Road Safety Assessment (RSA)

SR 84 – Niles Canyon Corridor
Alameda Co., California
May 2012

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BACKGROUND/ INTRODUCTION

In May 2012, a Road Safety Assessment (RSA) was conducted on a portion of California State Route 84 (SR 84) in Alameda County, California. This portion of SR 84 is located in the San Francisco Bay Area, approximately 25 miles southeast of Oakland. The study area (**Figure 1**) extends from just east of California State Route 238 (Mission Blvd) in Fremont to just west of Interstate Route 680 (I-680) near Sunol, a distance of about 7 miles.

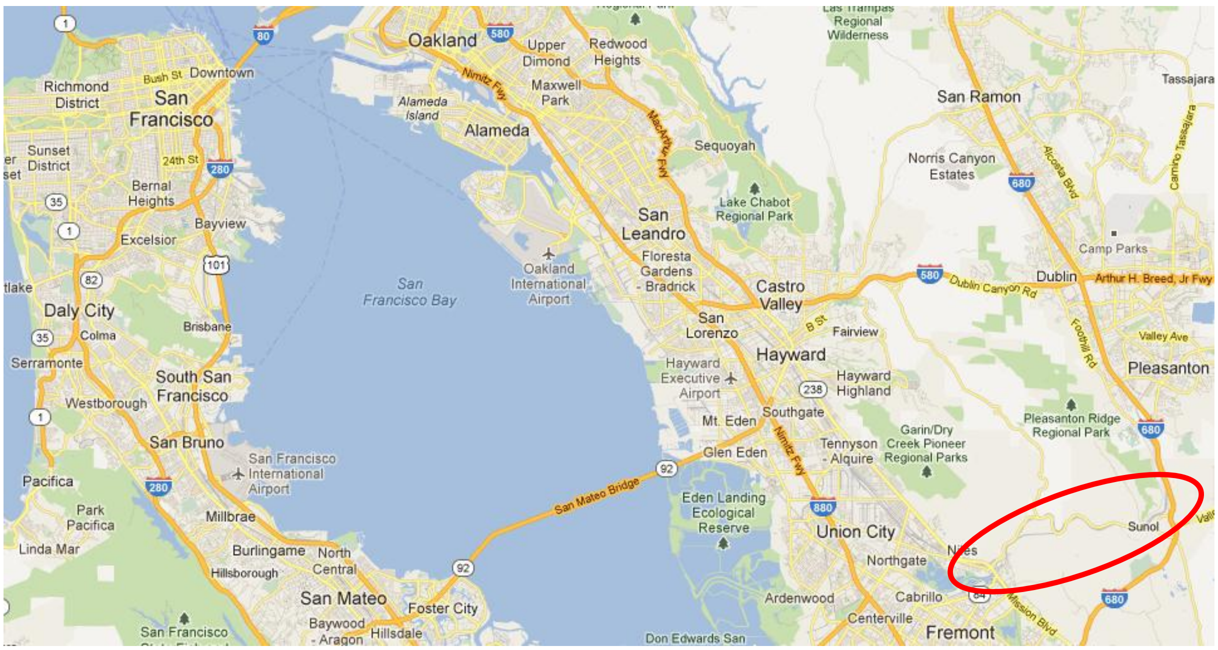


Figure 1: Corridor Study Location

Niles Canyon Corridor

SR 84 is a narrow, winding, gently rolling two-lane rural highway that traverses Niles Canyon. Much of the alignment is bordered by steep, often rocky or tree-lined slopes on one or both sides, with numerous sign supports, utility poles, fencing and guardrail.

Throughout much of its length, SR 84 is flanked by Alameda Creek, an important fish and wildlife habitat, and the Niles Canyon Railroad, once part of the Transcontinental Railroad and now a popular tourist attraction. There are also several other historic areas, both formal and informal, including an extensive aqueduct system and a site known locally as “The Spot”, believed to have been the setting for several Charlie Chaplin movies.

Most of the corridor is sparsely populated with only an occasional driveway.

The route was designated as a State Scenic Highway in 2007, has been identified as a cross-county corridor in the Alameda Countywide Bicycle Plan, yet also serves a significant volume of regional commute and truck traffic between the East Bay area on the west and the Tri-Valley area on the east. Traffic volumes near Palomares Rd. were in the neighborhood of 14,000 Annual Average Daily Traffic (AADT) in 2010.

The roadway itself generally consists of two 12-foot lanes, with paved shoulders varying in width from about a foot to as much as 8 feet. There are numerous curves, several of which are sharp enough to warrant reduced speed advisory signs. Two of these curves also coincide with very narrow bridges carrying the Niles Canyon Railroad over SR 84.

The posted speed throughout most of the corridor is 45 mph. Passing zones exist in short stretches of tangent alignment. Several widely separated “Tee” intersections join SR 84, with Stop Sign control for the side-road traffic. An all-direction, Stop Controlled intersection exists near the east end of the corridor. In addition, there are two “ramps” that join SR 84, an eastbound “off” ramp to Sunol and a west bound “on” ramp from Sunol.
Only the intersection at SR 238 is signalized.

Due to the crash history of the corridor and earlier project proposals that have not been fully implemented due to community concerns, the California Department of Transportation (Caltrans) requested that the Federal Highway Administration (FHWA) conduct an RSA to independently evaluate the safety of the corridor. The FHWA California Division Office requested the assistance of the FHWA Resource Center Safety and Design Technical Services Team, a team that responds to requests from across the country and the world to evaluate and recommend safety and design elements for all types of roadways.

RSA Purpose

The purpose of this RSA was to identify safety issues that may be contributing to the reported crashes along the corridor and to identify potential measures to mitigate these issues. Another goal of the RSA was to identify safety issues that have not yet resulted in crashes and suggest proactive improvements to address these issues.

FHWA defines an RSA as a “formal safety performance evaluation of an existing or future road or intersection by an independent, multidisciplinary team.”
RSAs conducted by a team that is independent of the design and operations of the facility are able to address safety through a thorough review of roadway, traffic, environmental, and human factors conditions.

(More detailed information on RSAs, including best practices, case studies and guidelines, can be found by visiting FHWA’s RSA website here: http://safety.fhwa.dot.gov/rsa)

RSA Team Role and Responsibilities

The RSA team was comprised of the following individuals whose collective experience and expertise includes highway engineering, law enforcement and environmental stewardship:

Name	Organization
Craig Allred	Federal Highway Administration - Resource Center
Keith Harrison	Federal Highway Administration - Resource Center
David Cohen	Federal Highway Administration - California Division
Lt. James Libby	California Highway Patrol - Dublin Area

A traditional RSA might typically include members from the host highway agency.
However, in this case, Caltrans' commitment to ensure an unbiased view by the RSA team and to promote transparency for the entire RSA process led to a mutual agreement to not have any of Caltrans staff serve on the team, so as to avoid even the *appearance* of any potential conflict of interest.

Another departure from a typical RSA was Caltrans' decision to arrange for a concurrent Value Analysis (VA) study for the Niles Canyon corridor. Although the VA Team members had no formal role in the RSA study, the two Teams did share their field observations with one another, and the RSA Team shared their preliminary findings, as these would serve as the starting point for the VA effort.

The RSA and VA Teams conducted separate field reviews from May 7th through 9th, observing the road conditions and traffic operations during weekday morning and evening peak periods and again during nighttime conditions. Time constraints prevented weekend and seasonal observations.

Immediately preceding the site visit, a public stakeholder meeting was held on May 7th in Fremont to familiarize the RSA and VA Teams with the stakeholders' thoughts, ideas, issues and concerns about the SR 84 corridor.

The corridor was driven in both directions by different members of the Teams over the course of several days. This afforded each driver an opportunity to share his impressions of the driving task and enabled passengers to make detailed observations of the roadway, roadside and other road users.

Where appropriate, the Teams made periodic stops to explore specific locations on foot.

A series of still photos and video footage were recorded to help supplement written notes.

As a preliminary result of the field investigation stage of the RSA effort, more than thirty potential areas for safety improvements were identified and shared with the VA Team. Some of these were location-specific; some involved systemic improvements throughout the corridor; many shared a common "theme".

To thoroughly capture these themes and to more broadly address overarching safety issues, they have been incorporated into one or more of the "General Safety Concerns" discussed later: *Roadside Quality, Limited Use Shoulders, Speed Management, Signs and Markings, Bicycles and Pedestrians,* and *Intersections and Curves*.

Although past project proposals for this corridor had been triggered by a high number of severe crashes, this RSA was undertaken with no pre-conceived notion about the relative degree of safety in the present context. It should also be understood that this RSA made no attempt to judge the appropriateness of any safety improvements incorporated in any past project or in any other way seek to "validate" any facet of other proposals.

The RSA Team's role was limited to conducting a purely technical study to identify safety concerns and possible countermeasures. The team did not evaluate the cost, feasibility, or environmental impact of any of these suggested improvements, as that was the role of the VA Team. For those details, the reader is encouraged to consult the separate report documenting the efforts of the independent VA Team.

Information Sources

Caltrans supplied the RSA Team with Traffic Accident Surveillance and Analysis System (TASAS) crash data covering a span of nearly 10 years, from January 1, 2001 through September 30, 2010. More recent crash data was not available, as there is typically a substantial time lag in migrating data from the Statewide Integrated Traffic Record System (SWITRS) into TASAS.

To help fill the gap, the Team was provided access to the crash database maintained by the California Highway Patrol (CHP). The CHP data includes all crashes to date within CHP "Beat 223", which encompasses all of the study area, except for a 2 mile section between Mission Blvd. and Palomares Rd. that is outside of CHP jurisdiction.

The Team was able to further supplement the TASAS and CHP data by querying the Transportation Injury Mapping System (TIMS) database tool developed and maintained by the University of California at Berkeley.

The different data bases helped the Team to better understand the roadway's safety characteristics and the typical challenges of analyzing and interpreting data from independent sources.

Additional background source documentation provided by Caltrans included traffic volume counts, area maps, environmental documents, plan sets and project reports.
These were not reviewed prior to conducting the actual assessment, but proved helpful in analyzing the crash data and identifying appropriate mitigation treatments.

On several occasions, where the written documentation may have lacked necessary detail or otherwise needed clarification, Team members contacted Caltrans technical staff with those questions. Several local government officials and concerned citizens were also very helpful to the Team in understanding the issues and challenges.

CRASH ANALYSIS

Methodology

All crash analysis was conducted independently by the RSA Team, using data from TASAS, CHP, and TIMS. Most of this data was imported into Microsoft Excel spreadsheets to identify general trends and to facilitate more detailed data analysis as well.

While every reasonable attempt has been made to minimize the possibility of errors, the accuracy and validity of the RSA Team's computational analysis cannot be guaranteed. Caltrans should not base any program or project decisions on this analysis without taking steps to confirm the accuracy and validity of these calculations and conclusions.

Since the RSA Team did not have ready access to detailed "as-built" data, it was not possible to compute an expected crash frequency for the corridor using the AASHTO Highway Safety Manual (HSM) procedures.

The HSM methodology provides an opportunity to set a benchmark for comparison that may be more useful than simply comparing crash rates to a statewide average. In particular, where detailed historical crash data is available (as is the case with TASAS), the use of the Empirical Bayes procedure can help improve the credibility of the crash frequency calculation.

Caltrans is encouraged to consider applying these procedures as a means to screen and prioritize future project improvements to enhance safety.

Technical assistance and training on the use of the HSM is available from the FHWA Resource Center.

Crash History and Crash Potential

One of the hallmarks of the RSA process is that the Team does not rely on historical crash data alone. Equally important is the capability to identify characteristics of the facility that may potentially lead to *future* crashes.

Identifying “hot spots” (locations where crashes are concentrated) by examining crash history is an important step in diagnosing the cause of crashes and in identifying targeted countermeasures. However, other locations that may have similar characteristics (outside of a curve, for example) should be considered for mitigation as well.

Unfortunately, crashes are random events. That is, we cannot reliably predict where a driver may commit an error, a vehicle may experience a mechanical failure, or a deer may cross the road. We can, however, apply proactive countermeasures that can reduce the likelihood of a crash as well as the severity of its outcome.

Indications and Trends

Crash Location

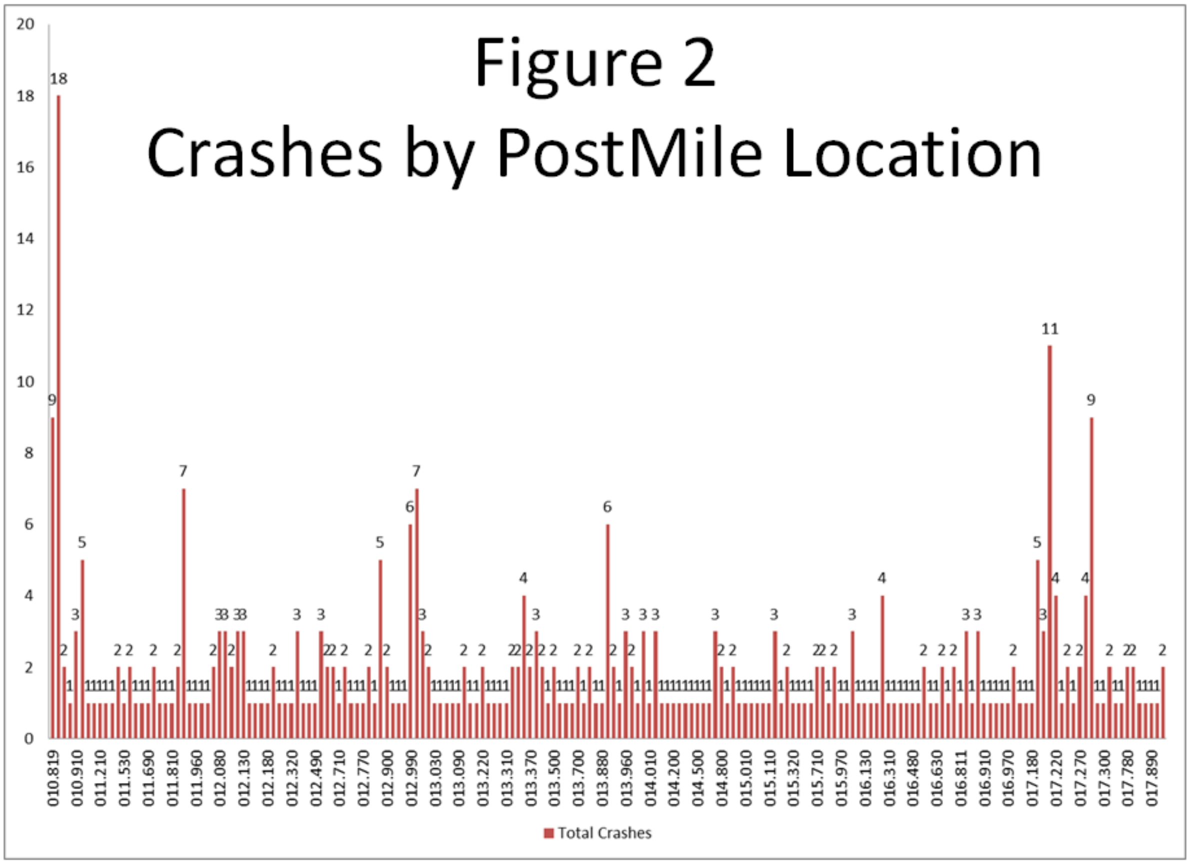
Tying crash occurrence to location can help pinpoint roadway characteristics that may either lead to driver error and/or may increase the risk of crashing when errors do occur. Knowing the location of “hot spots” is also useful in identifying spot improvements.

Since intersections in the study area are few and far between, it’s not surprising that these locations accounted for only 54 (15%) of all crashes along the corridor. Here, multi-vehicle crashes are common and traffic operational issues may play a larger role than roadway or roadside geometry.

Conversely, the vast majority (85%) of corridor crashes occurred along roadway segments, i.e. between intersections. In these locations, single vehicle crashes are more common and the roadway cross-section and roadside quality strongly influence crash occurrence and severity. Several sharp curves reflect this trend, but so do some relatively straight (“tangent”) sections.

The RSA Team has identified “spot” improvements for several specific intersections and curves. Other suggested countermeasures are not location specific, but rather are linked to common roadway or roadside characteristics that may exist almost anywhere in the corridor.

The RSA Team did not have the necessary tools and data to be able to independently map corridor crashes with any degree of accuracy. However, **Figure 2** gives a general sense of the dispersion of crashes throughout the corridor (referenced by “Post Mile” [PM]).



* Thru September 2010 SOURCE: TASAS

Selected Post Mile Numbering and Reference Points (Landmarks)

010.819		UI	*P*	MISSION BL (RTE 238)
010.820		UH	00.000	S JCT ST 238
010.820	EQUATES TO			
010.830	E	UH	01.265	S JCT ST 238
010.830		UI	*P*	MISSION BL VIA NILES CYN
011.020		UI		CANYON RD (RT)
012.095		UH	00.079	ROSEWARNES UP 33 34
012.174		UH	00.643	
012.817		UH	00.183	
013.000		UH	00.025	PALOMARES RD
013.000		UI		NILES CANYON RD AT PALO
013.025		UH	00.305	FARWELL UP 33 35
013.330		UH	00.032	ALAMEDA CR33-36;RCHD BR
013.362		UH	00.031	
013.393		UH	00.535	
013.840		UI		AT THE SPOT (LT)
013.928		UH	00.206	EAST BRIGHTSIDE TUNNEL
014.134		UH	00.190	
014.324		UH	00.188	ALAMEDA CR BOH 33 39
014.360		UI		OLD NILES CANYON RD(RT)
014.512		UH	02.421	
015.050		UI		AT KAISER PLANT (LT)
016.801		UR		NB OFF TO SUNOL
016.811		UR		SB ON FR SUNOL
016.933		UH	00.290	SILVER SPR RD UP 33 42
017.210		UI		NILES CANYON RD AT MAIN
017.223		UH	00.059	ARROYO DE LA LAGUNA
017.282		UH	00.005	
017.287		UH	00.700	PLEASANTON-SUNOL RD
017.287		UI		WAT TMPL -PLSNTN-SUNOL
017.961		UI		RAMPS 680-84

While there are obvious crash concentrations in several locations (such as near Palomares Rd. [PM 013.000] and near "The Spot" [PM 013.840]), the graphic also shows just how widely distributed the crashes are throughout the length of the canyon.

188 separate locations were linked to one or more crashes; 113 of these locations experienced just one crash.

While crash clusters help focus attention on obvious problem locations, diagnosis of these more isolated crash locations becomes more challenging. In these cases, review of other crash trends can provide additional insights.

Crash Severity

During a background briefing conducted by Caltrans in advance of the RSA, the RSA Team learned that the safety improvements contemplated by Caltrans were prompted, in large part, by severe crash frequencies above a pre-established "trigger" value.

Since 2002, SR 84 has been on Caltrans' Two and Three Lane Safety Monitoring Program list. That program was introduced in the 1990's in response to growing concerns about increasing number of fatal and injury crashes on such facilities. The monitoring threshold is reached when a roadway segment has a concentration of 3 or more cross centerline fatal collisions and a cross centerline fatal collision rate (FC Rate) of 0.12 collisions/mile/year or greater.

While fatal crashes are undeniably catastrophic, focusing on fatal crashes alone can sometimes distort the safety performance of a facility. Since injury crashes are many fold more frequent than fatal crashes, a measure that gauges injury crashes may give a more complete depiction of corridor safety.

With that in mind, another useful benchmark is the number of Fatal and Injury ("F&I") crashes as a proportion of Total crashes, sometimes called the "severity index".

Of 353 Total crashes that occurred from 2001 through most of 2010, 186 (53%) were F&I crashes. Even as the annual number of crashes has fallen in more recent years, the corresponding proportion of F&I crashes has remained at or near 50%. (**Figure 3**)

After filtering out 19 F&I crashes coded as "At Intersection", the remaining 167 F&I crashes can be considered "Segment" crashes. This still represents an F&I ratio of 167/353 = 47% for roadway segments – about a third higher than the 32.1% "default" proportion cited in the Highway Safety Manual for two-lane rural road segments.

Given these statistics, the RSA Team encourages Caltrans to continue to look for opportunities to reduce the risk of severe and fatal crashes in the SR 84 corridor.

Time of Crash

The times of crash occurrence trends were unremarkable.
"Month", "Hour of Day" and "Day of Week" data reflect crash patterns that are quite typical for a facility like this.

The highest months were May through October; the highest hours were 7 AM to 9 AM and 4 PM to 7 PM; the highest days were Sunday/Saturday/Friday.

Summer months, commute hours and weekends each tend to have higher traffic volumes which, in turn, often translate into higher crash frequencies.

"Environmental" Factors

Although we cannot control the weather, or when the sun rises and sets, knowing the extent that those "environmental" factors may have played in previous crashes can help identify appropriate countermeasures.

Of 353 total crashes, 26 (7%) occurred when the pavement was Wet/Snowy/Icy/Slippery.

If any of these crashes are clustered in any one location, it might suggest that the pavement skid resistance or roadway drainage should be investigated, and, in the case of a horizontal curve, the superelevation rate ("banking") should be evaluated.

101 crashes occurred under "Dark" conditions; another 16 at Dusk or Dawn. These 117 crashes represent approximately 1/3rd of all crashes. More important, nearly all of these occurred in locations that were without benefit of functioning street lights.

The location of these crashes should be mapped to see if there might be a concentration of crashes along curves or at intersections, for example.

In such locations, a vehicle's headlights may not adequately illuminate the path ahead for turning onto a crossroad or steering through a curve. Recognizing a pedestrian walking along the road or beginning to cross can also be more difficult, particularly if the pedestrian is wearing dark, non-reflective clothing.

Additional illumination of these darkened locations may help drivers better see and respond to the roadway geometry, signing, marking and other road users.

Primary Collision Factors

To better understand why crashes are occurring, it's particularly important to review the actions of drivers and other road users, i.e. the "human" factors. Toward that end, an examination of the Primary Collision Factor (PCF) is enlightening.

Figure 4 lists the number and percentage of crashes for each of the three highest PCFs.

Figure 3
Crash Severity

YEAR	ALL Crashes	Fatal Crashes No. (Pct)		Injury Crashes No. (Pct)		F & I Crashes No. (Pct)	
2001	50	2	4%	20	40%	22	44%
2002	42	1	2%	20	48%	21	50%
2003	46	0	0%	21	46%	21	46%
2004	43	1	2%	22	51%	23	53%
2005	31	1	3%	16	52%	17	55%
2006	29	1	3%	17	59%	18	62%
2007	36	2	6%	22	61%	24	67%
2008	29	0	0%	17	59%	17	59%
2009	19	0	0%	11	58%	11	58%
2010	27	1	4%	11	41%	12	44%
10 Yrs*	353	9	3%	177	50%	186	53%

* Thru September 2010 SOURCE: TASAS

Figure 4
Primary Collision Factor(PCF)

YEAR	Speeding No. (Pct)		Improper Turn No. (Pct)		Alcohol No. (Pct)	
2001	13	26%	12	24%	8	16%
2002	15	36%	9	21%	5	12%
2003	9	20%	11	24%	6	13%
2004	12	28%	10	23%	4	9%
2005	2	6%	9	29%	6	19%
2006	9	31%	3	10%	8	28%
2007	12	33%	9	25%	6	17%
2008	9	31%	9	31%	3	10%
2009	4	21%	5	26%	2	11%
2010	9	33%	8	30%	3	11%
10 Yrs*	94	27%	85	24%	51	14%

* Thru September 2010 SOURCE: TASAS

Speeding

94 (27%) of 353 crashes were in some way attributed to Speeding.

It is important to understand that "Speeding" does not always indicate that a driver has exceeded the posted speed limit. In many cases, the driver may have been going "too fast for conditions". In fact, 47 (50%) of these 94 crashes were coded as "Rear-End" crashes where the driver was likely operating well below the posted speed limit, yet could not slow enough to avoid running into a slowed or stopped vehicle in his path. (An additional 4 crashes coded as "Follow Too Close" might just as easily have been coded as Speeding.)

Nevertheless, that still leaves 43 crashes where excessive speed may have played a role.

The significance of speed in the severity of crashes is well known.
The adage "Speed Kills" is not just hyperbole. As speed increases, the risk of occupant injury increases dramatically. Higher speeds also reduce the time a driver has to recognize and respond to signs and markings, roadway cues, changes in alignment and other road users.

Caltrans should look for additional opportunities to partner with law enforcement, implement targeted engineering measures, and other strategies to enhance speed management in the Niles Canyon corridor.

Improper Turn

The next most frequently cited PCF was "Improper Turn".
85 crashes (24%) were coded as such.

Here again, the terminology can sometimes be misleading.

Improper Turn often means someone abruptly turned in front of someone at a driveway or intersection. But, this can just as easily mean that the driver simply failed to negotiate a curve (and perhaps ran off the road or crossed over the centerline).
In fact, the crash data shows that only 4 of the 85 crashes occurred "At Intersection"; 37 were coded as "Ran Off Road" or "Cross Centerline".

Improper Turn may be symptomatic of conflicting or confusing signs and markings or incompatible roadway geometry.

INFLUENCE OF ALCOHOL

One concern expressed by members of the public at the May 7 stakeholder meeting was that Drunk Driving is a significant contributing factor to corridor crashes. A number of attendees expressed the view that most of the severe crashes in Niles Canyon are alcohol related (and thus were perceived to be crashes that would not be mitigated by any of the safety measures that Caltrans had been proposing)

Alcohol consumption played a part in 51 (14%) of all crashes. These are incidents where the operator was known to have been drinking and usually considered to be "under the influence". (5 of the 51 crashes were coded as "Had Been Drinking – Impairment Unknown". These may have been individuals with an alcohol tolerance that made it difficult for law enforcement to judge whether the level of impairment met the "under the influence" criterion).

Of 9 Fatal Crashes that occurred between January 2001 and September 2010, 3 were Alcohol related. An additional 29 Alcohol related crashes injured one or more parties.

If we were to define a separate classification for "Impaired", it is worth noting that 4 other crashes involved a driver "Under Drug Influence" and 12 more crashes involved drivers who were suffering from "Fatigue". Adding these 16 crashes to the 51 alcohol-related crashes would raise the "Impaired" total to 67 (19%).

While it may seem that we can only throw up our hands and think that we can't do anything to combat Impaired driving, that's not really true. On a broad scale, public awareness and educational campaigns have begun to make a difference. At the local level, increased enforcement, such as periodic DUI checkpoints can be a deterrent.

While those strategies are intended to influence driver behavior, *engineering measures that accommodate driver behavior should not be overlooked. For example, providing a more "forgiving" roadside might allow impaired drivers an opportunity to at least partially recover control of their vehicles and could also allow "innocent" drivers to take evasive action to avoid a crash.*

Truck Involved Crashes

Another issue raised by the stakeholders on May 7th was the perception that large trucks are degrading the safety of the Niles Canyon corridor. (There may also be reasons for not wanting large trucks traversing the corridor that are only peripherally related to safety).

There is little question that the presence of large trucks in the traffic stream makes it difficult to share the road with bicyclists, particularly along stretches of SR 84 where shoulders are narrow and bicyclists must ride in the travel lane.

Figure 5: Trucks compete for road space

However, the crash history involving large trucks does not point to a substantial problem. After excluding pickup trucks and panel trucks, the data show that only 15 crashes in 10 years involved "large" trucks, such as tractor-trailers. Only one of these resulted in injuries.

A study conducted for the City of Fremont by consultant W-Trans ("Niles Canyon Road Truck Restriction Study – Initial Study") concluded that "approximately 4.4 percent of collisions involved large trucks, which is generally similar to the 3.4 to 7.1 percent of large (three or more axle) truck traffic on Niles Canyon Road".

Bicycle Safety

Although the RSA Team observed few bicyclists during any of the weekday and weeknight site visits, we learned from stakeholders and local government officials that there is significant recreational bicycling activity along the corridor, much of it concentrated on weekends. That said, there is clearly a concern for ensuring the continued safe usage of SR 84 by bicycling enthusiasts.

Historical crash data shows no significant safety issues. Only 4 crashes involving bicyclists occurred since 2001, and two of these did not involve a collision with a motor vehicle.

Nevertheless, Caltrans should consider augmenting existing signs and markings meant to alert drivers to the possible presence of bicyclists in the corridor and/or provide additional space for bicyclists to ride.

Pedestrian Safety

Pedestrian safety is a growing national concern, especially in view of policy changes at the Federal and State levels that emphasize "Complete Streets" and espouse the importance of walkability.

The land use context of Niles Canyon does not presently generate much pedestrian activity outside of Sunol. Residences are few and far between. Team members observed only a couple of pedestrians during our drive-throughs west of Sunol– one a jogger; the other a hiker wearing a backpack.

There is, however, a worn path behind guardrail in the northwest corner of the "Water Temple" intersection suggesting significant foot traffic. In addition, Caltrans installed a painted crosswalk at the intersection in 2001, at the request of the Citizens of Sunol.

Fortunately, only 1 pedestrian-involved crash took place in the corridor in ten years' time – a pedestrian was struck while walking along the road about ½ mile west of the Sunol ramps.

Nevertheless, several attendees at the May 7 stakeholder meeting expressed an interest in restoring limited access to Alameda Creek and facilitating other recreational uses that would tend to increase pedestrian activity. Should those land use changes materialize, pedestrian accommodation will take on a much higher priority. *In light of that, Caltrans should consider both near-term and longer term needs and opportunities to enhance pedestrian accessibility.*

Type of Collision

Identifying the type of collision helps to correlate driver's actions with specific crash outcomes. **Figure 6** lists the five highest ranked collision types.

"Hit Object" crashes account for more than a third (36%) of all crashes, double the next highest collision type - Rear End (18%).

In all but a handful of cases, the objects hit were outside of the traveled way.
Among "Objects Struck – Primary", 39 of 353 crashes were "Cut Slope or Embankment" or "Over Embankment"; Next highest were Guardrail at 25 and Trees and Utility Poles at 10 crashes each. Well over half (55%) of these crashes resulted in injuries.

A related crash statistic, "Movement Preceding Collision", shows that 63 (18%) of 353 total crashes were coded as Ran Off Road (ROR).

This statistic actually understates the ROR phenomenon. Whether or not the "Movement Preceding Collision" was coded as ROR, 150 crashes resulted in vehicles leaving the roadway and traveling <u>beyond the shoulder</u> before striking an object. (41 of these were encroachments to the <u>left</u> i.e., the vehicle crossed the centerline, the opposing lane and the opposite shoulder).

These statistics clearly speak to the importance of making the roadside more "forgiving" and to provide wider shoulders where practical.

Many of the Rear End Crashes occur at or near intersections where drivers fail to recognize and respond to slowed or stopped vehicles ahead. This condition is further aggravated where there are horizontal or vertical sight line obstructions that may "hide" vehicles.

Where feasible and practical, these sight line obstructions should be reduced or removed; where not, signs and markings advising of possible stopped traffic ahead or limited sight distance should be considered.

"Commute" Traffic

Knowing the "demographic" of the drivers involved in a crash can help target mitigation treatment for certain contributing crash factors. Building upon an old adage, one might say that "Familiarity breeds contempt and Unfamiliarity breeds confusion".

A review of data provided by CHP shows that nearly all of the crashes in the last 5 years involved an at-fault driver whose home address was a city in the immediate vicinity of the corridor (such as Fremont or Union City) or one of many "bedroom" communities to the Bay Area (such as Tracy) [**Figure 7**]

Familiarity with a roadway segment often may include positive and negative safety aspects. Familiar drivers may sometimes become too "comfortable" with a route and hence be less vigilant. They tend to be more aggressive, but also are aware of the potential hazards. Unfamiliar drivers have tendencies to not push the limits, but are not aware of potential hazards. The combination of both types of drivers can present challenges.

If a significant number of crashes involve tourists or other drivers who are not familiar with the roadway alignment, then the type and location of signs and markings may need to be re-evaluated in that context. Conversely, *if a large proportion of crashes involve commuters or other drivers who already know the route well, different strategies for signing and marking may need to be explored.*

Centerline Rumble Strip Project Effectiveness

In an attempt to reduce severe crashes, in mid-2007, Caltrans installed centerline rumble strips throughout the Niles Canyon corridor.

A number of attendees gathered for the May 7 kick-off meeting expressed their belief that the project had been very effective in reducing crashes (and thus concluded that additional safety treatments of the scope and magnitude being contemplated by Caltrans were no longer necessary).

Figure 6
Type of Collision

YEAR	Hit Object No. (Pct)		Rear End No. (Pct)		Broadside No. (Pct)		Head-On No. (Pct)		Sideswipe No. (Pct)	
2001	24	48%	9	18%	5	10%	3	6%	7	14%
2002	13	31%	11	26%	8	19%	2	5%	4	10%
2003	14	30%	6	13%	10	22%	8	17%	5	11%
2004	15	35%	7	16%	6	14%	6	14%	4	9%
2005	10	32%	2	6%	5	16%	7	23%	5	16%
2006	10	34%	7	24%	4	14%	4	14%	1	3%
2007	12	33%	9	25%	4	11%	3	8%	3	8%
2008	15	52%	2	7%	3	10%	0	0%	3	10%
2009	5	26%	4	21%	5	26%	1	5%	0	0%
2010	9	33%	5	19%	4	15%	1	4%	2	7%
10 Yrs*	127	36%	62	18%	54	15%	35	10%	34	10%

* Thru September 2010 SOURCE: TASAS

Figure 7
Driver Familiarity

City of At-Fault Driver	Number of Crashes*
Fremont	13
Pleasanton	11
Livermore	7
Union City	7
Tracy	4
Castro Valley	3
Hayward	3
Newark	3
Sunol	3
Stockton	2

* 2 or more crashes

SOURCE: CHP Database, Beat 223, 2007 thru 2011

Toward that end, they cited the previously-referenced safety analysis conducted for the City of Fremont. That study reported that the crash rate was cut nearly in half, from an average of 45 crashes per year to 25 crashes per year.

While these calculations are accurate, they are also a bit misleading.

Centerline Rumble Strips primarily target Head-On and Sideswipe crashes by alerting the driver that he is about to cross into opposing traffic. These crashes are almost always severe or fatal injury crashes.

A comparison of crash data from TIMS for three years before and after the installation year (2007) shows that 53 injury crashes occurred from 2004-2006, of which 12 (23%) were Head-On or Sideswipe. In the "After" period, from 2008-2010, 41 injury crashes occurred, of which only 4 (10%) were Head-On or Sideswipe.

The 13% reduction in the type of crashes targeted by the centerline rumble strip project is encouraging - whether a direct result of the project or something else. Nevertheless, 37 other injury crashes (i.e. 90%) in the "After" period were <u>not</u> Head-on or Sideswipe and were not likely influenced in any meaningful way by the presence of the centerline rumble strips.

Clearly, more needs to be done to further reduce fatal and injury crash risk.

GENERAL SAFETY CONCERNS

Roadside Quality

Much of SR 84 has roadsides that are of relatively low quality (in the context of safety). They are characterized by steep cut slopes or embankments with large rock formations, trees and shrubs. In addition, there are many man-made fixed objects (guardrail, sign supports, fencing, utility poles).

The crash analysis clearly shows an over-representation of Run-Off-Road (ROR) and Hit Object crashes that are indicative of the relatively unforgiving nature of the roadside.

Drivers that run off the road require space to safely recover. To do that, the roadside needs to be relatively free of fixed objects or steep slopes. This area for recovery is known as the Clear Recovery Zone or simply "Clear Zone".

Caltrans Traffic Manual describes the importance of this recovery area, citing studies that show that a 30 foot wide CRZ would likely accommodate up to 80% of roadside encroachments. However, Caltrans also recognizes that "On most conventional highways, a 30-foot clear zone distance may be difficult to justify for engineering, environmental or economic reasons. For these reasons, a minimum, traversable clear recovery area of 20 feet on conventional highways is advised."

Similar guidance from the AASHTO Roadside Design Guide, a nationally recognized technical reference, suggests a range of 20 to 22 feet or greater.

Where providing the full recommended clear zone is deemed impractical, other mitigation measures such as shielding with barrier can still achieve incremental improvements in roadside safety.

The potential for improving the roadside to reduce the frequency and severity of crashes is clearly evident from this Roadside Hazard Rating table from the HSM (**Figure 8**).

Table 13-25. Quantitative Descriptors for the Seven Roadside Hazard Ratings (16)

<table>
<tr><th>Rating</th><th>Clear zone width</th><th>Sideslope</th><th>Roadside</th></tr>
<tr><td>1</td><td>Greater than or equal to 30 ft</td><td>Flatter than 1V:4H; recoverable</td><td rowspan="2">N/A</td></tr>
<tr><td>2</td><td>Between 20 and 25 ft</td><td>About 1V:4H; recoverable</td></tr>
<tr><td>3</td><td>About 10 ft</td><td>About 1V:3H or 1V:4H; marginally recoverable</td><td>Rough roadside surface</td></tr>
<tr><td>4</td><td rowspan="2">Between 5 and 10 ft</td><td>About 1V:3H or 1V:4H; marginally forgiving, increased chance of reportable roadside crash</td><td>May have guardrail (offset 5 to 6.5 ft)
May have exposed trees, poles, other objects (offset 10 ft)</td></tr>
<tr><td>5</td><td>About 1V:3H; virtually non-recoverable</td><td>May have guardrail (offset 0 to 5 ft)
May have rigid obstacles or embankment (offset 6.5 to 10 ft)</td></tr>
<tr><td>6</td><td rowspan="2">Less than or equal to 5 ft</td><td>About 1V:2H; non-recoverable</td><td>No guardrail
Exposed rigid obstacles (offset 0 to 6.5 ft)</td></tr>
<tr><td>7</td><td>1V:2H or steeper; non-recoverable with high likelihood of severe injuries from roadside crash</td><td>No guardrail
Cliff or vertical rock cut</td></tr>
</table>

NOTE: Clear zone width, guardrail offset, and object offset are measured from the pavement edgeline.
N/A = no description of roadside is provided.

Figure 8 Roadside Hazard Ratings

Very few locations in the study corridor would likely be ranked a "3" or better ("1" being the best possible rating). However, *even modest improvements to the roadside in the most constrained canyon locations (so as to raise the Rating from, say, a "6" to a "5") has the potential to reduce total crashes by as much as 8%.*

Limited Use Shoulders

The shoulder of the road, which is part of the Clear Recovery Zone, allows many ROR drivers to recover and allows other drivers to take evasive action should an opposing vehicle cross the centerline. Unfortunately, in many locations along the SR 84 corridor, paved shoulders are very narrow or non-existent, and many have pavement edge drop-offs that can result in loss of control that can lead to crashes.

Even where paved shoulder widths are more generous, they are often very short sections, especially toward the middle of the canyon.

The limited width shoulders also limit other important functions of the shoulder, including safe refuge for motorists whose vehicle may break down, a place to walk or bike outside of the travel lane, and work space for road maintenance crews (**Figure 9**).

In addition, emergency response i.e. law enforcement, fire and EMS activities can be seriously hindered or prevented by inadequate shoulders.

Figure 9 Shoulders allow for law enforcement and maintenance activities

The relatively few clearly delineated safe stopping locations or pull offs within the corridor leads to reduced traffic violation enforcement and delayed emergency responses. Their scarcity severely limits safe stopping locations for law enforcement stops, as law enforcement officers must wait until the violator reaches areas where the roadway shoulders are improved or visible. Additionally, violators are often unwilling to pull off the roadway when the condition of the shoulder is unknown - risking damage to their vehicle or running off the roadway.

The reduced traffic violation enforcement decreases the overall corridor safety. Unenforced traffic laws diminish compliance.

The ability to respond to crashes is severely compromised. Emergency vehicle travel is encumbered by the lack of quick and safe areas to pull right and slow, as required by California law. As a result, emergency vehicles are unable to quickly and safely traverse the corridor.

Even traffic management during crash events is made more difficult.

CHP reports that it is often necessary to shut down SR 84 from Palomares to Main Street and detour traffic in order to allow emergency responders to deal with crashes in the canyon. This not only leads to congestion and confusion, but also could contribute to secondary crashes in the back up.

The HSM crash prediction data shows that paving and/or widening shoulders can have a tangible effect on head-on, sideswipe and ROR crashes. *Simply providing a 2ft wide shoulder where none exists could reduce those types of crashes by 20%.*

While the natural topography of the canyon makes shoulder widening difficult, *there already exist many locations where gravel borders ("shoulder backing") could be made more functional without widening* (**Figure 10**).

Figure 10 Gravel area can be paved without widening

Stabilizing or paving these areas could provide all the benefits of a widened shoulder without widening the existing "footprint" of the facility.

Speed Management

The issue of "speeding "was of keen interest to many of the stakeholders at the May 7 Kick-off meeting. Their concern is that too many motorists are already driving too fast through the corridor and that any roadway improvement that might make the roadway feel wider (such as widening shoulders or removing sight-line obstructions) will induce more speeding.

Speed management is a very difficult task to tackle. Many "speed" related crashes are not simple "speeding" but speed too fast for conditions, stopping sight distance, speed differential or failure to maintain control or lane position.

Another very difficult problem in speed management is the very high percentages of driver violating the speed limits. Many speed enforcement campaigns stop high numbers of violators who are local residents. The tendency is often that the more familiar drivers are with the roadway, the more aggressive they tend to drive. Reasons for exceeding the posted limits vary but the National Highway Traffic Safety Administration, (NHTSA), lists the top reasons (**Figure 11**).

While it is true that speed limit signs alone have limited effect on the speed drivers choose, proper lanes widths, pavement markings such as optical bars, coupled with feedback signs and enforcement can have a positive effect on travel speeds.

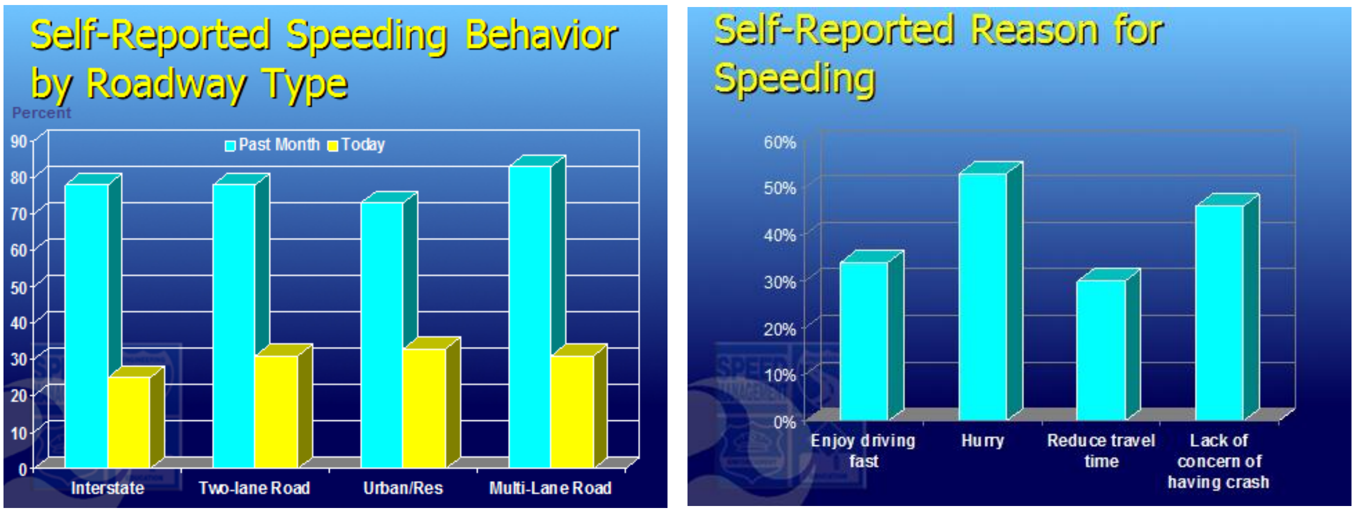


Figure 11 Motorists Self-Reported Speeding Behavior

The crash statistics clearly indicate that "Speeding" was most often cited as the PCF in SR84 crashes. While "Speeding" can sometimes mask other factors, excessive speed is a legitimate concern.

In several locations, tangent sections lead to horizontal curves that require drivers to reduce speed by as much as 20 mph. These curves are marked with "advisory" speed signs (black lettering on a yellow background). To help drivers transition from a high speed approach to a speed suitable for safely negotiating these curves, Caltrans has installed a series of signs advising of the reduced speed followed by a sign marking the beginning of a lower posted speed limit upstream of the curve. Crash patterns at several curves (Rosewarnes, and Farwell undercrossing, for example), suggest that drivers are not slowing enough.

The existing SR-84 has only a few locations where vehicles are allowed to pass. The inability to legally pass in other sections of the corridor may encourage speeding.

Different measures to try to influence driver speed behavior may be necessary in a number of locations in the corridor.

Speed by itself may aggravate the severity of crashes, but if speed limits are reasonable and credible, they can enhance safety. Proper speed limits need engineering studies, compatible designs, strong enforcement, adjudication and public support to succeed.

Signs and Markings

Signs, signals and pavement markings are key to providing drivers with positive guidance so that they can navigate the alignment confidently and understand the actions required of them.

As discussed previously, the centerline rumble strips are proving to be effective in reducing targeted crash types. Most other traffic control devices are equally effective in managing driver expectations.

There are, however, *opportunities to enhance their effectiveness by ensuring that they are more readily seen and placed where their message can be recognized and understood in time to make required or desired actions*.

If signs are partially obscured by vegetation or pavement markings are worn, their effectiveness can be diminished.

If signs are placed too close to a decision point, drivers may miss a turn or make erratic last-minute maneuvers. If signs are spaced too close together, they compete for the driver's attention, and make it more difficult for the driver to focus on the most relevant information.

Bicyclists and Pedestrians

While highway designers often focus first and foremost on the driver, the integration of the non-motorist or "active road user" into the State Highway System is equally important.

Admittedly, the rural nature of much of the SR84 corridor does not now generate a significant amount of walking or bicycle trips; nor does the historical crash data show any significant trends.

Nevertheless, crash potential is still an important consideration. As such, the RSA team observed opportunities for some low-cost enhancements that would make this segment of SR 84 more "complete." For example, *there are opportunities to increase the visibility and frequency of "share the road" signage for bicyclists, and possible co-benefits of wider shoulders for both pedestrian and bicycle safety. In addition, there may be opportunities for Caltrans to consider partnering with the local agencies to construct separate recreational trails along the SR 84 corridor*.

It is essential that Caltrans communicate its vision for accommodating and integrating active transportation into this segment of the SR 84 corridor as clearly and as openly as possible in their advance planning documents at the corridor concept planning level.

Intersections and Curves

Because intersections are natural points of conflict between vehicles, and curves pose additional task demands on drivers to maintain position in lane while steering, they tend to be locations where crashes are concentrated. The crash history for this corridor certainly reflects that trend.

As each spot location is unique, the safety concerns are also somewhat unique and, so, they are not discussed in any detail here.

Please refer to "Issues and Countermeasures" for specifics.

ISSUES AND COUNTERMEASURES

The specific safety concerns and associated mitigation treatments listed below often address one or several of the general safety concerns previously discussed. No attempt has been made to organize them in any particular way. Their order of presentation should not be interpreted as any indication of their relative importance, degree of urgency, nor sense of priority.

- Improve Visibility of Signs and Markings
- Reassess Sign Placement
- Rumble Strips
- Improve Palomares Rd. Intersection
- Reevaluate Roadside Barrier
- Widen and Harden Shoulders
- Reduce Pavement Edge Drop-Offs
- Mitigate Roadside Obstacles
- Contain Rock Fall
- Reduce Superelevation Variance
- Address Needs of Other Road Users
- Investigate Mission Blvd. and I-680 Intersections
- Improve Old Canyon Rd. Intersection
- Improve Rosewarnes Undercrossing
- Improve Farwell Undercrossing
- Improve Quarry Rd. Intersection
- Improve Sunol Off Ramp Intersection
- Improve Main St. and "Water Temple" Intersections
- Introduce Additional Speed Management Measures

Some of these suggested *countermeasures* may be accomplished in the near term, at modest cost, and with minimal social, economic or environmental (SEE) impacts. Others may take more time, more dollars and result in far more substantial SEE impacts.

While these factors are important considerations in any deliberations that may lead to future project proposals for the corridor, they are beyond the scope of this RSA. Instead, the reader is encouraged to consult the separate report documenting the efforts of the independent VA Team.

Improve Visibility of Signs and Markings

A number of signs were at least partially obscured by overgrown foliage. Consequently, a driver's ability to discern the sign message and respond appropriately may be impaired.

Figure 12: Curve warning sign partially obscured by vegetation

In other locations, pavement markings and sign faces are worn or faded, making them difficult to detect especially under adverse weather or lighting conditions.

More frequent cutting and trimming of vegetation and renewal of pavement markings and signs may be necessary to ensure that they continue to meet drivers' needs for positive guidance.

Reassess Sign Placement

In some locations, signs were too few or not located sufficiently in advance of a decision point to allow a driver to comfortably and confidently choose his desired path.

For example, the "off-ramp" to downtown Sunol is only marked by a single sign just upstream of the exit.

In several locations, there seemed to be too many signs presented to the driver. Although each sign was justified on its own merits, placing them too close together can make it difficult for a driver to recognize and respond to all of them and to be able to decide which provides the most critical information at a particular point in his journey. This "sign clutter" is an example of how too much information can challenge a driver in the same way that too little information can cause problems.

Figure 13: Adjacent signs sending mixed messages (?)

In still other locations, the proximity of two signs with seemingly contradictory messages may confuse drivers.

For example, along the westbound approach to Palomares, there is a sign indicating the presence of a crossroad from the right somewhere up ahead (implying the potential need to slow or stop). Yet just beyond this sign is a curve advisory sign with a 40 mph speed plaque that implies that reducing speed just 5 mph from posted speed is all that may be required.

Rumble Strips

The centerline rumble strips installed in the immediate vicinity of several of the sharper curves along the corridor provide very effective delineation of the upcoming change in alignment. The distinct contrast with the less bright upstream markings clearly communicates to the approaching driver that he is approaching a much different condition.

Figure 14: Centerline Rumble Strips effective, day and night

Avoid the temptation to "upgrade" other stretches of the corridor to this particular design detail, as making the entire corridor the same will negate the effect of the contrasting brightness. (If pavement markings are maintained by Caltrans maintenance forces, this advice should be communicated to them so that other stretches of the centerline are not inadvertently "upgraded" resulting in unintended consequences.)

Consider applying this design detail to the approaches to the Alameda Creek Bridge

Shoulder rumble strips are undulations rolled into or ground into a paved shoulder.

Consider locating rumble strips, just outside the edge of travelled way (fog line), on the shoulders

They are meant to alert motorists that stray outside their lane by producing both a loud humming noise and a noticeable vibration when driven over. The use of rumble strips at the edge of the travelled way warns drivers drifting off the roadway due to inattention or impairment thus reducing the probability and severity of a roadside crash.

Improve Palomares Rd. Intersection

Line of sight to/from this intersection is blocked by the north bridge support of the adjacent Farwell Undercrossing. This makes it difficult for drivers turning into or out of Palomares Rd. from being seen until the last minute. The lack of sight distance also makes left turns from Palomares Rd. very difficult, as these drivers do not have sufficient preview distance to choose gaps with confidence.

Palomares Rd. intersects SR 84 at a very severe skew angle. This means that drivers must turn their head or torso beyond 90 degrees to look for gaps in traffic. This is particular difficult for older drivers with limited head and neck mobility.

Figure 15: Palomares Rd. Intersection and Farwell Undercrossing

Consideration should be given to realigning the intersection by moving the access point so as to "tee" it up closer to a right angle. Doing so would help increase available stopping sight distance as well as mitigate the skew.

In addition, Caltrans should explore the possibility of installing dynamic warning signs that would alert westbound motorists that vehicles headed south on Palomares Rd. are at or near the intersection.

Further complicating the skew effect for drivers turning right from Palomares is the lack of a dedicated acceleration lane. At the same time, there is no separate left turn storage for vehicles turning left from SR 84 onto Palomares Rd. In both cases, drivers may impede through traffic or be pressured into accepting very short gaps.

Spot widening to provide for these movements may be appropriate.

The effectiveness of the existing painted channelization of the Palomares Rd approach is diminished due to wear and the lack of overhead lighting.

Installing raised channelization and/or street lights would help.

Reevaluate Roadside Barrier

Strong post W-beam ("Metal Beam") guardrail exists in spot locations throughout the corridor.

These installations should be reevaluated in light of current roadside hardware design to optimize roadside safety. Design details include identifying roadside obstacles that warrant shielding, providing sufficient length-of need, ensuring adequate deflection distance to fixed objects and incorporating crashworthy end treatments. Recent crash testing also demonstrated the importance of barrier height in capturing and redirecting errant vehicles.

At various locations throughout the corridor, portable concrete barrier ("K-Rail") has been installed. In some cases, these may have been intended as a temporary measure; In other cases, they function more to restrict property access than to shield roadside hazards.

If these are to remain, they should be reevaluated to ensure that design and installation details are appropriate for the specific context of each location.

In addition, consideration should be given to alternative design choices such as semi-rigid or flexible barrier systems or (in the case of access control) some type of fencing.

RSA Team members are not trained in bridge design. So, no findings or recommendations have been made regarding the safety (structural integrity, seismic resistance, etc.) of any of the bridges. However, *existing bridge rails should be evaluated for structural adequacy and consideration given to upgrading or retrofitting them to enhance their crashworthiness*.

While not technically a roadside "barrier", there are several locations within the corridor where variable height masonry walls exist. *If they are meant to act as roadside barriers, they may need to be modified to conform to current crashworthiness criteria. If not, they should probably be viewed as roadside fixed objects and treated accordingly.*

Figure 16: Variable height masonry walls

Specific guidance can be found in the AASHTO Roadside Design Guide and the Manual on Assessing Safety Hardware.

Widen and Harden Shoulders

Beyond their intrinsic function of providing safe refuge for vehicle breakdowns, paved shoulders are the first and most important opportunity for a ROR driver to recover. Shoulders also serve the needs of non-motorists, maintenance crews, law enforcement and first responders.

In a number of locations, widened shoulders may also improve stopping sight distance.

Where feasible, shoulders should be widened to as much as 8 feet. Preferably, they should also be paved or suitably hardened (stabilized) to ensure that their entire width is usable.

In many cases, gravel shoulder “backing” is already sufficiently wide to accommodate additional paved width within the existing roadway “footprint”.

Providing a contrasting color or texture for the paved shoulder may help calm traffic (control speed) and more clearly delineate road space where drivers should expect bicyclists and pedestrians.

Figure 17: Paved shoulders with contrasting color

Reduce Pavement Edge Drop-offs

Over time, gravel shoulders (shoulder “backing”) can subside, thus exposing the outer edge of the abutting pavement. This exposed edge or "drop-off" can cause a driver to lose control of his vehicle should he stray off the pavement onto the gravel and attempt to steer back onto the pavement.

Figure 18: Shoulder drop-offs can lead to crashes

Wherever the pavement (travel lane or shoulder) is planned to be widened, the outer edge of the paving should be finished with a "Safety Edge" and the gravel backing graded flush with the paved surface.

The Safety Edge is a construction technique that incorporates a fully compacted paved edge, sloped in a way that reduces the potential for drivers to lose control as they steer back toward the roadway. More details about the Safety Edge is available here: http://safety.fhwa.dot.gov/roadway_dept/pavement/safedge/

Mitigate Roadside Obstacles

In order to reduce the number of crashes involving a "Hit Object" on the roadside, additional measures should be contemplated to make the roadside more "forgiving" to drivers that leave the road.

Chapter 1 of the AASHTO Roadside Design Guide describes a hierarchical approach to enhance roadside safety. Understandably, the feasibility and practicality of each of these strategies will vary depending upon the specific context of each location.

"Cut Slope or Embankment" was the first "Object Struck" in most single-vehicle crashes. Given the severe topography in the canyon, this is not unexpected. In the case of Cut Slopes, the vehicle may have "nosed" into the ground or struck a rock outcropping; in other cases, the vehicle may have overturned. ("Overturned" was the most often cited "Other" Object Struck).

Where feasible, flattening the Cut Slope, moving the toe of the slope further from the edge of the travel way, and/or "smoothing" the slope should be explored.

In the case of Embankments, flattening the slope would be a first preference. But, where this is impractical, shielding with barrier might be considered, even if a particular location does not meet the embankment warrants in Caltrans Traffic Manual.

Guardrail was the second most frequently struck object.

That is not a bad thing, provided that the barrier served its purpose of shielding errant vehicles from reaching a more severe hazard. *Nonetheless, as mentioned under Reevaluate Roadside Barrier, the length, offset and placement of guardrail should be reviewed.*

Utility poles and trees were the 5th most frequent Primary Object Struck.

Where feasible, poles should be eliminated by consolidating with other poles serving other utilities (i.e. Joint use) or placed underground. Moving them further from the edge of the travel way or in other less vulnerable locations should be considered.

Trees with a trunk diameter in excess of 4 inches are considered fixed objects. Smaller diameter specimens spaced closer together than 7 feet apart are also considered fixed objects.

Trees with a history of being struck repeatedly or located in particularly vulnerable locations (such as the outside of a curve or close to the edge of the traveled way) should be given priority for mitigation.

Selective cutting of trees may be necessary. In other cases, shielding with barrier may be a more suitable countermeasure.

For example, the row of eucalyptus trees that define "The Spot", a site with considerable historic and community value, are very close to the edge of the traveled way and show evidence of having been struck..

Here, a properly-documented context-sensitive decision might be to spare these particular specimens by shielding them with a barrier.

Figure 19: Roadside barrier shielding trees

NCHRP Report 500 Series, Volume 3, Trees in Hazardous Locations and Volume 8, Utility Poles can be consulted for further insight.

Contain Rock Fall

There is evidence of fallen rock on the roadside in a number of locations in the canyon. There are various treatments being tried to contain the rock fall and/or stabilize the slopes.

Advance warning signs have been installed to alert motorists to the potential hazard.

Although only 4 crashes in 10 years were coded as "Loose material" or "Obstruction in Road", the rock fall is both a maintenance headache and a possible roadway hazard. *Additional rock fall mitigation is advised.*

Reduce Superelevation Variance

Although the Team did not have access to curve design data, some curves appeared to have a flatter cross slope than would be expected for the corresponding curve radius.

Driver expectation may lead drivers to enter the curve at a higher speed than appropriate. This is particularly important for truck drivers, as their vehicle's higher center of gravity makes them more prone to overturning.

Where feasible, the pavement profile and cross section should be adjusted to reduce or eliminate the superelevation variance. (In doing so, care should be taken to maintain adequate vertical clearance where the curve coincides with an undercrossing, e.g. Rosewarnes UC).

In addition, enhanced friction treatments might be applied at these and other curves to complement the superelevation. These treatments help keep the driver on the road and have also been shown to slightly reduce speeds.

Address Needs of Other Road Users

It is Caltrans' Complete Streets policy to integrate pedestrian and bicycle modes of transportation whenever feasible and in the best public interest. The public participation process during corridor concept planning usually determines to what extent this is desirable and at what cost, both financially and operationally.

Without engaging this kind of extensive public participation, the RSA team observed some opportunities to make SR 84 more "complete." For example, for bicyclists, the "*share the road" signage can be made more visible and more frequent to manage the motorists' expectation of a possible encounter with a bicyclist. In addition, shoulder widening may yield safety co-benefits for both bicyclists and pedestrians.* If Caltrans' corridor concept planning activities result in stronger public interest to make this roadway more appealing for bicyclists, *more aggressive countermeasures, such as green bicycle lanes and sharrow pavement markings can be considered. However, these more aggressive countermeasures should be deployed in a way that will not create a false sense of security for bicyclists or pedestrians.*

Figure 20: Special pavement markings help define space for bicyclists

In addition, the RSA team is anticipating that the proposed roundabout at the SR 84 / Water Temple intersection will yield co-benefits both in pedestrian safety and speed management.

Investigate Mission Blvd. and I-680 Intersections

The intersection of SR 84 and SR 238 (Mission Blvd) accounted for nearly 30 crashes from 2001 through mid-2010. Hence, the intersection warrants a careful diagnostic analysis.

However, the RSA Team did not explicitly study this particular intersection. That decision does not reflect a lack of concern for its safety performance, but rather, was meant to limit the length of the study corridor to keep it more manageable.

The intersection of SR 84 with I-680 was also excluded from the RSA study for similar reasons.

Improve Old Canyon Rd. Intersection

This intersection has some of the same characteristics of the Palomares Rd intersection (skew, sight distance obstructions). *Hence, some of the same mitigation treatments cited for Palomares might also be appropriate here.*

Other complicating factors specific to this intersection is the wide expanse of pavement at the throat of Old Canyon Rd, the dearth of channelizing markings, and the immediate upstream proximity of a local road that “tees” into Old Canyon Rd.

Improve Rosewarnes Undercrossing

SR 84 crosses under the trestle carrying the Niles Canyon RR here at a very acute angle approaching 90 degrees. At the same time, the roadway cross-section is very narrow and is slightly out of parallel as it crosses, in order to tie into the upstream and downstream approaches.

The undercrossing is further narrowed slightly by W-beam guardrail that is tied into the east bridge support and more significantly narrowed on the west side by temporary concrete barrier that intrudes onto the shoulder.

The north face of the east support appears to have been "chewed up" by vehicle impacts.

The eastbound approach is bordered by a steep cut slope on the north side and a run of W-beam guardrail on the south side.

The westbound approach shows evidence of periodic rock fall (the K-rail on the north side is in place partially to contain some of that debris).

A large ill-defined gravel area bordered by K-rail is on the south.

Since the "narrow subway" is not within the drivers view much in advance of the undercrossing, he may not be sufficiently persuaded by upstream signing and marking to slow down. In addition, the degree of narrowing may not be readily apparent and may cause drivers to shy away from the bridge walls and encroach into oncoming traffic.

The clustering of crashes in and around this bridge suggests that this behavior may indeed be contributing factors.

To more strongly influence drivers to slow down on approach, advance dynamic speed signs ("Your Speed Is") might be considered. Transverse striping or rumble strips ("jiggle bars") similar to those in use at the temporary curves on the SF Bay Bridge might be useful.

Placing centerline flexible post-mounted delineators upstream and through the undercrossing may help drivers feel "cramped" and more readily reduce speed as well as help keep drivers from encroaching into the opposing lane.

Removing the temporary K-rail from within the subway and tying the rail to the upstream end of the bridge wall would provide another foot of clearance.

Lighting the subway and installing delineators in line with upstream barrier-mounted delineation would provide continuity to the edge line positive guidance.

An even more ambitious mitigation would be to "true up" the roadway alignment through the undercrossing so that the centerline remains parallel to the bridge walls. Doing so would necessitate possible cut and fill on the approach roadways to avoid kinks in the alignment.

Even "shaving" the damaged corner of the east bridge wall would provide some much needed additional clearance.

Improve Farwell Undercrossing

See Rosewarnes Intersection discussion regarding speed reduction challenges and narrow subway.

Consider centerline post-mounted delineators, transverse rumble strips and dynamic warning signs, as possible countermeasures for this curve as well.

Improve Quarry Rd. Intersection

The center left turn lanes for traffic turning from and to eastbound SR 84 are not particularly conducive to the physical and operational characteristics of large trucks.

The presence of a crest vertical curve centered around the intersection partially hides oncoming traffic from oncoming passenger car drivers.

Consider lowering the profile and lengthening the left turn storage.

Improve Sunol Off Ramp Intersection

The gore area is not easily discerned especially during reduced lighting conditions.

Evaluate the possibility of installing overhead lighting and enhanced channelization to better define the diverge maneuver.

Improve Main Street and "Water Temple" Intersections

Traffic queues often extend west from the intersection at Pleasanton-Sunol Rd/Water Temple entrance to and beyond Main Street during morning and evening commute times. The four-way stop control at the Water Temple cannot efficiently handle the peak traffic volumes.

Beyond the driver frustrations evoked from the poor level of service, rear end crashes are quite frequent, and sometimes severe, especially when drivers do not expect stopped traffic and run into the end of the queue.

More than 60 crashes were recorded within the approximately ½ mile section of SR 84 from the Sunol ramps to the Water Temple intersection. 29 of these were Rear End crashes; another 13 were Broadside crashes.

This is a particularly vexing problem when the queue extends back into the sag vertical curve under the bridge carrying the eastbound off- ramp traffic into downtown Sunol. Here, the stopped vehicles can be hidden "down in the hollow" where traffic in the sag curve is even more concealed by a slight curve to the right. (A member of the VA Team observed a passenger car stopped at the west end (top) of the curve with 4-way flashers activated – presumably to warn approaching traffic of the stopped vehicles ahead)

An advanced dynamic warning sign would be well advised here.

Signalizing the Water Temple intersection might help reduce some of the queuing, however the team believes an even more effective choice would be to consider a modern roundabout in these locations. Reduction or elimination of queuing at the Water Temple and near the school in Sunol has the potential for not only improving safety by crash reductions but also by reducing the informal short cuts during queues through Sunol, especially near the school.

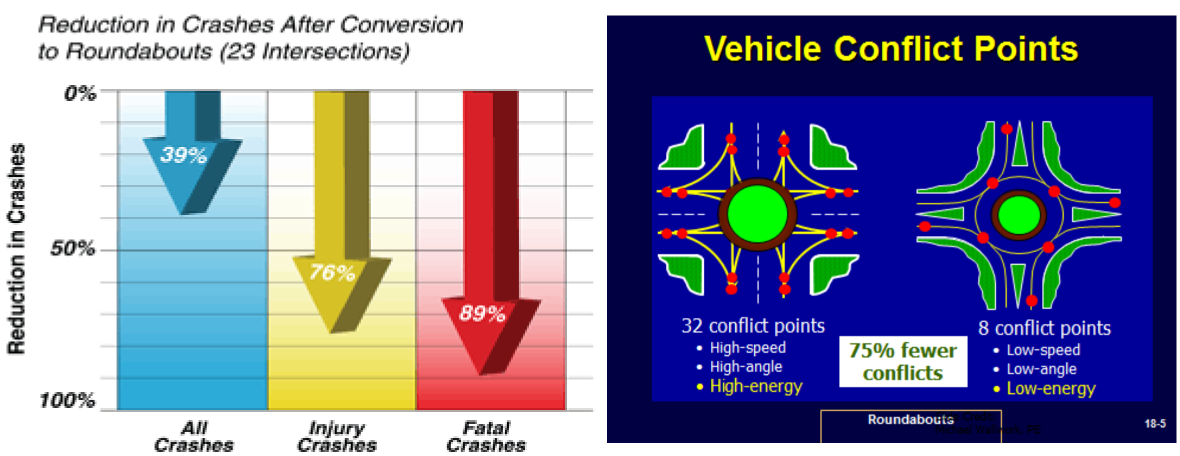


Figure 21: Modern roundabouts have fewer conflict points and fewer crashes

Modern roundabouts not only are "greener," but also quieter, reduce conflict points, slow speeds, are capable of handling farm equipment, can handle a higher number of vehicles and are one of the top proven safety countermeasures for enhancing safety.

Figure 22: Modern roundabouts are highly adaptable to both urban and rural settings

Introduce Additional Speed Management Measures

The most recent engineering speed survey measured free flow speed of 47 mph, which is very consistent with the posted speed of 45 mph. However, the plethora of speed-related crashes suggests that more targeted measures may be needed.

More aggressive law enforcement might be one component of a coordinated effort to manage speed in the corridor. However, *the ability of the CHP and local police to step up their enforcement efforts will continue to be constrained by the lack of adequate roadside space.*

Even spot widening of shoulders would help. An added benefit would be the ability to provide signed Turnouts to allow slower drivers to yield to faster drivers, thus discouraging unsafe passing and even higher speeds

Additional engineering countermeasures including traffic calming strategies can be found on both the FHWA and Institute of Transportation Engineers (ITE) web sites.

One concern expressed by a great many stakeholders at the May 7 Kickoff meeting is that any degree of pavement widening (shoulder widening in particular) will unquestionably result in higher speeds. These higher speeds are, in turn, perceived to be less safe.

While it's true that long stretches of "open road" may allow drivers to feel comfortable traveling at relatively high speeds, it is unlikely that short, intermittent stretches of widened pavement would significantly influence drivers to increase speed. In fact, many locations in the corridor already are graded wide enough to allow for stabilizing or paving the shoulder without increasing the actual available width.

Even if speed were to increase slightly, the safety benefits that would likely accrue from providing more clear recovery area and improved stopping sight distance and additional speed enforcement areas might help allay some of these concerns.