

## APPENDIX E

# TRAFFIC QUEUING ANALYSES

## MEMORANDUM

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**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**

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**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  
xxxxx VMK

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# 556 EL CAMINO REAL

BURLINGAME, CA

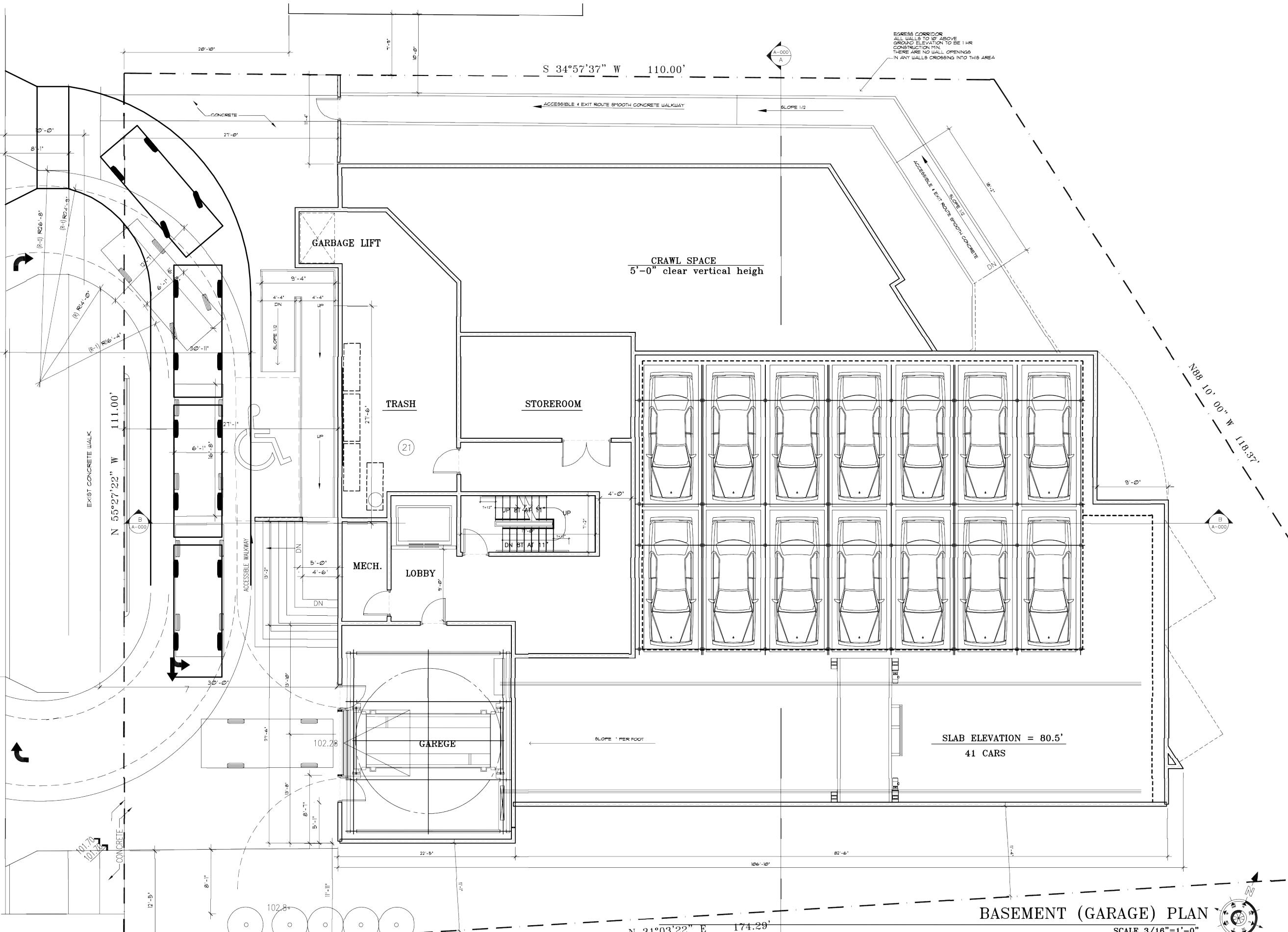
DATE 09/03/14  
SCALE 3/16"=1'-0"  
DRAWN VMK  
JOB ROMAN  
SHEET A-1  
OF SHEETS

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

20'-0" (N) CONCRETE DRIVEWAY TO CONFORM  
TO CITY OF BURLINGAME STANDARDS



24'-0" (N) CONCRETE DRIVEWAY TO CONFORM  
TO CITY OF BURLINGAME STANDARDS





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**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](mailto:rhopper@rkhengineering.com).

Sincerely,

**RKH**

*Richard K. Hopper*

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

INBOUND	OUTBOUND	TOTAL	VTE/HR.	
			AMPH	PMMPH
2	1	2		
1	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		

Reference: ITE Trip Generation, 9th Edition ©2012

Caltrans 13th Progress Report on Trip Ends Generation Research Counts



November 18, 2016

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. The project proposes to use 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 the 41 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 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 four vehicles queued in the driveway leading to the parking system entrance. However, at a more typical spacing of 20 to 25 feet per vehicle, only three inbound vehicles could queue in the same space. 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. However, the daily trip rate listed by RKH exceeds the trip rate for residential condominium/townhouse reported by ITE. Furthermore, the peak-hour percentages reported by RKH are greater than the ratio of peak-hour trips to daily trips reported by ITE. 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, 9th Edition*, which is the most widely accepted, comprehensive, and current source of data.

As seen in Table 1, based on ITE rates, the project is estimated to generate 122 daily trips, with 9 trips occurring during the AM peak hour (7-9 AM) and 11 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 327 seconds, or around one vehicle every five 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		
<b>Proposed Use</b>												
Residential Condominiums / Townhouse <sup>1</sup>	21	DUs	5.81	122	0.44	2	7	9	0.52	7	4	11
<b>Total Proposed Project Trips</b>				<b>122</b>		<b>2</b>	<b>7</b>	<b>9</b>		<b>7</b>	<b>4</b>	<b>11</b>

Notes:  
DUs = dwelling units; KSF = 1,000 square feet gross leasable area.  
<sup>1</sup>Residential Condominium/Townhouse (Land Use 230), *ITE Trip Generation, 9th Edition*, 2012, 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 Parkmatic, Inc. According to the Parkmatic website, service times vary depending upon design but generally range from 1.5 to 3 minutes.

Hexagon conducted a queuing analysis assuming an average parking/retrieval time of 155 seconds, which means that the automated parking system can service one vehicle every 2.5 minutes or 23 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)



$\lambda$  = 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 (23 vehicles per hour) in order to estimate the average number of inbound vehicles that could be served during the PM peak hour (19 vehicles per hour). This means that the automated parking system can service one inbound vehicle in an average time of 189 seconds.

As shown in Table 1, the project is expected to generate seven 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	0.4317	0.4317
1	0.3626	0.7943
2	0.1523	0.9467
3	0.0426	0.9893
4	0.0090	0.9983
5	0.0015	0.9998
6	0.0002	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 0.2 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 exiting vehicles.
- 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



Mr. Will Burns  
November 18, 2016  
Page 4 of 4

the ramp by providing flat queuing space for inbound traffic within the semi-circular 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.**

Michelle Hunt  
Vice President and Principal Associate