar Hill.

There are limited guidelines for the installation and use of warning beacons at pedestrian crossings. The California MUTCD specifies that a flashing warning beacon "may be used as emphasis for a midblock crosswalk." There is no pedestrian crossing volume warrant for the installation of warning beacons. The California MUTCD provides the design standards for warning beacons regarding size and placement within the proper field of view in Section 4K.

A relatively new pedestrian flasher option that is gaining popularity is the Rectangular Rapid Flashing Beacon (RRFB). While the RRFB is not included in the latest edition of the California MUTCD, its use is allowed throughout California as an Interim Approval as of August 10, 2011. RRFBs consist of a panel with two rectangular yellow LED lights that mounts underneath a typical crosswalk warning sign. The beacons can easily mount to a sign pole and can be solar powered. A recent study was conducted for a location where an RRFB system was applied on a high-speed roadway in Oregon. The highway in this case was divided with four lanes. The study reported driver compliance rates of 83 to 87 percent after installation of the device.

It is recommended that the crosswalk location warning signs (W11-2 with W16-7p) for both directions of travel be supplemented with RRFB. This recommendation is based on the speed of traffic on SR 28 (as driver's willingness to stop tends to decrease with higher speeds), and the higher compliance rate observed with this device. A properly designed beacon system with

active pedestrian activation will alert the approaching drivers that a pedestrian is definitely present and give him/her enough advance warning to yield comfortably.

# Pedestrian Hybrid Beacons

Pedestrian hybrid beacons (also known as High intensity Activated crossWalK or HAWK signal) are a new addition to the 2009 version of the federal MUTCD that provide a protected crossing for pedestrians. As of 2011, the Pedestrian Hybrid Beacon is not included in the California MUTCD and is not officially approved for use on California state highways. This section provides a summary of the beacon's operations and applicability to SR 28 in the Lake Tahoe Region, if it were to be included in a future revision to the California MUTCD.

The hybrid beacon is so-named as it combines the warning aspects of a flashing beacon with the regulatory aspects of a traffic signal. The hybrid pedestrian beacon includes a regulatory red indication, but is not as restrictive to vehicles as a full traffic signal. The hybrid beacon signal consists of overhead mounted signal heads for vehicles and pedestrian signal indications. The top row of the signal indications contains two adjacent red displays and below there is a single yellow indication. Hybrid beacons rest in a dark mode with the pedestrian indication displaying "Don't Walk" until a pedestrian activates the beacon. Once activated, the hybrid beacon sequences through four phases:

- 1. The first phase is a flashing yellow which is to alert drivers that the signal has been activated.
- 2. This phase is followed by a solid yellow phase.
- 3. The third phase is a solid red phase, during which a "Walk" phase is displayed to pedestrians.
- 4. The last phase is a flashing red phase for vehicle traffic and a flashing "Don't Walk" phase for pedestrians.

After this final pedestrian clearance interval, the beacon returns to the dark mode.

The NCHRP report studied hybrid beacons located at both 4-lane and 6-lane roadways. At both sites, the study reported over a 95 percent driver yielding rate, consistent with other pedestrian treatments that include a solid red indication. One of the advantages of the hybrid beacon is the flashing red phase. During this phase, vehicles can proceed through the crosswalk after stopping, if the crosswalk is clear. This condition reduces delay to vehicles significantly compared to a full midblock pedestrian signal, for which vehicles are lawfully required to remain stopped for the full pedestrian clearance interval, even if there are no pedestrians remaining in the crosswalk.

The 2009 edition of the nationwide MUTCD contains pedestrian and vehicle volume warrant guidelines for pedestrian hybrid beacons. The warrant guidelines consider pedestrian volumes, conflicting vehicle volumes, and crosswalk length. There are separate warrant guidelines for low-speed roadways (posted speed limit of 35 mph or less) and high-speed roadways (posted speed limit greater than 35 mph). Both warrants suggest a minimum crossing volume of 20 pedestrians during the peak hour to consider use of a pedestrian hybrid beacon.

A Pedestrian Hybrid Beacon is not recommended for use on SR 28, as the device has not been approved for use in California. Additionally, the use of a pedestrian hybrid beacon on a 3-lane highway with moderate traffic volumes would be excessive. It should be noted, however, that traffic volume counts along SR 28 and the trail usage estimation indicate that the applicable warrant for a Pedestrian Hybrid Beacon is satisfied. Should the device be approved for use in the future, a more detailed analysis could be conducted to determine if it would be suitable for use on SR 28.

#### Full Pedestrian Traffic Signal

The use of a full traffic signal at a midblock pedestrian crossing location is governed by the Pedestrian Volume Warrant (Warrant 4) presented in the California MUTCD. A full traffic signal at a pedestrian crossing location is a very restrictive traffic control measure and therefore, requires a high pedestrian crossing volume to justify. The MUTCD contains both a 4-hour pedestrian volume warrant and a peak hour pedestrian volume warrant. The 4-hour warrant requires 100 pedestrians for each of any four hours of an average day and the peak hour pedestrian warrant requires 190 pedestrians for any one hour of an average day. The warrant criteria also require that there be fewer than 60 adequate gaps in traffic during the peak pedestrian crossing times.

The minimum pedestrian crossing warrant values far exceed the crossing demand for the Dollar Creek Trail at SR 28. Therefore, the use a full traffic signal is not appropriate at midblock crossing locations on SR 28 and is not recommended.

#### Signalization of the SR 28/Dollar Drive Intersection

The peak hour signal warrant (CA MUTCD Warrant #3) was applied to the intersection turning movement counts obtained over Labor Day weekend 2011. The Dollar Drive approach to the intersection is wide enough for left and right-turning vehicles to queue separately at the stop sign even though the approach is not striped for two lanes; therefore, per guidance/support specified in the CA MUTCD, the right-turning traffic from Dollar Drive was subtracted from the approach volume. The analysis indicates that traffic volumes at the US 50/Dollar Drive intersection are not high enough to warrant a traffic signal. Additionally, as specified in the previous paragraphs, pedestrian crossing volumes at this intersection are not projected to be great enough to warrant a traffic signal. It is not recommended that a traffic signal be installed at this intersection with the construction of the proposed Dollar Creek Trail.

#### Conclusions

This section of SR 28 presents a unique situation for pedestrian and bicycle crossing. Not much information is available for at-grade crossings on high-speed, moderate volume, 3-lane highways. It will be necessary to provide a developed crossing beyond a simple painted crosswalk with construction of the proposed Dollar Creek Trail.

This evaluation indicates that it is feasible to provide an at-grade crossing at the preferred crossing location between Dollar Drive and the 7-11 access point. It is recommended that the crossing location be designed with the following features:

A marked crosswalk

- A pedestrian refuge should be provided in a portion of the existing TWLTL using flexible
  delineators in accordance with the California MUTCD, arranged in an isosceles triangle
  pattern on either side of the crosswalk. The delineators should be designed to be
  affixed to the pavement (using bolts or a metal sleeve in the pavement) each spring,
  and removed each fall to facilitate snow removal. A keep right symbol sign (R4-7)
  should be affixed to the post on the point of the triangles.
- The crosswalk should be supplemented with advance warning signs (W11-2), yield pavement markings with "Yield here to pedestrians" signage (R1-5a), and crosswalk location warning signs (W11-2 with W16-7p).
- The advance warning signs should be placed approximately 300 feet in advance of the crosswalk in each direction, in accordance with the California MUTCD.
- The crossing should also be supplemented with push-button activated Rectangular Rapid Flashing Beacons located in conjunction with the crosswalk location signs. The push-buttons should include appropriate signage instructing users of their operation (sign 2B-18(CA)).