

(REVISED) APPENDIX E
TRAFFIC QUEUING ANALYSES

MEMORANDUM

Date: May 1, 2015 **Job No.:** 2015-05

To: Vadim Malik-Karamov
VMK Design Group
3777 Stevens Creek Blvd., Suite 420
Santa Clara, CA 95051 **Copies To:** -

From: Easton McAllister, PE

Subject: 556 El Camino Real - Parking

Comments:

Vadim,

I have reviewed the information provided regarding a parking queue for residents while utilizing the automated parking structure. Based on the information provided, it appears that a traffic engineer has estimated that the peak 15-minute traffic rate generated from the new development would create a 3 car backup while operating the automated stacker. The current design provides ample room for three cars in the driveway, however the City is requesting additional space. It is unclear how many additional spaces the City is requesting.

It appears that room for a fourth car is almost available in the current design. Pulling building back from El Camino would only add one car, there is not enough space to add any more and maintain a single line. Extending the driveway closer to the property line would be more effective since there is more space to increase driveway length. Regardless, alternative means may be preferable to avoid backup on El Camino Real. My recommendations are summarized below:

Methods for improving circulation:

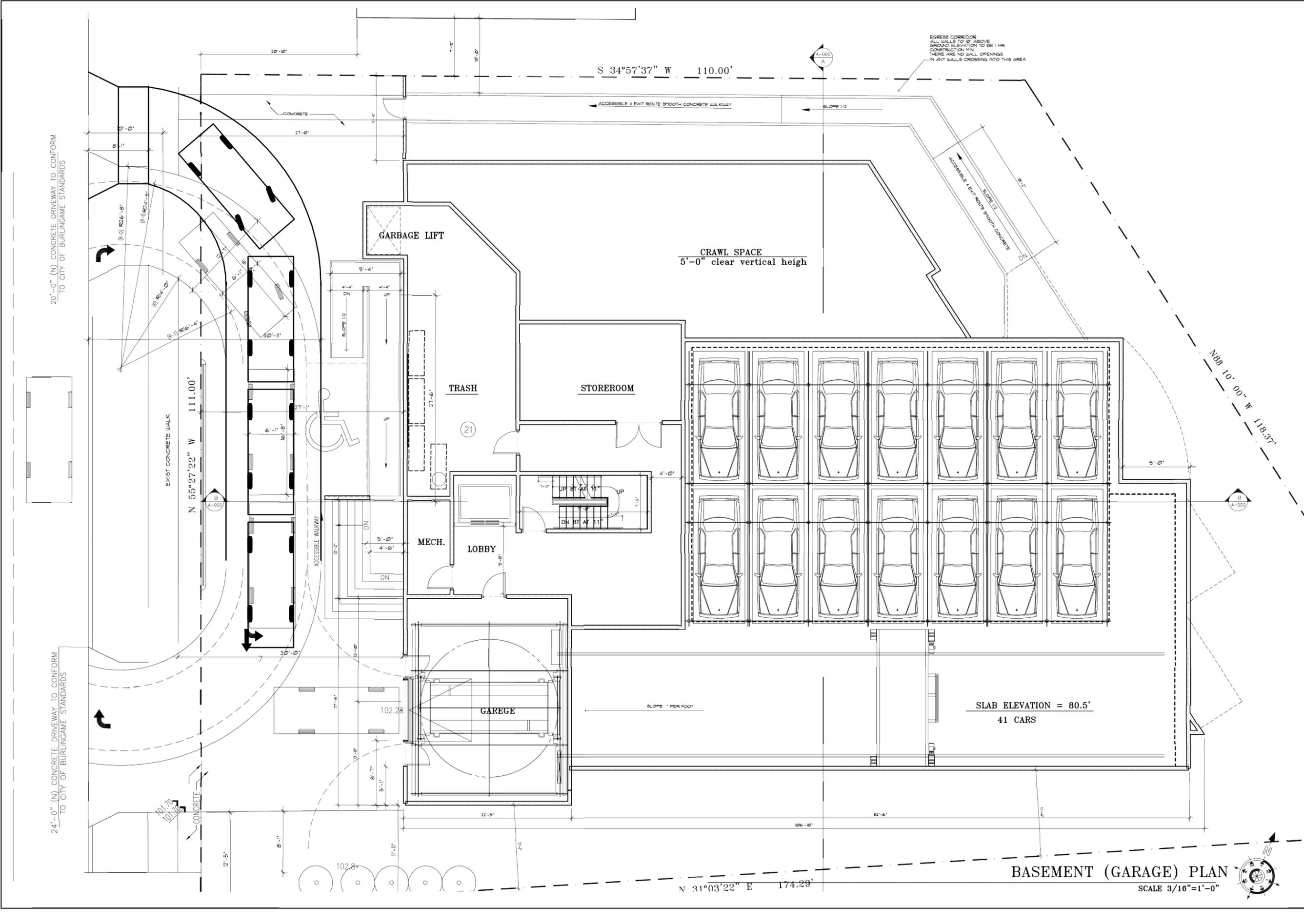
- Lengthen driveway towards the property's westerly boundary. This shift would be more effective than pulling back from El Camino since there is more space in that dimension.
- A fourth car would create a factor of safety of 33%, which seems adequate for this project.
- Notify future residents that blocking ECR is not allowed. If the queue is full, residents must circle the block.
- Provide signage to this effect as requested by traffic engineer.
- Paint stripes in driveway to place cars in order. This could prevent excessive separation between cars and show incoming residents whether all spaces in the queue are full.

No matter what the estimated queue would be, a higher number may occur on any given day. Requiring overflow to prevent blockage on El Camino would be a worthwhile requirement of the residents. Feel free to contact me if you have any questions or comments.

Signed,



Easton C. McAllister, PE



REVISION	BY
1	XXXXX
	VMK

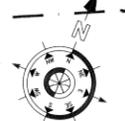
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556 EL CAMINO REAL
 BURLINGAME, CA

DATE	03/03/14
SCALE	3/16"=1'-0"
DRAWN	VMK
JOB	ROMAN
SHEET	A-1
OF	SHEETS

BASEMENT (GARAGE) PLAN
 SCALE 3/16"=1'-0"





Civil and Transportation Engineering
Celebrating 35 years of service in northern California

May 5, 2015

Mr. Vadim Melik-Karamov
VMK Design Group
3777 Stevens Creek Blvd., Suite # 420
Santa Clara, California 95051

RE: 556 El Camino Real, Burlingame

Dear Vadim:

I have evaluated your 22 unit residential condominium project with respect to vehicle trip generation and queuing. Enclosed is a table showing time of day vehicle trip generation for a 22 unit condominium development. During the morning peak hour it is projected that 12 vehicles will leave the site and three vehicles will enter the site. During the afternoon peak hour 11 vehicles are projected to enter the site and five vehicles will leave the site. The afternoon peak hour is the one during which the most vehicles will be entering the site and the one where queuing of vehicles waiting to enter the parking machine.

During the peak hour there will be a peak 15 minutes with the highest rate of vehicles entering and exiting the site. If you consider the peak rate within the peak hour to be 19 vehicles per hour and the service rate of the parking machine to be 30 vehicles per hour, the queue would be on the order of one vehicle during the peak 15 minutes of the peak hour. If the service rate of the machine drops to 25 vehicles per hour, the queue increases to 2.5 vehicles. As the service rate approaches 19 vehicles per hour, the queue increases exponentially. The greater the queue, the longer time it will take to clear the queue because of the lack of maneuverable space in front of the building. All this means a small decrease in the service rate of the parking machine will result in significant increases in queued vehicles. At the least you should plan to queue three vehicles at the front of the site waiting to enter the parking structure. The queue should not be so positioned to block those vehicles exiting the site from the parking structure.

If you have any questions, please feel free to call me at your convenience or e-mail me at rhopper@rkhengineering.com.

Sincerely,

RKH

A handwritten signature in black ink that reads "Richard K. Hopper". The signature is written in a cursive style.

Richard K. Hopper, P.E.
Principal

encl.

RESIDENTIAL CONDOMINIUM/TOWNHOUSE

(230)

Location: 556 El Camino Real, Burlingame

Date: 5/5/2015

LAND USE

22	DU
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TRIP GENERATION

7.83	VTE/DU
172	VTE/DAY

HOUR	%AWDT		
	INBOUND	OUTBOUND	TOTAL
12MN-1AM	1.0	0.3	1.3
1-2	0.5	0.2	0.7
2-3	0.2	0.2	0.4
3-4	0.2	0.1	0.3
4-5	0.1	0.1	0.2
5-6	0.1	0.5	0.6
6-7	0.4	1.9	2.3
7-8	1.0	5.1	6.1
8-9	1.5	7.0	8.5
9-10	1.4	4.1	5.5
10-11	1.3	2.7	4.0
11-12NN	2.2	2.0	4.2
12NN-1PM	2.7	1.8	4.5
1-2	2.4	2.1	4.5
2-3	2.5	2.5	5.0
3-4	3.1	2.5	5.6
4-5	4.4	2.5	6.9
5-6	6.4	3.1	9.5
6-7	5.5	3.0	8.5
7-8	3.8	3.0	6.8
8-9	3.1	2.1	5.2
9-10	2.5	1.6	4.1
10-11	2.1	1.2	3.3
11-12MN	1.6	0.4	2.0
	50.0	50.0	100.0

VTE/HR.		
INBOUND	OUTBOUND	TOTAL
2	1	2
1	0	1
0	0	1
0	0	1
0	0	0
0	1	1
1	3	4
2	9	11
3	12	15
2	7	9
2	5	7
4	3	7
5	3	8
4	4	8
4	4	9
5	4	10
8	4	12
11	5	16
9	5	15
7	5	12
5	4	9
4	3	7
4	2	6
3	1	3
86	86	172

AMPH

PMPH

Reference: ITE Trip Generation, 9th Edition ©2012

Caltrans 13th Progress Report on Trip Ends Generation Research Counts



February 13, 2018

Mr. Will Burns
David J. Powers & Associates, Inc.
1111 Broadway, Suite 1510
Oakland, California 94607

Re: *Peer Review of the Queuing Analysis Completed for the Proposed Residential Project at 556 El Camino Real in Burlingame, California*

Dear Mr. Burns:

Hexagon Transportation Consultants, Inc. has completed a peer review of the queuing analysis completed by RKH Civil and Transportation Engineering, dated May 5, 2015, for the proposed residential development at 556 El Camino Real in Burlingame, California. The proposed project would construct 21 residential condominium units. The peer reviewed traffic analysis was based on an earlier site plan, which showed 22 units. Thus, the traffic analysis by RKH is conservative in that it slightly overstates the project trip generation and queue lengths associated with the currently proposed project. Access to the site would be provided by a semi-circular one-way driveway that intersects El Camino Real at two locations; the northern end of the driveway would be the exit and the southern end of the driveway would be the entrance. There would be two surface parking stalls with electric vehicle charging stations along the northern edge of the site near the exit driveway. In addition, the project would provide a completely automated parking system in which users drive into the transfer compartment, exit the vehicle, and the vehicle is automatically delivered to one of 35 parking spaces. When the driver is ready to leave, he or she swipes a card or enters a code and the transfer compartment retrieves the vehicle. The automated parking system bay will meet ADA guidelines for accessibility. Of the 35 parking spaces, 23 would have sufficient vertical clearance to accommodate high-profile vehicles (e.g. vans or SUV's), while 12 spaces would be limited to low-profile vehicles (e.g. sedans).

The queuing analysis completed by RKH includes an estimate of project generated traffic and an analysis of the queue length for inbound vehicles waiting to enter the automated parking system to determine if the project may cause vehicle queues that spill back onto the public street. RKH recommended that the project driveway provide on-site storage space for at least three vehicles waiting to enter the automated parking system. Current site plans show three vehicles could queue in the driveway leading to the parking system entrance assuming a typical spacing of 20 feet per vehicle. Our independent analysis shows that the proposed on-site storage would be sufficient to prevent queues from extending onto El Camino Real based on the average parking system service times. Details of our peer review and additional recommendations to facilitate parking operations and to prevent excess queues during parking system malfunctions are presented below.

Project Trip Generation

The project trip generation estimates prepared by RKH list the Institute of Transportation Engineers (ITE) *Trip Generation Manual, 9th Edition* and the Caltrans *13th Progress Report on Trip Ends Generation Research Counts* as references. Subsequent to the analysis by RKH, the



10th Edition of the ITE *Trip Generation Manual* has been published, which indicates that midrise townhomes in suburban areas generate vehicle trips at a lower rate than previously reported. Thus, the project trip estimates prepared by RKH may overstate the actual trip generation. Hexagon recommends using daily and peak-hour trip rates from ITE's *Trip Generation Manual, 10th Edition*, which is the most widely accepted, comprehensive, and current source of data.

As seen in Table 1, based on current ITE rates, the project is estimated to generate 114 daily trips, with 8 trips occurring during the AM peak hour (7-9 AM) and 10 trips occurring during the PM peak hour (4-6 PM). Using the PM peak hour to account for the busiest time, this equates to an average demand on the automated parking system of one vehicle every 360 seconds, or around one vehicle every six minutes.

Table 1
Trip Generation for Proposed Residential at 556 El Camino Real

Land Use	Size	Units	Daily Rates	Daily Trips	AM Peak Hour			PM Peak Hour				
					Pk-Hr Rate	In	Out Total	Pk-Hr Rate	In	Out Total		
Proposed Use												
Residential Condominiums / Townhouse ¹	21	DUs	5.44	114	0.36	2	6	8	0.44	6	4	10
Total Proposed Project Trips				114		2	6	8		6	4	10
Notes:												
DUs = dwelling units												
¹ Multifamily Housing, Midrise, General Urban/Suburban (Land Use 221), <i>ITE Trip Generation, 10th Edition</i> , 2017, average rates are used.												

Queueing Analysis

It is unclear how RKH derived their conclusions regarding the probable queue length as the methodology is not described in their letter report, and there are no calculations attached. Furthermore, RKH reports the likely queue for a range of service rates. The applicant has indicated that the parking system will be provided by CityLift. According to CityLift, the proposed parking system would have an average service time of 90 seconds, which means that the automated parking system can service 40 vehicles per hour. Note that the same transfer compartment is responsible both for parking inbound vehicles and retrieving outbound vehicles. However, only the inbound vehicles would queue in the driveway while waiting to be parked, while outbound vehicles would remain in their parking space while waiting to be retrieved.

Vehicle queues were estimated using a Poisson probability distribution, which estimates the probability of “n” vehicles in the queuing system using the following formula:

$$P(x=n) = \frac{\lambda^n e^{-\lambda}}{n!}$$

Where:

P(x=n) = probability of “n” vehicles in queue

n = number of vehicles in the queue (including the vehicle in the transfer compartment)



λ = Average number of vehicles in the queue (vehicle arrivals per hour / vehicles processed by the parking system per hour)

The estimated outbound vehicle trips during the PM peak hour (4 vehicles per hour) were subtracted from the average service rate (40 vehicles per hour) in order to estimate the average number of inbound vehicles that could be served during the PM peak hour (36 vehicles per hour). This means that the automated parking system can service one inbound vehicle in an average time of 100 seconds.

As shown in Table 1, the project is expected to generate six inbound vehicle trips during the PM peak hour. However, the headway between inbound vehicles would not be uniform. The queuing analysis was conducted based on the estimated vehicle arrivals during the peak 15-minute period within the PM peak hour. To be conservative, it is assumed that four vehicles would arrive during the peak 15-minute period, which equates to a rate of 16 vehicle arrivals per hour. The vehicle queue estimates and a tabulated summary of the findings are provided in Table 2.

Table 2
Queuing Analysis

Number of Queued Vehicles (n) *	Individual Probability P (x=n)	Cumulative Probability P (x<=n)
0	0.6412	0.6412
1	0.2850	0.9261
2	0.0633	0.9895
3	0.0094	0.9989
4	0.0010	0.9999
5	0.0001	1.0000

* includes vehicle in the transfer compartment in the process of parking/retrieving.

The analysis indicates that during the peak 15-minute period, there is only about a 0.01 percent chance that there would be more than four vehicles in the queue including one vehicle in the transfer compartment and three vehicles queued in the inbound driveway.

Recommendations

The following recommendations are provided to ensure the proposed automatic parking system does not disrupt traffic flow on El Camino Real.

- The site driveway should include signage and/or striping to instruct inbound vehicles where to wait so as not to block vehicles exiting the transfer compartment.
- The ramp that leads to the parking system entrance has a slope that ranges from 8 to 18 percent. Vehicles may have difficulty stopping and maintaining their position in a queue on such a steep slope. The previous site design, which showed vehicles entering from the northern end of the semi-circular driveway, would avoid the need for vehicles to queue on the ramp by providing flat queuing space for inbound traffic within the semi-circular



Mr. Will Burns
February 13, 2018
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driveway and signaling for a vehicle to proceed down the ramp when the parking system is available to receive the next incoming vehicle.

- Clear signage should be provided at the top of the ramp advising of the parking system's vehicle size limits and whether visitors are permitted to park in the parking system. The signage is important because there is no space for vehicles to turn around at the bottom of the ramp if they discover they are not able to enter the parking system.
- The automated parking entrance should include some means to communicate with drivers the expected wait time and any malfunction of the parking system. Residents should be notified that parking and/or stopping is not permitted on El Camino Real. Furthermore, residents should be informed of the nearest alternative legal parking locations to be used if the automated parking system is inoperable.

Thank you for the opportunity to conduct this peer review. If you have any questions, please do not hesitate to call.

Sincerely,

HEXAGON TRANSPORTATION CONSULTANTS, INC.

A handwritten signature in black ink that reads "Michelle Hunt".

Michelle Hunt
Vice President and Principal Associate