October 11, 2021

Mr. Michael Plotnik, TE
CITY OF LA HABRA
110 East La Habra Boulevard
La Habra, CA 90631

Subject: Imperial & Euclid Residential Development Trip Generation & VMT Analysis, City of La Habra, CA

Dear Mr. Plotnik:

A. Introduction

RK ENGINEERING GROUP, INC. (RK) is pleased to provide this Trip Generation Analysis and Vehicle Miles Traveled (VMT) Analysis for the proposed Imperial and Euclid Residential Development project.

The City has requested a trip generation evaluation and VMT analysis for the proposed project to determine if additional traffic analysis might be required for the project.

B. Project Description

The project site is located at 251-351 Imperial Highway, north of Imperial Highway and west of Euclid Street, in the City of La Habra.

The project consists of constructing 117 multifamily residential dwelling units on approximately 4.91 acres. The following is the breakdown of the units by bedroom count:

- Two bedroom units: 40 units
- Three bedroom units: 66 units
- Four bedroom units: 11 units

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Access to the project site is proposed via One (1) proposed unsignalized access driveway along Imperial Highway.

The proposed project is planned to open in Year 2024. Exhibit A shows the location of the proposed project. Exhibit B shows the proposed site plan.

The proposed project will displace the existing land uses on the project site which are as follows. Exhibit C shows the existing uses.

- Manufacturing: 25,632 Square Feet
- Workshop / Manufacturing: 1,680 Square Feet
- Used Auto Sales: 5,292 Square Feet
- Gymnasium: 9,906 Square Feet
- Vehicle Storage / General Light Industrial: 12,800 Square feet; and
- Office: 5,758 Square feet.

Access for the site is planned via one gated access on Imperial Highway. Since the existing site has a total of five (5) access locations, the proposed project will reduce the number of driveway from five (5) down to one single access driveway.

The project's existing and proposed land use summary is shown in Table 1.

Table 1
Land Use Summary

Land Use	Quantity	Metric[1]
Existing Land Use		
Manufacturing	27.312	TSF
Auto Sales (Used)	5.292	TSF
Health Club/Fitness Center	9.906	TSF
General Light Industrial	12.800	TSF
General Office	5.758	TSF
Proposed Land Use		
Multi-Family Residential (220)	117	DU

[1]TSF = Thousand Square Feet; DU = Dwelling Units.

C. Project Trip Generation

Trip generation represents the amount of traffic that is attracted and produced by a development.

Trip generation is typically estimated based on the trip generation rates from the latest *Institute of Transportation Engineers (ITE) Trip Generation Manual.* The latest and most recent version (10th Edition, 2017) of the ITE Manual has been utilized for this trip generation analysis. This publication provides a comprehensive evaluation of trip generation rates for a variety of land uses.

The ITE trip generation rates for the existing and proposed land uses are shown in Table 2.

Table 2
ITE Trip Generation Rates

Land Use	Units[2]	ITE Code	Weekday						
			AM			PM			Daily
			In	Out	Total	In	Out	Total	
Existing Uses									
Manufacturing	TSF	140	0.48	0.14	0.62	0.21	0.46	0.67	3.93
Auto Sales (Used)	TSF	841	1.62	0.51	2.13	1.76	1.99	3.75	27.06
Health Club/Fitness Center	TSF	492	0.67	0.64	1.31	1.97	1.48	3.45	34.50
General Light Industrial	TSF	110	0.62	0.08	0.70	0.08	0.55	0.63	4.96
General Office	TSF	710	1.00	0.16	1.16	0.18	0.97	1.15	9.74
Proposed Use									
Multifamily Housing (Low-Rise)	220	DU	0.11	0.35	0.46	0.35	0.21	0.56	7.32

Source: *2017 ITE Trip Generation Manual, 10th Edition*; TSF = Thousand Square Feet; DU = dwelling units

Utilizing the ITE trip generation rates in Table 2, Table 3 shows the trip generation for the existing and proposed uses.

Table 3
Net Project Trip Generation[1]

Land Use (ITE Code)	Quantity	Units[2]	Weekday						
			AM			PM			Daily
			In	Out	Total	In	Out	Total	
Existing Uses									
Manufacturing (140)	27.3	TSF	13	4	17	6	13	19	107
Auto Sales - Used (841)	5.3	TSF	9	3	12	9	11	20	143
Health Club/Fitness Center (492)	9.9	TSF	0	0	0	19	15	34	340
General Light Industrial (110)	12.8	TSF	8	1	9	1	7	8	63
General Office (710)	5.8	TSF	6	1	7	1	6	7	56
Existing Land Use Sub-Total			**36**	**9**	**45**	**36**	**52**	**88**	**709**
Proposed Use									
Multi-Family Residential (220)	117.0	DU	12	41	53	41	24	65	856
Net Trip Generation			***-24***	***+32***	***+8***	***+5***	***-28***	***-23***	***+147***

[1] Source: *2017 ITE Trip Generation Manual, 10th Edition*;

[2] TSF = Thousand Square Feet; DU = dwelling units

As shown in Table 3, when compared to the existing uses, the proposed project is forecast to generate approximately 147 NET additional daily trips, approximately 8 NET additional AM peak hour trips and approximately 23 NET fewer PM peak hour trips.

Hence, the proposed project is expected to not result in a significant adverse impact on the operations of the roadway network and intersections and a full traffic study and level of service analysis is not required for the proposed project.

D. VMT Screening

Senate Bill (SB) 743 mandates that VMT replace LOS as the transportation metric under CEQA. As a result, the City of La Habra (along with Orange, Buena Park, Placentia, Brea, Fullerton and Yorba Linda) developed North Orange County Collaborative (NOCC+) to review and develop appropriate VMT methodologies, thresholds of significance, and feasible mitigation measures for CEQA documents.

The California Governor's Office of Planning and Research (OPR) issued a Technical Advisory in December 2018 which described their recommended procedures and methodology for VMT analysis.

A key element of SB 743, signed in 2013, is the elimination of automobile delay and LOS as the sole basis of determining CEQA impacts. Pursuant to CEQA guidelines, Section 15064.3, VMT is the most appropriate measure of transportation impacts. However, SB 743 does not prevent a city or county from continuing to analyze delay or LOS as part of other plans (i.e., the general plan), studies, or ongoing network monitoring.

Consistent with the recommendations of the OPR Technical Advisory and the City of La Habra Guidelines, screening thresholds may quickly identify whether or not a project should be expected to have a less than significant impact without conducting a detailed project-level assessment.

There are four types of screening criteria that can be applied to effectively screen projects from project-level assessment. These are summarized below:

- *Transit Priority Area (TPA) Screening*
- *Low VMT Area Screening*
- *Project Type Screening based on Local-Serving Uses*
- *Project Generating Less than 836 VMT*

Low VMT Area Screening

Residential projects located within a low VMT-generating area may be presumed to have a less than significant impact absent substantial evidence to the contrary.

In anticipation of the change to VMT, seven North Orange County Cities (Fullerton, La Habra, Brea, Buena Park, Orange, Placentia, and Yorba Linda) formed a collaborative and are currently completing the North Orange County Cities (NOCC) SB 743 Implementation Study to assist with answering important implementation questions about the methodology, thresholds, and mitigation approaches for VMT impact analysis. The NOCC study includes the following main components.

- Thresholds Evaluation Memorandum – Potential thresholds north county cities could consider when establishing thresholds of significance for VMT assessment
- Sample Projects Memorandum – Types of VMT that could be considered for impact assessment and how project assessment could be performed.
- Tools Evaluation Memorandum – Types of tools that could be used to estimate VMT and the pros/cons associated with each tool
- Mitigation Memorandum – Types of mitigation that can be considered for VMT mitigation
- VMT Screening and Mitigation Testing Tool – A spreadsheet tool that can be used for VMT screening. This tool is currently under development but will be available for the seven cities to use.

The NOCC can utilize the information produced through the Implementation Study to adopt their own methodology and significance thresholds for use in CEQA compliance. As noted in CEQA Guidelines Section 15064.7(b), lead agencies are encouraged to formally adopt their significance thresholds and this is key part of the SB 743 implementation process.

Utilizing the NOCC+ (North Orange County Collaborative) VMT Traffic Study Screening Tool, **the proposed project is located within a low VMT-generating area based on residential home-based VMT, work home-based VMT, and total VMT.**

As a result, the proposed project is screened out based on Low VMT Area Screening, and may be presumed to have a less than significant impact on VMT under CEQA. Therefore, no further VMT analysis is required.

Transit Priority Area (TPA) Screening

Projects located within a TPA may be presumed to have a less than significant impact absent substantial evidence to the contrary.

Utilizing the NOCC+ (North Orange County Collaborative) VMT Traffic Study Screening Tool, **the proposed project is located within a Transit Priority Area.**

In addition, based on the NOCC+ (North Orange County Collaborative) VMT Traffic Study Screening Tool, the project VMT per service population is expected to be below the existing VMT per service population *and is expected to be consistent with the OPR Technical Advisory, screening threshold or 15% of less.*

As a result, **the proposed project is screened out based on the Low VMT Area Screening and Transit Priority Area Screening, and may be presumed to have a less than significant impact on VMT under CEQA. Therefore, no further VMT analysis is required.**

The NOCC+ (North Orange County Collaborative) VMT Traffic Study Screening Tool output for the proposed project is provided in Appendix A.

E. On-Site Parking

As requested by the City, an analysis has been prepared to determine if adequate on-site parking spaces are planned to be provided by the proposed project.

Parking for the proposed project has been provide din accordance with Senate Bill (SB) 1818 which permits projects to use a reduced parking ratio when providing 10 percent moderate income affordable units.

Per SB 1818, upon the request of the developer, no city, county, or city and county shall require a vehicular parking ratio, inclusive of handicapped and guest parking, of a development meeting the criteria of subdivision (b), that exceeds the following ratios:

- Zero to one bedrooms: one on-site parking space.
- Two to three bedrooms: two on-site parking spaces.
- Four and more bedrooms: two and one-half parking spaces.
- If the total number of parking spaces required for a development is other than a whole number, the number shall be rounded up to the next whole number. For purposes of this subdivision, a development may provide "on-site parking" through tandem parking or uncovered parking, but not through on-street parking.
- This subdivision shall apply to a development that meets the requirements of subdivision (b) but only at the request of the applicant. An applicant may request additional parking incentives or concessions beyond those provided in this section, subject to subdivision (d).

More information on SB 1118 can be found using the following website link:

https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200320040SB1818

Table 4 shows the project's required on-site parking per SB 1118.

Table 4
On-Site Parking Required per SB 1118

Land Use	Unit Count	Required Parking Rate	Spaces Required
Two Bedroom Units	40	2 onsite parking spaces per unit	80
Three Bedroom Units	66	2 onsite parking spaces per unit	132
Three Bedroom Units	11	2.5 onsite parking spaces per unit	27.5
Total	**117**		**239.5**
		Rounded Up	**240**
		Parking Provided	259
		Parking Deficit / Surplus	+19
		Adequate Parking Provided?	**Yes**

As shown in Table 4, per SB 1118, the proposed project is required to provide a total of 240 on-site parking spaces. Since the proposed project is planned to provide a total of 259 on-site parking spaces, the project is providing more than adequate on-site parking capacity.

F. Project Access Sight Distance

An evaluation of the required sight distance has been performed for the project site access in accordance with the Caltrans Highway Design Manual (HDM).

The existing posted speed limit on Imperial Highway in the project site vicinity is 45 miles per hour. Based on the HDM, the required decision Sight Distance for 45 miles per hour is 675 feet.

Hence, a minimum of 675 feet of sight distance is required at the project site access.

A limited use area should be established and maintained to provide a clear line of sight for vehicles negotiating the project access. The trees and heights that are allowed could be different depending on the access and roadway setup, including elevations, vertical curves, horizontal curves, etc.

No structure, tree, bush and/or landscaping should interfere with the sight distance.

The required sight distance, the line of sight, and the limited use area for the project site access is shown in Exhibit D.

G. Trash Truck On-Site Turning Maneuvers

An analysis has been prepared utilizing the AutoTurn software to determine if trash trucks will be able to navigate and maneuver the onsite circulation roadway network without conflicting with obstacles such as buildings, curbs, etc.

The results of the analysis are graphically depicted in Exhibit E.

As shown in Exhibit E, trash trucks, and therefore passenger cars as well, are expected to be able to adequately and effectively navigate the onsite circulation.

H. Gate Queue Analysis

RK has conducted an analysis of gate stacking to determine the required amount of stacking and vehicular queuing capacity at the project access location after implementation of gated entry. The analysis is based on the intensity of the inbound traffic which is a factor of the arrival rate of vehicles at the entry location and also the service rate at which the vehicles are served by the gate system while entering the project site.

The Crommelin methodology has been utilized to determine the appropriate stacking capacity at the project entry location. The methodology utilizes the arrival rate of vehicles and the service rate at which arriving vehicles are processed to determine the traffic intensity and resulting vehicular queues building up behind the gate. The methodology calculates the number of vehicles which are waiting in the queue behind the one vehicle that is being served at the gate. The traffic intensity is calculated by dividing the average arrival rate by the average service rate. Crommelin analysis methodology is contained in Appendix B.

As previously shown in Table 2, during the PM peak hour (when most of the inbound traffic is expected to occur), the proposed project is forecast to generate approximately 41 inbound trips.

Based on the Crommelin methodology, a typical gated entry where direction and information is provided has a design service rate of 195 vehicles per hour.

Assuming an arrival rate of 41 vehicles per hour and a service rate of 195 vehicles per hour, (traffic intensity of 0.21), the 99-percentile required stacking capacity at the project access is forecast to be less than two vehicles (rounded up to two vehicles) when accounting for the one vehicle in front of the queue that is being served at the gate.

Detailed Crommelin analysis work sheet is shown in Exhibit F.

Based on information provided by the project applicant, a distance of approximately 85 feet is provided between the gate and Imperial Highway.

Hence, based on the Crommelin analysis, the 85 feet o stacking capacity is more than adequate to accommodate the queue of two (2) vehicles (approximately 40 to 50 feet, or 20 to 25 feet per vehicle).

I. Caltrans

As previously noted, access for the site is planned via one gated access on Imperial Highway. Imperial Highway is designated as State Route 90 and is under the jurisdiction of Caltrans.

Hence, a Caltrans encroachment permit will be required for the project.

The applicant will work with Caltrans to obtain the required permits.

Since the existing site has a total of five (5) access locations, the proposed project will reduce the number of driveway from five (5) down to one single access driveway, potentially improving traffic operations on Imperial Highway.

RK Engineering Group, Inc. appreciates this opportunity to assist on this project. If you have any questions regarding this study, please do not hesitate to contact us at (949) 474-0809.

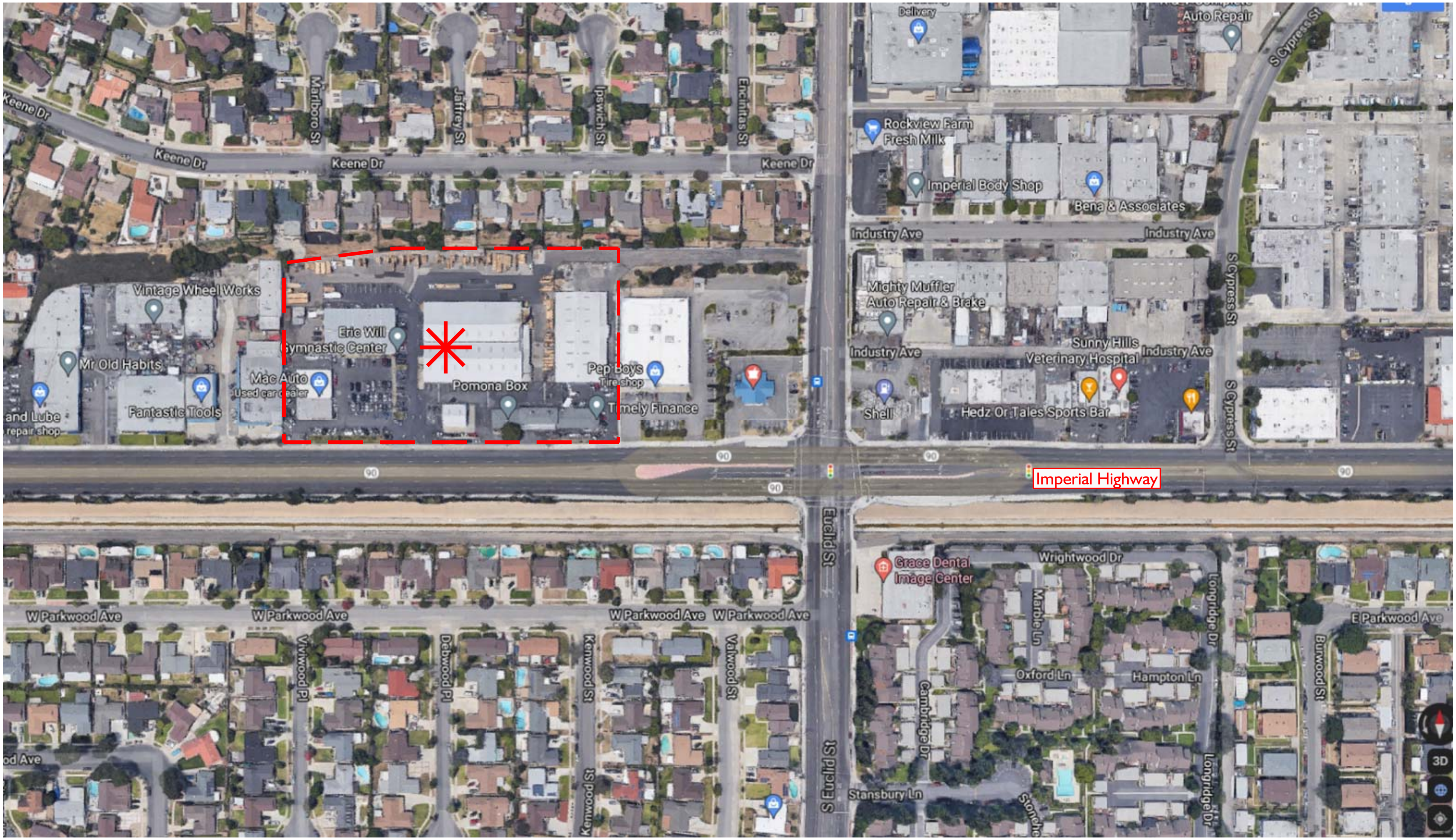
Sincerely,

RK ENGINEERING GROUP, INC.

Alex Tabrizi, PE, TE
Principal

Exhibits

Location Map



Legend:

= Project Site

N

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Exhibit B
Site Plan

N

RK engineering group, inc.

Existing Land Use

Exhibit D

Sight Distance Evaluation

Legend:

= Limited Use Area

N

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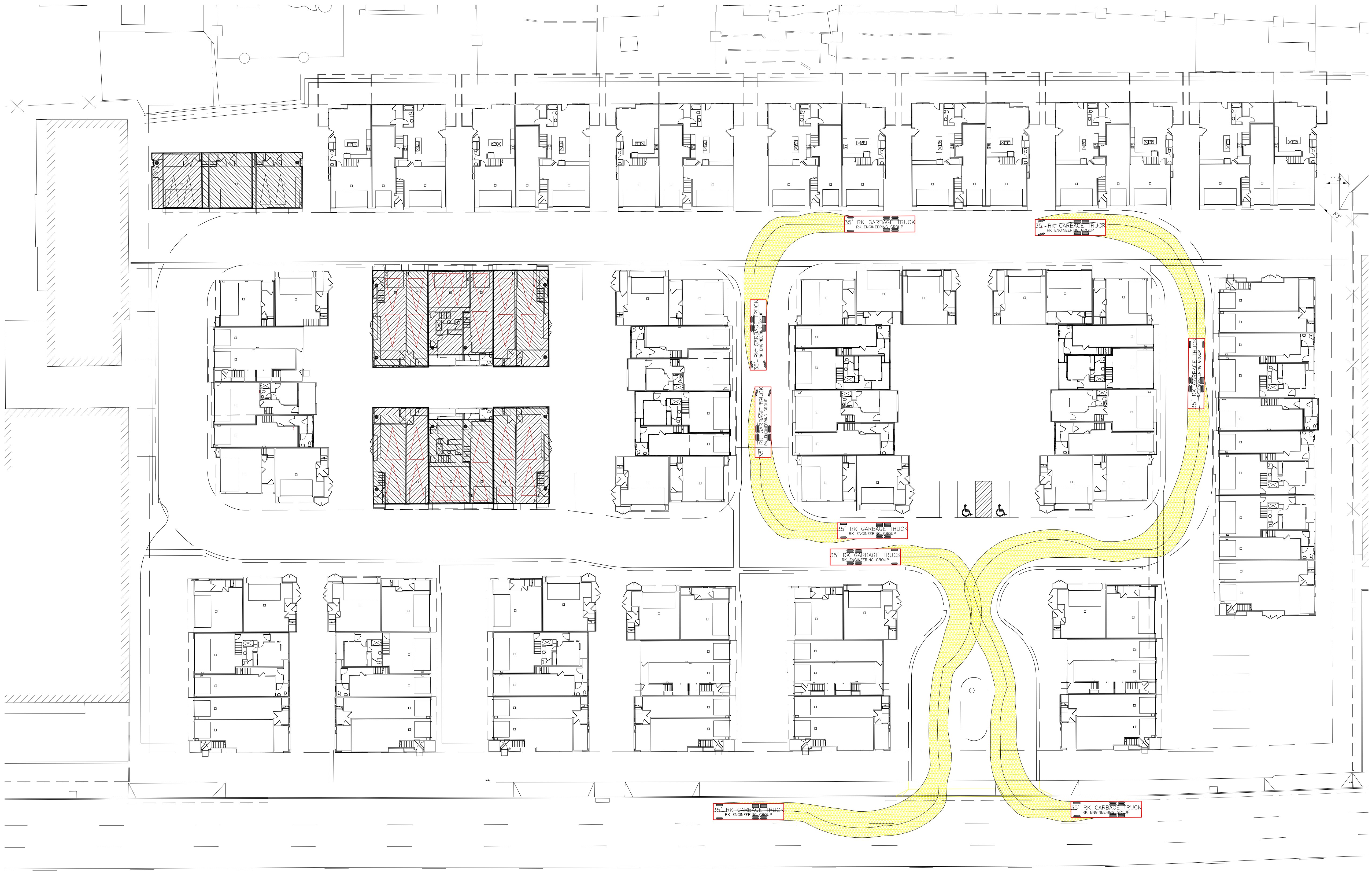
35' Trash Truck Turning Template

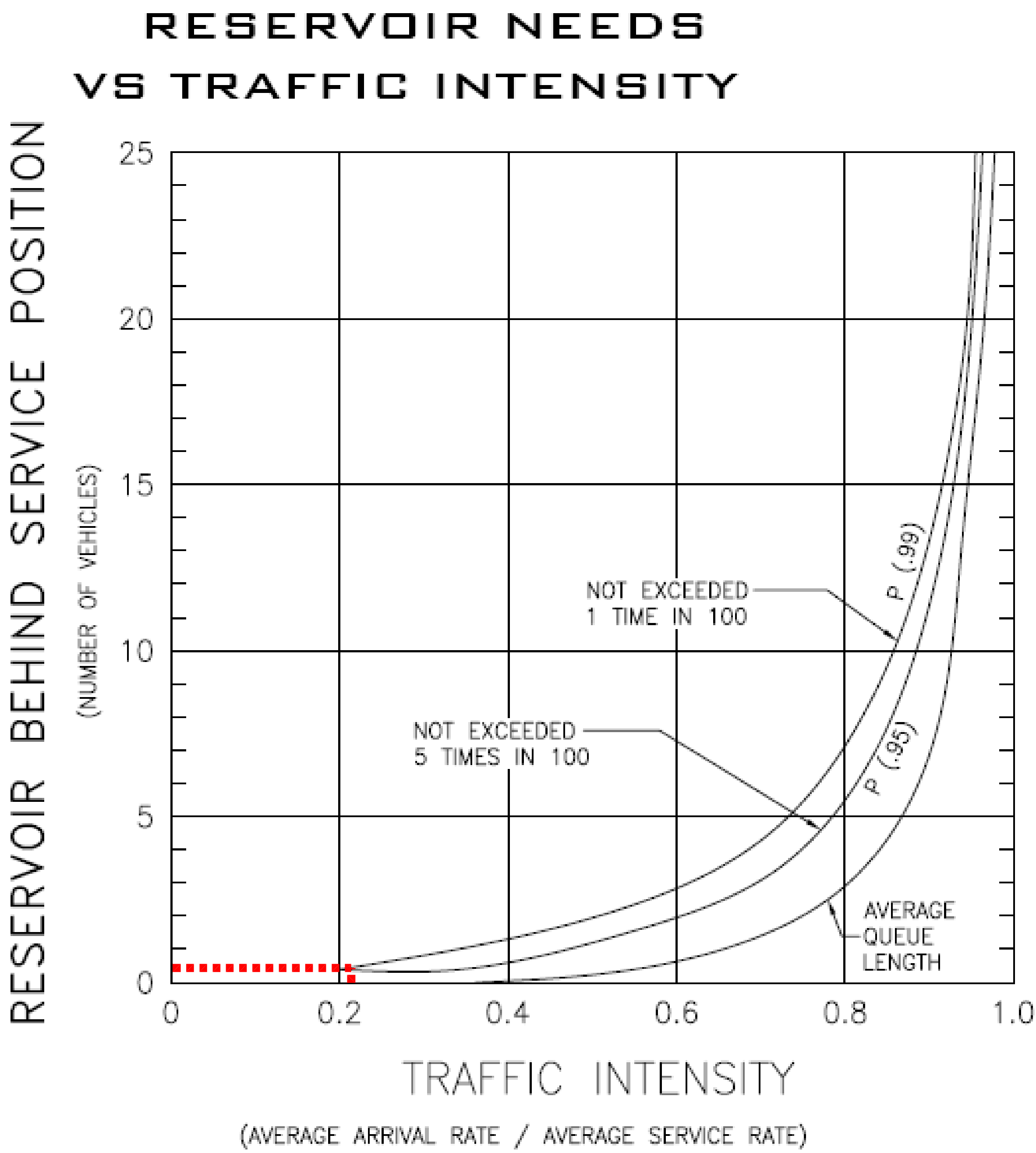


Truck Design Notes:

Tractor Width: 8.00'
Tractor Truck: 7.50'
Lock to Lock Time: 6 seconds
Steering Lock Angle: 36.8 degrees
Articulating Angle: 70.0 degrees

RK engineering group, inc.

Crommelin Gate Stacking Analysis
PM Peak Hour



Appendices

Appendix A

Vehicle Miles Traveled (VMT)
NOCC+ VMT Screening Tool Output

NOCC+

North Orange County Collaborative VMT Traffic Study Screening Tool

Project Information

Project Name	Opening Year
Imperial & Euclid Residential Development Traffic Impact Analysis	2023

Parcel Number (OCTAM TAZ#28)

019-042-21

Screening Criteria for La Habra

Is the project location in a Transit Priority Area?	Yes
Is the project location in a low VMT generating zone?	Yes
Is the Project one of these land use types? (show land use types)	No
Does the project generate fewer than 836 VMT? (enter project land use in the section below)	No

The Project can be considered for screening from additional analysis.
Please refer to the 'secondary screening checks' table in the User Guide.

Project Land Use Information

		Unit
Residential : Single Family Homes	0	Dwelling Units
Residential : MultiFamily Homes	117	Dwelling Units
Office	0.000	1,000 Sqaure Feet
Retail	0.000	1,000 Sqaure Feet
Industrial	0.000	1,000 Sqaure Feet
Private School	0	Students
University	0	Students
Entertainment	0.000	1,000 Sqaure Feet
Hotel	0	Rooms

Project Trips and VMT Information

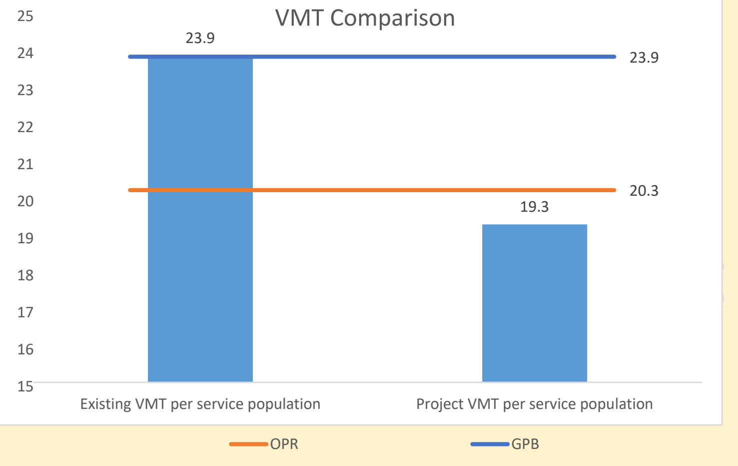
VMT Methodology: Origin Destination (OD)

Daily Trips: 853 Average Trip Length: 6.6 Service Population: 293

VMT per service population 19.3

Project VMT Thresholds Comparison

- ☑ OPR Guidance (15% Below Existing)
- ☐ GHG Reduction Targets (14.3% Below Existing)
- ☐ Below Existing
- ☑ Better than General Plan Buildout



FEHR & PEERS

Appendix B

Crommelin Methodology

Retyped Verbatim From the Original

ENTRANCE-EXIT DESIGN AND CONTROL FOR MAJOR PARKING FACILITIES

Robert W. Crommelin, P.E., President
Robert Crommelin and Associates, Inc.
Encino, California

Prepared for Presentation at:

"SEMINAR '72" Los Angeles Parking Association, Biltmore Hotel
Los Angeles, California, October 5, 1972

It hasn't been too many years since a 500-space garage was thought of as a large parking facility. In recent years, garages with over 4,000 spaces have been placed in operation and larger ones are on the drawing boards. Success in the operation of these major parking facilities is dependent upon proper design of access to the facility, in addition to efficient management. Provision of adequate access design and control is a significant item which must be considered as part of the first design concept. The traffic engineer, teamed with the owner's representatives, the architect, and the future parking operator, must work together to develop a proper access and control plan. I have recently read a statement by a nationwide garage design consultant that reservoir space for entrances to garages is no longer an important consideration because of the capacity of ticket dispensers with gates. This is completely untrue as will be brought out later. Thinking of this type can lead to ineffective design which causes backup onto public streets with the accompanying potential hazards and congestion.

This paper covers three principal areas of concern: (1) determination of the number of entrance and exit lanes required based upon the parking control strategy and type of parker served; (2) data to allow comparison of the capacities of the various types of control strategies to allow selection of the one appropriate for each facility, and; (3) determination of needed reservoir space based upon the control strategy selected.

Typical capacity values for the various methods of parking control are included in this paper. A word of caution is necessary since there is much variation in capacity values due to physical conditions present as well as the familiarity of the parker with the parking facility itself. Each major facility requires detailed analysis of its needs and generalized factors are not always adequate.

Design Methodology

In order to provide adequate access design and control for major parking facilities, it is necessary to identify the probable characteristics of the future users of the facility. In this paper it is assumed that the size of the garage has been determined based upon a comprehensive parking study (general public facilities), or the amount necessary to serve a given land use (single purpose facility).

The first step is to determine directional peak hour volumes as related to the total size of the parking garage. Based upon the principal land use served, tables are included in this paper which allow the designer to prepare an estimate of peak hour volumes. In general, our research has found that it is adequate to assume for design purposes that the morning inbound peak flows are approximately equal to the evening outbound peak flows. After determining the peak volumes, a control strategy must be selected which would be appropriate for the intended operation of the garage. Selection of whether it would be best to allow parkers to enter without charge and pay as they leave or to pay a flat fee on the way in and have no control upon exiting will have a significant impact upon traffic capacity. Whether to use no fee, a flat fee, a variable fee, or a combination of fees must be determined as well as whether it is possible to receive the payment in advance, or to collect individual payment of the fee. All of these alternatives should be considered for each individual parking facility in order to determine its proper control strategy.

When the peak hour volumes and control strategy have been determined, it is then possible to determine the number of lanes which will be required to adequately serve inbound and outbound traffic to the parking facility. This requires knowledge of typical service rates of various methods of parking control. The next step is to determine the amount of reservoir space required to serve the parking control location. Following all of these steps will lead to an efficient, well-working garage which will have minimum impact upon the surrounding street system.

Determination of Peak-Hour Volumes

Comprehensive parking studies have provided much information concerning the characteristics of the users of major parking facilities. In general, it may be stated that the traffic characteristics of a garage will be principally related to the trip purpose of the user and the type of land use served by the facility. Both of these items relate to the length of time the parker is in the facility and the time of day during which major traffic flows occur.

Table 1 was prepared which compares the trip purpose of the parker with the length of time which he parks as observed in the Los Angeles Central Business District. Employees are considered long-term parkers since 80 percent parked three hours or longer; at the peak time of day, 84 percent of the daily employee parkers were present; and, their average parking duration was 5.6 hours.

A garage, which serves employees primarily, would tend to have higher peak hour volumes than would one which serves the other uses shown in the table. As an example, 85 percent of the shoppers had a parking duration of less than three hours with an average duration of 1.6 hours. More importantly, only 26 percent of the total daily parkers with a shopping trip purpose were present at the time of peak accumulation. This indicates that the peak hour inbound or outbound volume will be less for a garage serving principally shopper parkers than for a similar sized facility serving only employees.

Table 1

TRIP PURPOSE VS. LENGTH OF TIME PARKED

TRIP PURPOSE	PERCENT OF DAILY PARKERS WITH DURATION SHOWN		RATIO OF PEAK ACCUMULATION TO TOTAL DAILY PARKERS	AVERAGE DURATION
	SHORT-TERM (less than 3 hrs.)	LONG-TERM (3 hrs. or longer)		
	(percent)	(percent)		(hours)
Work	20	80	0.84	5.6
Shopping	85	15	0.26	1.6
Commercial Business	86	14	0.25	1.5
Social-Recreational	91	9	0.24	1.2
Personal Business	94	6	0.21	1.0
Eat Meal	97	3	0.22	0.9

Source: Los Angeles CBD Parking Study, 1967

In order to relate the type of land use served with peak hour volumes, the term entering-leaving ratio has been used. This term represents the volume of cars entering or leaving during a peak hour divided by the maximum accumulation of cars in the parking facility (taken as the size of the facility). If the inbound morning or outbound evening peak hour is equal to half the number of spaces in the garage, the entering-leaving ratio is 0.50. Using data obtained by special counts taken by personnel of my firm, as well as information reported in various parking studies, Table 2 was prepared which shows the range of values of the entering-leaving ratio for various land uses served. It may be seen in the table that the range of values for an individual parking facility may vary considerably. This variation may be explained by the typical length of time parked as well as the variation in the times when employees must start work or are let out of work. In locations where there is some staggering of employment hours, the entering-leaving ratio tends to be lower. The characteristics of the potential users of the parking facility must be studied in detail to arrive at the proper entering ratio.

Once the entering-leaving ratio has been selected, it is possible to determine the actual peak hour design volumes to be used in determining the parking control strategy and the design of access lanes.

Table 2

LAND USE SERVED VS. ENTERING-LEAVING RATIO

PRINCIPAL LAND USE SERVED	ENTERING-LEAVING RATIO [a] (Range of Values)
Hotel-Motel	0.25-0.35
College-University	0.40-0.60
Retail Commercial	0.45-0.65
Public Office Building	0.45-0.65
Private Offices-Multiple Tenant	0.45-0.60
Private Offices-Single Tenant	0.55-0.75
Hospital	0.60-0.70
Medical Offices	0.70-0.85
Airport (public parking)	0.70-0.85
Manufacturing Plant	0.70-0.90
Restaurant (sit-down)	0.80-0.95
Branch Bank	0.90-1.20

[a] Volume of cars entering and leaving in peak hour divided by maximum accumulation of cars (capacity of facility)

Source: Special counts by RC and A; various parking studies by others

Parking Control Strategy Selection

Selection of the proper type of parking control strategy is exceedingly important in the successful operation of a major parking facility. The strategy involves the method of parking control, the charge which will be placed upon the user, and the type of payment to be collected from the user. Table 3 shows the application of various control strategies as related to the type of parking facility used as well as to the type of parking control equipment. For shopper and business parkers, it is normal to allow free entry with payment of a variable fee on an individual basis as they exit the garage. In the case of employees, it is more normal to allow them to enter freely and have a prepaid monthly charge which could be checked through the use of parking permits, coded cards, tokens, or other means as they exit. Parkers at sports events exhibit high peak volumes but have a length of time parked which can be estimated. For this type of condition, it is much more appropriate to collect a flat fee inbound and to have no control outbound. This latter type of control was the one which we recommended for use at the Los Angeles Convention Center.

Table 3

APPLICATION OF VARIOUS CONTROL STRATEGIES

ITEM	CONTROL STRATEGY APPLICABILITY: CONTROL METHOD — Free-In Pay-Out	Pay-In Free-Out	TYPE CHARGE — Flat Fee	Variable Fee	TYPE PAYMENT — Pre-Paid	Individual Payment
Preferred Method to Serve:						
Employee	X	X	X		X	
Office Building Visitor	X			X		X
Sports Event		X	X			X
Shopper	X			X		X
Student	X		X		X	
Air Traveler	X			X		X
Control Type:						
Ticket Spitter	X			X		X
Cashier/Attendant	X	X	X	X	X	X
Time Stamp Ticket Manually	X			X		X
Coded Card	X	X	X		X	
Coin-Operated Gate	X		X			X
Token-Operated Gate	X	X	X	X	X	
Parking Meter	-	-	X	X		X

Parking Control Operating Characteristics

Table 4 indicates our findings concerning the service rates for various types of parking controls. We have taken the design service rate as being equal to 80 percent of the maximum service rate. There is considerable variation in service rates and careful study must be given to the probable characteristics of the users of the parking facility as well as the experience of the personnel operating the facility.

For the control measures normally used in entering a facility, the average headways vary from 3.6 seconds per vehicle for a clear aisle with no control to 20.4 seconds per vehicle for a coin-operated gate. In terms of design hourly capacities, the rates would be 800 per hour per lane for clear aisles and only 140 per hour per lane for coin-operated gates. The most common type of control used at major parking facilities is the ticket dispenser with a gate. Research in England identified the fact that there is a significant difference in the capacity of this equipment depending upon whether the parker has an easy direct approach or if a sharp turn is required to approach the equipment. This is obvious since a straight approach allows a parker to position himself in a reasonable location to pull the ticket to open the gate. Thus, the design of the approach to a ticket dispenser can cause the hourly capacities to vary between 305 and 520 vehicles per hour.

Internally, the circulation pattern can affect the capacity of the inbound approach. It is very important to have a minimum of interference within the parking facility so that once a driver leaves the entrance parking control, he can do so without delaying the next inbound parker immediately behind him. This can be accomplished by avoiding situations where <u>outbound</u> parkers queued up from the exit control block parkers entering the facility.

The capacity of exits from a major parking facility are dependent upon adequate space approaching the exit control location as well as adequate reservoir between that location and the driveway to the public street. Analysis must be conducted on both of these reservoir needs and sufficient lanes as well as sufficient reservoir length provided to allow proper operation. The emphasis of this paper will be upon the capacity of the exiting parking control itself. The most common type of operation involves use of a cashier collecting a variable fee from a parker based upon length of time parked. This type of control has a capacity of approximately 150 vehicles per hour. Another approach might be to have the parker pay his fee to the cashier <u>before</u> entering his car and then utilize a token operated gate as a means of exit control. This control strategy would have over twice the capacity of a cashier lane itself and could have application where there is insufficient space to provide an adequate number of cashier lanes.

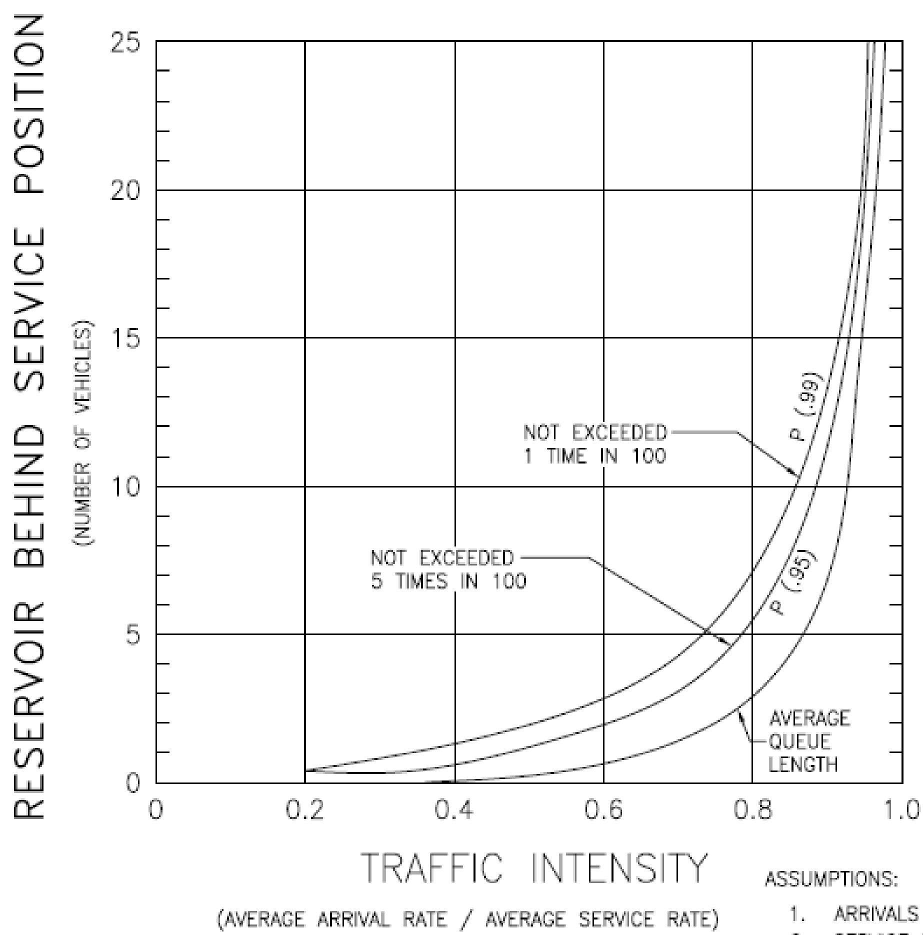
Table 4

PARKING CONTROL SERVICE RATE

TYPE OF CONTROL	TYPICAL SERVICES RATES PER LANE [a] AVERAGE HEADWAY (Sec/Veh)	HOURLY CAPACITY Design [b] (Veh/Hr)	HOURLY CAPACITY Maximum (Veh/Hr)
Entering:			
Clear Aisle, no control	3.6	800	1,000
Ticket dispenser, no gate	5.0	575	720
Time Stamp and hand to driver	8.5	340	425
Coded-card operated gate	8.9	340	425
Cashier, flat fee, no gate			
No information given	9.2	310	390
Direction-info needed	14.8	195	250
Ticket Dispenser w/gate			
Sharp turn at approach	9.5	305	380
Easy direct approach	5.5	520	650
Coin operated gate	20.4	140	175
Internal:			
Clear aisle or ramp, no parking	2.0	1,200	1,800
Straight ramp w/bend at end	2.2	1,000	1,610
Circular ramp, 30' R at C/L	2.2	840	1,650
Aisle with adjacent 9 x 18' stalls			
Inbound	3.5	830	1,040
Outbound	8.6	335	420
Exiting:			
Light street congestion	7.2	400	500
Moderate street congestion	9.0	320	400
Coded-card/token-operated gate	9.0	320	400
Cashier, flat fee w/gate	13.4	215	270
Casher, variable fee w/gate	19.5	150	185
Coin operated gate	20.4	140	175

[a] Assumes no significant interference by pedestrians, other traffic, etc.
[b] Taken as 80% of maximum rate; require 6 car lengths reservoir in advance of control points.

RESERVOIR NEEDS VS TRAFFIC INTENSITY



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ASSUMPTIONS:

1. ARRIVALS FOLLOW A POISSON DISTRIBUTION
2. SERVICE RATE CAN BE REPRESENTED BY AN EXPONENTIAL PROBABILITY FUNCTION.
3. FLOW IS EQUALLY DIVIDED BETWEEN EACH LANE IF MORE THAN ONE IS AVAILABLE.

Reservoir Needs

If you have ever watched cars approaching any type of parking control, you know that they do not come at an even rate. Even though there may be nearby traffic signals which may cause the approaching parkers to arrive in groups or platoons, random arrival is the normal approach characteristic assumed. Research has shown that random arrivals or events in a traffic stream tend to follow the Poisson mathematical distribution. This distribution provides a means that, if the average rate is known, the probability of exceeding a given volume in a unit of time may be calculated. Thus, if you know the average volume, you may calculate the surges in volume to allow design of reservoir space. As an example, if the average number of cars in a five-minute interval is 10, use of Poisson statistical techniques will yield the fact that no more than 18 cars will arrive in the five-minute interval within a probability that this amount will be exceeded only one time in 100 five-minute intervals. Use of these calculation techniques allow the determination of the amount of reservoir required to serve a given type of parking control.

The relationship between the arrival of vehicles and the ability of the parking control equipment or strategy to handle these vehicles are the most important items in determining reservoir space. If the average number of arrivals per unit of time is called "v" and "s" is the average rate of service (discharge) per unit of time, the ratio of v/s is used to determine the amount of reservoir space. This ratio is called traffic intensity ("i"). The average length of the queue ($\bar{q}$) behind the vehicle being serviced is equal to $\bar{q} = \frac{i^2}{(1-i)}$. This formula assumes that the arrival of vehicles at the service point follows a random distribution, the servicing time for vehicles can be represented by an exponential probability function, and that the flow is equally divided among service facilities if there is more than one lane serving a given area of the garage.

Knowing the average queue length and selecting a probability value which represents the frequency that the design length will be exceeded, will allow the designer to determine the amount of reservoir required behind the service position. These formulas and probabilities were utilized to prepare Figure 1 which compares traffic intensity with required reservoir for common probabilities used in design. The mathematics are such that, as the average volume approaches the average service rate, the amount of backup will be infinite. In addition, the probability that the amount of reservoir space for a given volume will never be exceeded also is infinite. In actuality, these conditions do not occur but the general relationships hold true based on our field observations.

As may be noted in the figure, an insignificant amount of reservoir is required when the average arrival rate is 50 percent or less of the average service rate of the parking control device. At this level, only a two-car reservoir would be required. As the ratio of traffic intensity increases above 0.7, the amount of reservoir space increases rapidly. We have selected a traffic intensity of 0.8 as appropriate for design and a probability that the determined reservoir would be exceeded only five times in 100. Thus, if the average service rate for a given type of parking control is known and sufficient lanes are provided so that the average arrival rate during the peak hour is 0.8 times the average service rate, a reservoir of six car lengths behind each service position would be adequate to meet the needs of the facility. If this is physically impossible, a traffic intensity of 0.6 should be used to determine the number of lanes requiring only a two-car reservoir.

Summary

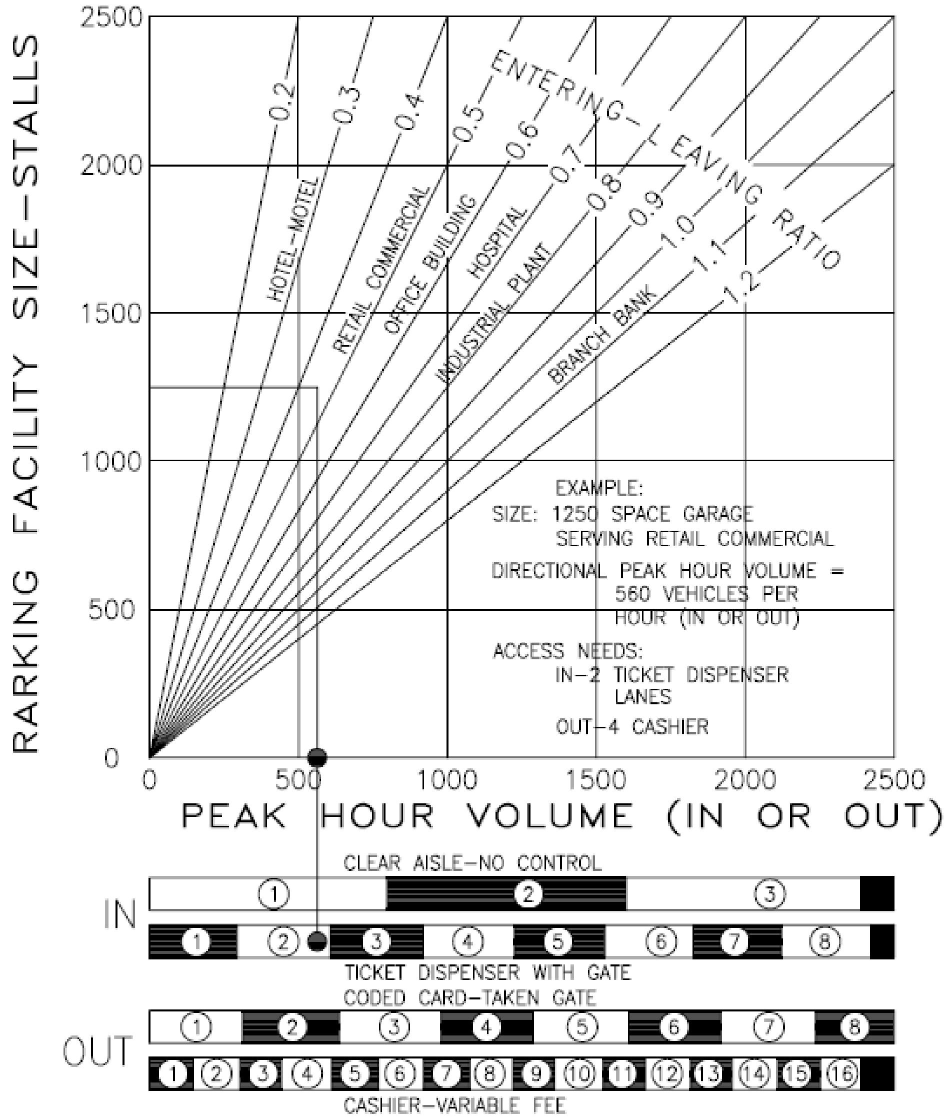
Having determined the peak hour volumes, the parking control strategy, the number of lanes, and the reservoir length to adequately serve the peak-hour volumes, the physical design of the facilities then may be made. As noted previously, having an inadequate capacity to serve the traffic volumes approaching the control means can have a very drastic effect upon the backup which will occur. This backup creates adverse operating characteristics in and around the facility and also causes the length of time that a parker is involved in entering or leaving a garage to grow significantly. Thus, the design features of the facility can have an impact on the attitudes of the users and indirectly affect the success or failure of the parking facility in attracting customers or users.

To provide a means of easily determining the number of lanes necessary for various types of parking garages, Figure 2 was prepared which allows the designer to directly translate the size of the garage and the type of land use served into the number of necessary access lanes for the parking control strategy assumed. The example shows that a 1,250-space garage serving a retail commercial facility will normally have a directional peak hour volume of 560 vehicles per hour. If inbound ticket dispensers with gates are used, two lanes will be adequate to serve this garage. If cashiers collect variable fees, a total of four exit cashier lanes will be required. Normally these four lanes will not be provided all in the same location and, of course, it could be necessary to operate all four only during peak hours.

In the case of an office building rather than a retail facility, it would be possible to use coded card exit gates for monthly parkers. This would significantly reduce the required number of exit lanes since transient visitors are a much lower percentage of the peak hour volumes for an office building than they are in a garage serving a retail facility. The reduction in construction and operating cost would be significant.

A warning is necessary concerning the use of Figure 2 since it was based upon very generalized information. Each individual major parking facility must be considered on its own and its access needs determined in light of the characteristics of the probable users of the facility itself. In order to have satisfied customers and users of a major parking facility, thorough investigation and determination of access needs must be accomplished.

PARKING FACILITY SIZE VS ACCESS NEEDS



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