KOA CORPORATION
PLANNING & ENGINEERING

TECHNICAL MEMORANDUM

Date: March 13, 2017

To: Joe Dyer, Assistant City Engineer

From: Min Zhou, P.E., Vice President – KOA Corporation

Subject: Carbon Canyon Road (SR142) Corridor Initial Study – Phase 1

KOA Corporation (KOA) is pleased to submit this technical memorandum to summarize the initial study for the Carbon Canyon Corridor.

INTRODUCTION

The first phase of this study (initial study) was commissioned by City of Chino Hills, for the purpose of providing background information and recommendations on what steps to take to fully address the traffic issues along Carbon Canyon Road (SR-142). The second phase will be to conduct a full and in-depth study of the corridor. The corridor being studied consists of Carbon Canyon Road (SR-142) between Valencia Avenue in the City of Brea and Chino Hills Parkway in the City of Chino Hills. In recent years, the corridor has experienced an increase in both passenger vehicles and truck traffic. Consequently, motorists have to endure long traffic delays along the route during peak travel times. Congestion impacts residents who live in neighborhoods adjacent to Carbon Canyon Road, as well as other areas where Chino Hills Parkway provides an outlet to. These conditions are further magnified when nearby freeways (Route 57, Route 60, Route 91 and Route 71) become congested, which shifts traffic to Carbon Canyon Road (SR-142). In addition, the roadway's configuration at several locations, is not conducive to safe large-truck movement.

This report provides a summary of roadway conditions and characteristics, identifies problem locations and transportation needs, and examines the cause of traffic-related problems. The report presents the City of Chino Hills and other related agencies such as Caltrans and the City of Brea with recommendations to improve upon the identified problems and the next steps that need to be taken.

BACKGROUND

Study Area

The study corridor is approximately an 8.4 mile long section of Carbon Canyon Road (SR-142) defined to include Carbon Canyon Road between the intersection roadway approaches from Valencia Avenue in the City of Brea and Chino Hills Parkway in Chino Hills. Figure 1 shows the location of the study corridor. In the City of Chino Hills, Carbon Canyon Road is composed of a two-lane highway classified as a principal arterial, with Class 2 bike lanes provided in both directions between Old Carbon Canyon

Road and Chino Hills Parkway. In the City of Brea, Carbon Canyon Road (SR-142) goes from a six-lane primary arterial to a two-lane highway as one enters the canyon. Speeds are posted at 15, 35, 40, 45 mph throughout the corridor. Carbon Canyon Road (SR-142) serves the Chino Hills communities of Sleepy Hollow, Canyon Estates, Oak Tree Downs, Carriage Hills, Summit Ranch and Western Hills Golf Course. The corridor allows local residents access to shopping centers, schools, entertainment, SR-71, SR-90, Orange County, the Western Hills Country Club, and the Chino Hills State Park. The corridor is also heavily used by commuters as an alternate route to travel between San Bernardino and Orange County.

In recent years the roadway has undergone improvements on the Brea side with shoulder improvements extending from Valencia Avenue to just before reaching the Sleepy Hollow community.

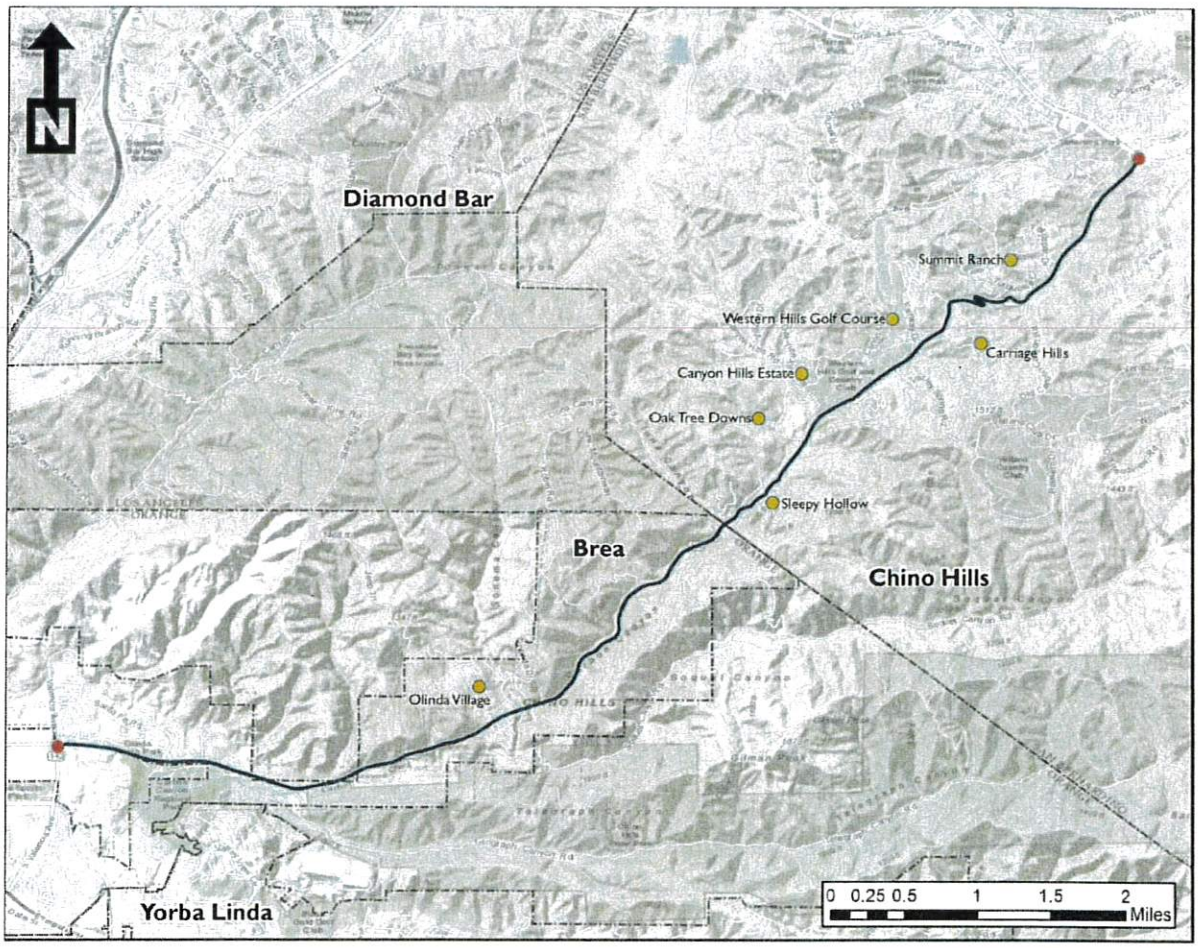


Figure 1: Map of Study Area

Area-Wide Highway Network

The studied corridor consisted of a network wherein Carbon Canyon Road (SR-142) intersects with nineteen streets. Of these, five are controlled with traffic signals, while the remaining fourteen have stop controls on minor streets. Most streets lead to small communities within Carbon Canyon.

Signalized Intersections	Stop Controlled on Minor Street
Valencia Avenue	Brea Hills Avenue
E Santa Fe Road	Onyx Street
Ruby Street	Olinda Drive
Olinda Place	Rosemary Lane (South) / Hillside Drive
Chino Hills Parkway / Rustic Drive	Oak Way Lane
	Rosemary Lane (North)
	Canyon Hills Road
	Canon Lane
	Valley Springs Road
	Fairway Drive / Ginseng Lane
	Carriage Hills Lane
	Azurite Drive
	Old Carbon Canyon Road
	Feldspar Drive

Table 1: List of Intersections within Carbon Canyon Road

PHASE 1: SCOPE OF STUDY

As directed by City staff, this initial phase focuses on four principal areas of concern: **(1)** identification of existing policies, both state and local **(2)** identification of existing conditions along the corridor, **(3)** development of problem statement, and **(4)** an outline of the second phase of the study consisting of evaluation methods and potential improvement alternatives.

1. EXISTING POLICIES

There are several existing policies that govern the use of trucks on City streets. Some of these policies, relative to vehicle weight and size, are established by Caltrans. Other policies, dealing with the right to regulate trucks and enforce weight limits come from the California Vehicle Code. The Cities of Chino Hills and Brea also have some of their own local policies that regulate the specific streets that trucks are allowed to use. This section summarizes the existing City of Chino Hills, City of Brea and State policies that pertain to the corridor.

City Policies

City of Chino Hills

The General Plan (2015) provides a discussion of goals, actions and policies to guide the City during the next 20 years. The overriding goal of the General Plan is to maintain the City's high quality of life.[1] The vision for transportation includes supporting a transportation system that ensures adequate and efficient access to, from, and within the city.[2] As described in the Circulation Element, Carbon Canyon Road (SR-142) is a designated State Highway, State Route 142 (SR-142).

The General Plan's Circulation Element includes a number of policies and actions. One action is to continue to assert that all improvements to and maintenance of the portion of Chino Hills Parkway/ Carbon Canyon Road that is part of SR-142 shall be the responsibility of Caltrans. A second action is to continue to enforce heavy truck travel restrictions throughout the City. A third action is to retain the switchbacks on Carbon Canyon Road between Feldspar Drive and the Western Hills Country Club. The switchbacks offer a safety factor because it forces drivers to drive at slower speeds.

As per the City of Chino Hills' latest Traffic Impact Study (TIS) Guidelines, level of service (LOS) "D" is the minimum acceptable grade for intersections in Chino Hills. The traffic study conducted for the circulation element identified one of the sections within the corridor, Chino Hills Parkway at Carbon Canyon, as significantly impacted for Future Years 2027 and 2037 and identified some improvements.

Short term and long term projects were identified within the General Plan traffic study for this location. Short term projects were assumed to be operations based, with long term involving design and construction.

- Short-term: Modify signal phasing to include a northbound right-turn protected overlap for vehicles on Carbon Canyon Road (SR-142) to turn east concurrently with westbound left turning vehicles on Chino Hills Parkway.
    - To date the short-term improvement has already been installed; however, the high traffic delay specifically during the P.M. peak hours for this movement is still present. The high amount of vehicles that travel along the corridor through the City of Chino Hills and truck traffic are major contributors to this added delay.

- Long-term: Construction of a channelized right-turn lane on the Carbon Canyon Road (SR-142) approach of the intersection. The City of Chino Hills and Caltrans would need to coordinate the implementation of these improvements.
    - This improvement was identified at the buildout stage however this may already be necessitated in order to alleviate the deteriorating traffic conditions. A detailed engineering feasibility study is recommended in order to evaluate the different alternatives. It is also recommended that Synchro and SimTraffic, a macroscopic and microscopic traffic software that is used to simulate a wide variety of traffic controls that measures the full impact of queuing and blocking, be included in the feasibility study. Synchro will assist in determining macro level of LOS and delays and SimTraffic will simulate the existing conditions to identify the "problems" that may not be fully realized with a macro-level model.

[1] City of Chino Hills General Plan (2015)
[2] Ibid p. 7

City of Brea

City of Brea's General Plan was developed in 2003. This plan provides a vision and goals for the community that also pertains to the evaluation of Carbon Canyon Road (SR-142). The Circulation Element discusses a range of mobility options that reduce dependence on the automobile.[3] Carbon Canyon Road (SR-142) is classified as a principal arterial in the plan. It was specifically described in the Circulation Element as follows:

> "During evening commute hours, Valencia Avenue and Lambert Road/Carbon Canyon Road (SR-142) experience LOS F conditions. Carbon Canyon Road (SR-142) is one of the few roads that connect Brea and Orange County to San Bernardino County to the east. Thus, commuters use the road as a regional link between housing in San Bernardino and Riverside Counties and employment in Orange County. East of the Olinda Ranch neighborhood, Carbon Canyon Road (SR-142) remains a two-lane highway with severe traffic congestion during both A.M. and P.M. peak hours. Topography and sensitive habitat within Carbon Canyon severely limit opportunities to widen the roadway to relieve congestion." P. 2-46

City of Brea - Olinda Ranch & Blackstone Communities Traffic Calming Plan

The City of Brea recently implemented traffic calming measures around the Olinda Ranch development. This development spans from Valencia Avenue to Brea Hills Avenue along Carbon Canyon Road (SR-142). One of the major concerns residents identified was speeding on Santa Fe Road and cut-through traffic. The study discussed the different options to address the residents' concerns and two of the recommendations fall along the corridor. The recommendation at Santa Fe Road and Carbon Canyon was to replace the No Left Turn, 4-7 P.M. restriction with a permanent Right Turn Only restriction, to be implemented with a raised "pork chop" island and acceleration lane to help discourage motorists from going around the pork chop. This improvement has been temporarily implemented as shown in Figure 2.

Figure 2: Temporary pork chop prohibiting left turns onto Carbon Canyon off of Santa Fe Road

[3] City of Brea General Plan p. 1-10

The second set of improvements, Figure 3, that were recommended but have not been implemented yet, involves extending the eastbound left turn on Carbon Canyon Road (SR142) at Brea Hills Avenue back to just east of Valencia Avenue. This would require special treatments at some of the intersections as well as some type of physical barrier along the lane to prevent through traffic from using it as a bypass lane.

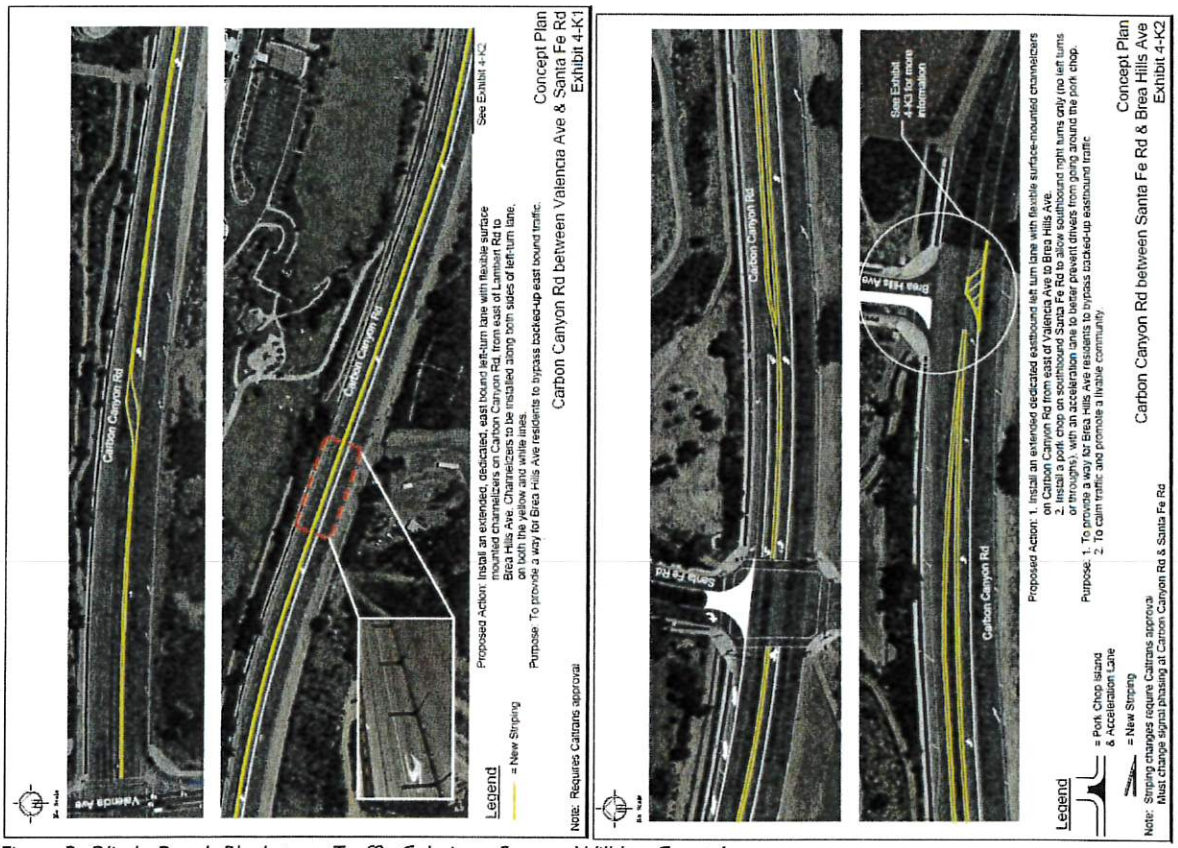


Figure 3: Olinda Ranch-Blackstone Traffic Calming - Source: Willdan Group Inc.

Caltrans Truck Route Evaluation

The Caltrans Highway Design Manual, Topic 404, lists a set of criteria for evaluating STAA Truck Routes. The following is an excerpt from the Highway Design Manual:

Traveled way	a) To accommodate turn movements(e.g., at intersections, driveways, alleys, etc.),the travel way width and intersection design should be such that tracking width and swept width lines for the design vehicle do not cross into any portion of the lane for opposing traffic. Encroachment into the shoulder and bike lane is permitted. b) Along the portion of roadway where there are no turning options, vehicles are required to stay within the lane lines. The tracking and swept widths lines for the design vehicle shall stay within the lane as defined in Index 301.1 and Table 504.3A. This includes no encroachment into Class II bike lanes.
Shoulders	Both tracking width and swept width lines may encroach onto paved shoulders to

	accommodate turning. For design projects where the tracking width lines are shown to encroach onto paved shoulders, the shoulder pavement structure should be engineered to sustain the weight of the design vehicle. See Index 613 for general traffic loading considerations and Index 626 for tied rigid shoulder guidance. At corners where no sidewalks are provided and pedestrians are using the shoulder, a paved refuge area may be provided outside the swept width of turning vehicle.
Curbs and Gutters	Tires may not mount curbs. If curb and gutter are present and any portion of the gutter pan is likewise encroached, the gutter pan must be engineered to match the adjacent shoulder pavement structure.
Edge of Pavement	To accommodate a turn, the swept width lines may cross the edge of pavement provided there are no obstructions. The tracking width lines must remain on the pavement structure, including the shoulder, provided that the shoulder is designed to support vehicular traffic. If truck volumes are high, consideration of a wider shoulder is encouraged in order to preserve the pavement edge.
Bicycle Lanes	Where bicycle lanes are considered, the design guidance noted above applies. Vehicles are permitted to cross a bicycle lane to initiate or complete a turning movement or for emergency parking on the shoulder. To accommodate turn movements (e.g., intersections, driveways, alleys, etc. are present), both tracking width and swept width lines may cross the broken white painted bicycle lane striping in advance of the right-turn, entering the bicycle lane when clear to do so.
Sidewalks	Tracking width and swept width lines must not encroach onto sidewalks or pedestrian refuge areas, without exception.
Obstacles	Swept width lines may not encroach upon obstacles including, but not limited to, curbs, islands, sign structures, traffic delineators/channelizers, traffic signals, lighting poles, guardrails, trees, cut slopes, and rock outcrops.
Appurtenances	Swept width lines do not include side mirrors or other appurtenances allowed by the California Vehicle Code, thus, accommodation to non-motorized users of the facility and appurtenances should be considered

There are currently no special restrictions on Carbon Canyon Road (SR-142). The route is designated as an advisory truck route that advises trucks over 50 feet in length to not travel this route. Advisory signs are posted adjacent to the roadway.

Figure 4: Truck Advisory Signage in Chino Hills (above left) and Brea (above right)

2. EXISTING CONDITIONS

Roadway Characteristics

Near each end of the corridor approaching both Valencia Avenue and Chino Hills Parkway, Carbon Canyon Road (SR-142) widens out to provide additional capacity. However, other than these two approaches to these major intersections, Carbon Canyon Road (SR-142) is two-lanes wide, and with the exception of the Sleepy Hollow area, left turn bays are provided at critical intersections. Specifically, in the Sleepy Hollow area, there are no left turn bays provided at Hillside Drive, Oak Way Lane, or Rosemary Lane intersection. There is direct driveway access from adjacent properties for much of the route. The high point or summit of the route is located just east of Carriage Hills Lane. Moving west to east, the roadway generally has an upward grade through Carbon Canyon up to the summit. The grades from the summit to Chino Hills Parkway are steeper, and include a switchback section. There are four signalized intersections within the corridor and one on each end.

Peak Hour Field Observations

KOA staff conducted initial field observations at different peak hours and noticed multiple factors that contribute to delay along the corridor. Key observation points included Chino Hills Parkway at Carbon

Canyon, switchbacks, Sleepy Hollow community, Olinda Place intersection and Valencia Avenue.

A.M. Peak Hour

During the A.M. peak hour there is a high demand traveling westbound towards Orange County. The City of Chino Hills has seen the need to prohibit right turns for the A.M. peak hour at Chino Hills Parkway/Rustic Drive traveling northbound and left turns traveling southbound due to drivers seeking to avoid the long queues. The General Plan traffic study conducted in 2012 shows that approximately 1,900 vehicles during the peak hour are entering the corridor off of Chino Hills Parkway. Due to the large volume of vehicles traveling this corridor, any slight delay within the corridor will create a significant delay. Key delays that were observed during the A.M. peak hour were the following:

- Vehicles blocking intersection of Chino Hills Parkway and Carbon Canyon
    - 1,200 foot queue was observed on both directions during A.M. peak hour
- Large trucks were observed at multiple instances creating a significant delay especially at the switchbacks since they had to maneuver slower than passenger vehicles around the tight turns. Currently there is no safe place for the trucks to pull over to allow traffic that was delayed to proceed through the corridor
- Multiple school bus stop locations exist along the corridor. The Brea Olinda Unified School District has identified a bus stop at the Hollydale Mobile Estates off of Olinda Place. Chino Valley Unified School District also has bus stops within the community of Sleepy Hollow where buses (between 7:00-7:40 a.m.) will stop approximately every 1,000 feet and pick up children. These buses will display their red lights and the stop arm which will stop traffic in both directions. School buses will flash yellow lights when preparing to stop to let children off the bus. The yellow flashing lights warn you to slow down and prepare to stop. When the bus flashes red lights (located at the top front and back of the bus), motorist must stop from either direction until the children are safely across the street and the lights stop flashing.
    - The law requires you remain stopped as long as the red lights are flashing (CVC §22454). If you fail to stop, you may be fined up to $1,000 and your driving privilege could be suspended for 1 year.
- Motorcycles have been observed driving on the narrow shoulder to avoid the long queues along the corridor.

P.M. Peak Hour

The demand for corridor travel during the P.M. peak hour is heavy heading eastbound from Brea to Chino Hills Parkway. Vehicle queues begin to form by 3:00 p.m. and continue up until 7:00 p.m. depending on the traffic conditions on the SR-57. Queues on Lambert Road range between 1,200-2,500 feet in length depending on the hour. Queues on Valencia Avenue range from 600-1,400 feet during the hours of 4:30-6:00 p.m. During this time the following were observed as being key delays in the corridor:

- Large trucks have been observed taking this route and have contributed an approximately 10-20

minutes of delay. The steep grades and tight turns provide a challenge for trucks that travel the corridor and are also another cause of traffic congestion.

- Southbound left turns off of Santa Fe Road have recently been eliminated by the installation of traffic control which has decreased the cut-through traffic within the Olinda Community however it has increased the queue along Valencia Avenue and Lambert Road. This would need to be studied further to reevaluate the new traffic flow pattern.
- School bus drop-off along the corridor stops traffic in both directions causing delay
- P.M. peak hour volumes identified in the General Plan traffic study shows approximately 470 vehicles turning left and 2,060 turning right onto Chino Hills Parkway from Carbon Canyon. An increase in traffic from development in recent years would necessitate a review of new traffic conditions.

During both the A.M. and P.M. peak hour traffic flow characteristics were evaluated. There are two signalized intersections within the corridor. Because of close proximity, the intersections of Olinda Place and Ruby Street currently operate off of one controller. The side street traffic is limited, so actuation is provided. When triggered, the minor approaches receive 20-25 seconds green time depending on the amount of queue. Both Ruby Street and Olinda Place receive green time at the same time. The signals reduce the amount of capacity available on Carbon Canyon Road, which is shown to result in delays to through traffic movement. While the function of the signalized intersection seemed to be operating in a manner needed to provide efficient side street access, further analysis is recommended consisting of new peak hour counts and evaluation of signal timing in order to evaluate the balance of side versus through travel delays at these locations.

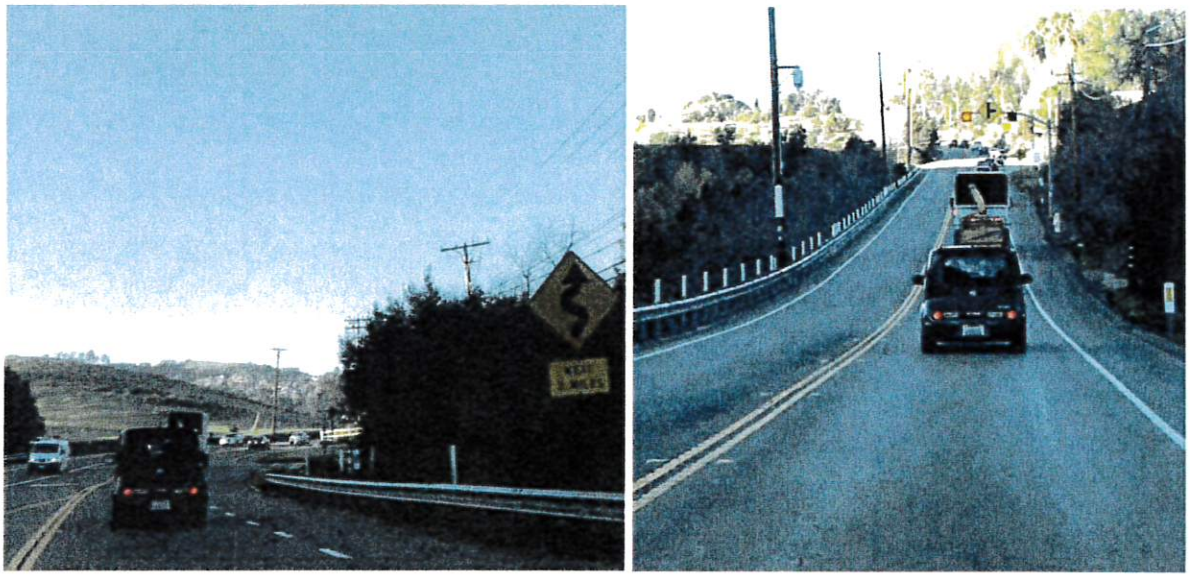
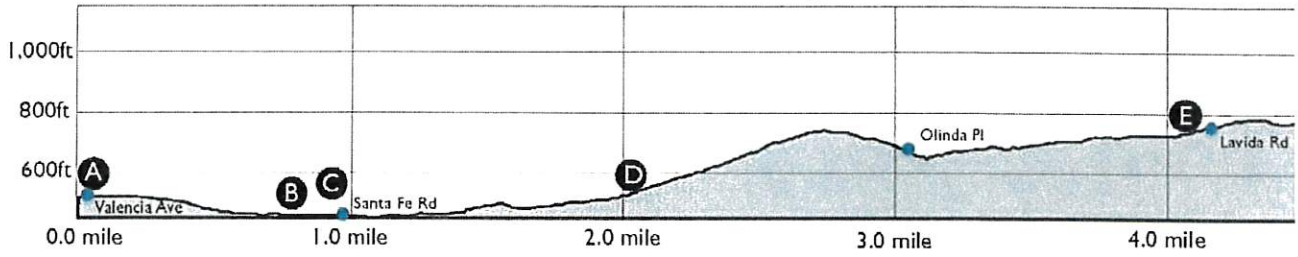


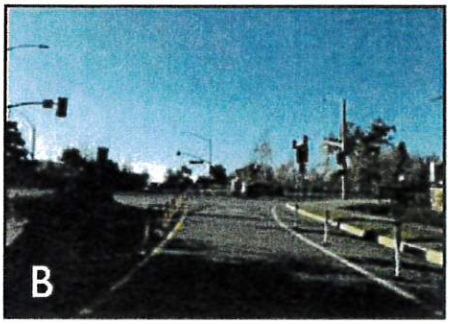
Figure 5: Traffic flow during A.M. peak hour approaching switchbacks (above left) and Olinda Place (above right)

Figure 6 on the next page includes pictures of additional choke points that were identified as critical delay factors along the corridor.

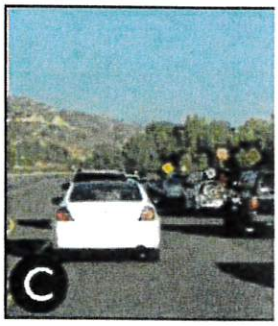
Corridor Statistics: Elevation Gain Traveling East: 852ft, Elevation Gain Traveling West: 653ft, Corridor Distance: 8.4 Miles, and S-Turn Average Grade(%): 8% traveling westbound



Mile 0: Roadway begins transition (Valencia Ave and Carbon Canyon Rd) from three lanes to two lanes and eventually down to one lane in the eastbound direction.



Mile 0.7: No southbound left turn strategy has been recently implemented due to vehicular traffic cutting through within the residential area.



Mile 0.8: At this loca lane drops and traffic creating a bottleneck lane transition).

Mile 4.8: Narrow bridge location creates safety risk for bicyclist and vehicles when trucks are present.

Mile 5: When entering vehicles try to enter the stream of traffic it becomes unsafe due to the disruption in normal traffic flow.

Mile 5.9: School bus location creates a b AM and PM peak hou fic stopping in bo when school bus is their flashing lights ar

Figure 6: Additional Carbon Canyon (SR142) Choke Points along the Corridor

Traffic Volume

Arterial capacity is often determined by intersection operations. Intersection turning movement counts and operational analysis will be conducted in the second phase of the study. However, general estimates of capacity can be made for traffic flow along highway segments. The type of traffic flow is measured by comparing traffic volumes with roadway segment capacity. Roadway capacity is affected by the type of roadway, the number of lanes, grades, intersections and driveway access. In general, a single lane of traffic on a street or highway can be expected to carry between 800 and 1,200 vehicles per hour. For segments with steep grades, more driveway and side street access, and where traffic signals are located close together, the capacity is near the low end of the range. Specific estimates of capacity were taken from generalized calculations provided by the Highway Capacity Manual. There is a peak flow of traffic westbound in the A.M. peak hour and eastbound in the P.M. peak hour. These volumes suggest that the Carbon Canyon Roadway (SR-142) is operating at or even over this typical theoretical capacity in those peak directions. The year 2015 CALTRANS traffic count, general estimates of roadway capacity and level-of service ratings are listed in the table below.

Location	AADT	Peak Hour	General Segment Capacity	General LOS
Carbon Canyon Park Entrance	21,900	2,600	3040	D
Olinda Creek	18,900	2,200	1600	F
Orange Ct./San Bernardino Ct. Line	14,000	1,700	1600	F
SR142 at Chino Hills Prkwy/Rustic Dr.	17,500	2,100	3040	D

Note: Segment capacity would be further restricted at locations of tight curves or steep grades

Table 1: Traffic Counts and General Level of Service

Safety Evaluation

The existing conditions safety analysis seeks to identify higher-collision intersections along the corridor. Collision data from Statewide Integrated Traffic Records System (SWITRS) was obtained for the total number of collisions for a five year period from December 1, 2010 through November 30, 2015. For this five year period, there were 66 total collisions from Valencia Ave to SB County Line and 26 total collisions from the county line to Chino Hills Parkway[4].

Severity of Injuries

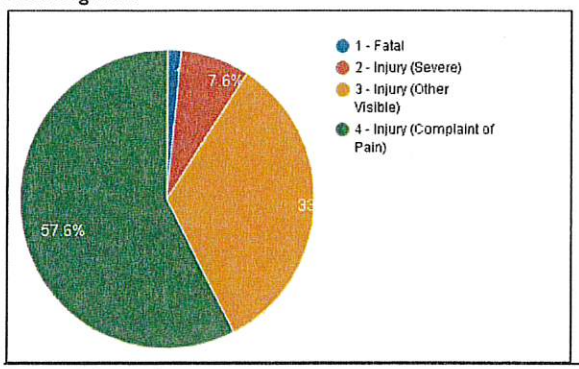
The 92 collisions along the corridor resulted in 156 injuries of which 3 resulted in fatalities. Comparing the two segments, the severity of collisions was greater on the Chino Hills segment than on the Brea segment. Table 2 summarizes the severity of collisions according to each city. Figure 7 presents the percentage breakdown of the severity of injuries associated with the collisions.

[4] SWITRS data does not include non-injury collisions

	Fatality	Injuries
Chino Hills	2[5]	52
Brea	1[6]	101
Total	3	153

Table 2: Severity of Injuries by City

Brea Segment



Chino Hills Segment

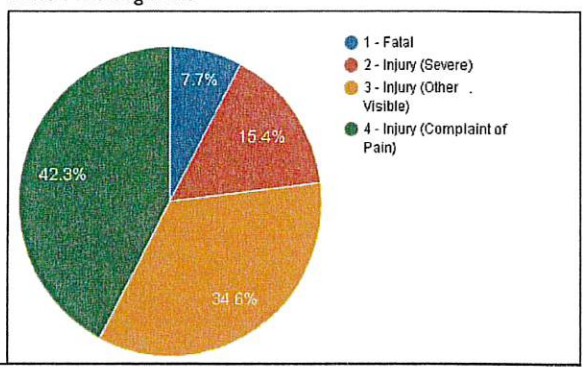


Figure 7: Injury Severities

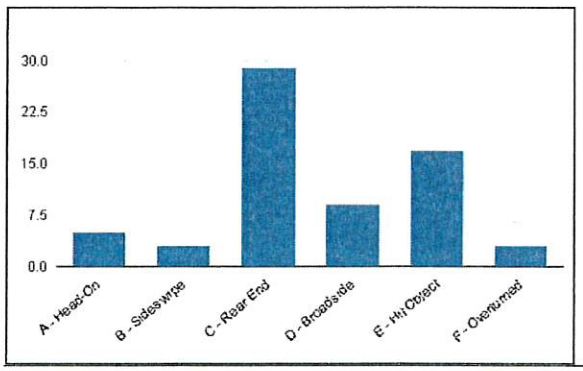
Type of Vehicle Collisions and Primary Factors

Different types of collisions are more common along each segment. In the Brea segment, rear end collisions (29) and collisions with objects (17) were most common, and made up (46) of the (66) total collisions. This may be a result of curves requiring traffic particularly on the downgrade westbound to slow down resulting in rear end collisions. In the Chino Hills segment, broadside (6) and rear end collisions (5) were the most common, and made up (11) of the (26) total collisions. This may be a result of a greater number of cross streets and driveways on this segment.

Unsafe speed and improper turning were the two leading causes of collisions. Approximately 42% of all collisions were related to unsafe speed while 21% occurred due to improper turning.

[5] Reports #5907120 and #5403366
[6] Report # 5911612

Brea Segment



Chino Hills Segment

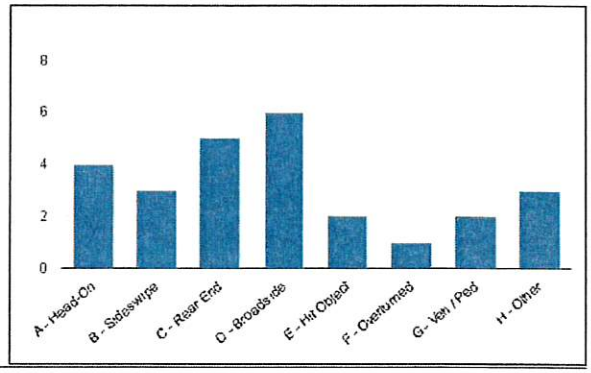


Figure 8: Collision Types

Brea Segment

Primary Collision Factor	Collisions	Percentage
00 - Unknown	1	1.5%
01 - Driving or Bicycling Under the Influence of Alcohol or Drug	6	9.1%
03 - Unsafe Speed	29	43.9%
05 - Wrong Side of Road	6	9.1%
06 - Improper Passing	3	4.5%
08 - Improper Turning	12	18.2%
09 - Automobile Right of Way	2	3%
12 - Traffic Signals and Signs	4	6.1%
18 - Other Than Driver (or Pedestrian)	2	3%
21 - Unsafe Starting or Backing	1	1.5%

Chino Hills Segment

Primary Collision Factor	Collisions	Percentage
01 - Driving or Bicycling Under the Influence of Alcohol or Drug	1	3.8%
03 - Unsafe Speed	11	42.3%
05 - Wrong Side of Road	2	7.7%
08 - Improper Turning	7	26.9%
09 - Automobile Right of Way	1	3.8%
10 - Pedestrian Right of Way	2	7.7%
11 - Pedestrian Violation	1	3.8%
18 - Other Than Driver (or Pedestrian)	1	3.8%

Table 2: Primary Factor for Collisions

Location of Vehicular Collisions

Collisions are concentrated in certain key locations along the corridor. We conducted a collision heat analysis, shown in Figure 9, where we identified that the largest concentration of collisions existed in the Brea segment within the vicinity of the Chino Hills Discovery Center entrance and at the intersection of Valencia Avenue. For the section in Chino Hills, shown in Figure 10, a concentration of collisions was identified at the switchbacks, but also throughout the portion of the route near Sleepy Hollow in the more "canyon-like" portion of the corridor. This area has residences within 50 feet of the roadway and creates a high collision risk factor.

Pedestrian and Bicycle Collisions

A total of 8 pedestrian and bicycle collisions occurred on this corridor. Two bicycle collisions were reported on the Brea segment. The Chino Hills segment had six collisions; four involved pedestrians and two involved bicyclist of which one was fatal[7], and the other experienced injuries[8].

[7] Report #5403366
[8] Report #6326591

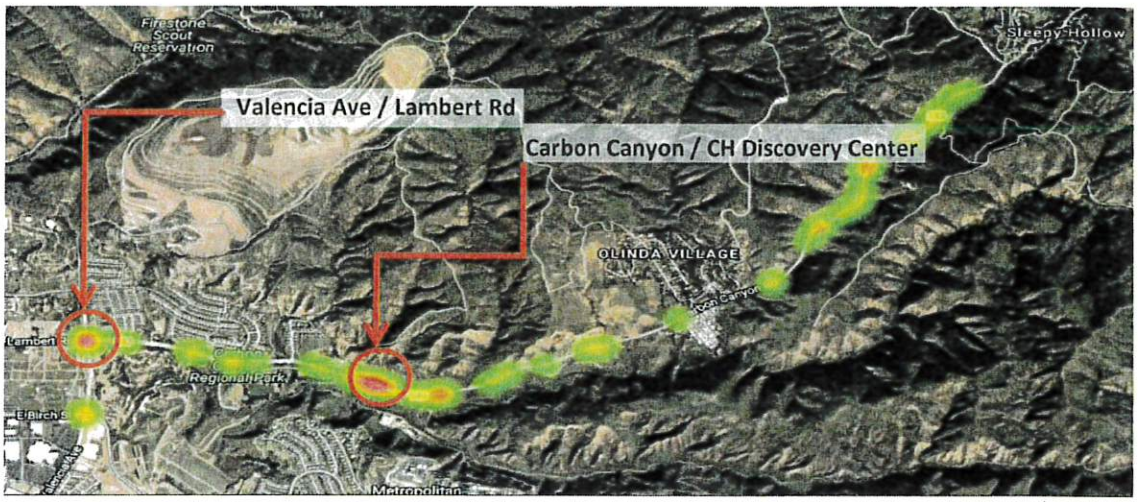


Figure 9: Heat Map of Collision Locations - Brea Segment

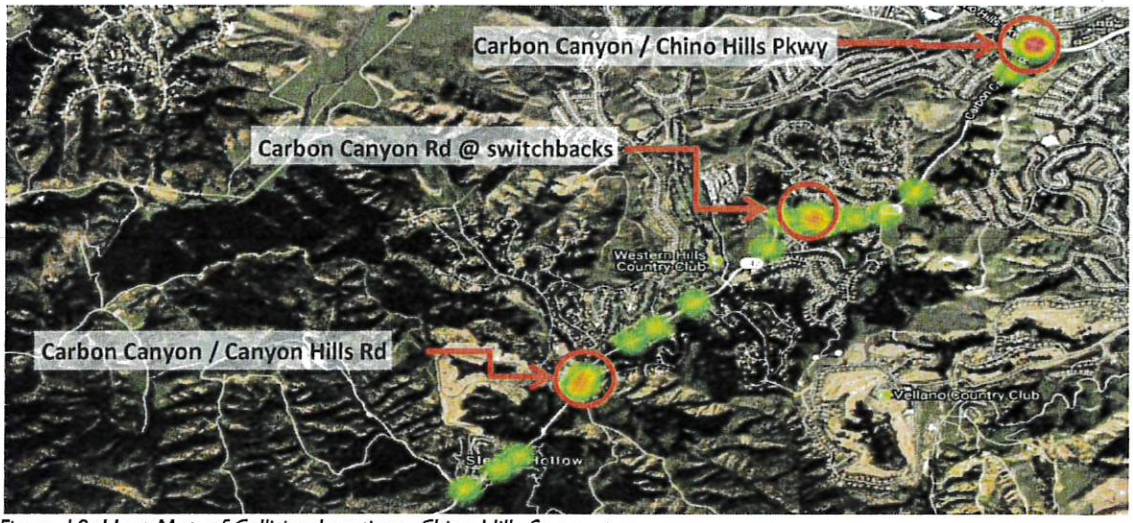


Figure 10: Heat Map of Collision Locations- Chino Hills Segment

Collision Diagram

Collision diagrams are used to display and identify similar accident patterns. They provide information on the type and number of accidents; including conditions such as time of day, day of week, climatic conditions, pavement conditions, and other information critical to determining the causes of safety problems. Road collisions cannot be totally prevented but by providing suitable traffic engineering and management, the collision rate can be reduced to a certain extent. For this reason a systematic study of traffic collisions will need to be carried out. Proper investigation of the cause of collisions will help to propose preventive measures in terms of design and control. A detail investigation of the collisions will be conducted for Phase 2.

Geometric Deficiencies

Geometric standards for a state highway were researched and compared to the existing lane geometrics on Carbon Canyon Road (SR-142). The study of locations where geometric standards are not met for turning radius, shoulders and grades, pavement markings and striping as well as driver visibility at intersections will require additional study and this can be completed in the future Phase 2 study.

Horizontal Alignment

Table 203.2
Standards for Curve Radius

Design Speed mph	Minimum Radius of Curve (ft)
20	130
30	300
40	550
50	850
60	1,150
70	2,100
80	3,900

Source: Caltrans Highway Design Manual Table 203.2

The switchbacks west of Old Carbon Canyon Road (SR-142) is one location where this roadway clearly does not meet current design standards. The radius is approximately 30 feet based on our initial review. Note that even at a design speed of only 20 mph, the minimum curve radius per HDM is set at 130 ft. The posted speed limit for Carbon Canyon Road (SR-142) is 40-45 mph, meaning that current design standards would require a minimum curve radius of at least 550 feet. The switch backs on SR-142 are shown in Figure 11. As shown in Figure 12, there is evidence that trucks are having problems making the turns within the existing paved area. Trucks appear to be scraping on the asphalt curb, and using the unpaved area in order to make the turn.

Figure11 : Switchbacks on Carbon Canyon Road

Figure 12: Evidence of Truck or Vehicle Scraping

A WB-40 AASHTO truck turning template was used to conduct a preliminary review for truck mobility through the corridor. Two key locations were selected as conflict points along the corridor. Trucks are bigger and heavier than passenger vehicles, and therefore, are slower to accelerate, require longer stopping distances, and have larger turning radii than a passenger vehicle. Trucks are more adversely impacted by uphill grades. The truck operating speed on a roadway is determined by the truck speed at

the beginning of the grade, the grade of slope, and the grade length. On long uphill grades, trucks eventually reach a crawl speed. Within the corridor on both approaches there are slopes that average between 6-8% which can affect the trucks travel speeds without slowing down the traffic flow within the corridor. Furthermore the turn radii's are tight, trucks often have to swing wide, encroaching into the adjacent lane, so that the trucks do not ride up onto a shoulder area. This is of particular concern on two lane streets where the trucks must encroach into the oncoming traffic lane such as at the switchbacks. Due to the higher volumes of vehicular traffic, such turning movements can seriously disrupt the flow of traffic and can create safety concerns.

Figure 13: Truck path along narrow section within Sleepy Hollow community near Oak Way Lane

Trucks traveling along the corridor encounter many tight areas such as the one depicted in Figure 13 above. Based on the identified truck path, the trucks may take up the entire lane in certain areas. This becomes increasingly dangerous in the Sleepy Hollow community because of the narrow shoulders and residences being adjacent to the roadway. Figure 14 shows areas near Rosemary Lane and Francis Drive where the roadway is approximately 24 feet with a 2 foot shoulder within the Sleepy Hollow community. This creates an unsafe condition for bicyclist that may travel along this route.

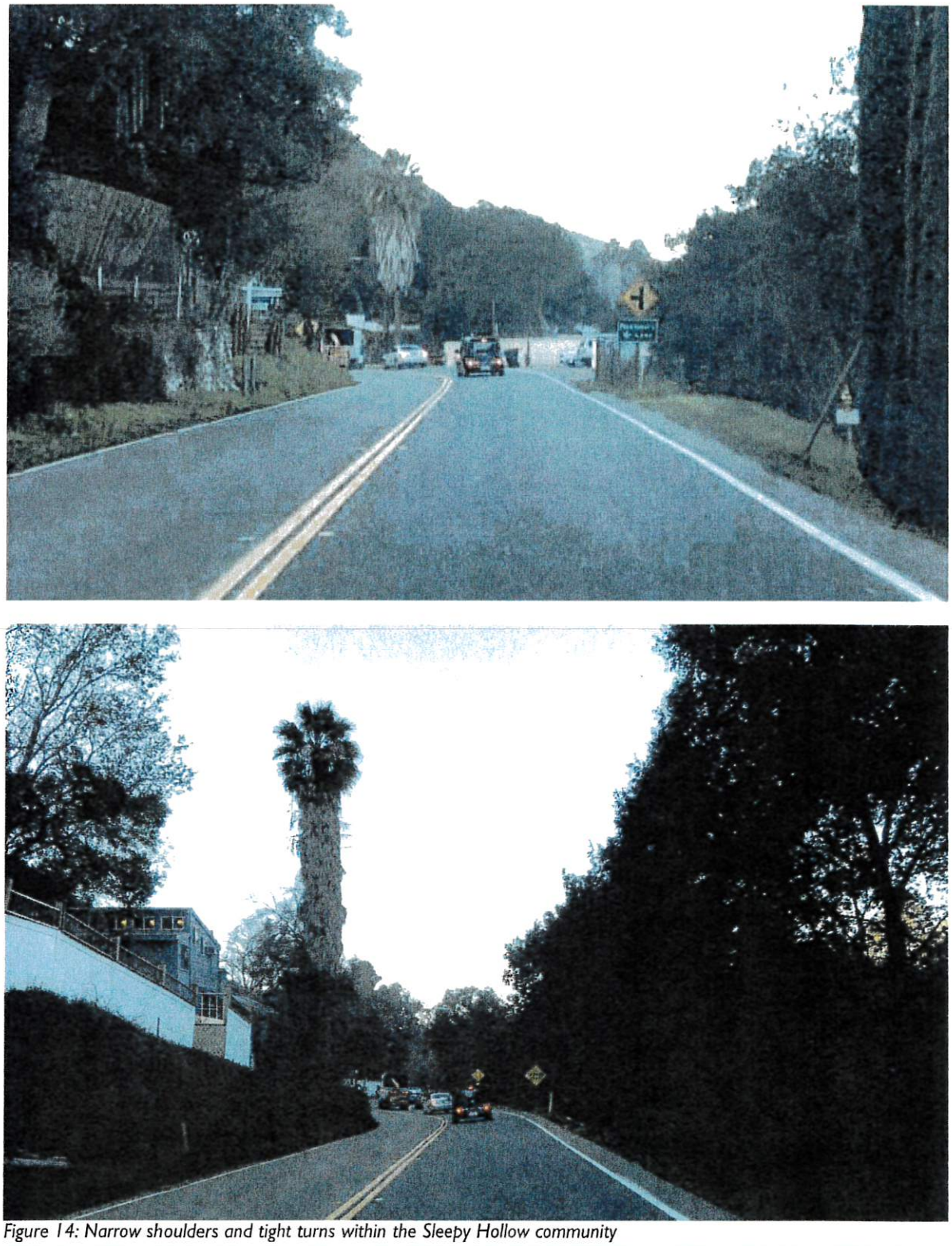


Figure 14: Narrow shoulders and tight turns within the Sleepy Hollow community

The truck turning radius was also evaluated at the switchbacks located within the City of Chino Hills. It is the length of wheel base that governs the truck turning path for each truck type. The longer the wheel base, the wider the turning radius of the truck. Figure 15 below shows the truck path traveling westbound along Carbon Canyon Road (SR-142). During one of our corridor observations, multiple truck sizes were observed using the roadway. The largest truck observed to use this roadway was a WB-40 type truck. The observer was traveling ahead of the truck in order to log the approximate delay time that this size of truck would cause on the corridor and identified a 15-minute window that traffic was delayed coming out of Carbon Canyon onto Chino Hills Parkway. This was probably due to the grade approach leading up to Carriage Hills Lane and maneuvering through the switchbacks. Below is the typical approach a truck would take to maneuver through the switchbacks. It is important to note that this is the recommended alignment a truck should take. The alignment drivers take differ depending on their experience driving the truck and knowledge of the route.

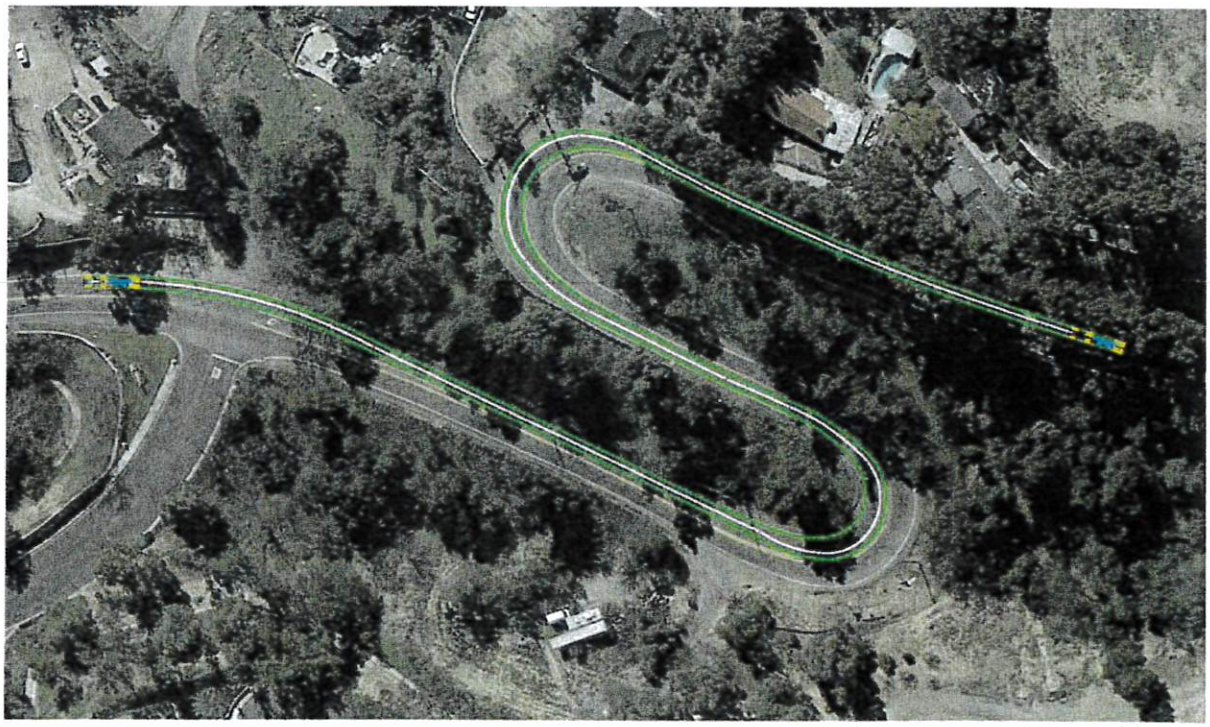


Figure 15: Recommended truck turning alignment on Chino Hills switchbacks

Figure 16 on the next page shows the traffic flow on the switchbacks during A.M. and P.M. peak hours. Traffic was observed during both the A.M. and P.M. peak hours traveling approximately 5-10 mph through the switchbacks. Traffic builds up approaching the switchbacks due to the low speeds needed to maneuver around the tight turns and grades from both approaches.

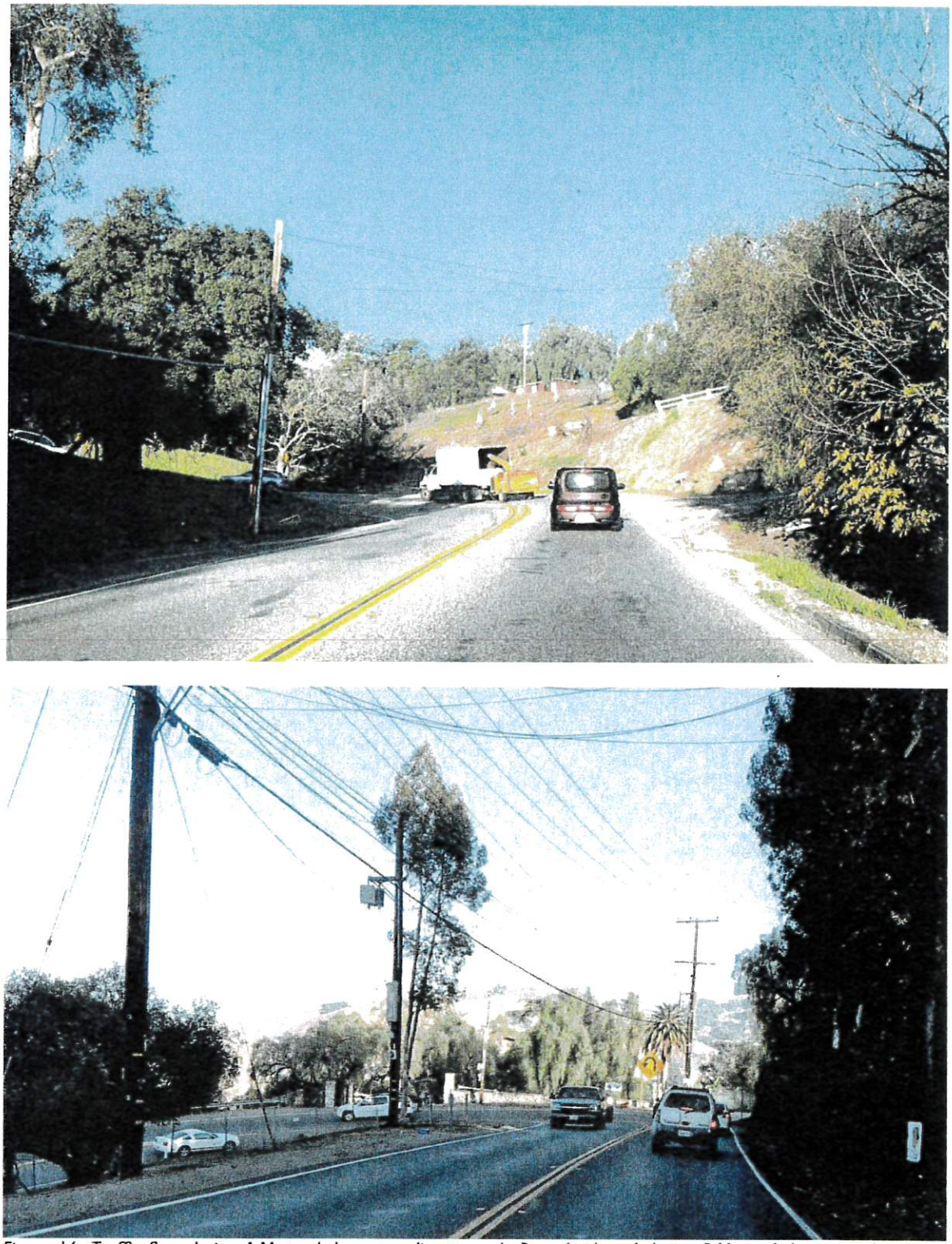


Figure 16: Traffic flow during A.M. peak hour traveling towards Brea (top) and during P.M. peak hour traveling towards Chino Hills (bottom)

Vertical Alignment

Steep grades greatly affect truck operating speeds, as well as overall roadway capacity. Section 204.5 in the Caltrans Highway Design Manual offers guidance on Sustained Grades, which are applicable along Carbon Canyon Road (SR-142) due to the mountainous terrain. The length of an uphill grade also affects the roadway capacity, LOS and truck travel speed. When the truck running speed falls 10 miles per hour or more below the running speed of remaining traffic, a climbing lane should be considered. KOA anticipates that these criteria would be met along Carbon Canyon (SR-142), however due to the mountainous terrain; the addition of this roadway width may not be feasible. A 4-foot shoulder would be required on the right side of the climbing lane per HDM Table 302.1. As can be seen in Figure 17 below, traffic flow is already minimized and trucks traveling this route would create additional constraints. Figure 18 on the next page depicts the typical traffic buildup on the steep grade traveling eastbound approaching Olinda Place and Ruby Street.

Table 204.3

Maximum Grades for Type of Highway and Terrain Conditions

Type of Terrain	Freeways and Expressways	Rural Highways	Urban Highways
Level	3%	4%	6%
Rolling	4%	5%	7%
Mountainous	6%	7%	9%

Source: Caltrans Highway Design Manual Table 204.3

Figure 17: Traffic backs up on the climb leading into the switchbacks during the A.M. peak hours

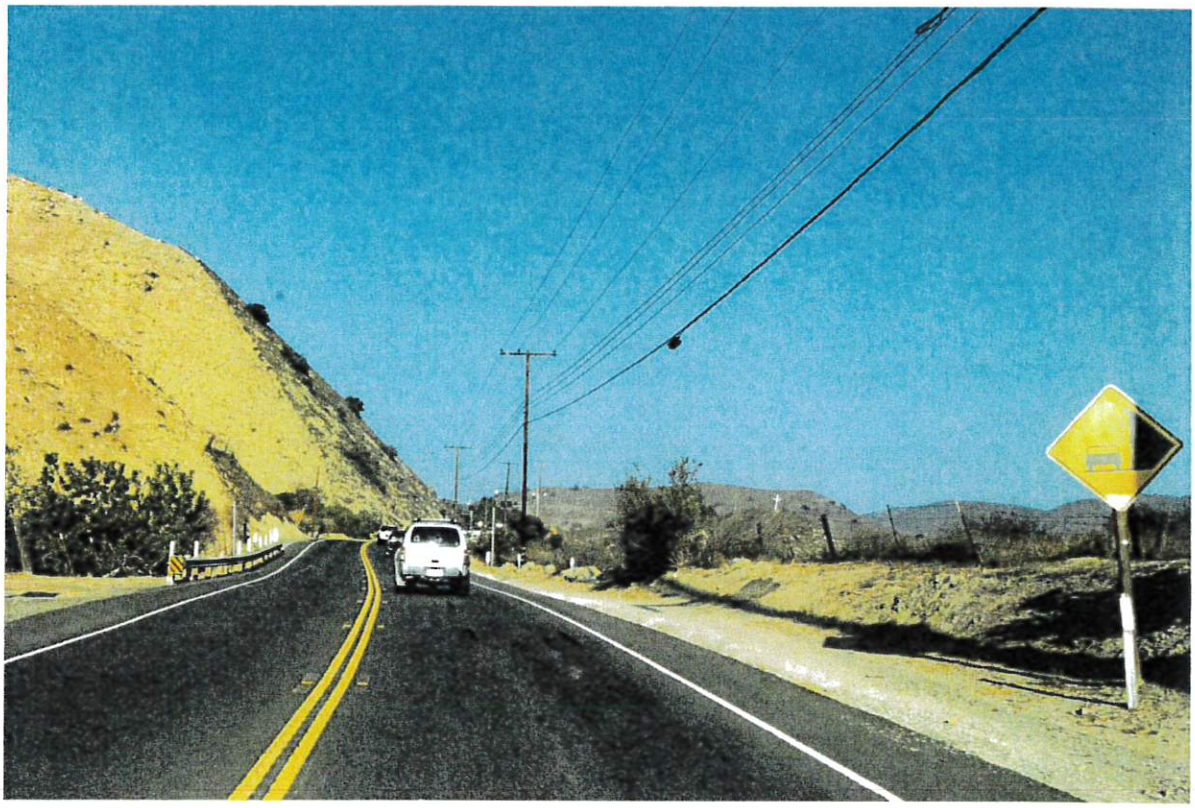


Figure 18: Traffic backs up on the steep grade heading towards the signalized intersections of Olinda Place and Ruby Street during the P.M. peak hours

Roadway Width & Cross Section

HDM Topic 301 discusses Traveled Way Standards. The minimum lane width on a two-lane roadway is 12 feet, which appears to be met throughout this segment of SR-142. Typical shoulder widths for resurfacing, restoration and rehabilitation (3R) and pavement resurfacing and restoration (2R) projects on two-lane roadways is provided in Table 2.

TABLE 2

Two-Lane Conventional Highway 3R Standards for Shoulder Widths

Existing ADT (vehicles)	3R Bridge Shoulder Width (ft)	3R Shoulder Width (ft)	Minimum Existing In-Place Bridge Shoulder Width (ft)	Minimum Existing In-Place Shoulder Width (ft)
0-250	4	0 *	0	0
251-1000	4	2 *	2	0
1001-3000	8	4 *	4	2
3001-6000	8	8	6	4
6001-18,000	8	8	8	4
Over 18,000	8	8	8	8

*** See discussion in Section 3.3.3.6.1.2.1, "Roadbed." Under certain conditions, the minimum width of the adjacent right shoulder shall be 4 feet, or 5 feet where a gutter is present.**

Source: DIB 79-03, Table 2

Eight foot shoulders would likely be infeasible throughout this corridor. However, maintaining a 4 foot shoulder for bicycle use and for tight curves is recommended wherever possible.

Clear Zone

When widening or modifying existing embankment slopes, a 4:1 or flatter side slope should be used. A 1V:4H slope is considered the maximum slope that would be recoverable for motorists. The AASHTO Roadside Design Guide indicates that approximately 14-22 feet of clear zone (inclusive of the roadway shoulder) are recommended for 40-45 mph roadways, with ADT over 6,000 (as we have on SR-142). Where the recommended slopes and clear zone widths are not practical, alternative countermeasures can be considered such as shielding the roadway with guardrails or the use of roadway delineators (per DIB 79-03, Table 1).

Bicycle Facilities

There are existing bike lanes from Old Carbon Canyon Road (SR-142) to Chino Hills Parkway, as shown in Figure 21. Bike lanes are not provided west of Old Carbon Canyon Road.

West of Old Carbon Canyon Road, the roadway narrows at the switchbacks, leaving no shoulder or bike lanes. It is possible that a bicycle boulevard utilizing local streets could avoid this area by way of Old Carbon Canyon Road and Carriage Hills Lane however this would create another challenge making a left turn onto Old Carbon Canyon Road. Although it is still steep, this route could be further investigated as an alternate to the switchback section of Carbon Canyon Road (SR-142) for bicycles, as

it would be a lower volume roadway with better visibility on curves. Figure 19 shows where the bike lane headed eastbound begins after Old Carbon Canyon Road.

Figure 19: Bike Lanes headed eastbound away from Old Carbon Canyon Road

West of the switchbacks, variable width shoulders are available and could be used for cycling. The minimum shoulder width for use by bicyclists and pedestrians is 4 feet, however wider shoulders or physically separated facilities are preferred due to the high speeds along this roadway.

Pedestrian Facilities

Currently there is minimal to no pedestrian infrastructure in the corridor. The next iteration of this report will examine pedestrian facility connectivity and feasibility.

3. PROBLEM STATEMENT

Based on the information, data and analysis described above, the following problem statement was developed:

Carbon Canyon Road (SR-142) is a two-lane highway that directly connects Orange County and San Bernardino County. This section of roadway experiences significant elevation gains resulting in grades of over the typical standard of seven percent. The roadway is an alternative to regional freeways (i.e. Route 57, Route 60 and Route 91) and attracts additional regional traffic when these regional freeways become congested. Caltrans has determined that traffic levels will continue to increase, and a *Transportation Concept Report* completed in 2016 by Caltrans indicated that achieving congestion

reduction would require widening the route. Because of the terrain and proximity of development, this widening is not possible. Major traffic delays occur at signalized intersections at the ends of the study corridor and where lanes drop from four lanes to two lanes as well as at sections of the roadway with steep grades.

The steep grades impact the ability of trucks to move through the corridor at speeds near posted speeds. Roadway switchbacks present near the highest part of the route provide a challenge to truck movements and other vehicle movements. Slow truck movements also impact other vehicle movements.

Collision data indicated a number of higher collision locations. These locations occur at tight curves, where lane reductions occur and at unsignalized intersections. The major causes of collisions were high speeds on downhill grades and improper turning at intersections. The predominate type of collisions is rear end collisions resulting from braking on downhill sections or slowing down as one moves through uphill sections. The high number of fixed object collisions is a result of narrow or non-existent travel shoulders for portions of the route.

There are sections of the Carbon Canyon Road where current roadway geometry is below standard. These are primarily where travel shoulders are narrow or not provided, or where steep grades or tight horizontal curves exist. The narrow shoulders also impacts bicycle travel.

4. NEXT STEP - PHASE 2 SCOPE OF WORK

The purpose of the initial study was to provide an overview, identify problem locations and the cause and provide recommendations for the next step. The second phase (Phase 2) will consist of a full and in-depth study of the corridor. Coordination with cities of Chino Hills and Brea, Caltrans (District 8 and District 12) and outreach to other stakeholders will be part of the effort for the second phase of the study.

The Phase 2 study will examine how traffic movement can be enhanced along Carbon Canyon Road by reducing delays and enhancing travel safety. A number of tasks are proposed as listed below. The improvement of travel flow will involve examining traffic operations at traffic signals and intersections, traffic operations of trucks and school buses, bicycle and pedestrian connectivity, and examining side-street and driveway access. Collision data will also be examined in greater detail. Recommendations and conceptual drawings will be developed for improved roadway, bicycle and pedestrian infrastructure and intersection improvements.

Task 1: User Origin and Destination Evaluation

Complete a comprehensive review of user origin and destination survey to understand travel patterns and determine through versus local traffic use of Carbon Canyon Road. New technologies are available that can capture and analyze anonymously, real-time, cellular-signal data points to identify travel patterns and transportation trends. It is anticipated that the majority of the users may not be directly from cities of Chino Hills or Brea but other cities in the counties of Orange and San Bernardino.

- KOA will utilize the cellular-signal data in conjuction with a travel run time analysis to understand commuter patterns, reduce traffic flow restrictions, congestion and transportation system bottlenecks on both City of Chino Hills and Brea street networks.
- KOA will make recommendations that will improve the commute times and congestion along the corridor.

Task 2: Project Coordination

- KOA will reach out to other related agencies including City of Brea and Caltrans (both District 8 and District 12) to identify multi-agency collabrative solutions.
- KOA will host and facilitate a working meeting with key stakeholders to discuss findings and possible recommendations to the corridor.

Task 3: Traffic Operations

Complete a comprehensive review of existing traffic operational analyses at major intersections, including collecting peak hour turning movement counts, signal timing sheets, and conducting travel time runs and quantitative queuing/delay evauations.

- KOA will analyze the key signalized intersections within the City of Chino Hills along Chino Hills Parkway (intersections towards the SR-71 freeway) and in the City of Brea along Lambert Road and Valencia Avenue (intersections towards SR-57).
- KOA will evaluate all collision data and create collision diagrams, identify improvement locations and create conceptual drawings for the safety treatments.
- KOA will conduct traffic signal warrants at key locations due to increased development in the area such as Canyon Hills Road.

Task 4: Geometric Deficiencies Evaluation and Improvement Recommendations

- KOA will conduct a comprehensive review of existing roadway geometric conditions, including cross slopes and clear zones.
- KOA will conduct a truck turning template analysis for both directions for the corridor to identify the largest truck that can safely traverse this alignment. Based on this analyses, KOA will identify possible opportunities to improve this alignment by widening shoulders or adjusting the roadway striping.
- KOA will review existing topographic information to identify grade reduction opportunities, cut/fill volumes, and costs associated with them. KOA will also review the need for climbing lanes as well as the space/roadway cross section requirements.
- KOA will evaluate connectivity within the corridor that will involve conducting sight distance analysis, left turn pocket warrants, acceleration and deceleration lane warrants, and the need for truck turnouts.
- KOA will prepare conceptual drawings for potential roadway and spot improvement recommendations.

Task 5: Bicycle Route Evaluation

Examine the corridor for a bicycle route and make recommendations for improving the connection. There are currently bicyclists who already travel through the corridor.

- KOA will review pavement widths and identify potential bicycle facilities. KOA understands that the San Bernardino portion of SR-142 (from Chino Hills Parkway to the Orange County line) is a proposed Class 3 bikeway.
- KOA will review existing shoulder and lane widths for the entire corridor and identify opportunities to add shoulders, or widen shoulders to a 4 foot minimum width to accommodate bicycle traffic and create a consistant network. This will include preparing conceptual drawings for the proposed improvements in accordance with Caltrans Design Guidline and MUTCD latest guidelines.

Task 6: Travel Demand Management Plan

- KOA will research other traffic demand management policies and provide recommendations.
- KOA will evaluate the feasibility of providing designated school bus stops off of the corridor to lessen the impact during traffic peak hours.
- KOA will identify and list potential Inteligent Transportation Systems traveler information options.

Task 7: Pedestrian Connectivity Evaluation

Examine the pedestrian infrastructure and make recommendations for improving the connectivity and safety for the corridor.

- KOA will evaluate and identify potential pedestrian network facilities that would improve intersection safety and connectivity to public parks and recreational areas within the corridor.
- KOA will prepare conceptual drawings in accordance with Caltrans Design Standard and MUTCD latest guidelines.

Task 8: Improvement Cost Estimation and Project Prioritization

KOA will prepare rough magnitude of cost estimates for both non-infrastructure and infrastructure improvements. We will work with City of Chino Hills and other agencies to priorize the projects into action plans including immediate, interim and long range recommendations.