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DRAFT MEMORANDUM

To: Los Angeles County Metropolitan Transportation Authority (LA Metro)

From: Iteris, Inc.

Date: May 25, 2018

Subject: Metro Orange Line – Calibration of Traffic Simulation Model for Existing Conditions

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As part of the Environmental Impact Analysis Task Order for the Metro Orange Line (MOL) Grade Separation and Four-quadrant Gate Study, Iteris was tasked to update and expand the traffic simulation model previously developed for the MOL Grade Separation Feasibility Study completed in 2017. This model had served as the traffic operations analysis tool for comparing potential improvement alternatives for the MOL. This technical memorandum documents the components of the model update, recalibration and validation under existing conditions for the MOL Grade Separation/4-Quadrant Gate impact evaluation.

I. Model Update

The microsimulation platform VISSIM was used to develop the model. The VISSIM model was first developed for the MOL Speed Evaluation Study (completed in 2015) using VISSIM build 6.00-21 and was calibrated for existing year 2015 PM conditions. The VISSIM model included the existing roadway geometrics, traffic signal parameters, and driver behavior characteristics. For the MOL Grade Separation/4 Quadrant Gate evaluation, the model analysis was expanded to include the AM peak hour in addition to the previously available PM peak hour. New turning movement counts were collected in December 2017 at intersections closest to the MOL Busway corridor and input into the model. Travel times collected from previous projects were utilized to calibrate the model travel times. Additional bus travel times were collected in April 2018 to capture existing operations. This model update was performed using VISSIM build 9.00-06.

Unlike static analyses conducted according to the Highway Capacity Manual (HCM), a simulation model includes “virtual drivers” that travel through the model network, from entry nodes to exit nodes, along “logical” network paths that are assigned by the analyst to simulate driver behavior under existing conditions. The model uses random seeds and probability distributions for a number of traffic flow characteristics, such that each model run would produce slightly different outputs. Each seed contains random variables to account for variations in driver behavior and departure times. This model is therefore stochastic; it allows for simulating the random fluctuations that are typically observed in real-time traffic networks. This feature makes the results more robust and realistic, given that they are based on the average of multiple observations or model runs, rather than a single calculation.

Network Coding

The initial model network was coded to match the geometric configurations from an imported aerial image that was drawn and scaled in VISSIM. The network included the Metro Orange Line busway between the North Hollywood Station and the western terminus of the busway at the Chatsworth Metrolink Station. The following parallel roadway corridors were also included:

- Chandler Boulevard between North Hollywood Station and Ethel Avenue
- Oxnard Street between Woodman Avenue and Sepulveda Boulevard
- Victory Boulevard between Densmore Avenue and Balboa Boulevard
- Oxnard Street between White Oak Avenue and Corbin Avenue
- Victory Boulevard between Topham Avenue and De Soto Avenue
- Canoga Avenue between Vanowen Street and Prairie Avenue

The model update maintained the initial network boundaries, as shown in **Figure 1**.

Figure 1 – Simulation Model Network

Signal Timing Data

The network contains approximately 50 signalized intersections, including the busway signals and signalized intersections on parallel roadways. Signal timing data was provided by LADOT for the initial model development. The signal timing inputs in the model were validated to the signal timing sheets as part of the update.

Traffic Count Data

Intersection turning movement counts were collected in December 2017 at locations closest to the MOL busway corridor for the AM and PM peak periods. The new peak hour volumes for vehicles, pedestrians, and bicycles were entered into the model at these count locations as part of the model update.

Travel Time Data

For the MOL Speed Evaluation Study (*Attachment A*) and the MOL Grade Separation Feasibility Study (*Attachment B*), travel time runs were conducted using the floating car method. The travel time data in **Table 1** was assembled from the previous Studies:

Table 1 – Travel Time Data

TRAVEL TIME CORRIDOR	SEGMENT	Date Collected	AM		PM	
			Average Travel Time (mm:ss)	Average Speed (mph)	Average Travel Time (mm:ss)	Average Speed (mph)
WB MOL Busway	North Hollywood Station to Canoga Station	January 2017	39:48	20.0 mph	41:18	19.3 mph
	Canoga Station to Chatsworth Station	August 2015	13:06	19.7 mph	14:12	18.1
EB MOL Busway	Chatsworth Station to Canoga Station	August 2015	14:00	18.2 mph	13:48	18.5
	Canoga Station to North Hollywood Station	January 2017	39:18	20.4 mph	38:4	20.9
NB Canoga Avenue	Vanowen Street to Nordhoff Street	November 2015	08:24	20.7 mph	08:24	20.8
SB Canoga Avenue	Nordhoff Street to Vanowen Street	November 2015	09:12	19.0 mph	08:24	20.7
EB Chandler Blvd	Coldwater Canyon Boulevard to Tujunga Avenue	November 2015	04:12	28.8 mph	08:18	26.3
WB Chandler Blvd	Tujunga Avenue to Coldwater Canyon Boulevard	November 2015	05:06	23.7 mph	07:30	25.6

II. Calibration Methodology

The objective of model calibration is to obtain the best match possible between the outputs estimated by the simulation model performance and data from the field measurements of the performance. However, there are diminishing returns where large investments in effort yield small improvements in accuracy at a certain point in the calibration process. The Federal Highway Administration (FHWA) has set calibration procedures and standards for microsimulation models which were used in this calibration process. These FHWA calibration targets were applied as follows:

Hourly Flows, Model Versus Observed

- Individual Link Flows
    - Within 100 vehicles/hour (v/h), for Flows < 700 v/h
    - Within 15%, for 700 v/h < Flow < 2,700 v/h
    - Within 400 v/h, for Flow > 2,700 v/h
- Sum of All Link Flows
    - Within 5% of the sum of all link counts
- GEH Statistic* < 5 for Individual Link Flows > 85% of cases
- GEH Statistic* for Sum of All Link Flows GEH < 4 for sum of all link counts

**The use of the GEH statistic (named after its developer, Geoffrey E. Havers) "stems from the inability of either the absolute difference or relative difference statistics to cope with flows over a wide range" of values (Scottish Transport Appraisal Guidance, 2002). The GEH statistic is a modified Chi-squared statistic that incorporates both relative and absolute differences to compare modeled and observed characteristics. The form of the GEH statistic allows for greater absolute differences for low volumes while requiring lower relative differences for large volumes. The expression for the GEH statistic is GEH = [square root of 2[(E - V).sup.2] / (E + V)] (2) Where E = model estimated characteristic; V = observed characteristic.*

Travel Times, Model Versus Observed

- Travel Times, Network within 15% (or 1 minute, if higher) of > 85% of cases

Visual Audits - Bottlenecks

- Visually acceptable queuing – to analyst's satisfaction

III. Calibration Results

VISSIM Model Run Procedure

The model is set to run for 5,400 simulation seconds (a simulation period of 1 hour and 30 minutes). This allows for a 30-minute "warm-up" period (0 to 1,800 seconds) where congestion can develop, and then a 60-minute period (1,800 to 5,400 seconds) when the analysis statistics are collected. The simulation resolution is set at 10 time steps per simulation second. In order to increase the confidence level of the data obtained from the simulation runs, a total of 10 simulation runs, each with a different random seed, were performed for the AM and PM peak hours, and the average of these runs were used in the calibration.

Results

A comparison of the input demand volumes and corresponding simulated VISSIM volume outputs are included in **Table 2** and **Table 3** for the AM and PM peak hours, respectively. The comparisons show the magnitude of vehicles that VISSIM is capable of processing during the simulation versus the actual number of vehicles that were assigned as input volumes. **Table 4** summarizes the results for calibration criteria of traffic flow. As shown in these tables, all calibration targets based on volumes were achieved.

Table 4 – Volume Calibration Results

VOLUME CALIBRATION MEASURE	ACCEPTANCE TARGET	AM		PM	
		Results	Target Achieved?	Results	Target Achieved?
Individual Vehicle Flow					
Within 100 veh/h, for flow < 700 veh/h	> 85% of cases	100%	Yes	100%	Yes
Within 15 % for 700 veh/h < flow < 2700 veh/h	> 85% of cases	100%	Yes	100%	Yes
Within 400 veh/h, for flow> 2700/h	> 85% of cases	-	-	-	-
Sum of all Links	Within 5%	-0.4%	Yes	0.0%	Yes
GEH Statistic < 5 for Individual Link Flows	> 85% of cases	99%	Yes	100%	Yes
GEH Statistics for sum of all link flows	Less than 4	1.29	Yes	0.02	Yes

Directional travel time data collected along the busway and parallel roadways from previous MOL Studies were used for calibration. In total, an average of 10 models runs were compared for the AM and PM peak hours. A comparison of the travel time output results from the models with the actual field observations for AM and PM peak hours are presented in **Table 5** and **Table 6,** respectively. As shown, the average travel times simulated in the existing peak hour models for the MOL busway and parallel corridors in both directions are all within the prescribed FHWA acceptable calibration targets.

Table 5 – AM Travel Time Calibration Results

TRAVEL TIME CORRIDOR	SEGMENT	AM Travel Time (min)		Difference		Target Achieved?
		Field	Simulated	Absolute	Percentage	
WB MOL Busway	North Hollywood Station to Canoga Station	40.5	46.3	5.8	14.2%	Yes
	Canoga Station to Chatsworth Station	12.0	12.8	0.7	5.9%	Yes
EB MOL Busway	Chatsworth Station to Canoga Station	13.8	13.9	0.1	0.9%	Yes
	Canoga Station to North Hollywood Station	40.2	42.5	2.4	5.9%	Yes
NB Canoga Avenue	Vanowen Street to Nordhoff Street	8.4	7.4	1.0	11.9%	Yes
SB Canoga Avenue	Nordhoff Street to Vanowen Street	9.2	8.8	0.4	4.2%	Yes
EB Chandler Blvd	Coldwater Canyon Boulevard to Tujunga Avenue	4.2	4.7	0.6	13.6%	Yes
WB Chandler Blvd	Tujunga Avenue to Coldwater Canyon Boulevard	5.1	4.8	0.3	5.0%	Yes

Table 6 – PM Travel Time Calibration Results

TRAVEL TIME CORRIDOR	SEGMENT	PM Travel Time (min)		Difference		Target Achieved?
		Field	Simulated	Absolute	Percentage	
WB MOL Busway	North Hollywood Station to Canoga Station	40.9	45.8	4.9	12.0%	Yes
	Canoga Station to Chatsworth Station	13.3	13.6	0.4	2.8%	Yes
EB MOL Busway	Chatsworth Station to Canoga Station	14.5	15.4	0.9	6.1%	Yes
	Canoga Station to North Hollywood Station	41.7	44.7	3.0	7.2%	Yes
NB Canoga Avenue	Vanowen Street to Nordhoff Street	8.4	7.4	1.0	11.5%	Yes
SB Canoga Avenue	Nordhoff Street to Vanowen Street	8.4	8.8	0.3	4.1%	Yes
EB Chandler Blvd	Coldwater Canyon Boulevard to Tujunga Avenue	4.6	4.8	0.2	4.4%	Yes
WB Chandler Blvd	Tujunga Avenue to Coldwater Canyon Boulevard	4.7	4.5	0.2	3.4%	Yes

The VISSIM model provides an average intersection delay per vehicle and intersection level of service (LOS) for the AM and PM peak hours, as shown in **Table 7**.

IV. General Findings

The efforts of this model update resulted in achieving the calibration targets defined and prescribed by FHWA for the existing AM and PM VISSIM model along the MOL busway and for the newly counted intersection links. For the volume calibration criteria, the model meets FHWA criteria for individual vehicle flows, sum of all links, and both GEH statistics. The model also meets the FHWA criteria targets for travel times. Overall, it is concluded that the AM and PM peak VISSIM models developed for MOL are well suited to analyze conditions of proposed improvements at these calibrated locations.

Table 2 – AM Volume Calibration Results

Network Link	AM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
Entering Network							
Chandler Blvd North Westbound	93	88	-5	-5.4%	0.53	Less than 100	Yes
Chandler Blvd South Westbound	154	154	0	0.3%	0.03	Less than 100	Yes
Tujinga Ave Southbound	462	459	-3	-0.7%	0.16	Less than 100	Yes
Tujinga Ave Northbound	282	285	3	1.2%	0.20	Less than 100	Yes
Colfax Ave Southbound	678	664	-14	-2.1%	0.56	Less than 100	Yes
Colfax Ave Northbound	578	574	-4	-0.7%	0.16	Less than 100	Yes
Laurel Cyn Southbound	1,417	1,410	-7	-0.5%	0.18	Within 15%	Yes
Laurel Cyn Northbound	795	774	-21	-2.6%	0.74	Within 15%	Yes
Corteen Pl Southbound	156	146	-10	-6.7%	0.85	Less than 100	Yes
Corteen Pl Northbound	83	77	-6	-6.8%	0.63	Less than 100	Yes
Whitsett Ave Southbound	1,199	1,097	-102	-8.5%	3.01	Within 15%	Yes
Whitsett Ave Northbound	400	397	-3	-0.8%	0.16	Less than 100	Yes
Bellaire Ave Southbound	272	263	-9	-3.2%	0.53	Less than 100	Yes
Bellaire Ave Northbound	37	36	-1	-1.8%	0.11	Less than 100	Yes
Coldwater Cyn Southbound	1,264	1,252	-12	-0.9%	0.33	Within 15%	Yes
Coldwater Cyn Northbound	591	583	-8	-1.3%	0.31	Less than 100	Yes
Ethel Ave Southbound	96	96	0	-0.3%	0.03	Less than 100	Yes
Ethel Ave Northbound	50	50	0	0.1%	0.01	Less than 100	Yes
Chandler Blvd South Eastbound	1,301	1,291	-10	-0.8%	0.27	Within 15%	Yes
Fulton Ave Southbound	1,017	977	-40	-3.9%	1.26	Within 15%	Yes
Fulton Ave Northbound	781	778	-3	-0.4%	0.10	Within 15%	Yes
Burbank Blvd Westbound	1,145	1,129	-16	-1.4%	0.46	Within 15%	Yes
Burbank Blvd Eastbound	1,486	1,485	-1	-0.1%	0.03	Within 15%	Yes
Oxnard St near Woodman Ave Westbound	1,190	1,202	12	1.0%	0.35	Within 15%	Yes
Woodman Ave Southbound	1,516	1,516	0	0.0%	0.01	Within 15%	Yes
Woodman Ave Northbound	941	935	-6	-0.6%	0.19	Within 15%	Yes
Hazeltine Ave Southbound	769	768	-1	-0.2%	0.04	Within 15%	Yes
Tyrone Ave Southbound	115	155	40	34.6%	3.42	Less than 100	Yes
Tyrone Ave Northbound	117	125	8	6.5%	0.69	Less than 100	Yes
Van Nuys Blvd Southbound	2,091	2,074	-17	-0.8%	0.38	Within 15%	Yes
Vesper Ave Southbound	350	264	-86	-24.5%	4.90	Less than 100	Yes
Kester Ave Southbound	1,533	1,512	-21	-1.4%	0.54	Within 15%	Yes
Sepulveda Blvd Southbound	2,021	1,952	-69	-3.4%	1.55	Within 15%	Yes
Victory Blvd near Woodley Ave Westbound	2,036	2,191	155	7.6%	3.37	Within 15%	Yes
Woodley Ave Southbound	1,105	1,094	-11	-1.0%	0.35	Within 15%	Yes
Woodley Ave Northbound	406	410	4	1.0%	0.20	Less than 100	Yes
Balboa Blvd Southbound	1,506	1,510	4	0.2%	0.09	Within 15%	Yes
Balboa Blvd Northbound	647	632	-15	-2.4%	0.60	Less than 100	Yes
Victory Blvd near Balboa Blvd Eastbound	2,091	2,093	2	0.1%	0.04	Within 15%	Yes
Oxnard St near White Oaks Ave Westbound	213	221	8	4.0%	0.57	Less than 100	Yes
White Oaks Ave Southbound	1,623	1,630	7	0.4%	0.17	Within 15%	Yes
White Oaks Ave Northbound	910	909	-1	-0.1%	0.02	Within 15%	Yes
Lindley Ave Southbound	1,398	1,292	-106	-7.6%	2.90	Within 15%	Yes
Lindley Ave Northbound	782	780	-2	-0.2%	0.07	Within 15%	Yes
Reseda Blvd Southbound	1,151	1,168	17	1.4%	0.49	Within 15%	Yes
Reseda Blvd Northbound	830	915	85	10.2%	2.87	Within 15%	Yes
Wilbur Ave Southbound	1,385	1,380	-5	-0.4%	0.14	Within 15%	Yes
Wilbur Ave Northbound	809	795	-14	-1.8%	0.50	Within 15%	Yes
Tampa Ave Southbound	1,458	1,421	-37	-2.6%	0.99	Within 15%	Yes
Tampa Ave Northbound	1,151	1,136	-15	-1.3%	0.45	Within 15%	Yes
Corbin Ave Southbound	970	968	-2	-0.2%	0.05	Within 15%	Yes
Corbin Ave Northbound	641	631	-10	-1.5%	0.38	Less than 100	Yes
Victory Blvd near Winnetka Ave Westbound	1,703	1,699	-4	-0.2%	0.09	Within 15%	Yes
Mason Ave Southbound	1,410	1,184	-226	-16.0%	6.27	Within 15%	Yes
Mason Ave Northbound	188	184	-4	-2.1%	0.29	Less than 100	Yes
De Soto Ave Southbound	2,031	1,999	-32	-1.6%	0.72	Within 15%	Yes

Network Link	AM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
De Soto Ave Northbound	1,318	1,307	-11	-0.8%	0.31	Within 15%	Yes
Victory Blvd near De Soto Ave Eastbound	1,048	1,039	-9	-0.9%	0.28	Within 15%	Yes
Vanowen St Eastbound	964	955	-9	-0.9%	0.29	Within 15%	Yes
Vanowen St Westbound	1,250	1,238	-12	-1.0%	0.35	Within 15%	Yes
Sherman Way Eastbound	821	817	-4	-0.5%	0.16	Within 15%	Yes
Sherman Way Westbound	1,211	1,166	-45	-3.7%	1.29	Within 15%	Yes
Valerio St Eastbound	209	210	1	0.6%	0.08	Less than 100	Yes
Valerio St Westbound	341	342	1	0.4%	0.07	Less than 100	Yes
Saticoy St Eastbound	1,032	1,032	0	0.0%	0.01	Within 15%	Yes
Saticoy St Westbound	1,223	1,233	10	0.8%	0.28	Within 15%	Yes
Roscoe Blvd Eastbound	1,133	1,137	4	0.3%	0.12	Within 15%	Yes
Roscoe Blvd Westbound	1,366	1,361	-5	-0.3%	0.13	Within 15%	Yes
Parthenia St Eastbound	557	564	7	1.3%	0.30	Less than 100	Yes
Parthenia St Westbound	1,322	1,325	3	0.3%	0.10	Within 15%	Yes
Nordhoff St Eastbound	618	632	14	2.3%	0.57	Less than 100	Yes
Nordhoff St Westbound	1,098	1,093	-5	-0.4%	0.14	Within 15%	Yes
Prairie Ave Eastbound	40	41	1	2.0%	0.12	Less than 100	Yes
Canoga Ave Southbound	576	574	-2	-0.3%	0.08	Less than 100	Yes
Exiting Network							
Chandler Blvd South Eastbound	719	677	-42	-5.9%	1.60	Within 15%	Yes
Tujinga Ave Southbound	706	698	-8	-1.1%	0.29	Within 15%	Yes
Tujinga Ave Northbound	217	202	-15	-7.1%	1.07	Less than 100	Yes
Colfax Ave Southbound	784	733	-51	-6.5%	1.84	Within 15%	Yes
Colfax Ave Northbound	510	530	20	3.8%	0.86	Less than 100	Yes
Laurel Cyn Southbound	1,414	1,357	-57	-4.0%	1.54	Within 15%	Yes
Laurel Cyn Northbound	766	702	-64	-8.3%	2.35	Within 15%	Yes
Corteen Pl Southbound	81	76	-5	-6.5%	0.60	Less than 100	Yes
Corteen Pl Northbound	101	142	41	41.1%	3.76	Less than 100	Yes
Whitsett Ave Southbound	1,368	1,300	-68	-4.9%	1.85	Within 15%	Yes
Whitsett Ave Northbound	463	467	4	0.9%	0.19	Less than 100	Yes
Bellaire Ave Southbound	116	120	4	3.8%	0.40	Less than 100	Yes
Bellaire Ave Northbound	86	86	0	0.0%	0.00	Less than 100	Yes
Coldwater Cyn Southbound	1,321	1,321	0	0.0%	0.01	Within 15%	Yes
Coldwater Cyn Northbound	564	566	2	0.4%	0.11	Less than 100	Yes
Ethel Ave Southbound	62	56	-6	-9.4%	0.76	Less than 100	Yes
Ethel Ave Northbound	115	118	3	2.3%	0.25	Less than 100	Yes
Chandler Blvd North Westbound	1,050	1,003	-47	-4.5%	1.47	Within 15%	Yes
Fulton Ave Southbound	1,103	1,050	-53	-4.8%	1.63	Within 15%	Yes
Fulton Ave Northbound	774	765	-9	-1.2%	0.34	Within 15%	Yes
Burbank Blvd Westbound	1,112	1,100	-12	-1.1%	0.37	Within 15%	Yes
Burbank Blvd Eastbound	1,440	1,447	7	0.5%	0.18	Within 15%	Yes
Oxnard St near Woodman Ave Eastbound	1,276	1,224	-52	-4.1%	1.47	Within 15%	Yes
Woodman Ave Southbound	1,343	1,329	-14	-1.1%	0.40	Within 15%	Yes
Woodman Ave Northbound	922	922	0	0.0%	0.01	Within 15%	Yes
Hazeltine Ave Northbound	548	531	-17	-3.2%	0.75	Less than 100	Yes
Tyrone Ave Southbound	146	125	-21	-14.4%	1.80	Less than 100	Yes
Tyrone Ave Northbound	121	118	-3	-2.3%	0.25	Less than 100	Yes
Van Nuys Blvd Northbound	1,322	1,357	35	2.7%	0.97	Within 15%	Yes
Vesper Ave Northbound	156	207	51	32.5%	3.77	Less than 100	Yes
Kester Ave Northbound	821	909	88	10.7%	2.98	Within 15%	Yes
Sepulveda Blvd Northbound	1,233	1,192	-41	-3.4%	1.19	Within 15%	Yes
Victory Blvd near Woodley Ave Eastbound	2,036	2,024	-12	-0.6%	0.27	Within 15%	Yes
Woodley Ave Southbound	1,686	1,647	-39	-2.3%	0.96	Within 15%	Yes
Woodley Ave Northbound	314	299	-15	-4.7%	0.85	Less than 100	Yes
Balboa Blvd Southbound	1,781	1,742	-39	-2.2%	0.93	Within 15%	Yes
Balboa Blvd Northbound	638	632	-6	-0.9%	0.22	Less than 100	Yes
Victory Blvd near Balboa Blvd Westbound	1,788	1,855	67	3.7%	1.57	Within 15%	Yes
Oxnard St near White Oaks Ave Eastbound	786	932	146	18.6%	4.98	Within 15%	Yes
White Oaks Ave Southbound	1,655	1,630	-25	-1.5%	0.62	Within 15%	Yes

Network Link	AM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
White Oaks Ave Northbound	978	993	15	1.6%	0.48	Within 15%	Yes
Lindley Ave Southbound	1,381	1,347	-34	-2.5%	0.93	Within 15%	Yes
Lindley Ave Northbound	873	865	-8	-1.0%	0.28	Within 15%	Yes
Reseda Blvd Southbound	1,174	1,256	82	7.0%	2.36	Within 15%	Yes
Reseda Blvd Northbound	828	848	20	2.4%	0.68	Within 15%	Yes
Wilbur Ave Southbound	1,269	1,270	1	0.1%	0.04	Within 15%	Yes
Wilbur Ave Northbound	810	800	-10	-1.2%	0.35	Within 15%	Yes
Tampa Ave Southbound	1,465	1,421	-44	-3.0%	1.15	Within 15%	Yes
Tampa Ave Northbound	1,010	992	-18	-1.8%	0.57	Within 15%	Yes
Corbin Ave Southbound	919	935	16	1.8%	0.53	Within 15%	Yes
Corbin Ave Northbound	719	714	-5	-0.7%	0.20	Within 15%	Yes
Victory Blvd near Winnetka Ave Eastbound	912	981	69	7.6%	2.25	Within 15%	Yes
Mason Ave Southbound	693	676	-17	-2.5%	0.65	Less than 100	Yes
Mason Ave Northbound	461	502	41	8.9%	1.86	Less than 100	Yes
De Soto Ave Southbound	2,059	2,127	68	3.3%	1.49	Within 15%	Yes
De Soto Ave Northbound	1,129	1,125	-4	-0.3%	0.11	Within 15%	Yes
Victory Blvd near De Soto Ave Westbound	1,781	2,114	333	18.7%	7.54	Within 15%	Yes
Vanowen St Eastbound	914	906	-8	-0.9%	0.27	Within 15%	Yes
Vanowen St Westbound	1,055	1,051	-4	-0.4%	0.14	Within 15%	Yes
Sherman Way Eastbound	845	833	-12	-1.5%	0.43	Within 15%	Yes
Sherman Way Westbound	1,100	1,059	-41	-3.7%	1.25	Within 15%	Yes
Valerio St Eastbound	180	184	4	2.5%	0.33	Less than 100	Yes
Valerio St Westbound	323	356	33	10.1%	1.77	Less than 100	Yes
Saticoy St Eastbound	1,031	1,022	-9	-0.8%	0.27	Within 15%	Yes
Saticoy St Westbound	1,129	1,146	17	1.5%	0.51	Within 15%	Yes
Roscoe Blvd Eastbound	1,099	1,083	-16	-1.4%	0.47	Within 15%	Yes
Roscoe Blvd Westbound	1,314	1,284	-30	-2.3%	0.84	Within 15%	Yes
Parthenia St Eastbound	660	660	0	0.0%	0.01	Less than 100	Yes
Parthenia St Westbound	733	761	28	3.9%	1.04	Within 15%	Yes
Nordhoff St Eastbound	899	909	10	1.1%	0.34	Within 15%	Yes
Nordhoff St Westbound	717	704	-13	-1.7%	0.47	Within 15%	Yes
Prairie Ave Westbound	72	70	-2	-2.7%	0.23	Less than 100	Yes
Canoga Ave Northbound	591	588	-3	-0.5%	0.12	Less than 100	Yes

SUM OF ALL LINKS	**132,118**	**131,649**	**-469**	**-0.4%**	**1.29**	**Within 5%**	**Yes**
						GEH < 4	**Yes**

Table 3 – PM Volume Calibration Results

Link	PM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
Entering Network							
Chandler Blvd North Westbound	117	112	-5	-4.0%	0.43	Less than 100	Yes
Chandler Blvd South Westbound	265	262	-3	-1.3%	0.21	Less than 100	Yes
Tujinga Ave Southbound	305	299	-6	-1.8%	0.32	Less than 100	Yes
Tujinga Ave Northbound	421	421	0	-0.1%	0.01	Less than 100	Yes
Colfax Ave Southbound	403	393	-10	-2.5%	0.51	Less than 100	Yes
Colfax Ave Northbound	597	591	-6	-1.0%	0.23	Less than 100	Yes
Laurel Cyn Southbound	746	736	-10	-1.4%	0.38	Within 15%	Yes
Laurel Cyn Northbound	1,196	1,172	-24	-2.0%	0.70	Within 15%	Yes
Corteen Pl Southbound	55	51	-4	-6.9%	0.52	Less than 100	Yes
Corteen Pl Northbound	67	62	-5	-7.2%	0.60	Less than 100	Yes
Whitsett Ave Southbound	427	437	10	2.3%	0.48	Less than 100	Yes
Whitsett Ave Northbound	755	743	-12	-1.6%	0.45	Within 15%	Yes
Bellaire Ave Southbound	41	43	2	4.2%	0.27	Less than 100	Yes
Bellaire Ave Northbound	58	55	-3	-4.5%	0.34	Less than 100	Yes
Coldwater Cyn Southbound	577	576	-1	-0.2%	0.05	Less than 100	Yes
Coldwater Cyn Northbound	1,123	1,124	1	0.1%	0.03	Within 15%	Yes
Ethel Ave Southbound	42	40	-2	-4.9%	0.32	Less than 100	Yes
Ethel Ave Northbound	17	15	-2	-9.2%	0.39	Less than 100	Yes
Chandler Blvd South Eastbound	755	749	-6	-0.8%	0.22	Within 15%	Yes
Fulton Ave Southbound	314	312	-2	-0.8%	0.14	Less than 100	Yes
Fulton Ave Northbound	830	831	1	0.1%	0.04	Within 15%	Yes
Burbank Blvd Westbound	1,274	1,253	-21	-1.6%	0.59	Within 15%	Yes
Burbank Blvd Eastbound	1,312	1,312	0	0.0%	0.00	Within 15%	Yes
Oxnard St near Woodman Ave Westbound	1,178	1,156	-22	-1.8%	0.63	Within 15%	Yes
Woodman Ave Southbound	729	717	-12	-1.6%	0.43	Within 15%	Yes
Woodman Ave Northbound	1,268	1,236	-32	-2.5%	0.90	Within 15%	Yes
Hazeltine Ave Southbound	516	518	2	0.4%	0.09	Less than 100	Yes
Tyrone Ave Southbound	93	73	-20	-21.2%	2.16	Less than 100	Yes
Tyrone Ave Northbound	112	117	5	4.8%	0.51	Less than 100	Yes
Van Nuys Blvd Southbound	1,007	1,008	1	0.1%	0.04	Within 15%	Yes
Vesper Ave Southbound	131	125	-6	-4.2%	0.49	Less than 100	Yes
Kester Ave Southbound	859	851	-8	-1.0%	0.28	Within 15%	Yes
Sepulveda Blvd Southbound	1,363	1,318	-45	-3.3%	1.23	Within 15%	Yes
Victory Blvd near Woodley Ave Westbound	2,108	2,164	56	2.6%	1.20	Within 15%	Yes
Woodley Ave Southbound	536	516	-20	-3.7%	0.87	Less than 100	Yes
Woodley Ave Northbound	1,015	1,006	-9	-0.9%	0.29	Within 15%	Yes
Balboa Blvd Southbound	679	676	-3	-0.4%	0.11	Less than 100	Yes
Balboa Blvd Northbound	1,455	1,448	-7	-0.5%	0.19	Within 15%	Yes
Victory Blvd near Balboa Blvd Eastbound	1,872	1,873	1	0.1%	0.02	Within 15%	Yes
Oxnard St near White Oaks Ave Westbound	444	453	9	2.1%	0.44	Less than 100	Yes
White Oaks Ave Southbound	801	800	-1	-0.1%	0.03	Within 15%	Yes
White Oaks Ave Northbound	1,089	1,080	-9	-0.8%	0.27	Within 15%	Yes
Lindley Ave Southbound	731	684	-47	-6.5%	1.78	Within 15%	Yes
Lindley Ave Northbound	870	870	0	-0.1%	0.01	Within 15%	Yes
Reseda Blvd Southbound	919	832	-87	-9.5%	2.94	Within 15%	Yes
Reseda Blvd Northbound	1,071	1,068	-3	-0.2%	0.08	Within 15%	Yes
Wilbur Ave Southbound	592	597	5	0.8%	0.19	Less than 100	Yes
Wilbur Ave Northbound	801	786	-15	-1.9%	0.53	Within 15%	Yes
Tampa Ave Southbound	717	717	0	0.0%	0.00	Within 15%	Yes
Tampa Ave Northbound	1,458	1,452	-6	-0.4%	0.15	Within 15%	Yes
Corbin Ave Southbound	411	399	-12	-2.8%	0.57	Less than 100	Yes
Corbin Ave Northbound	888	880	-8	-0.9%	0.26	Within 15%	Yes
Victory Blvd near Winnetka Ave Westbound	1,116	1,133	17	1.6%	0.52	Within 15%	Yes
Mason Ave Southbound	430	432	2	0.5%	0.10	Less than 100	Yes
Mason Ave Northbound	511	592	81	15.9%	3.47	Less than 100	Yes
De Soto Ave Southbound	1,093	1,092	-1	-0.1%	0.03	Within 15%	Yes

Link	PM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
De Soto Ave Northbound	1,598	1,584	-14	-0.9%	0.36	Within 15%	Yes
Victory Blvd near De Soto Ave Eastbound	2,154	1,988	-166	-7.7%	3.66	Within 15%	Yes
Vanowen St Eastbound	1,120	1,109	-11	-1.0%	0.33	Within 15%	Yes
Vanowen St Westbound	1,040	1,035	-5	-0.4%	0.14	Within 15%	Yes
Sherman Way Eastbound	896	891	-5	-0.5%	0.16	Within 15%	Yes
Sherman Way Westbound	937	937	0	0.0%	0.00	Within 15%	Yes
Valerio St Eastbound	305	304	-1	-0.3%	0.06	Less than 100	Yes
Valerio St Westbound	166	176	10	6.3%	0.80	Less than 100	Yes
Saticoy St Eastbound	1,155	1,166	11	0.9%	0.32	Within 15%	Yes
Saticoy St Westbound	1,008	1,021	13	1.3%	0.41	Within 15%	Yes
Roscoe Blvd Eastbound	1,279	1,291	12	0.9%	0.34	Within 15%	Yes
Roscoe Blvd Westbound	1,099	1,098	-1	-0.1%	0.03	Within 15%	Yes
Parthenia St Eastbound	657	668	11	1.7%	0.43	Less than 100	Yes
Parthenia St Westbound	817	824	7	0.9%	0.25	Within 15%	Yes
Nordhoff St Eastbound	613	627	14	2.3%	0.56	Less than 100	Yes
Nordhoff St Westbound	939	940	1	0.1%	0.02	Within 15%	Yes
Prairie Ave Eastbound	134	130	-4	-2.7%	0.31	Less than 100	Yes
Canoga Ave Southbound	671	665	-6	-0.9%	0.24	Less than 100	Yes
Exiting Network							
Chandler Blvd South Eastbound	672	642	-30	-4.4%	1.17	Less than 100	Yes
Tujinga Ave Southbound	430	425	-5	-1.2%	0.25	Less than 100	Yes
Tujinga Ave Northbound	256	240	-16	-6.3%	1.03	Less than 100	Yes
Colfax Ave Southbound	452	431	-21	-4.7%	1.01	Less than 100	Yes
Colfax Ave Northbound	612	603	-9	-1.4%	0.35	Less than 100	Yes
Laurel Cyn Southbound	751	739	-12	-1.6%	0.45	Within 15%	Yes
Laurel Cyn Northbound	1,205	1,215	10	0.8%	0.29	Within 15%	Yes
Corteen Pl Southbound	63	57	-6	-9.1%	0.74	Less than 100	Yes
Corteen Pl Northbound	90	80	-10	-11.6%	1.14	Less than 100	Yes
Whitsett Ave Southbound	475	467	-8	-1.6%	0.36	Less than 100	Yes
Whitsett Ave Northbound	759	748	-11	-1.5%	0.41	Within 15%	Yes
Bellaire Ave Southbound	42	43	1	1.8%	0.11	Less than 100	Yes
Bellaire Ave Northbound	81	80	-1	-1.1%	0.10	Less than 100	Yes
Coldwater Cyn Southbound	625	635	10	1.5%	0.38	Less than 100	Yes
Coldwater Cyn Northbound	991	1,029	38	3.8%	1.19	Within 15%	Yes
Ethel Ave Southbound	27	24	-3	-10.6%	0.57	Less than 100	Yes
Ethel Ave Northbound	51	62	11	21.9%	1.48	Less than 100	Yes
Chandler Blvd North Westbound	661	634	-27	-4.1%	1.07	Less than 100	Yes
Fulton Ave Southbound	362	349	-13	-3.5%	0.66	Less than 100	Yes
Fulton Ave Northbound	765	764	-1	-0.2%	0.05	Within 15%	Yes
Burbank Blvd Westbound	1,276	1,258	-18	-1.4%	0.50	Within 15%	Yes
Burbank Blvd Eastbound	1,328	1,329	1	0.1%	0.04	Within 15%	Yes
Oxnard St near Woodman Ave Eastbound	1,111	1,181	70	6.3%	2.07	Within 15%	Yes
Woodman Ave Southbound	656	681	25	3.8%	0.98	Less than 100	Yes
Woodman Ave Northbound	1,242	1,291	49	3.9%	1.38	Within 15%	Yes
Hazeltine Ave Northbound	773	736	-37	-4.8%	1.34	Within 15%	Yes
Tyrone Ave Southbound	67	49	-18	-26.9%	2.37	Less than 100	Yes
Tyrone Ave Northbound	111	111	0	0.4%	0.04	Less than 100	Yes
Van Nuys Blvd Northbound	1,403	1,452	49	3.5%	1.28	Within 15%	Yes
Vesper Ave Northbound	124	128	4	2.9%	0.32	Less than 100	Yes
Kester Ave Northbound	1,168	1,159	-9	-0.7%	0.25	Within 15%	Yes
Sepulveda Blvd Northbound	2,039	2,151	112	5.5%	2.44	Within 15%	Yes
Victory Blvd near Woodley Ave Eastbound	2,226	2,220	-6	-0.3%	0.12	Within 15%	Yes
Woodley Ave Southbound	305	270	-35	-11.4%	2.04	Less than 100	Yes
Woodley Ave Northbound	771	750	-21	-2.7%	0.76	Within 15%	Yes
Balboa Blvd Southbound	788	792	4	0.5%	0.14	Within 15%	Yes
Balboa Blvd Northbound	1,250	1,352	102	8.1%	2.82	Within 15%	Yes
Victory Blvd near Balboa Blvd Westbound	1,907	2,035	128	6.7%	2.89	Within 15%	Yes
Oxnard St near White Oaks Ave Eastbound	258	283	25	9.5%	1.49	Less than 100	Yes
White Oaks Ave Southbound	806	800	-6	-0.7%	0.20	Within 15%	Yes

Link	PM Volume		Difference	Difference %	GEH	Target	Achieved?
	Field	Simulated					
White Oaks Ave Northbound	1,328	1,332	4	0.3%	0.12	Within 15%	Yes
Lindley Ave Southbound	682	661	-21	-3.0%	0.80	Less than 100	Yes
Lindley Ave Northbound	1,063	1,040	-23	-2.2%	0.71	Within 15%	Yes
Reseda Blvd Southbound	959	984	25	2.6%	0.80	Within 15%	Yes
Reseda Blvd Northbound	1,088	1,084	-4	-0.4%	0.12	Within 15%	Yes
Wilbur Ave Southbound	598	626	28	4.8%	1.15	Less than 100	Yes
Wilbur Ave Northbound	857	854	-3	-0.3%	0.10	Within 15%	Yes
Tampa Ave Southbound	714	719	5	0.7%	0.18	Within 15%	Yes
Tampa Ave Northbound	1,429	1,430	1	0.1%	0.04	Within 15%	Yes
Corbin Ave Southbound	364	355	-9	-2.5%	0.49	Less than 100	Yes
Corbin Ave Northbound	909	900	-9	-1.0%	0.31	Within 15%	Yes
Victory Blvd near Winnetka Ave Eastbound	1,677	1,790	113	6.7%	2.72	Within 15%	Yes
Mason Ave Southbound	202	202	0	0.2%	0.02	Less than 100	Yes
Mason Ave Northbound	863	798	-65	-7.6%	2.26	Within 15%	Yes
De Soto Ave Southbound	1,144	1,153	9	0.8%	0.27	Within 15%	Yes
De Soto Ave Northbound	1,664	1,594	-70	-4.2%	1.75	Within 15%	Yes
Victory Blvd near De Soto Ave Westbound	1,358	1,402	44	3.2%	1.18	Within 15%	Yes
Vanowen St Eastbound	1,503	1,542	39	2.6%	0.99	Within 15%	Yes
Vanowen St Westbound	1,058	1,086	28	2.6%	0.85	Within 15%	Yes
Sherman Way Eastbound	1,166	1,160	-6	-0.5%	0.17	Within 15%	Yes
Sherman Way Westbound	943	937	-6	-0.7%	0.21	Within 15%	Yes
Valerio St Eastbound	393	402	9	2.4%	0.47	Less than 100	Yes
Valerio St Westbound	134	155	21	15.6%	1.74	Less than 100	Yes
Saticoy St Eastbound	1,335	1,321	-14	-1.1%	0.39	Within 15%	Yes
Saticoy St Westbound	997	995	-2	-0.2%	0.08	Within 15%	Yes
Roscoe Blvd Eastbound	1,436	1,418	-18	-1.2%	0.47	Within 15%	Yes
Roscoe Blvd Westbound	1,059	1,031	-28	-2.7%	0.87	Within 15%	Yes
Parthenia St Eastbound	1,106	1,105	-1	-0.1%	0.03	Within 15%	Yes
Parthenia St Westbound	554	559	5	1.0%	0.23	Less than 100	Yes
Nordhoff St Eastbound	1,034	1,054	20	2.0%	0.63	Within 15%	Yes
Nordhoff St Westbound	596	588	-8	-1.4%	0.35	Less than 100	Yes
Prairie Ave Westbound	14	15	1	10.4%	0.38	Less than 100	Yes
Canoga Ave Northbound	703	749	46	6.6%	1.71	Within 15%	Yes

SUM OF ALL LINKS	**117,057**	**117,051**	**-6**	**0.0%**	**0.02**	**Within 5%**	**Yes**
						GEH < 4	**Yes**

Table 7 – Existing Year Simulation Intersection Operations

Intersection	Existing Transit Signal Priority (TSP) Intersection?	Existing AM		Existing PM	
		Average Intersection Delay (veh/sec)	LOS	Average Intersection Delay (veh/sec)	LOS
Chandler Boulevard North/Tujunga Avenue	--	16.3	B	13.7	B
Tujunga Avenue/MOL Busway	--	4.3	A	3.9	A
Chandler Boulevard South/Tujunga Avenue	--	28.5	C	32.3	C
Chandler Boulevard/Colfax Avenue/MOL Busway	TSP	30.8	C	28.5	C
Chandler Boulevard/Laurel Canyon Boulevard/MOL Busway	TSP	33.9	C	29.6	C
Chandler Boulevard/Corteen Place/MOL Busway	TSP	14.5	B	10.1	B
Chandler Boulevard/Whitsett Avenue/MOL Busway	TSP	37.4	D	28.6	C
Chandler Boulevard/Bellaire Avenue/MOL Busway	TSP	15.1	B	7.1	A
Chandler Boulevard/Coldwater Canyon Boulevard/MOL Busway	TSP	33.4	C	32.9	C
Chandler Boulevard/MOL Busway	--	4.4	A	5.4	A
Ethel Avenue/MOL Busway	--	7.2	A	8.8	A
Ethel Avenue/Chandler Boulevard	--	6.4	A	4.8	A
Burbank Boulevard/Fulton Avenue/MOL Busway	--	47.8	D	20.9	C
Oxnard Street/Buffalo Avenue/MOL Busway	--	7.0	A	3.2	A
Woodman Avenue/MOL Busway	--	9.9	A	2.9	A
Woodman Avenue/Oxnard Street	--	23.2	C	19.4	B
Hazeltine Avenue/MOL Busway	--	7.1	A	3.9	A
Tyrone Avenue/MOL Busway	--	3.6	A	2.9	A
Van Nuys Boulevard/MOL Busway	--	6.0	A	3.9	A
Van Nuys Boulevard/Aetna Street	--	4.7	A	4.4	A
Vesper Avenue/MOL Busway	--	5.6	A	4.7	A
Kester Avenue/MOL Busway	--	2.3	A	1.3	A
Sepulveda Boulevard/MOL Busway	--	4.6	A	3.7	A
Woodley Avenue/Victory Boulevard	--	36.7	D	26.1	C
Woodley Avenue/MOL Busway	TSP	12.7	B	**69.8**	**E**
Victory Boulevard/Balboa Boulevard	--	34.2	C	29.3	C
Balboa Boulevard/MOL Busway	--	3.0	A	9.4	A
Oxnard Street/White Oak Avenue/MOL Busway	--	32.7	C	25.5	C
Oxnard Street/Lindley Avenue/MOL Busway	--	34.4	C	28.9	C
Reseda Boulevard/MOL Busway	--	4.7	A	5.2	A
Reseda Boulevard/Oxnard Street	--	24.5	C	25.5	C
Wilbur Avenue/Oxnard Street/MOL Busway	--	40.6	D	34.4	C
Tampa Avenue/Topham Street/MOL Busway	--	38.0	D	29.1	C
Corbin Avenue/Topham Street/MOL Busway	--	29.9	C	29.6	C
Victory Boulevard/Topham Street/MOL Busway	--	15.7	B	12.1	B
Winnetka Avenue/MOL Busway	--	4.1	A	3.1	A
Victory Boulevard/Mason Avenue/MOL Busway	TSP	43.4	D	35.3	D
Victory Boulevard/De Soto Avenue/MOL Busway	TSP	40.0	D	49.6	D
Canoga Avenue/Vanowen Street/MOL Busway	TSP	44.4	D	41.2	D
Canoga Avenue/Sherman Way	--	26.9	C	31.0	C
Canoga Avenue/Valerio Street/MOL Busway	TSP	17.1	B	19.1	B
Canoga Avenue/Saticoy Street/MOL Busway	TSP	32.2	C	36.3	D
Canoga Avenue/Roscoe Boulevard/MOL Busway	TSP	30.8	C	29.3	C
Canoga Avenue/Parthenia Street/MOL Busway	TSP	32.6	C	31.4	C
Canoga Avenue/Nordoff Street/MOL Busway	TSP	28.8	C	29.1	C
Canoga Avenue/Prairie Avenue/MOL Busway	TSP	7.3	A	10.9	B

Attachment A

Metro Orange Line Speed Evaluation Study

Metro Orange Line Speed Evaluation Study

Final Report

Contract Number PS4010-3041-DD-04 (Discipline 4)
Task/Revision Number CIMS PO: AE319760011867

December 10, 2015

Submitted to:

Metro

Sam G. Morrissey
California Registered Professional
Traffic Engineer #TR 2555

J16-1763

Innovation for better mobility

ITERIS

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Administrative Draft Report	September 18, 2015	1.0
Draft Report	September 29, 2015	1.1
Final Report	November 6, 2015	2.0
Final Report	December 4, 2015	2.1
Final Report	December 10, 2015	2.2

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APPENDICES (BOUND SEPARATELY)

1 EXECUTIVE SUMMARY

Iteris, Inc. (Iteris) was selected by the Los Angeles County Metropolitan Transportation Authority (Metro) to complete the Orange Line Speed Improvement Study. The purpose of the study is to determine the criteria appropriate for designation of safe intersection crossing speeds for Metro buses that will reduce signal delay encountered by buses along the Orange Line busway. The bus speeds identified in the study will be used to determine how best to make changes in the current signal timing program used by the City of Los Angeles.

This study consists of six (6) primary components:

1. Line rides to observe existing bus operations, and a review of existing operator instructions
2. Collection and review of traffic data (speeds, volumes, queuing, dwell times and travel times) for buses and vehicles
3. Review of collision records along the busway
4. Field review of existing traffic control devices and geometric conditions at all busway crossings
5. Review and simulation of traffic signal operations
6. Development of recommendations of optimal crossing speed for each busway crossing intersection, as well as any additional mitigation measures and timing adjustments that may be required to support the recommended optimal crossing speeds

The study findings can be summarized as follows:

- The Orange Line is currently the only bus transit service operating on an exclusive right-of-way in Los Angeles County, and the operations of the traffic signal controlled crossings are similar to other street running light rail operations throughout the County.
- Since a series of high-profile bus-involved collisions occurred in the months following the opening of the line in 2005, bus-involved collision rates along the line have subsequently reduced and are consistent with collision rates experienced on other roadways in Los Angeles County where buses operate.
- There are a combination of factors resulting in a general sense of uncertainty for bus operators of cross-traffic activity at the intersections along the alignment. By addressing and reducing the factors creating this sense of uncertainty, bus speeds can be increased.
- There are some immediate minor modifications that can be made to improve stopping sight distance and signage visibility at selected crossings along the Orange Line; in general, there are no unique or major geometric or operational concerns at any crossing.
- There are ten crossing locations along the corridor where adjacent sound walls and/or structures limit sight distances for buses approaching the crossing, which therefore requires bus operators to approach the crossing at reduced speeds.
- Current operator instructions restrict bus speeds at all crossings to 10 miles per hour (mph), and should be immediately modified to allow for increased bus speeds at signalized crossings.
- At increased travel speeds, the benefits of the existing traffic signal timing parameters should be realized, and travel time savings of 10 minutes or more could be achieved along the entire alignment.

- o Based on signal timing plans provided by the Los Angeles Department of Transportation (LADOT), it appears that the buses should be able to progress along the route at roughly 35 mph.
- o Due to the current slow order, it cannot be determined if the current signal timing is optimized for the progression of buses; therefore, immediate travel time reductions from increased bus speeds may be reduced.
- There is no data – in terms of collision records, observed field conditions, or documented bus operator concerns – to indicate that increasing bus speeds at crossings would increase the frequency of collisions along the busway. With higher bus speeds, it is likely that the severity of any bus-involved collision would be greater.

The key recommendations of the study are summarized below:

- Immediate modifications to landscaping to address sight distance constraints.
- Various improvements to signage, traffic control, and/or geometric features to reduce the uncertainties of traffic – vehicular, pedestrian, and bicycle - entering or crossing the busway at crossing intersections.
- Rescinding of the existing "Slow Order," thereby allowing bus operators the ability to improve travel times by traveling at faster speeds through intersections.
    - o There are ten crossings where sight distance and visibility constraints cannot be mitigated; therefore, crossing speed increases over the existing speeds as stipulated by the "Slow Order" will be minimal.
- Adjustment of bus operating procedures to account for both bus operating characteristics and operator orders.
- Traffic signal timing improvements may be necessary to reduce delay experienced by buses at signalized crossing locations and improve progression through signalized crossings between stations along the busway.
    - o Once the slow order is rescinded, then it will be beneficial to reevaluate signal operations to determine the extent of any traffic signal timing improvements necessary.
    - o Any signal adjustments have to account for required changes in pedestrian and bicycle timing per new State requirements, and will therefore require close coordination with LADOT staff.
- Improve the current system to register and monitor the functionality of bus transponders, or discontinue the practice of "registering" transponders, instead allowing any transponders to activate the transit signal priority (TSP) functions along the busway.
- The collision history indicates that approximately 80% of bus-involved collisions were due to vehicles running red lights and/or disregarding posted signs. At locations along the Orange Line where red light photo enforcement cameras have been implemented, the rate of violations has declined since the cameras were installed, and violations still occur. This evidence suggests that in order to reduce the potential of collisions due to such violations, Metro should consider installing red light photo enforcement cameras at all intersections along the alignment.
- During line rides and interviews with senior Metro bus operators, it was noted that the presence of in-roadway warning light systems reduced operator uncertainty regarding vehicle activities at crossings. Metro should consider expanding this feature to other intersections which may provide

an added level of assurance and confidence to operators as bus speeds are increased through the intersections.

- Consider a pilot program to implement an in-vehicle signal timing notification system to provide real-time signal information to bus operators, notifying them of the status of the green or red signals at an approaching signalized crossing. Such a system could provide bus operators with a recommended speed to approach a crossing to ensure they would not stop abruptly at a red light.

2 INTRODUCTION

The Metro Orange Line (MOL) opened in October 2005 from North Hollywood to Warner Center along the former Southern Pacific Railroad right-of-way, followed by an extension to Chatsworth in 2012. The Metro Orange Line totals nearly 18 miles in length from North Hollywood to Chatsworth, and includes 38 signalized crossings, with an additional five pedestrian only crossings. The line diverges in Canoga Park near the intersection of Canoga Avenue and Victory Boulevard, with the dedicated busway continuing north to Chatsworth and the line to Warner Center running on the street in mixed-flow traffic. **Figure 1** shows the extents of the line as well as the station locations.

The North Hollywood Station provides a connection with the Metro Red Line to Hollywood and Downtown Los Angeles as well as other local services and the Los Angeles DOT 549 Commuter Express. The Chatsworth Station provides a connection with the Metrolink Ventura County Line and Amtrak Pacific Surfliner. Connections are provided to Metro Rapid service at the Van Nuys, Sepulveda, Reseda, and Warner Center Stations.

2.1.1 Purpose

Immediately following the opening of the first segment of the Orange Line, in November and December 2005, there were a series of high-profile bus-involved collisions along the line at crossing intersections. It became apparent that some motorists did not react to the new traffic signals that controlled the busway and the street crossings, and there were 11 collisions in the first two months of initial operation. The cause of the collisions were attributed to driver inattentiveness and/or disregard of traffic signals.

The traffic signals were originally programmed for allow for bus operators to drive through signalized crossings at speeds similar to those of vehicles on adjacent surface streets. Because of the number and severity of the collisions immediately following the opening of the line, Metro, in consultation with the Los Angeles Police Department (LAPD), Los Angeles Sheriff's Department (LASD), and the Los Angeles City Council, determined that a "slow order" would be issued for all crossings along the Orange Line. The slow order requires operators to slow to 10 mph approaching and crossing all intersections, and then to accelerate to cruising speed after ascertaining that the intersection was safe to enter. The ultimate result of this action was to slow the operation of Orange Line buses across the Valley such that the average speed fell to 21 mph or less.

The MOL serves as the backbone of the San Fernando Valley's transit service. In order to improve service, the Metro Board of Directors approved a motion directing staff to work with the Los Angeles Department of Transportation (LADOT) to adjust traffic signal timing to advantage the buses, improve travel times and speeds, and provide smoother and more reliable service for Metro's customers. Metro then initiated a competitive procurement process using their approved bench of on-call contractors, and initiated the Orange Line Speed Evaluation study in July 2015.

There is a desire on the part of many stakeholders – from the Metro Board, Metro staff, Metro operators, riders, and members of the Los Angeles City Council - to see improvements in MOL travel times from North Hollywood to Warner Center and Chatsworth. The MOL service is the premier bus rapid transit (BRT) experience in Los Angeles County, and riders continue to express frustration with the seemingly purposeless stops that are experienced on the buses at signalized crossings. The purpose of the study is to determine the criteria appropriate for designation of safe intersection crossing speeds for Metro buses that will reduce signal delay encountered by buses along the Orange Line busway. The bus speeds identified in the study will be used to determine changes necessary, if any, to the current signal timing program used by the City of Los Angeles.

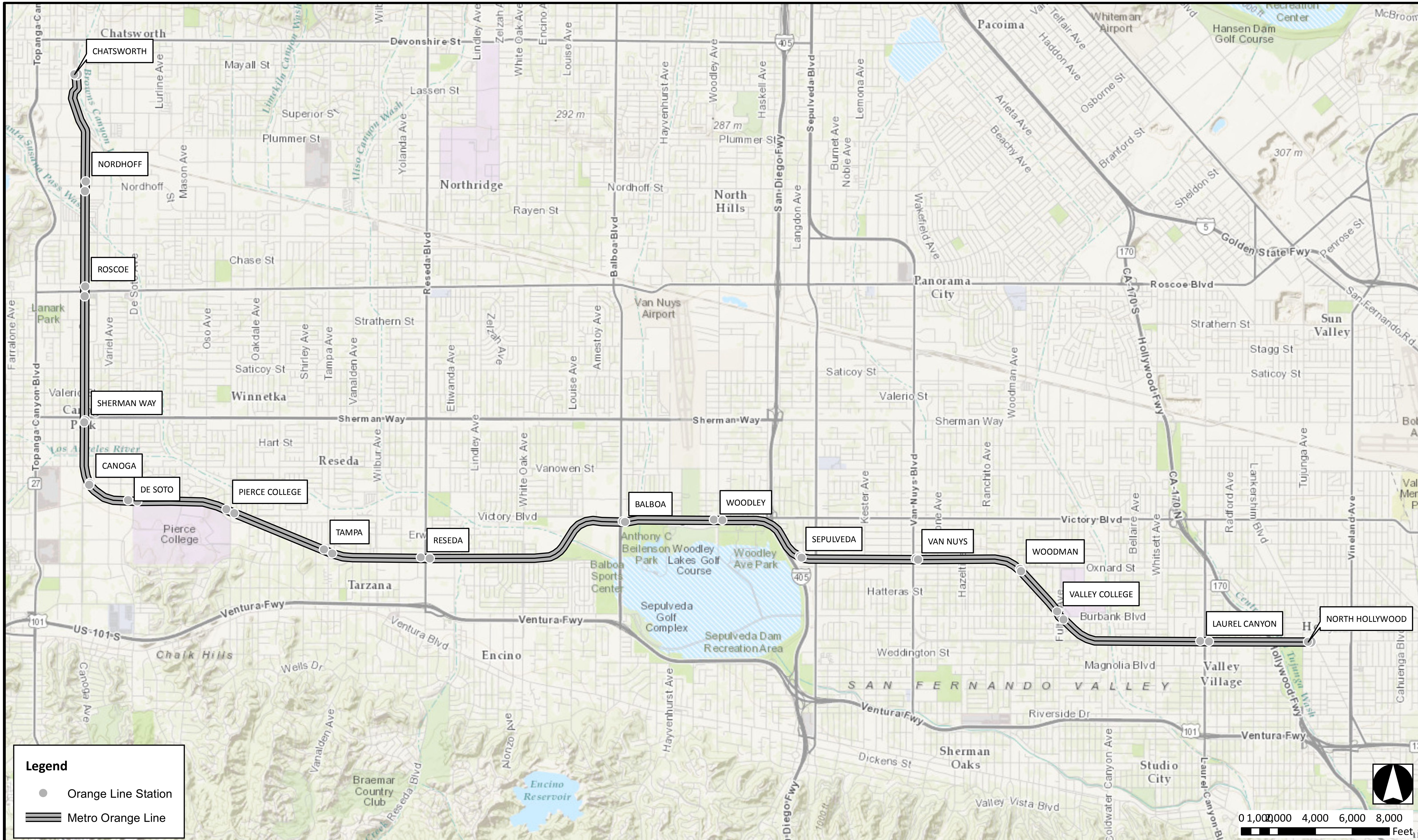


Figure 1
Metro Orange Line

3 EXISTING OPERATING CHARACTERISTICS

This section provides the results of the consultant team's review of the existing MOL operating characteristics. This review included several line rides by the consultant team, interviews with current bus operators, review of current bus operating instructions, field visits to intersection crossings, evaluation of traffic data, and an assessment of collision history in the vicinity of the route.

3.1.1 Summary of Line Rides

The Iteris consultant team conducted a total of 35 line rides on the MOL in August 2015. The majority of line rides were conducted during the afternoon peak periods, when surface street congestion levels are at their highest. **Table 1** presents a summary of the average travel times recorded during line rides conducted during the weekday morning, mid-day, and afternoon periods. **Figure 2** displays a more detailed view of the travel times by presenting average ranges between stations. **Figure 3** shows the average dwell/loading times at each station per direction. As shown, loading times are highest at the Van Nuys, Sepulveda, Balboa, Reseda, and Nordhoff stations, with average loading times exceeding 30 seconds. An inventory of the travel time data from each line ride is provided in **Appendix A**.

The following exhibits highlight observations from the line rides.

Exhibit 1: High ridership during peak hours, including bicycles and wheelchairs

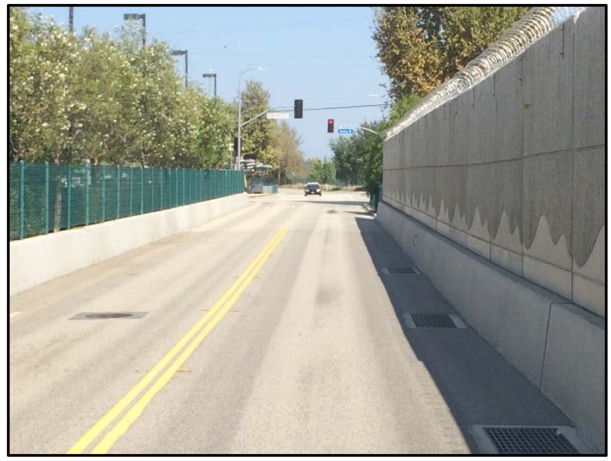
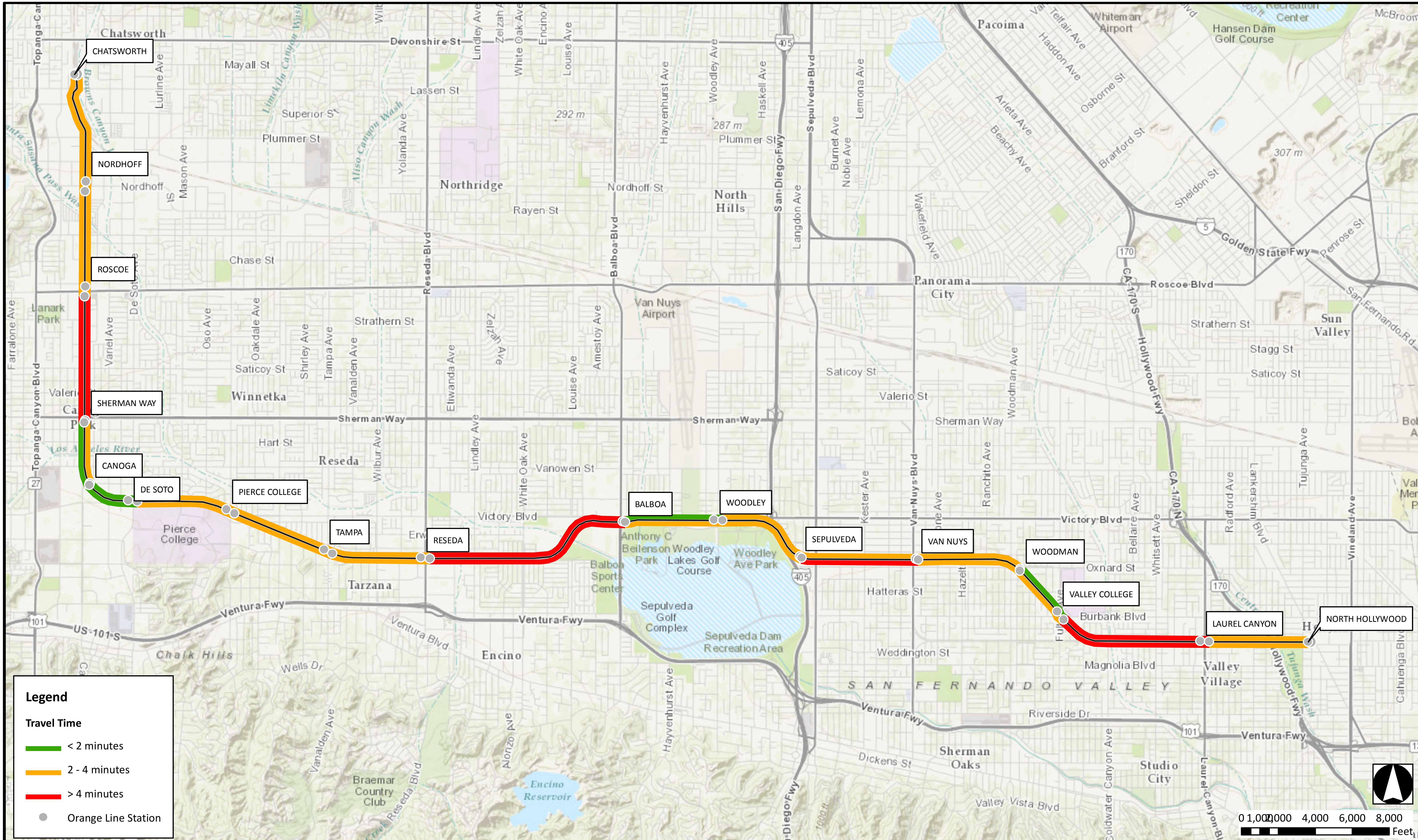


Exhibit 2: Sight distance constraints due to landscaping, buildings, and walls



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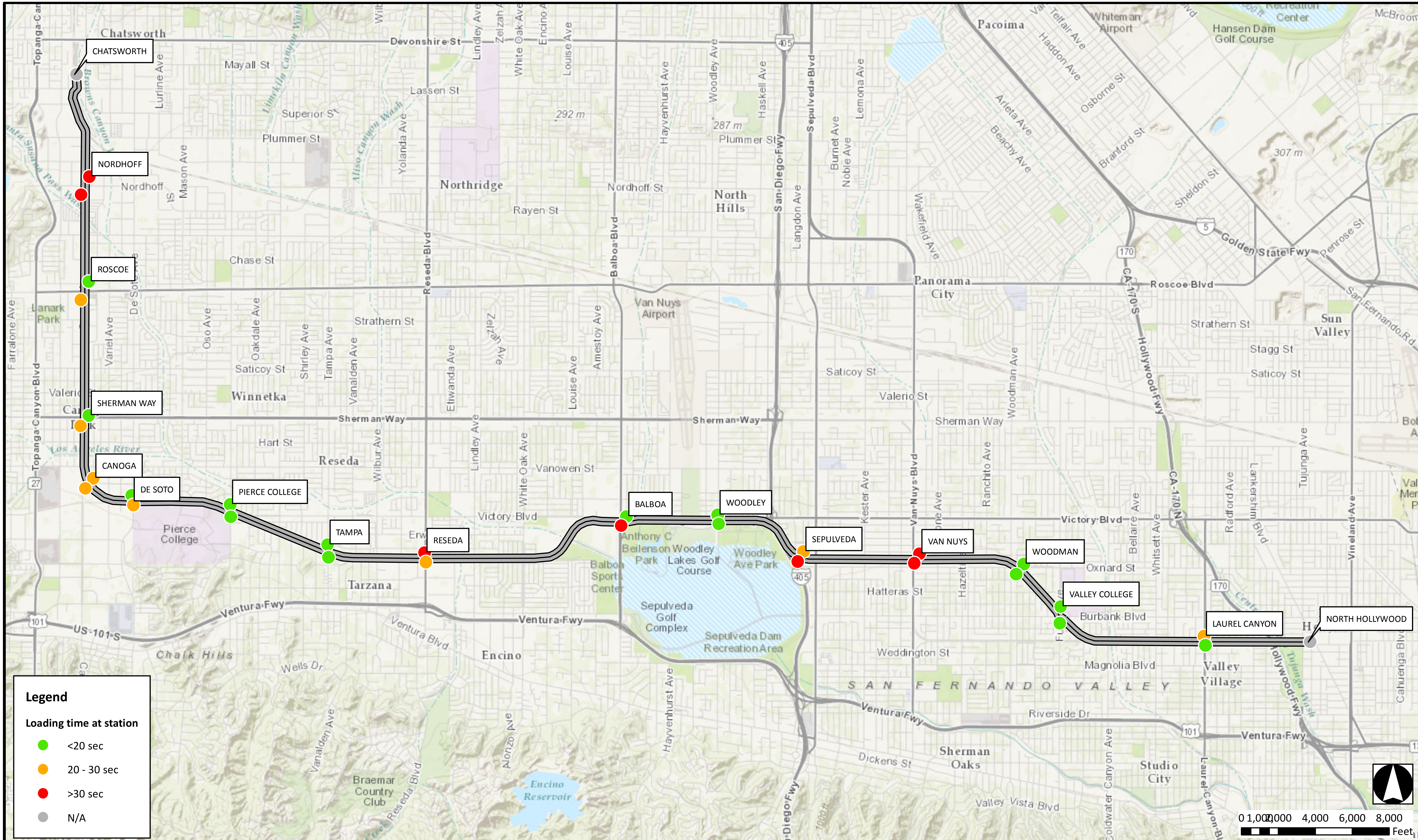
Speed Improvement Study

Figure 2
Average Travel Time



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Speed Improvement Project

Figure 3
Average Loading Time

Table 1 – Metro Orange Line Average Travel Times

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)				EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)			
	AM[1]	MID-DAY[1]	PM[1]	DAY[1]	AM[1]	MID-DAY[1]	PM[1]	DAY[1]
North Hollywood to Canoga Time between stations[2] (min)	39	40	42	40	38	42	39	39
Canoga to Chatsworth Time between stations[3] (min)	14	16	14	15	15	12	14	14
North Hollywood to Chatsworth Total travel time (min)[4]	53	56	56	55	53	54	53	53

Source: Iteris Travel Time Runs, August 2015
Notes:
[1] The travel times shown represent the average travel times of all line rides conducted during this time period. AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM; DAY is the average for all three time periods.
[2] The distance between the North Hollywood station and the Canoga station is approximately 13.5 miles.
[3] The distance between the Canoga station and the Chatsworth station is approximately 4.5 miles.
[4] Total travel time results include dwell times for boarding/alighting at stations.

As shown in **Table 1**, the average travel time in the eastbound direction is generally a few minutes shorter than the westbound direction for the mid-day and PM time periods, whereas the average travel time during AM time period was approximately the same for each direction.

Note that these travel times include dwell time at stations for passenger boardings/alightings. Dwell times can vary significantly, particularly with high demand for bicycles and/or wheelchairs. During field observations, bicycle and wheelchair loadings were minimal – approximately one or two instances per route. With more bicycle and/or wheelchair loading, or increased numbers attempting to board the buses, dwell times may increase.

It is also important to note the number of times buses stop at traffic signals along the route. **Table 2** shows two type of stops at the signalized intersections: buses slowing down to approach the red light and buses making a full stop at the red light.

Table 2 – Number of Red Lights Encountered Along Bus Route

SEGMENT	AM PEAK[1]			MID-DAY[1]			PM PEAK[1]		
	App. Red Light[2]	Stop Red Light	Total	App. Red Light[2]	Stop Red Light	Total	App. Red Light[2]	Stop Red Light	Total
North Hollywood to Chatsworth (Westbound/Northbound)	10	5	**15**	9	4	**13**	8	5	**13**
Chatsworth to North Hollywood (Eastbound/Southbound)	9	4	**13**	5	5	**10**	5	2	**7**

Source: TransLink Consulting, LLC, August 2015
Notes: [1] AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM.
[2] Approached Red Light – Driver slowed bus approximately 100 feet prior to intersection to avoid a full stop at the signal.

Table 2 shows that during the AM peak period, buses slow down or come to a full stop at 13-15 signalized crossings. During the midday peak period, buses slow down or come to a full stop at 10-13 signalized crossings. During the PM peak period, buses slow down or come to a full stop at 7-13 signalized crossings. Based on the field observations, bus travel times can increase by up to five (5) minutes due to traffic signal delays at crossings.

3.1.2 Automobile Travel Times on Parallel Surface Streets

In November 2015, travel time data was collected for automobiles travelling on roadways parallel to the MOL, as shown in **Table 3**. The automobile travel time data was then compared to the MOL travel times. **Table 3** shows that the MOL travel times are very similar, and sometimes even lower than driving automobiles. For instance, in the eastbound direction, it was observed that the average driving travel time during the AM peak hours is 62 minutes, while the MOL buses take an average of 53 minutes. In the westbound, it was observed that the average driving travel time during the PM peak hours is 63 minutes, while the MOL buses take an average of 56 minutes. It should be noted that during the mid-day peak hours, in both directions, the MOL travel times are between 5-8 minutes higher than automobile travel times. Overall, it appears that during morning and afternoon peak weekday commute periods, buses on the MOL traverse the corridor faster than automobile drivers on surface streets.

Table 3 – Automobile Travel Times on Parallel Surface Streets

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)			EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)		
	AM[1]	MID-DAY[1]	PM[1]	AM[1]	MID-DAY[1]	PM[1]
North Hollywood to Canoga Time between stations (min)	42	36	51	45	34	33
Canoga to Chatsworth Time between stations (min)	12	15	12	17	12	12
North Hollywood to Chatsworth Total travel time (min)	54	51	63	62	46	45

Source: Translink Consulting Travel Time Runs, November 2015
Notes:
[1] The travel times shown represent the average travel times of all line rides conducted during this time period. AM time period occurred from 7:00-10:00 AM, Mid-day occurred from 10:00 AM -3:00 PM, PM period occurred from 3:00-7:00 PM; DAY is the average for all three time periods.

In addition to the drive alone travel time surveys, automobile travel time estimates were collected the week of November 16th from Google Maps and Waze, which are navigation tools that collect current traffic data and provide real-time travel time estimates based on this data. **Table 4** shows the peak hour estimated travel times on a regular weekday for automobiles traveling along the corridor on parallel surface streets. It was observed that the estimated travel times are comparable to the automobile travel time survey, within 0 – 5 minute range, validating the observations that the MOL buses currently run faster than automobiles on surface streets during peak weekday commute periods.

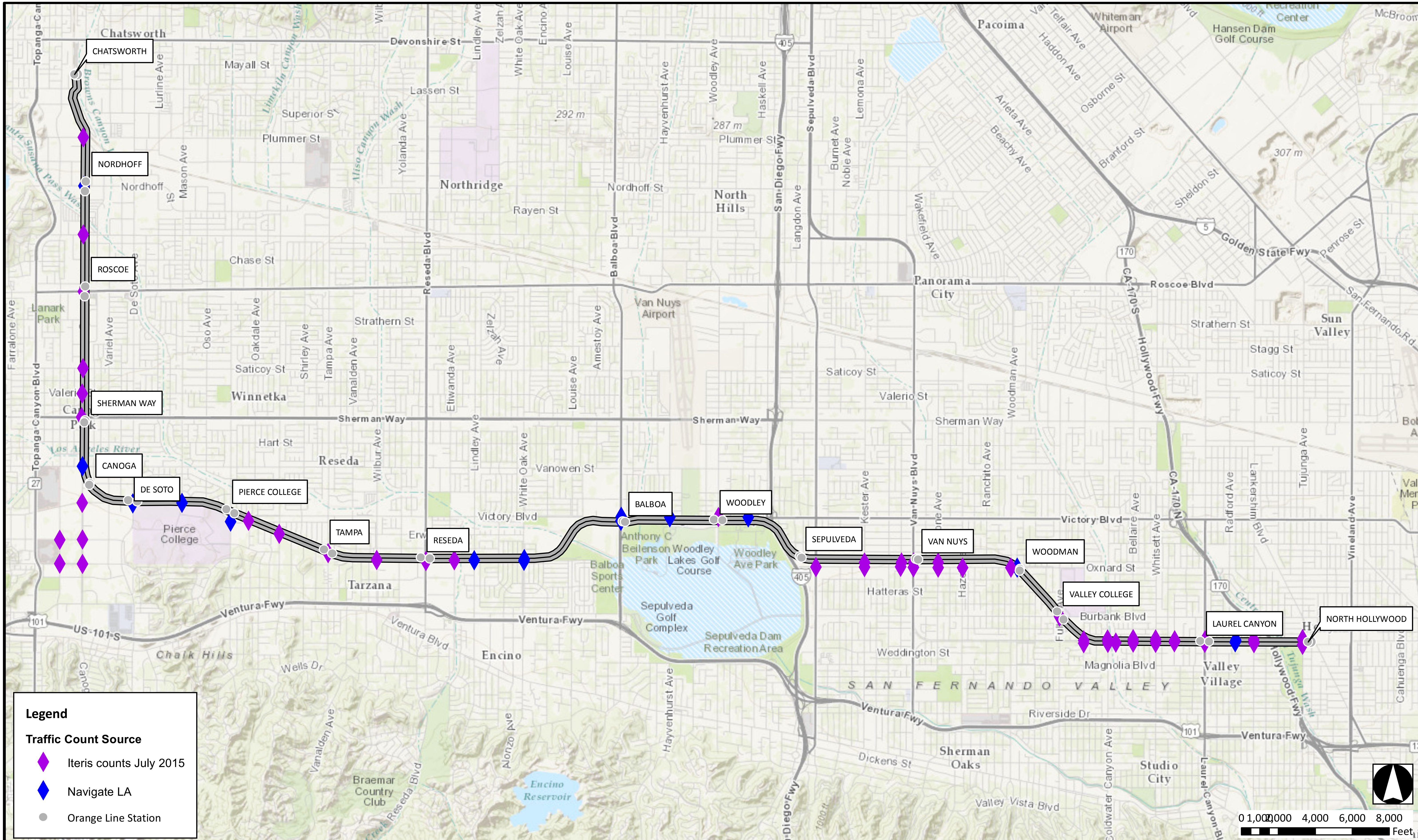
Table 4 – Google Maps/Waze Estimated Travel Times on Parallel Surface Streets

SEGMENT	WESTBOUND/NORTHBOUND TRAVEL TIME (MIN)			EASTBOUND/SOUTHBOUND TRAVEL TIME (MIN)		
	AM	MID-DAY	PM	AM	MID-DAY	PM
North Hollywood to Canoga Time between stations (min)	40	40	44	50	37	37
Canoga to Chatsworth Time between stations (min)	14	15	15	16	14	13
North Hollywood to Chatsworth Total travel time (min)	54	55	59	66	51	50

Source: Iteris, Inc., 2015 via Google Maps (https://www.google.com/maps/) and Waze (https://www.waze.com/livemap)

3.1.3 Traffic Data

Existing available traffic data was compiled from sources provided by Metro and the City of Los Angeles. New traffic counts were collected, during AM and PM peak periods, for each signalized intersection in the vicinity of MOL crossings where existing count data was not available. **Figure 4** summarizes the locations and sources of peak period intersection counts through the study area. In addition to traffic counts, travel time runs were performed along corridors parallel to the MOL in order to validate the computer simulation model (discussed in Section 5). All traffic count data sheets are provided in **Appendix B**.


CHATSWORTH
NORDHOFF
ROSCOE
SHERMAN WAY
CANOGA
DE SOTO
PIERCE COLLEGE
TAMPA
RESEDA
BALBOA
WOODLEY
SEPULVEDA
VAN NUYS
WOODMAN
VALLEY COLLEGE
LAUREL CANYON
NORTH HOLLYWOOD
Legend
Traffic Count Source
Iteris counts July 2015
Navigate LA
Orange Line Station
0 1,000 2,000 4,000 6,000 8,000
Feet

3.1.4 Collision History

This section summarizes the findings from the collision data provided by Metro and obtained from the Statewide Integrated Traffic Records System (SWITRS). Metro-provided data listed all bus-involved collisions along the Orange Line since its opening in 2005. In addition, Metro provided data for bus-involved collisions along the 750 and 910 Lines. Line 750 runs along Ventura Boulevard and represents a bus route traveling on local streets in a similar geographic vicinity. Line 910 is the Silver Line that predominantly runs on I-110 and I-10 in the ExpressLanes, a limited access facility.

3.1.4.1 MOL

MOL Collision data at busway crossing locations was provided by Metro, from 2005 when the MOL first opened, to April 2015. This collision data focused on collisions along the busway and involving Metro buses with vehicles and pedestrians. A summary of the total collisions at signalized crossings and the identified cause of each collision is provided in **Table 5a**.

Table 5a – Bus-Involved Collision History (Metro, 2005 – 2015)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION			
		RAN RED LIGHT (THRU MOVEMENT)	PROHIBITED LEFT/RIGHT TURN	HIT & RUN	OTHER*
Tujunga Ave	1	1			
Colfax Ave	2				2
Laurel Cyn Blvd	1				1
Whitsett Ave	3	3			
Bellaire Ave	1	1			
Coldwater Cyn Ave	4		4		
Ethel Ave	1	1			
Burbank Blvd-Fulton Ave	1				1
Oxnard St	1				1
Woodman Ave	10	9			1
Hazeltine Ave	5	4			1
Tyrone Ave	2	2			
Van Nuys Blvd	6	3			3
Vesper Ave	3	3			
Kester Ave	9	9			
Sepulveda Blvd	9	4			5
Densmore Ave	2	2			
Woodley Ave	5	5			
Balboa Blvd	6	5			1
White Oak Ave	3			1	2
Lindley Ave	1		1		
Reseda Blvd	3	3			
Wilbur Ave	3		2		1
Tampa Ave	2	1	1		
Corbin Ave	10	1	9		

Table 5a – Bus-Involved Collision History (Metro, 2005 – 2015)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION			
		RAN RED LIGHT (THRU MOVEMENT)	PROHIBITED LEFT/RIGHT TURN	HIT & RUN	OTHER*
Victory Blvd	4	1			3
Winnetka Ave	2	2			
Mason Ave	11	7	4		
De Soto Ave	5	2	2		1
Vanowen St	N/A				
Sherman Wy	N/A				
Valerio St	N/A				
Saticoy St	1				1
Roscoe Blvd	N/A				
Parthenia St	N/A				
Nordhoff St	N/A				
TOTAL	**117**	**69**	**23**	**1**	**24**
		59%	**20%**	**>1%**	**21%**

Source: Metro, 2015
* Cause of collision not provided
N/A – No record of collisions in Metro database

As shown in **Table 5a**, the majority of collisions were caused by motorists running a red light at a through movement crossing the busway. In other cases, illegal left turns or right turns on red were made resulting in a collision. The signalized crossings at Mason Avenue, Corbin Avenue, Woodman Avenue, Kester Avenue, and Sepulveda Boulevard show the highest frequency of collisions over the ten year period.

The Metro collision records highlight some important points:

- The entire line has averaged slightly over 10 bus-involved collisions per year since opening.
- Almost 80% of all bus-involved collisions were caused by vehicles either running red lights or disobeying signs prohibiting turns.
- The locations with the highest numbers of collisions average approximately one collision per year since the opening of the line.
- Bus-involved collisions on the Orange Line are not any more frequent than bus-involved collisions on any other roadway in Los Angeles County.

While **Table 5a** summarizes the data set provided by Metro, Iteris also obtained additional collision information from the SWITRS database. This data identifies all bus-involved collisions along the busway from 2011 to 2014. A summary of the SWITRS collision records is provided in **Table 5b.**

Table 5b – Bus-Involved Collision History (SWITRS, 2011 – 2014)

CROSSING	TOTAL COLLISIONS	CAUSE OF COLLISION				
		DUI	UNSAFE SPEEDS	DRIVER ERRORS	RIGHT-OF-WAY/SIGNAGE	OTHER*
Vanowen St	4	1	2	1		
Sherman Wy	2			1	1	
Valerio St	1				1	
Saticoy St	2			1		1
Roscoe Blvd	5	1	1	1	2	
Parthenia St	3	1		1	1	
Nordhoff St	1		1			
TOTAL	**18**	**3**	**4**	**5**	**5**	**1**
		17%	**22%**	**28%**	**28%**	**6%**

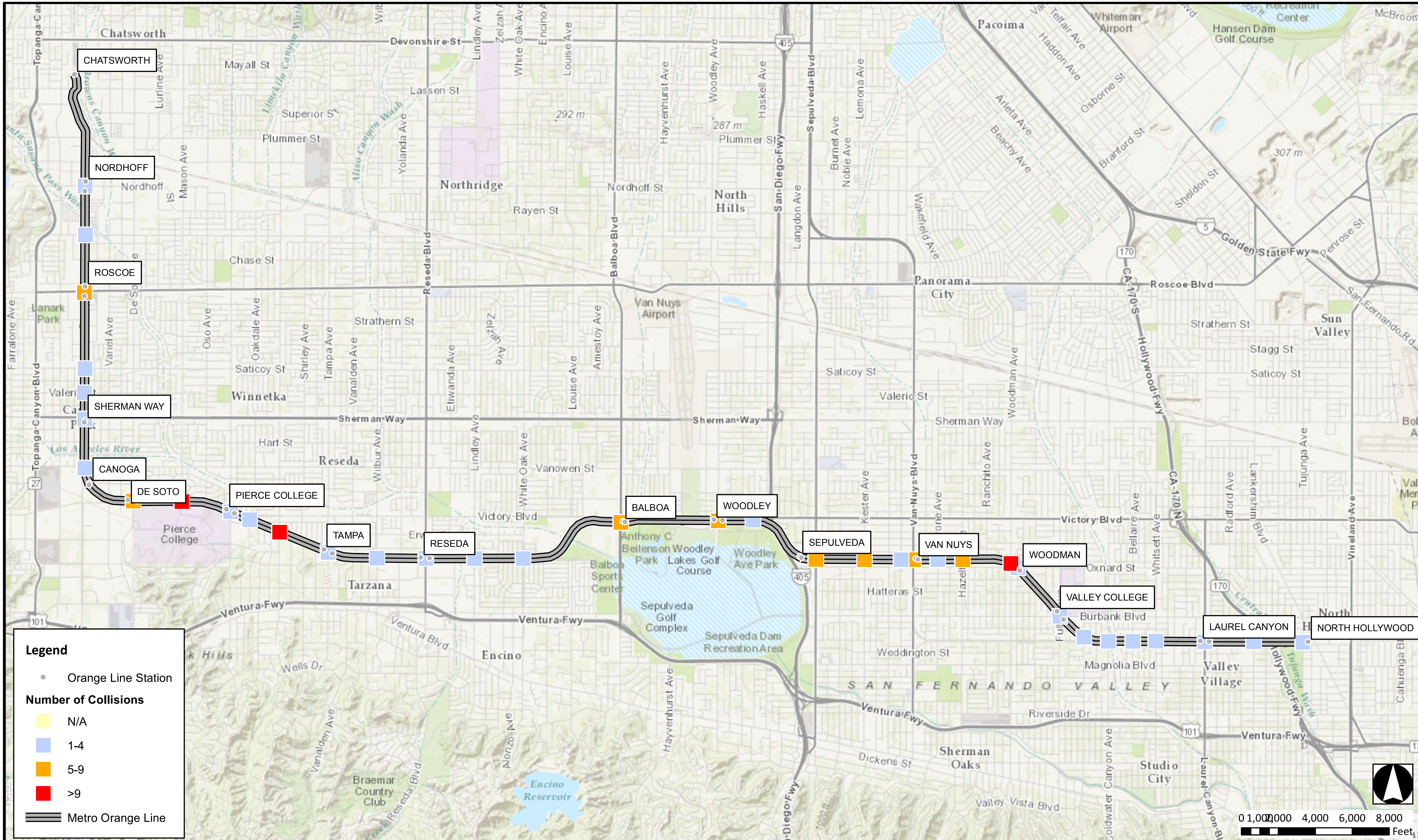
Source: SWITRS 2011 – 2014
Driver error collisions include: vehicles following too closely, improper passing, and unsafe lane change;
Right-of-way/signage collisions include: improper turning, automobile right of way, and traffic signals and signs.
* Cause of collision not provided
N/A – No record of collisions in Metro database

The SWITRS collision records also highlight some important points:

- The line has averaged approximately four bus-involved collisions per year.
    - Note that the Metro data indicates an average of 10 collisions per year; therefore, this study considers the higher average rate which is inclusive of collisions solely within Metro's right-of-way.
- Almost 95% of all bus-involved collisions were caused by motorists.
- The locations with the highest numbers of collisions average approximately one collision per year.
- Bus-involved collisions on the Orange Line are not any more frequent than bus-involved collisions along any other roadway in Los Angeles County.

Based on the collision records collected from both Metro and SWITRS, it should be noted that pedestrian-involved collisions are not common on the MOL. Only one pedestrian-involved collision was identified in February 2011 at the De Soto Avenue crossing (*Source: SWITRS – Case ID 5066099*), and this collision did not involve a bus. Therefore, pedestrian-involved collisions with buses do not appear to be a concern; likely due to the fact that the highest levels of pedestrian activity occur at stations, where the buses are already slowing to a stop.

Detailed collision history, identifying the collisions per year, is provided in **Appendix C**. The total number of collisions at each crossing is also shown in **Figure 5**.



Metro Orange Line
Speed Improvement Study

Figure 5
Collision History

3.1.4.2 Metro Line 750 and Line 910

MOL collision data was compared to the data of Metro Lines 750 and 910. A brief description and corresponding characteristics, including routes and frequencies of Metro Lines 750 and 910 are provided below:

- Metro Line 750 operates between Universal City and Warner Center. This line travels along Ventura Boulevard and Topanga Canyon Boulevard. This route operates from 5:30 a.m. to 10:00 p.m. with 15 minute headways during the weekday peak periods. No service is provided on weekends.

- Metro Line 910 operates between the Harbor Gateway Transit Center in Gardena, Union Station in Downtown Los Angeles, and El Monte Transit Station. This lines uses High Occupancy Vehicle (HOV) lanes/High Occupancy Toll (HOT) lanes outside of Downtown Los Angeles. Within Downtown, the line shares the road with other vehicles. This route operates from 3:30 a.m. to 1:00 a.m. with 4-10 minute headways during the weekday peak periods. Service is also provided on weekends with 20 minute headways.

Collision data for Metro Lines 750 and 910 was provided by Metro from 2011 to 2015. A summary of the total collisions at signalized crossings and whether the collision was considered avoidable or not is provided in **Table 5c**.

Table 5c – Bus-Involved Collision History (Metro, 2011 – 2015)

LINE	TOTAL COLLISIONS	COLLISION WAS		
		AVOIDABLE	UNAVOIDABLE	OTHER*
Line 750 – Ventura Boulevard Line	69	23	44	2
		33%	*64%*	*3%*
Line 910 – Silver Line	163	70	90	3
		43%	*55%*	*2%*
TOTAL	**232**	**93**	**134**	**5**
		40%	**58%**	**2%**

Source: Metro 2011 – 2015
Avoidable collisions do not involve other vehicles (i.e. bus hitting a tree/branch)
Unavoidable collisions involve other vehicles.
* Cause of collision not provided.

Table 5c shows that Line 750, running along Ventura Blvd, averages more than 10 bus-involved collisions per year, with more than 60% of the collisions identified as “unavoidable.” On Line 910 there were more than 30 bus-involved collisions per year, with 55% of the collisions identified as “unavoidable.” Metro determines collisions are “unavoidable” if the cause of the collisions was determined to be outside of the control of the bus operator or the bus operator would not have been able to avoid the collision through evasive maneuvers. In nearly every case, an “unavoidable” collision is directly attributed to another motor vehicle colliding with a Metro bus or in some other way causing the Metro bus to collide.

Comparing the MOL and Lines 750 and 910, it is clear that the collision rates are independent of the facility – the highest annual frequency of bus-involved collisions appears to occur on Line 910, which operates on the semi-exclusive rights-of-way along the HOV /HOT lanes outside of Downtown Los Angeles. With an average of approximately 10 bus-involved collisions per year, the MOL is very similar to Line 750. Furthermore, on the MOL alignment, a greater percentage of collisions (80% or more) are caused by drivers disobeying traffic signals and signs.

3.1.5 Field Review

Iteris staff completed detailed field evaluations of each crossing. The field evaluations included a review and inventory of all existing traffic control devices (signage, markings, and traffic signals), measurement of stopping-sight distance for buses traveling on the busway, and the documentation of other conditions that would not be readily apparent to bus operators. Detailed observations from the field reviews include:

- All signage and traffic control devices were documented to be installed per the approved design plans. However, some enhancements of existing signage and traffic control devices could be implemented at certain locations, including:
    - Vanowen intersection
    - Canoga station
    - Mason intersection
    - Pierce College station
    - Van Nuys station
    - Woodman station
    - Van Nuys intersection
    - Tyrone intersection
    - Valley College station

  Enhancements include replacing faded signage or relocating signage to increase visibility.

- Along the corridor, the stopping sight distance for a bus to observe crossing activities is constrained due to landscaping (e.g., trees, bushes, and/or other landscaping features) at the following locations:
    - Ethel Avenue (all sides)
    - Hazeltine Avenue (southeast and southwest corner)
    - Vesper Avenue (southeast and southwest corner)
    - Kester (southeast and southwest corner)
    - Sepulveda Boulevard
    - Woodley Avenue (southwest corner)
    - Hayvenhurst Avenue (northeast side of crossing)
    - White Oak Avenue
    - Lindley Avenue (northwest corner)
    - Reseda Boulevard
    - Wilbur Avenue
    - Tampa Avenue

  - Mason Avenue/Victory Boulevard
  - Valerio Street
  - Saticoy Street
  - Roscoe Boulevard
  - Parthenia Street
  - Nordhoff Street

- Along the corridor, the stopping sight distance for a bus to observe crossing activities is constrained due to the proximity of a sound wall/structure/fence at the following locations:

  - Tujunga Avenue
  - Tyrone Avenue
  - Kester Avenue
  - Sepulveda Boulevard
  - Tampa Avenue
  - Corbin Avenue
  - Victory Boulevard/Topham Street
  - Sherman Way
  - Valerio Street
  - Saticoy Street

Further details on each specific crossing are provided in Section 3.6.

3.1.6 Current Operator Instructions

Bus operators are provided "Paddles" which refer to the schedule of work for each bus operator showing all routes they will operate for the day, including the times to depart and return to the bus garage, and arrival and departure times at key timepoints for the specific directions of travel. Operating schedules are developed by the Metro Scheduling Department and provided to each bus operating garage for the bus routes operated from that garage for distribution to bus operators. Operating schedules are constantly reviewed based on feedback from bus operators, scheduling staff and passengers to ensure their accuracy based on the current operating environment. Metro makes adjustments to bus schedules approximately every six months as needed.

Metro provides paddles for each bus operator assignment on the MOL for weekday, Saturday, and Sunday service. A review of the MOL paddles with an effective date of June 28, 2015 provides the following information regarding the scheduled performance of the MOL:

- MOL service is based out of Metro's Division 8 Chatsworth bus garage. The current bus schedule requires a maximum total of 33 buses in service during peak periods on weekdays, and 13 buses on Saturday and Sunday. At the start of the day, buses are scheduled to leave the Division 8 Chatsworth garage and begin service at either the Chatsworth MOL Station or at the Warner Center Transit Terminal. Bus operators are provided nine minutes to operate between Division 8 and the Chatsworth MOL Station, and 15 minutes to operate between Division 8 and Warner Center.
- During the work day, when a bus operator has completed their work assignment before reaching the end of the route, they are relieved from service along the route by a new bus operator. This

action is done in-route to keep the bus in service and not have the operator take the bus out of service and return to the garage to end their work day. For the MOL, the paddles indicate that bus operator relief is made at the Nordhoff Metro Orange Line Station, which is adjacent to the Division 8 bus garage.

- For weekday service during the greater part of the day, MOL bus operators are scheduled to "interline" buses for operation from the North Hollywood MOL Station to both Warner Center and Chatsworth Stations on alternate trips. Interlining is done to provide more efficient scheduling and resource utilization by minimizing the number of buses required for service, and efficiently balancing the amount of layover time between the two branches of the MOL. Weekend service is not interlined, and bus operator assignments are scheduled to operate to either Chatsworth or Warner Center throughout their assignment. On all service days, after approximately 7:00 PM, MOL buses are scheduled to operate one routing between North Hollywood and Chatsworth with a link to Warner Center. The MOL schedule also provides for a separate shuttle schedule that operates exclusively between Chatsworth and Warner Center during weekday peak hours.

In addition, shortly after the MOL opened in 2005, Metro issued a "Slow Order" instructing bus operators to cover the brakes and not exceed 10 mph while entering and continuing through all intersections on the busway. It is generally understood that the decision was made in response to the frequency of initial vehicular collisions. The observed results are that the MOL does not reach the intended operating speeds for which the dedicated busway service was designed. It is also understood that the Slow Order was not meant to be a permanent measure to fix any perceived safety issues, but rather a short term fix. Nevertheless, the order has continued to be in effect to this day.

3.1.7 Compilation of Findings by Crossing

Based on the observations and data collected, a compilation of the findings related to the busway physical characteristics at each crossing has been prepared. **Table 6** summarizes detailed findings at each MOL crossing, and includes documentation of additional traffic control devices present at selected crossings. Additional traffic control devices include red light cameras and in-road warning lights. Red light cameras are used as a traffic enforcement mechanism capturing images of vehicles entering an intersection during a red phase. In-road warning lights (IRWL) are flashing warning light systems installed in the roadway surface to provide additional warning to motorists to adhere to traffic control devices (e.g., warning signs and/or signals).

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
Tujunga Ave	8,350	1	Red light cameras	Constrained due to adjacent property and fencing	35 mph
Colfax Ave	9,280	2	-	-	
Laurel Cyn Blvd	24,930	1	-	-	
Corteen Pl	1,280	-	-	-	
Whitsett Ave	12,270	3	-	-	
Bellaire Ave	1,640	1	-	-	

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
Coldwater Cyn Ave	18,090	4	-	-	
Chandler Blvd	5,910	-	-	-	
Ethel Ave	980	1	-	Constrained due to landscaping and fencing	35 mph
Burbank Blvd-Fulton Ave	Burbank: 13,430 Fulton: 13,335	1	-	-	
Oxnard St	26,160	1	Red light cameras	-	
Woodman Ave	24,850	10	Red light cameras	Constrained due to adjacent property	
Hazeltine Ave	16,770	5	-	Constrained due to landscaping	
Tyrone Ave	2,690	2	-	Constrained due to fencing	
Van Nuys Blvd	31,150	6	-	-	45 mph
Vesper Ave	3,090	3	-	-	
Kester Ave	23,340	9	Right light cameras	Constrained due to adjacent property and landscaping	
City of Los Angeles, Bureau of Street Maintenance, Van Nuys District Yard Private Dwy	N/A	-	-	Buses cannot see vehicles at private driveway	
Sepulveda Blvd	43,090	9	Red light cameras	Constrained due to landscaping, fencing, wall, adjacent property	35 mph 25 mph
Woodley Ave	19,130	5	Red light cameras	-	35 mph EB 55 mph WB
Balboa Blvd	28,340	6	Red light cameras	Constrained due to fencing, landscaping, wall, adjacent property	
White Oak Ave	33,570	3	Red light cameras	-	55 mph EB
Lindley Ave	24,420	1	Red light cameras	Constrained due to landscaping and fencing	
Reseda Blvd	22,010	3	Red light cameras	Constrained due to adjacent property and landscaping	
Wilbur Ave	15,400	3	-	-	
Tampa Ave	24,770	2	-	Constrained due to wall and landscaping	
Corbin Ave	14,220	10	-	Constrained due to wall	
Victory Blvd	28,890	4	-	-	
Winnetka Ave	25,920	2	-	-	45 mph
Mason Ave	14,050	11	Red light cameras	Constrained due to landscaping	

Table 6 – Factors Affecting Bus Operating Speeds

CROSSING STREET	CROSSING TRAFFIC VOLUME (ADT)	COLLISIONS[4]	TRAFFIC CONTROL[1]	STOPPING SIGHT DISTANCE[2]	EXISTING SPEED LIMIT[3]
De Soto Ave	33,990	5	Red light cameras	-	45 mph
Vanowen St	23,520	-	Red light cameras In-road warning lights	-	
Sherman Wy	22,100	-	Red light cameras In-road warning lights	Constrained due to adjacent property, fencing	
Valerio St	4,920	-	Red light cameras In-road warning lights	Constrained due to fencing	
Saticoy St	25,400	1	Red light cameras In-road warning lights	Constrained due to wall and fencing	
Roscoe Blvd	30,250	-	Red light cameras In-road warning lights	Constrained due to fencing, landscaping	45 mph
Parthenia St	18,940	-	Red light cameras In-road warning lights	-	
Nordhoff St	21,420	-	Red light cameras In-road warning lights	Constrained due to landscaping	45 mph

Source: Metro, City of Los Angeles, and Iteris; August 2015
ADT – Average Daily Traffic
[1] Traffic Control refers to devices installed to improve driver adherence to traffic signals and signs.
[2] Stopping Sight Distance refers to a minimum distance required for a bus operator to observe a potential obstacle (crossing vehicle, bike, or pedestrian) and bring the bus to a complete stop. A detailed plan-view is provided in Appendix D.
[3] This is the posted speed limit on the busway approaching the crossing street
[4] Collisions involving Metro buses on the busway (2005-2015)

For each crossing, a detailed plan-view figure is provided in **Appendix D** to show the location of existing signage as well as the locations where stopping sight distance was observed to be constrained by the physical environment adjacent to the busway.

4 CONSULTANT TEAM FINDINGS

Based on the existing operating characteristics discussed in Section 3, the following section presents a summary of findings related to bus speeds, operations, collisions, and other factors.

4.1.1 Criteria Affecting Bus Speeds

In general, bus speeds appear to be most impacted by three criteria:

1) Uncertainty of cross-traffic activity when approaching a crossing, as shown in **Exhibit 4**:

    - A history of collisions, as well as observed intrusions into the busway by vehicles, bicycles, and pedestrians, creates a general sense of uncertainty for bus operators as to whether the intersection will be clear. It is important to note that this uncertainty is certainly not unique to the Orange Line busway when looking at all Metro bus routes in the greater Los Angeles area.
    - Sight distance constraints, limited by landscaping, adjacent soundwalls, or structures, can further exacerbate the sense of uncertainty at certain crossings.

Exhibit 4: Sight distance constraints at intersection crossing

2) Signal timing at crossings:

    - Traffic signal timing operations also create a sense of uncertainty for bus operators. The more seasoned operators are familiar with existing signal timing and phasing, and can modulate bus approach speeds to maintain forward motion without having to come to a complete stop at red lights. For more junior operators, it is clear that the signal operations are not apparent. During many line rides, consultant team staff observed signals changing from green to red as the buses approached, as shown in **Exhibit 5**.

Exhibit 5: Traffic signal changes from green to red as bus approaches intersection

3) Bus operational characteristics:

- The bus vehicles themselves have some limitations in terms of acceleration and deceleration rates. These limitations make it difficult for a bus vehicle to accelerate to posted speed limits between crossings, and also require deceleration well in advance of stations and/or crossings.
- In order to "trigger" traffic signals and exclusive bus timing features, only those buses that have been "registered" with LADOT will be recognized by LADOT's traffic signal system. Each bus is outfitted with a transponder to communicate with the traffic signal system. Due to regular maintenance and scheduling demands, Metro regularly substitutes different buses along the Orange Line. These buses are not "registered" with LADOT, and therefore their transponders are not recognized by the signal system. This results in the buses not communicating with the traffic signal system, stopping for more red lights, and generally proceeding at a much slower rate.

The slowest segments of the Orange Line, in terms of relative bus speeds, are the following segments:

- **Westbound/Northbound:**
  - Between North Hollywood and Valley College
  - Between Sepulveda Boulevard and Woodley Avenue
  - Between Tampa Avenue and Pierce College
  - Between Roscoe Boulevard and Chatsworth

- **Eastbound/Southbound:**
  - Between Sherman Way and Canoga
  - Between Woodley Avenue and Van Nuys Boulevard
  - Between Valley College and Laurel Canyon Boulevard

Figure 6 shows the maximum bus speeds through the corridor.

4.1.2 Operators

During interviews with Metro bus operators, Iteris staff identified specific operating procedures or considerations that directly affect bus speeds. These items are summarized below:

- Operators, in the course of their assigned duties providing a customer service to passengers, strive to operate the buses smoothly. This means that rapid acceleration and deceleration is avoided. This can affect the ability of a bus to achieve the posted speed limit between crossings and stations.
- Following a series of bus-involved collisions in the early years of operation, a “slow order” was issued requiring all bus operators to adhere to a maximum speed of 10 mph at all crossings.

4.1.3 Collisions

Although initial collisions spurred some immediate changes in operations, the data does not indicate collisions as a specific criteria impacting bus speeds, and collisions on the Orange Line are consistent with collision rates of other Metro bus lines.

More than half of all collisions that have occurred in the past 10 years have been attributed to red light violations. Almost 20% of the collisions are attributed to vehicles disobeying left- or right- turn prohibitions. Between these two types of collisions, almost **80% of all collisions along the Orange Line busway are attributable to vehicles disobeying traffic signals and signs**. Furthermore, there has been only one pedestrian-involved collision (*Source: SWITRS February 2011 – Case ID 5066099*) along the MOL, but the collision did not involve a bus.

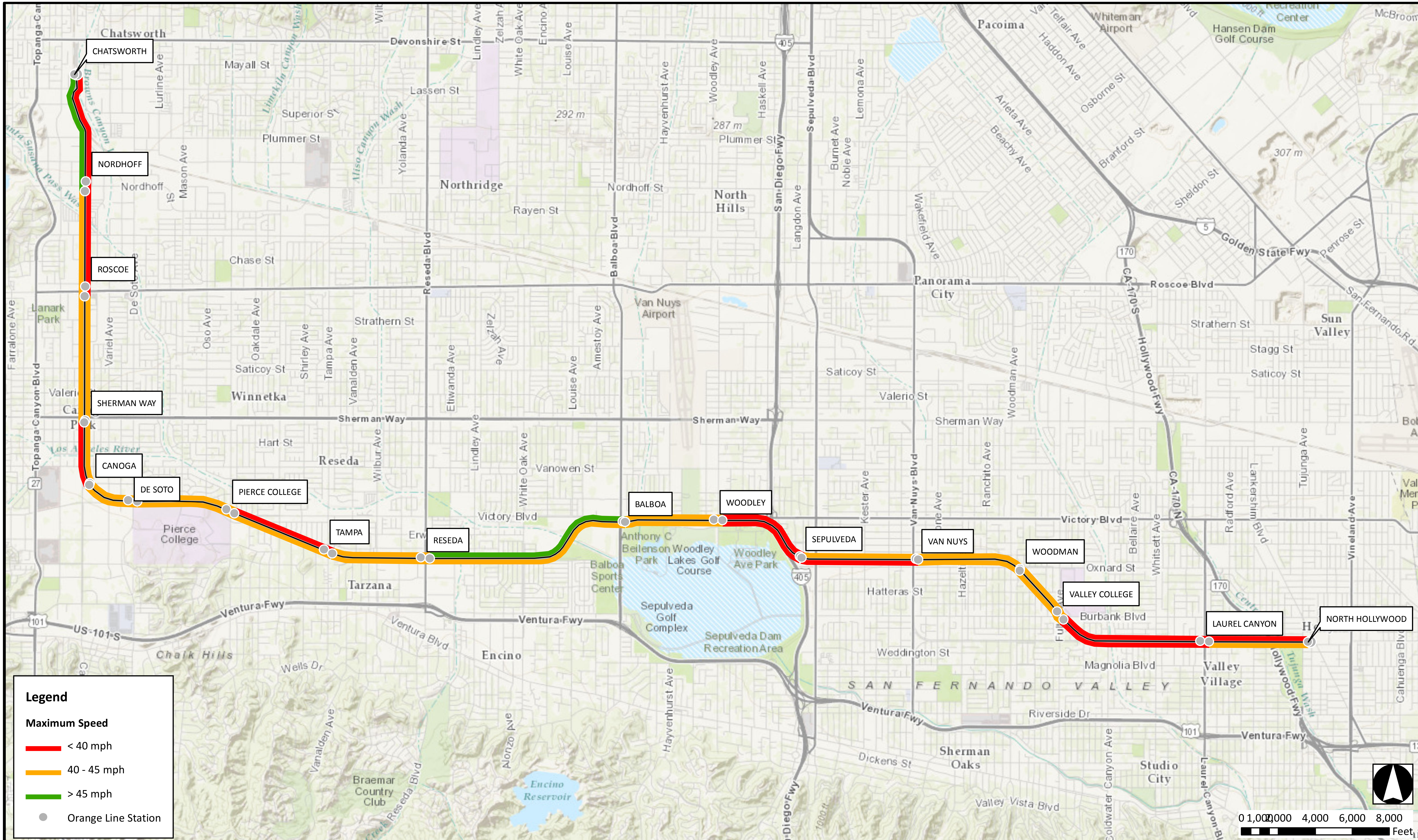


Figure 6
MOL Maximum Speed

5 MICROSIMULATION

Utilizing the data and findings collected in the previous tasks, Iteris prepared a computer simulation, using VISSIM, of the operation of the MOL. This section describes the steps taken to develop the VISSIM model, the results of an existing conditions simulation, and the results of potential operational scenarios simulations.

5.1 Model Development, Calibration, and Validation

5.1.1 Model Development

The microsimulation platform VISSIM was used to develop the model. The VISSIM model was developed using VISSIM build 6.00-21, and was calibrated for existing year 2015 conditions. The VISSIM model developed for this project includes roadway geometrics, traffic signal parameters, and driver behavior characteristics. Unlike static analyses conducted according to the Highway Capacity Manual (HCM), a simulation model includes "virtual drivers" that travel through the model network, from entry nodes to exit nodes, along network paths that are assigned by the analyst. The model uses random seeds and probability distributions for a number of traffic flow characteristics, such that each model run will produce slightly different outputs. Each seed contains random variables to account for variations in driver behavior and departure time. This model is therefore stochastic; it allows simulating the random fluctuations that are typically observed in real-time traffic networks. This feature makes the results more robust, given that they are based on the average of multiple observations or model runs, rather than a single calculation.

<u>Network Coding</u>
The existing network includes the Metro Orange Line busway between the North Hollywood Station and Chatsworth Station. An aerial image of the existing network was used as a background and scaled in VISSIM. Links and connectors were coded to match the geometric design and configuration. There are approximately 50 signalized intersections coded in the VISSIM network along the busway and parallel streets. Signal timing plans were provided by LADOT. The following parallel streets were included in the network:

- Chandler Boulevard between North Hollywood Station and Ethel Avenue
- Oxnard Street between Woodman Avenue and Sepulveda Boulevard
- Victory Boulevard between Densmore Avenue and Balboa Boulevard
- Oxnard Street between White Oaks Avenue and Corbin Avenue
- Victory Boulevard between Topham Avenue and De Soto Avenue
- Canoga Avenue between Vanowen Street and Prairie Avenue

<u>Data Inputs</u>
To develop data to be used as inputs as well as calibration targets, multiple data resources were used:

- Traffic Volumes – Intersection counts conducted in August 2015
- Travel Time – Travel time runs using floating car method conducted in August 2015
- Lane Configuration – Field Survey
- Signal Timing Plan – Provided by LADOT

Error Checking

The error correction process involved software error checking, input coding, and animation review. Input coding included geometry, demand, signal timing, traffic volumes, and route choices. The animation review was to determine if it is showing unrealistic vehicle behavior and if there were coding errors causing the simulation model to represent travel behaviors. Also during this step, the error file produced by VISSIM was checked and errors were eliminated based on minor coding adjustments. Error checking was completed for this project before calibration began.

5.1.2 Calibration

The objective of model calibration is to obtain the best match possible between model performance estimates and the field measurements of performance. However, there are diminishing returns where large investments in effort yield small improvements in accuracy at a certain point in the calibration process. The Federal Highway Administration (FHWA) has set calibration procedures and standards for microsimulation models and these were used in the calibration process. FHWA calibration targets were applied as follows:

Hourly Flows, Model Versus Observed

- Individual Link Flows
  - Within 100 vehicles/hour (v/h), for Flows < 700 v/h
  - Within 15%, for 700 v/h < Flow < 2,700 v/h
  - Within 400 v/h, for Flow > 2,700 v/h
- Sum of All Link Flows
  - Within 5% of the sum of all link counts
- GEH Statistic* < 5 for Individual Link Flows > 85% of cases
- GEH Statistic* for Sum of All Link Flows GEH < 4 for sum of all link

*The use of the GEH statistic (named after its developer, Geoffrey E. Havers) "stems from the inability of either the absolute difference or relative difference statistics to cope with flows over a wide range" of values (Scottish Transport Appraisal Guidance, 2002). The GEH statistic is a modified Chi-squared statistic that incorporates both relative and absolute differences to compare modeled and observed characteristics. The form of the GEH statistic allows for greater absolute differences for low volumes while requiring lower relative differences for large volumes. The expression for the GEH statistic is GEH = [square root of 2[(E - V).sup.2] / (E + V)] (2) Where E = model estimated characteristic; V = observed characteristic.

Travel Times, Model Versus Observed

- Travel Times, Network within 15%

Visual Audits

Bottlenecks

- Visually Acceptable Queues – To analyst's satisfaction

5.1.3 Calibration Results

VISSIM Model Run Procedure

The model is set to run for 5,400 simulation seconds (1 hour and 30 minutes). This allows for a 30-minute "warm-up" period (0 to 1,800 seconds) where congestion can develop, and then a 60-minute period

(1,800 to 5,400 seconds) when the analysis statistics are collected. The simulation resolution is set at 10 time steps per simulation second. In order to increase the confidence level of the data obtained from the simulation runs, a total of 10 simulation runs, each with a different random seed, were performed for the p.m. peak hour, and the average of these runs was used in the calibration.

Results

A comparison of the input demand volumes and corresponding simulated VISSIM volume output is included in **Appendix E**. The comparison in **Appendix E** indicates the magnitude of vehicles that VISSIM has processed in the simulation versus the actual number of vehicles that were entered as inputs. **Table 7** summarizes the results for calibration criteria of traffic flow. **Table 7** shows that all calibration targets based on volumes were achieved.

Table 7 – Calibration Criteria – Volume

CRITERIA - VOLUME	TARGET	RESULTS	ACHIEVED?
Individual Vehicle Flow			
Within 100 veh/h, for flow < 700 veh/h	> 85% of cases	100%	Yes
Within 15 % for 700 veh/h < flow < 2700 veh/h	> 85% of cases	100%	Yes
Within 400 veh/h, for flow> 2700/h	> 85% of cases	-	-
Sum of all Links	Within 5%	-0.4%	Yes
GEH Statistic < 5 for Individual Link Flows	> 85% of cases	100%	Yes
GEH Statistics for sum of all link flows	Less than 4	1.41	Yes

Travel time data was collected along busway and parallel streets, in both directions. In total, 10 travel time runs were compared. A comparison of travel time data from the VISSIM model and the actual field observations is presented in **Appendix E**. **Table 8** summarizes the results for calibration criteria of travel time. **Table 8** shows that 100% of the travel time corridors met the calibration criteria.

Table 8 – Calibration Criteria – Travel Time

CRITERIA – TRAVEL TIME	TARGET	
	(FHWA CRITERIA)	ACHIEVED
Within 155 (or 1 min, if higher)	85%	100%

5.1.4 Existing Operational Simulation

The existing conditions VISSIM model is shown to be well calibrated and within applicable thresholds of the FHWA. For the volume calibration criteria, the model meets FHWA criteria for: individual vehicle flows, sum of all links, and both GEH statistics. The model also meets FHWA criteria for travel time. Overall, the VISSIM model is well suited to analyze future conditions with the proposed improvements.

Existing conditions were simulated in the VISSIM model to establish baseline conditions. Video recordings of the existing simulation are provided separately.

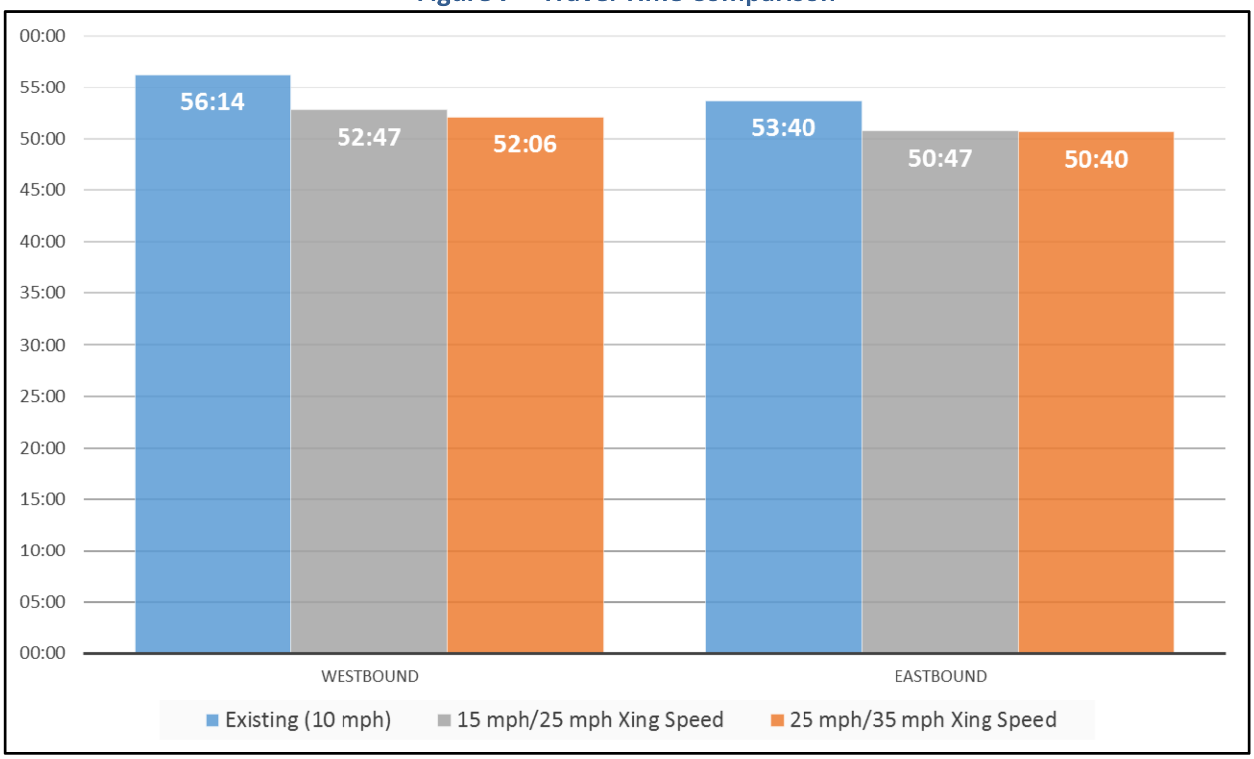
5.1.5 Potential Operational Scenarios Simulation

Potential operating scenarios, reflecting changes in bus operating speeds and/or traffic signal timing parameters, were simulated in a VISSIM model. The operating scenarios are used to develop recommendations presented in Section 6.0. The following different operating scenarios have been simulated:

1. Existing operations (calibrated to reflect operating conditions observed during field investigations).
2. Buses driving at increased speeds between stations. The intersection crossing speeds are 15 mph (at station crossings) and 25 mph (at all other crossings). This scenario includes LADOT traffic signal priority, and delays at stops and signalized crossings.
3. Buses driving at the posted speed limit between stations. The intersection crossing speeds are 25 mph (at station crossings) and 35 mph (at all other crossings). This scenario includes LADOT traffic signal priority, and delays at stops and signalized crossings.

Figure 7 below presents a summary of the modeled travel time along the entire alignment, under the three scenarios described above.

Figure 7 – Travel Time Comparison



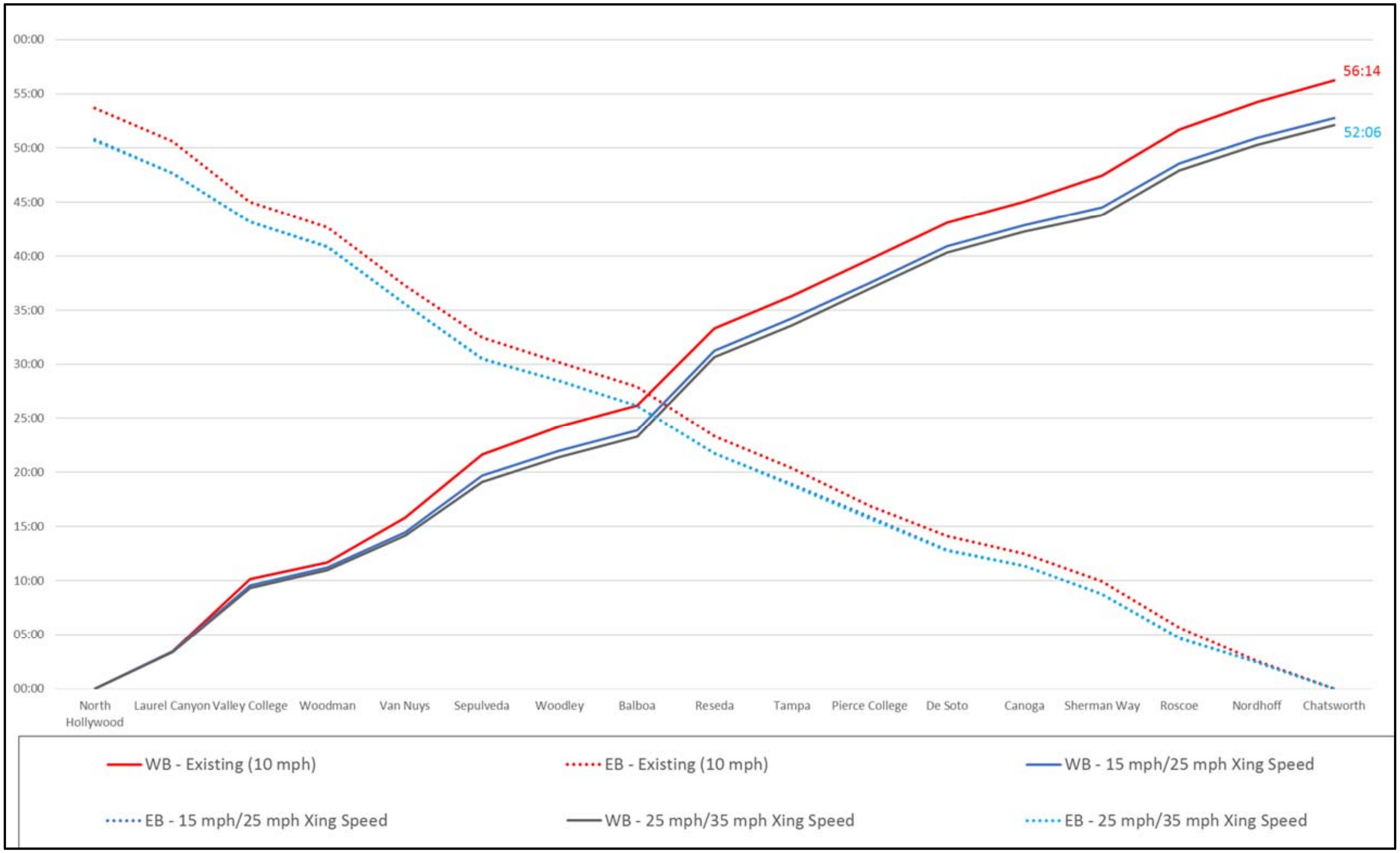
As shown in **Figure 7**, the "Immediate" scenario shows a maximum travel time savings of approximately three and a half minutes, while the "Recommended" scenario provides travel time savings of over four (4) minutes.

The consultant team recognizes that these travel time savings are identified via a simulation model; therefore, the likely reduction in travel time would be somewhat less.

Figure 8 below plots the eastbound and westbound travel times along the entire alignment, by stop, under the three simulated operational scenarios.

As mentioned before in Section 3.1.2, the existing MOL travel times are very similar to the drive-alone travel times. During the PM peak hours, the westbound travel time for vehicles is 63 minutes, compared to the MOL buses at 56 minutes. Similarly, the eastbound travel time for vehicles is 45 minutes, compared to the MOL buses at 53 minutes. The field observations show the existing MOL already as a more convenient mode of transportation versus driving an automobile on surface streets. Furthermore, once the bus speeds are increased, it is expected that the MOL buses would traverse the corridor up to approximately 10 minutes faster, or more, than driving an automobile on surface streets.

Figure 8 – Eastbound and Westbound Travel Time Plots



As shown in **Figure 8**, travel times between North Hollywood and Canoga currently take approximately 45 minutes. The travel time could be reduced to approximately 30 minutes or less by eliminating stop delays at signalized crossings between stations, and increasing bus speeds to the existing posted speed limits.

6 CONCLUSIONS AND RECOMMENDATIONS

Based on the observations and data collected, as well as the findings described in Section 4 and simulation results documented in Section 5, Iteris has developed a set of recommendations to improve bus speeds and travel times:

- **Recommendations for Immediate Implementation:** These recommendations should be implemented as quickly as possible. Many of these recommendations may appear to have no direct effect on bus speeds; however, these actions will position the line for speed improvement following the subsequent recommendations. These recommendation are described below:
    - It is recommended that Metro rescind the "Slow Order", which went into effect shortly after the MOL opened in 2005, allowing bus operators the ability to improve travel times by traveling at faster speeds through intersections. The order was considered a short-term measure to alleviate safety concerns resulting from drivers not being familiar with traffic control at crossings. However, ten years later, the order remains despite collision data showing that drivers are much more familiar with the MOL.
        - Recommended intersection crossing speeds are shown on **Table 9.**
    - It is recommended that Metro improve its current system to monitor the functionality of bus transponders. One option is that Metro should consider providing a list of transponders to LADOT to verify if the transponders are communicating with the traffic signal system. Another option is for Metro to review all current transponders in buses operating on the MOL and verify that the transponders are operational. A third option would be for LADOT to discontinue the practice of “registering” transponders, and instead allowing any transponders to activate the transit signal priority (TSP) functions along the busway.
    - There are certain locations, noted in Section 3.4 (and shown in **Appendix D**), where existing landscaping is overgrown and reduces stopping sight distance for buses approaching crossings. The landscaping should be trimmed, and a regular program for monitoring landscaping growth and regular trimming should be implemented by Metro. As this suggestion would likely prove difficult to implement, an alternate consideration should be for the removal and replacement of existing landscaping in the locations identified. Any new landscaping or design features should require little to no maintenance, to ensure that the improvement to sight distance is permanent. Any landscaping or design improvements should provide stopping sight distance clearance in compliance with Highway Design Manual (HDM) standards.
    - Signage at the busway crossings should be identifiable and legible. It is recommended that signage improvements be implemented at the locations identified in Section 3.4 to better guide motorists and pedestrians.

- **Three-Month Observation Period:** Following the immediate recommendations, Metro should monitor bus operations at the increased speeds for approximately three months.
    - As the “slow order” is currently causing buses to quickly fall out of any coordinated signal timing plans, it is impossible to effectively assess the existing TSP system along the MOL.

Therefore, once the "slow order" is rescinded, it is recommended that Metro monitor bus operations to ensure that the TSP is operating according to LADOT's existing timing plans. These plans should allow buses to operate at the recommended crossing speeds, and should minimize delays caused by stops at red traffic signals. It is important to note that buses are expected to stop at some crossings, where the traffic signals may provide a red indication to buses along the busway. However, it is anticipated that the number of stops at red traffic signals should be less than the number observed during field investigations (approximately four to five stops in each direction).

  - Metro should monitor bus operations, particularly any collisions that may be attributed to increased bus speeds.

- **Additional Considerations:** Although not directly recommended due to identified criteria impacting bus speeds, there are additional features that could be added to intersection crossings.
  - In-roadway warning lights (IRWLs) should be considered, in accordance with MUTCD guidelines. Intersections along the MOL extension from Canoga to Chatsworth already have in-road warning lights. Bus operators have expressed that they feel more comfortable when crossing at these locations. By installing IRWLs, Metro would ensure that the same features are present at all intersection crossings.
    - Metro should coordinate with LADOT for the installation, maintenance and inspection of the IRWLs.
    - All IRWL systems currently installed along the Orange Line are subject to the guidance of the California Traffic Control Devices Committee (CTCDC) and should be considered as part of the ongoing experiments titled "The Evaluation of Steady Red Stop Line Lights – Los Angeles (Official Ruling Number 4-341 (E))" and "Request to Experiment with In-Roadway Warning Lights (IRWL) System that would supplement existing traffic signals along the Metro Gold Line – (LA County Metro)" (For more information, see: http://www.dot.ca.gov/hq/traffops/engineering/ctcdc/).
  - Additional red light photo enforcement cameras should be considered at all crossings. Red light cameras are currently located at 19 crossings along the MOL. For consistency purposes, and because they have proven to be effective at reducing (though not eliminating) red light violations at MOL signalized crossings, additional red light cameras should be installed at all crossings on the MOL route.
  - It is recommended that Metro consider a pilot program to implement an in-vehicle signal timing notification system to provide real-time signal information to bus operators. New technologies exist that could provide this feature wirelessly directly to operators. Metro should consider deploying such technology on a pilot basis, working with LADOT to receive real-time traffic signal information via the City's centralized traffic signal control system. Operators would be made aware of the status of the green or red times at an approaching signalized crossing. This program could be used as a test to determine the overall benefits to bust travel times.

Table 9 summarizes the recommendations by crossing.

Table 9 – Recommendations and Additional Considerations

(A) CROSSING STREET (EAST TO WEST / SOUTH TO NORTH)	(B) IMMEDIATE RECOMMENDATION		(E) THREE-MONTH OBSERVATION PERIOD	(F) ADDITIONAL CONSIDERATIONS	
	(C) RECOMMENDATION	(D) CROSSING SPEED	TARGET CROSSING SPEED AFTER THREE MONTHS	(G) IMPROVEMENT	(H) CROSSING SPEED
Tujunga Ave[1]	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights	25 mph[3]
Colfax Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Agnes Ave-Pedestrian Crosswalk	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Laurel Cyn Blvd[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Corteen Pl	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Whitsett Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Bellaire Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Goodland Ave-Pedestrian Crosswalk	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Coldwater Cyn Ave	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Chandler Blvd	• Rescind "Slow Order"	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Ethel Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Burbank Blvd-Fulton Ave[1]	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "No Right on Red" sign to increase visibility.	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install light cameras	25 mph[3]
Oxnard St[1]	• Rescind "Slow Order" • Install pedestrian fence • Improve signage: o Faded "No Right on Red" sign	15 mph	25 mph	• Install in-road warning lights	25 mph
Woodman Ave	• Rescind "Slow Order" • Improve signage: o Faded "No Right on Red" sign o Visibility constraint. Consider relocating "Look Both Ways" sign to increase visibility.	25 mph	35 mph	• Install in-road warning lights	35 mph
Hazeltine Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Tyrone Ave	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "Look Both Ways" sign to increase visibility.	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Van Nuys Blvd[1]	• Rescind "Slow Order" • Improve signage: o Vandalized Flashing bus signal o Speed limit "45 mph" covered by trees	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install light cameras	25 mph[3]
Vesper Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Kester Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints.	15 mph[4]	25 mph[5]	• Install in-road warning lights	25 mph[5]
City of Los Angeles, Bureau of Street Maintenance, Van Nuys District Yard Private Dwy	• Rescind "Slow Order"	25 mph	35 mph		35 mph
Sepulveda Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2,4]	25 mph[3,5]	• Install in-road warning lights	25 mph[3]
Densmore Ave	• Rescind "Slow Order"	25 mph	35 mph		35 mph

Table 9 – Recommendations and Additional Considerations

(A) CROSSING STREET (EAST TO WEST / SOUTH TO NORTH)	(B) IMMEDIATE RECOMMENDATION		(E) THREE-MONTH OBSERVATION PERIOD	(F) ADDITIONAL CONSIDERATIONS	
	(C) RECOMMENDATION	(D) CROSSING SPEED	TARGET CROSSING SPEED AFTER THREE MONTHS	(G) IMPROVEMENT	(H) CROSSING SPEED
Woodley Ave[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Hayvenhurst Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph		35 mph
Balboa Blvd[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
White Oak Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights	35 mph
Lindley Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights	35 mph
Reseda Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Wilbur Ave	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph	• Install in-road warning lights • Install red light cameras	35 mph
Tampa Ave[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2,4]	25 mph[3,5]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Corbin Ave	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Victory Blvd	• Rescind "Slow Order"	15 mph[4]	25 mph[5]	• Install in-road warning lights • Install red light cameras	25 mph[5]
Winnetka Ave[1]	• Rescind "Slow Order" • Improve signage: o Faded "Do Not Enter" sign o Faded "No Ped Xing" sign	15 mph[2]	25 mph[3]	• Install in-road warning lights • Install red light cameras	25 mph[3]
Mason Ave	• Modify landscaping to address sight distance constraints • Improve signage: o Broken Flashing bus signal o "No Right on Red" sign blocked by trees o "Stop Here on Red" sign blocked by trees	25 mph	35 mph	• Install in-road warning lights	35 mph
De Soto Ave[1]	• Rescind "Slow Order"	15 mph[2]	25 mph[3]	• Install in-road warning lights	25 mph[3]
Vanowen St	• Rescind "Slow Order" • Improve signage: o Visibility constraint. Consider relocating "No Right on Red" sign to increase visibility.	25 mph	35 mph		35 mph
Sherman Wy[1]	• Rescind "Slow Order"	15 mph[2,4]	25 mph[3,5]		25 mph[3]
Valerio St	• Rescind "Slow Order"	15 mph[4]	25 mph[5]		25 mph[5]
Saticoy St	• Rescind "Slow Order"	15 mph[4]	25 mph[5]		25 mph[5]
Roscoe Blvd[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]		25 mph[3]
Parthenia St	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	25 mph	35 mph		35 mph
Nordhoff St[1]	• Rescind "Slow Order" • Modify landscaping to address sight distance constraints	15 mph[2]	25 mph[3]		25 mph[3]

Notes:
1. Station location
2. As current operating procedures require all buses to stop at all stations, busses are accelerating or decelerating at adjacent crossings. Therefore, crossing speeds are posted for guidance only.
3. If operating procedures change and buses no longer stop at all stations, Metro may consider increasing bus speeds consistent with the adjacent crossing streets.
4. At these locations, stopping sight distance is reduced due to an adjacent fence/structure/soundwall; therefore, minimal speed increases are recommended.
5. During the three-month evaluation, speed increases to 25 mph could be implemented; however, increasing speeds above 25 mph is not recommended due to the limited stopping sight distance.

How to Read this Table:
(A) At each crossing street indicated in this column, the recommended improvements listed in column (B) should be implemented. Specific improvements for each crossing are shown in column (C), with associated maximum crossings speeds listed in column (D). Once the immediate recommendations have been implemented and new maximum crossing speeds are observed, Metro should incrementally increase crossing speeds during a three-month observation period. The maximum crossing speeds during this three-month observation period should not exceed those listed in column (E). After the three-month observation period, Metro may consider additional improvements as described in column (F). Specific additional improvements for consideration are listed in column (G), and are not provided for every intersection along the alignment. Once the additional improvements are implemented, Metro may consider increasing the maximum crossing speed to those listed in column (H).

A potential recommendation that has been discussed by Metro staff and concerned citizens in the past is to design and install extinguishable "No Turn on Red" signage at all crossings, and prioritize based on those locations with the highest volumes of left- and right-turning vehicles adjacent to the busway. Based on the research of the consultant team, it is understood that LADOT and Metro have evaluated this particular improvement and concluded that it would not be feasible for the following reasons:

- Lack of available space on existing traffic signal poles,
    - Traffic signal poles and their associated foundations are rated for a certain amount of signage, based on weights and wind sheer calculations. Existing sign poles were evaluated and it was determined that no existing poles were located in acceptable locations with available space for additional signage.
- Lack of available power supply for extinguishable signs, and
- Preponderance of existing static signage.

Attachment B
Metro Orange Line Grade Separation and Operational Improvements Technical Study

iteris®

Metro Orange Line Grade Separation Analysis and Operational Improvements Technical Study
Final Report

November 11, 2017

Submitted to:

Metro

17J17-0750 | Prepared by **Iteris, STV, TransLink,** and **WSP**

Innovating Through Informatics™

DOCUMENT VERSION CONTROL

DOCUMENT NAME	SUBMITTAL DATE	VERSION NO.
Task 10.0 Final Report Draft	October 17, 2017	1.0
Task 10.0 Final Report	November 11, 2017	2.0

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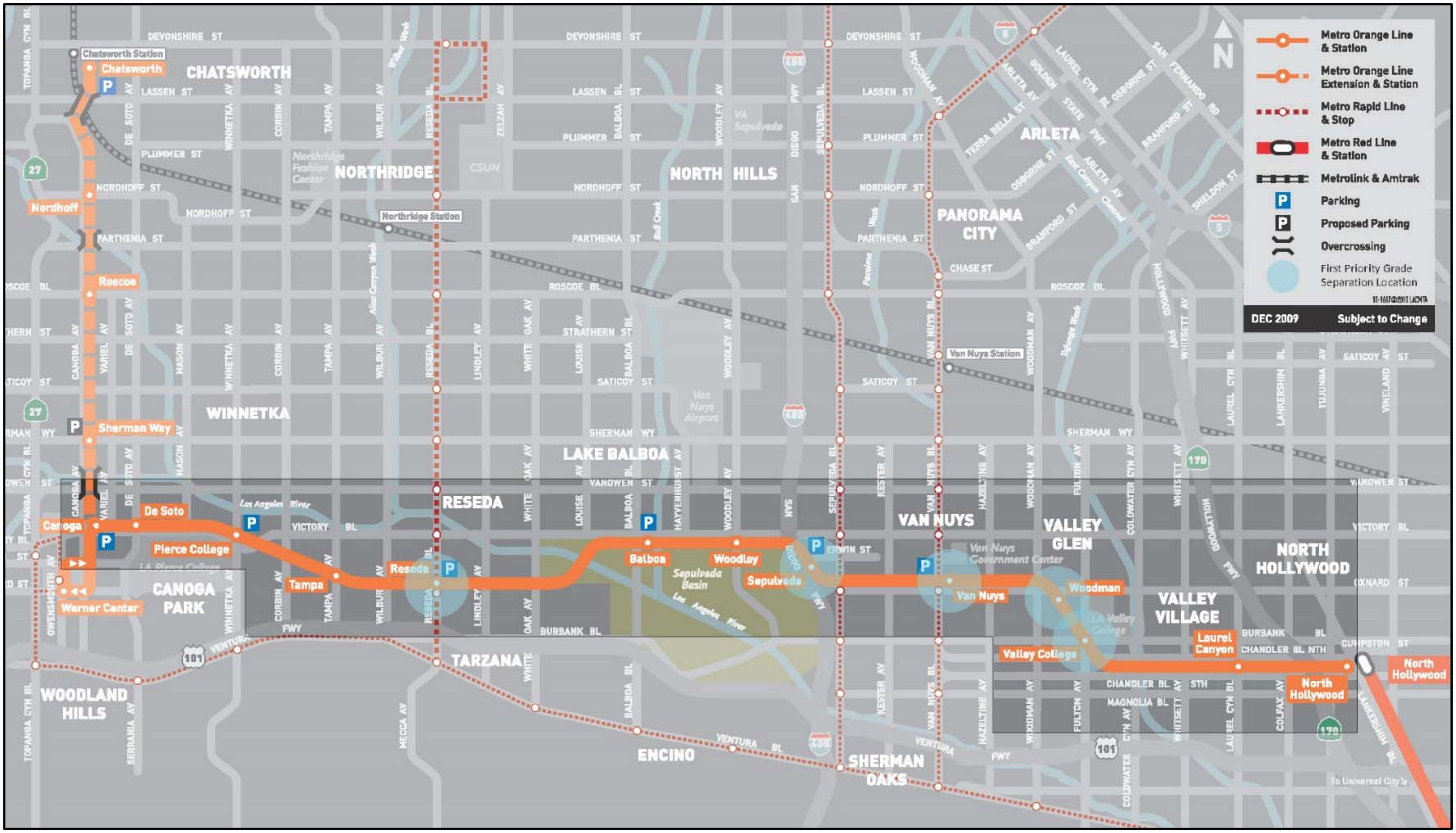
1.0 INTRODUCTION

Iteris, Inc. (Iteris), leading a team of technical subconsultants, was selected by the Los Angeles County Metropolitan Transportation Authority (Metro) to study the feasibility of grade separation improvements at key intersections and other improvements that would enhance existing bus service, performance, and ridership. Other improvements evaluated included minor street closures, better Transit Signal Priority (TSP) technology, improved bus signal communication, and a four quadrant gating system. This study covers approximately 12.7 miles of the MOL from the North Hollywood station to the Canoga station, and it does not include the Warner Center or the Chatsworth extensions. The project study area is shown in **Figure 1**.

This study was introduced prior to the passage of Measure M, in order to support a specific project identified in the Measure. As described in the Measure, the project was titled “Orange Line Bus Rapid Transit (BRT) Improvements” and was described as follows: “Enables Orange Line BRT buses to bypass several key intersections to improve bus speeds and passenger travel times.” The specific locations of improvements were not called out in the Measure, as the complete scope of improvements was subject only to preliminary estimates prior to this current study effort. With the passage of Measure M in November 2016 the Orange Line BRT Improvements were included as a part of “Operation Shovel Ready,” with a commitment to break ground in 2019. The purpose of this study is to further refine the specific improvements to be constructed, in order to meet the commitments made in the Measure.

At the conclusion of the feasibility study, Iteris and the consultant team worked with Metro staff to identify packages of improvements that could be brought to the Metro Board. Among the packages of improvements, Iteris and the consultant team developed a single recommended base alternative for the Board’s consideration. This alternative would address the operational needs of Orange Line buses and passengers, while also falling within the budget allocated in the Measure M Expenditure Plan for early improvements to Orange Line crossings. This document further details the technical analysis and ultimate recommendation.

Figure 1 – Study Area



2.0 PROJECT PURPOSE AND NEED

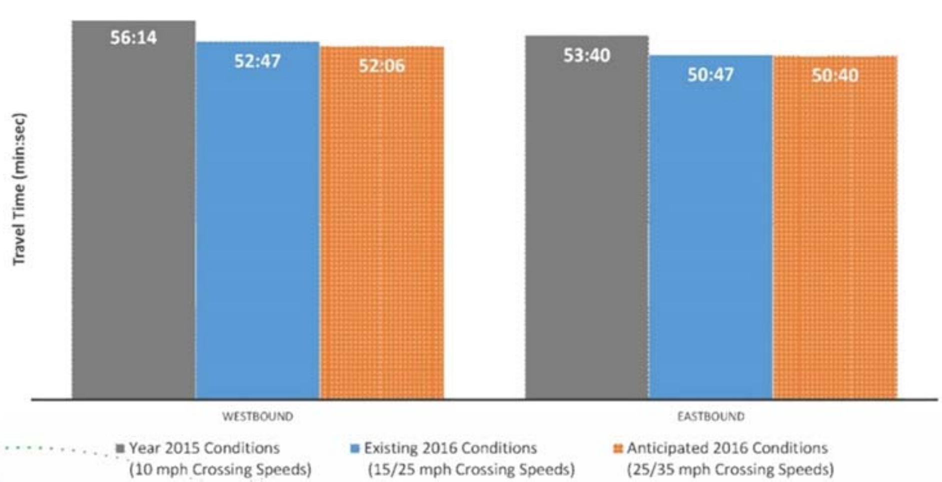
The Metro Orange Line (MOL) opened in October 2005 from North Hollywood to Warner Center, followed by an extension to Chatsworth in 2012. The Purpose and Need Statements for the original MOL and the MOL Extension each addressed the following key points, and provided a starting point for the development of a similar statement of this study:

- Setting
- Regional Context
- Demographics
- Activity Centers
- Land Use Planning and Policies
- Existing Traffic Conditions
- Potential Travel Markets
- Existing Transit Services
- Urban Design Considerations
- Goals and Objectives

The Purpose and Need Statement for this study addresses how the improvement in service on the MOL will affect each of the issue areas identified above. With the additional technical analyses required of this project, specific issues were expanded, and additional issues were investigated in more detail. The Purpose and Need Statement for this grade separation and operation improvement study is more focused on near and long term improvements, while not precluding conversion to light rail in the future. Several types of improvements were evaluated throughout this technical study to improve operations, address safety concerns, minimize environmental and community impacts, and ensure cost effectiveness. The purpose of the project is to identify the optimal improvements to address specific goals, as described further below:

- **Improve Operating Speeds** - Improving operating speeds addresses current public complaints of excessive cross-Valley travel times and delays at intersections. Year 2015 intersection crossing speed for MOL buses was 10 miles per hour (mph). In 2016, intersection crossing speeds were increased to 15/25 mph. When the MOL is modeled with improved intersection crossing speeds of 25 mph (crossings adjacent to stations) and 35 mph (at all other crossings) and at the posted speed limit between stations, travel time savings of nearly four minutes may be achieved. **Figure 2** shows the MOL modeled travel time savings with the implementation of higher intersection crossing speeds. Travel time savings may likely be higher with additional enhancements such as grade separations or gate systems, to reduce the potential for cross street traffic (vehicles, pedestrians, and bicycles) entering the busway.

Figure 2 – MOL Travel Time Comparison



- **Address Safety Concerns** - Given current incident data, there are key locations that would benefit from improvements along the MOL corridor to reduce conflicts between MOL buses, vehicles, bicyclists, and pedestrians. In particular, grade separations at key intersections can minimize conflicts and prevent incidents by physically separating the MOL corridor, potentially including the adjacent bike path, from the crossing roadways. Controlled crossings (e.g., gate controls) would address safety concerns by managing and restricting vehicle and bicycle/pedestrian interactions with MOL operations. Overall, the MOL corridor experienced 23 bus-involved collisions between 2015 and 2016, and these collisions would likely be reduced by additional crossing improvements analyzed as a part of this project.

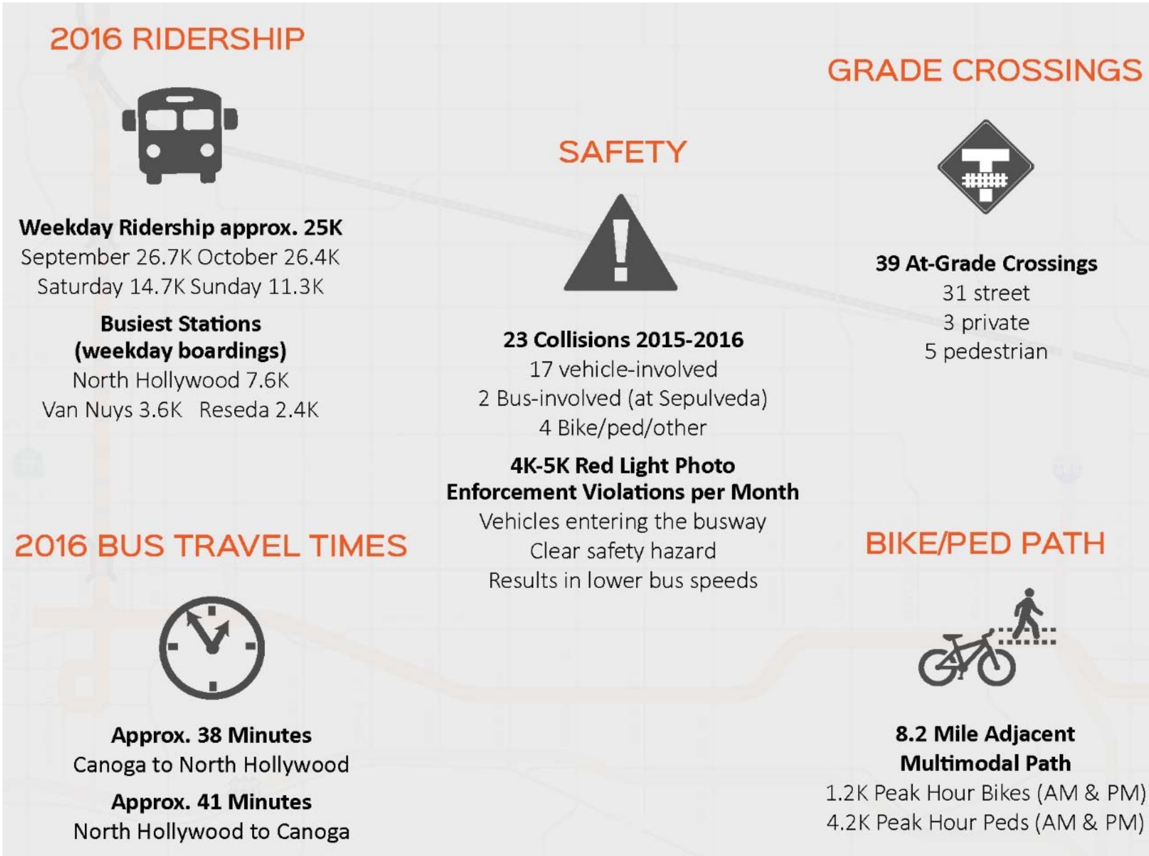
- **Benefit the Surrounding Community** – Improvements to the MOL corridor can increase bus speeds, decrease end-to-end travel times, increase ridership, improve safety conditions, and provide better overall mobility options for the San Fernando Valley. However, any improvements along the MOL corridor will need to consider impacts during construction and on existing and planned transportation facilities during operation. This includes effects to parking supply, minimizing pedestrian and bicycle impacts, and any degradations to traffic operations on adjacent streets. It would not be desirable to significantly delay existing MOL riders during construction, as this could reduce ridership by creating lengthy off-corridor detours for the MOL buses. The 2012 Orange Line BRT Sustainable Corridor Implementation Plan (Implementation Plan) called for substantial investment in the corridor including additional housing in station areas and improved active transportation access to/from stations. The Implementation Plan also described the need for short- and long-term operational improvements along the corridor, such as better signal timing, crossing gates, and grade separation at specific intersections. It is important that improvements to the MOL corridor incorporate and reflect these plans and programs, and consider any impacts/effects to San Fernando Valley neighborhoods and communities.

- **Ensure Cost Effectiveness** - The MOL is a successful system as it has an estimated ridership of 25,090 weekday daily boardings (2016 year to date) through the San Fernando Valley. As a BRT facility, the MOL has delivered cost-effective service with an estimated $10 cost per new daily transit trip compared to a light rail service of around $25 per new rider. Improvements to the MOL corridor must ensure costs are commensurate with benefits to continue the overall cost effectiveness of the system. This goal is to ensure financial feasibility in order for the project to achieve reasonable benefits today and in the long term. Short-term improvements must be designed to not preclude conversion to LRT in the future.

2.1 Existing Physical Configuration

A summary of key physical constraints, operational issues and other pertinent challenges related to proposed grade separations and other operational improvements are presented highlighted in **Figure 3**, and also included in *Task 4 Existing Conditions Technical Memorandum*.

Figure 3 – Key Operational Highlights



2.1.1 At-Grade Crossings

The MOL has 39 at-grade crossings: 31 vehicular crossings, three private driveways and five pedestrian crossings. **Table 1** lists the at-grade crossings in between stations.

Table 1 – MOL At-Grade Crossings within Study Area

SEGMENT (STATION-TO-STATION)	# OF CROSSINGS	AT-GRADE CROSSINGS
North Hollywood & Laurel Canyon	4	Tujunga Ave crossing
		Colfax Ave crossing
		Agnes Ave (Pedestrian crossing)
		Laurel Canyon Blvd
Laurel Canyon & Valley College	8	Corteen Pl
		Whitsett Ave
		Bellaire Ave
		Goodland Ave (Pedestrian crossing)
		Coldwater Canyon Ave
		Chandler Blvd
		Ethel Ave
		Fulton Ave/Burbank Blvd
Valley College & Woodman	0	-

SEGMENT (STATION-TO-STATION)	# OF CROSSINGS	AT-GRADE CROSSINGS
Woodman & Van Nuys	4	Oxnard St
		Woodman Ave
		Hazeltine Ave
		Tyrone Ave
Van Nuys & Sepulveda	5	Van Nuys Blvd
		Vesper Ave
		Kester Ave
		City of Los Angeles, Bureau of Street Maintenance, Van Nuys District Yard (Private)
		Sepulveda Blvd
Sepulveda & Woodley	4	Sepulveda Station (Pedestrian crossing)
		Densmore Ave (Gated Driveway)
		Driveway (Private)
		Woodley Ave
Woodley & Balboa	2	Hayvenhurst Ave (Pedestrian crossing)
		Balboa Blvd
Balboa & Reseda	4	White Oak Ave
		Zelzah Ave (Pedestrian crossing)
		Lindley Ave
		Reseda Blvd
Reseda & Tampa	2	Wilbur Ave
		Tampa Ave
Tampa & Pierce College	3	Corbin Ave
		Victory Blvd
		Winnetka Ave
Pierce College & De Soto	2	Mason Avenue
		De Soto Avenue
De Soto & Canoga	1	Canoga Avenue

Notes: ☐ First Priority Grade Separation Locations

As shown in **Table 1,** the segment between Laurel Canyon and Valley College consists of the highest number of at-grade crossings: seven roadways and one pedestrian crossing.

2.1.2 Pedestrian/Bicycle Facilities

There are Class II and Class I bicycle facilities running parallel to the MOL corridor. Class II bike lanes run from the North Hollywood Station to just west of Coldwater Canyon Avenue, and a Class I dedicated bike path and pedestrian trail runs west of Coldwater Canyon Avenue to Canoga Avenue. The bikeway runs adjacent to the MOL busway. Bicycle lane configuration, racks and lockers were reviewed and recorded at each crossing, as detailed in *Task 4 Existing Conditions Technical Memorandum* prepared as part of this study. Bicycle racks and lockers are offered to Metro riders and are located at each station. A total of 247 bicycle racks and 188 lockers are available within the study corridor.

2.1.3 Station Parking Facilities

Seven of the 13 study area MOL stations have parking facilities: North Hollywood, Van Nuys, Sepulveda, Balboa, Reseda, Pierce College and Canoga. The stations with the highest daily parking utilization percentages are North Hollywood, Van Nuys, Balboa and Reseda, respectively. Parking inventory and utilization percentage is presented in *Task 4 Existing Conditions Technical Memorandum*.

2.1.4 Utilities

Because the project site is an existing use with a BRT operating within the right of way, longitudinally orientated utilities and crossings are located throughout the alignment. It is assumed that existing utilities are at standard or minimum depth. This will be determined in future phases of work should the ultimate project be carried forward. The typical utilities that are located within the project area include but are not limited to: storm drain, sewer, water, gas, electrical, communication and oil.

2.1.5 Existing Operating Conditions

The consultant team performed a thorough review of the existing MOL operating characteristics, including line rides, review of current bus operating instructions, field visits to intersection crossings, evaluation of traffic data, and an assessment of collision history, traffic violations in the vicinity of the route, and operating conditions of intersecting roadways.

2.1.6 Service Efficiency and Effectiveness

Metro provided average ridership data from the Automatic Passenger Count (APC) for October and November 2016. Based on the average daily ridership and the amount of service operated on the MOL, several service productivity factors are indicated in **Table 2**.

Table 2 – MOL Efficiency and Effectiveness Indicators

DAY OF WEEK	BOARDINGS PER HOUR	BOARDING PER REV. MILE	BOARDINGS PER TRIP
Weekday	68.9	4.4	144.5
Sunday	51.6	3.4	113.3

Source: Metro APC October 2016

2.1.7 Intersecting Roadway Operating Conditions

All traffic signals along the corridor operate according to timing plans developed by the Los Angeles Department of Transportation (LADOT) during the initial construction of the line. The signal timing plans provided by LADOT were reviewed as a part of the Speed Evaluation Study completed in 2016. Based on signal timing plans provided, the existing TSP functions along the busway should allow the MOL buses to progress along the route at roughly 35 mph, with some red light stoppage at various points along the corridor. The current speed of buses at the intersections crossing the MOL are between approximately 15 and 25 mph. The signals currently operate at cycle lengths of between 60 and 120 seconds per cycle, with the vast majority of time provided for crossing traffic and major roadways having longer cycle lengths. As a part of the Speed Evaluation Study, a VISSIM microsimulation model was developed. This model allowed for the evaluation of traffic operations at each crossing, as well as an assessment of potential measures to increase bus speeds along the corridor. The VISSIM model provided delay and p.m. peak hour Level of Service (LOS), as shown in **Table 3**.

Table 3 – 2015 PM Peak Hour Intersection Delay and LOS

INTERSECTION	DELAY (SEC)	LOS	SIGNAL CYCLE (SECONDS)
1. Tujunga & Busway	10.4	B	120
2. Tujunga & Chandler North	19.0	B	120
3. Tujunga & Chandler South	24.9	C	120
4. Chandler Blvd & Colfax Ave & Busway	30.9	C	120
5. Chandler Blvd & Laurel Cyn Blvd & Busway	30.2	C	120
6. Chandler Blvd & Corteen Pl & Busway	15.5	B	120
7. Chandler Blvd & Whitsett Ave & Busway	29.0	C	120
8. Chandler Blvd & Bellaire Ave & Busway	13.7	B	120

INTERSECTION	DELAY (SEC)	LOS	SIGNAL CYCLE (SECONDS)
9. Chandler Blvd & Coldwater Canyon Ave & Busway	27.9	C	120
10. Chandler Blvd & Busway	5.3	A	60
11. Ethel Ave & Busway	13.1	B	60
12. Ethel Ave & Chandler Blvd	23.2	C	90
13. Burbank Blvd & Fulton Ave & Busway	13.1	B	90
14. Buffalo Ave & Oxnard St & Busway	10.4	B	90
15. Woodman Ave & Busway	27.9	C	120
16. Woodman Ave & Oxnard St	27.0	C	90
17. Hazeltine Ave & Bessemer St & Busway	9.3	A	90
18. Hazeltine Ave & Oxnard St	24.3	C	90
19. Tyrone Ave & Busway	6.9	A	45
20. Van Nuys Blvd & Aetna St & Busway	10.7	B	90
21. Van Nuys Blvd & Oxnard St	15.7	B	90
22. Vesper Ave & Busway	6.1	A	90
23. Vesper Ave & Oxnard St	7.0	A	60
24. Kester Ave & Busway	3.2	A	90
25. Kester Ave & Oxnard St	23.6	C	90
26. Sepulveda Blvd & Busway	7.5	A	120
27. Sepulveda Blvd & Oxnard St	24.9	C	120
28. Victory Blvd & Densmore Ave & Busway	5.8	A	120
29. Hayvenhurst Ave & Victory Blvd	13.3	B	120
30. Victory Blvd & Woodley Ave & Busway	50.3	D	120
31. Balboa Blvd & Busway	9.2	A	120
32. Balboa Blvd & Victory Blvd	36.8	D	120
33. Oxnard St & White Oak Ave & Busway	28.9	C	120
34. Oxnard St & Lindley Ave & Busway	27.1	C	120
35. Oxnard St & Reseda Blvd & Busway	38.8	D	120
36. Oxnard St & Wilbur Ave & Busway	32.6	C	120
37. Tampa Ave & Topham St & Busway	27.1	C	120
38. Corbin Ave & Topham St & Busway	30.9	C	120
39. Victory Blvd & Topham St & Busway	13.1	B	120
40. Winnetka Ave & Busway	2.6	A	120
41. Winnetka Ave & Victory Blvd	32.8	C	120
42. Victory Blvd & Mason Ave & Busway	21.1	C	120
43. Victory Blvd & De Soto Ave & Busway	35.2	D	120
44. Canoga Ave & Vanowen & Busway	42.2	D	120

Source: Iteris 2015

As shown in **Table 3**, all 32 intersections are operating at LOS D or better in the p.m. peak hour. Note that some intersections operate at very favorable levels of service (i.e. LOS C and above), which may be perceived as contrary to field conditions. Intersection LOS is developed based on a number of factors, including the vehicle volumes per travel lane and the amount of traffic in each direction of a crossing. For many crossings along the MOL, the busway itself is one intersecting facility, with a public street being the other intersecting facility. Given that the busway carries only Metro vehicles, and has a relatively short amount of green-light time provided for the buses to pass, this allows the intersection to operate at an acceptable LOS, regardless of the volumes of traffic on the public street. In other locations, the vehicles per lane of the intersecting public street are relatively low (due to the number of lanes on the roadway), which can also result in an improved LOS. In all cases, the acceptable LOS is based on the average delay per vehicle, and can be significantly improved when the number of vehicles per lane is reduced or when one of the intersecting facilities carries a limited volume of vehicles (such as the busway).

2.1.8 Travel Time

The Iteris consultant team conducted line rides on the MOL from North Hollywood to Canoga in December 2016. The line rides were conducted during the afternoon peak periods, when surface street congestion levels are at their highest. **Table 4** presents a summary of the average travel times recorded during the line rides.

Table 4 – MOL North Hollywood to Canoga Average PM Peak Travel Time

SEGMENT	WESTBOUND		EASTBOUND	
	2015[1]	2016[2]	2015[1]	2016[2]
North Hollywood and Canoga	42:00	41:15	39:00	38:21

Source: [1]Metro Speed Improvement Study 2015, [2]Iteris December 2016
Notes: Total travel time results include dwell times for boarding/alighting at stations. Line rides took place during the evening peak hours 3:00 – 7:00 PM.

Based on the data shown in **Table 4**, MOL buses are currently operating at an average speed of 19.6 mph in the westbound direction and 21.1 mph in the eastbound direction. The travel time includes boarding/ alighting at stations, bus delays at red lights, and buses slowing down at crossing intersections. In 2016, Metro implemented the immediate recommendations from the MOL Speed Evaluation Study such as the increase of intersection crossing speed from 10 mph to either 15 mph or 25 mph, depending on crossing configurations and station proximity. Consequently, when comparing the existing 2016 travel time data to the MOL Speed Evaluation Study (August 2015) data, it is observed that the MOL is currently running approximately one minute faster in each direction.

2.1.9 Bus Delays

MOL travel times are impacted by many factors including the number of times buses stop at traffic signals along the route, dwell time at stations, the number of crossings between stations, and traffic violations/ collisions on the busway.

2.2 Purpose and Need Statement

Since the project began in September 2016, the project team has conducted the following tasks: Developed a clear purpose and need statement, conducted a review of existing conditions, developed screening criteria to identify improvements and alternatives for further evaluation, conducted detailed technical analyses of a variety of improvements, prepared a preliminary environmental checklist, performed travel demand modeling, developed a matrix of recommended solutions, identified a series of improvement packages for consideration as a part of an identified Measure M expenditure, and identified a recommended base alternative for further consideration and study. All these tasks were conducted in order to further document and evaluate the criteria specified in the project's purpose and need statement:

The Metro Orange Line Grade Separation and Operational Improvements Technical Study seeks to provide safe and cost-effective strategies to improve operating speeds, capacity, and safety, while addressing passenger needs and minimizing disruption to the San Fernando Valley residents.

3.0 EVALUATION, SCREENING, AND RECOMMENDED IMPROVEMENTS

Based on the factors described in the purpose and need section, the project team identified the following goals, criteria, and performance metrics presented in **Table 5**.

Table 5 – Evaluation Criteria and Performance Measures

GOAL	CRITERIA	PERFORMANCE MEASURE
Improve Operating Speeds	• Reduce bus delays from red lights • Reduce overall person-delay • Improve consistency of bus speeds across the corridor	• Average bus speed at crossing • Red light delay for buses at crossing • Total rider delay • Average bus speed per segment • Stop-to-stop travel time
Address Safety Concerns	• Decrease modal conflicts at crossings • Improve pedestrian and bicyclist safety	• Collisions with buses • Collisions from right-turn-on-red violations • Visibility restrictions • Near-miss collisions • Bicycle/pedestrian collisions
Benefit the Surrounding Community	• Serve surrounding community • Preserve/enhance pedestrian and bicycle connections • Reduce delays for cross-traffic	• Population & employment density • Traffic volumes of cross-streets • Level-of-service of cross-streets • Per-lane volumes of cross-streets
Ensure Cost Effectiveness	• Maximize cost-effectiveness	• Capital costs • Operations and maintenance costs • Annual cost/ridership added

3.1 Improving Operating Speeds

Improving the MOL operating speeds requires an understanding of which crossings suffer from the most delay, where the most riders are affected by delay, and which segments along the corridor are the slowest in terms of bus travel speeds. The following quantitative performance measures were used to determine where there is a high need for bus operational improvements:

- **Average bus speed**: the speed of the bus as it passes through each crossing.
- **Red light delay**: the time the bus spent waiting at each crossing.
- **Total rider delay**: the red light delay multiplied by the bus load at each crossing (helping prioritize crossings where more MOL riders are affected).
- **Average speed, previous crossing to next**: the average bus speed over the distance between the crossings before and after the crossing in question, which provides a snapshot of speed within the corridor around each crossing, and helps define larger areas of the corridor in need of improvement.

3.2 Addressing Safety Concerns

While increasing MOL speed is a key goal that provides benefits to transit riders, improving safety is also a priority. Metro tracks collisions that involve Orange Line vehicles, and there are several factors that describe the safety of a crossing, such as visibility constraints for the bus operators and near-miss collisions not captured in collision datasets. The following performance measures were used to determined where need for safety improvements is high:

- **Bus collisions**: the number of collisions involving a MOL bus, whether with a car, a bicycle, or pedestrian, as tracked by Metro.
- **Collisions from right-turn-on-red (RTOR) violations**: the number of collisions caused by vehicles making illegal right turns on red lights across the busway, as tracked by Metro.
- **Near-miss collisions**: the likelihood of near-miss collisions, as identified by MOL operators, attributable to roadway geometrics, signal timing, or other activity within the area.
- **Visibility constraints**: the presence of physical obstructions, including landscaping, incorrect signage, structures, etc. that limit the operator's visibility and increase collision potential.
- **Bicycle/pedestrian collisions**: the number of bicycle and pedestrian collisions with vehicles within a 200-feet radius of the crossing, as reported by the California Highway Patrol Statewide Integrated Traffic Records System (SWITRS).

3.3 Benefiting the Surrounding Community

Metro seeks to provide benefits to the surrounding community, whether it is minimizing cross-traffic delays or serving high density areas with many transit riders. The following quantitative performance measures were used to determined where need for community improvements is high:

- **Pedestrian activity:** boardings at stations and/or pedestrian traffic activity reported by Metro operators.
- **Population & employment density**: the population and employment densities within a 0.25-mile radius of the crossing.
- **Traffic volumes of cross-streets**: the average daily traffic (ADT) of the cross-street.
- **Level-of-service of cross-streets**: the level-of-service (LOS) of the cross-street.
- **Per-lane volumes of cross-streets**: the peak-hour per-lane volume of the cross-street.

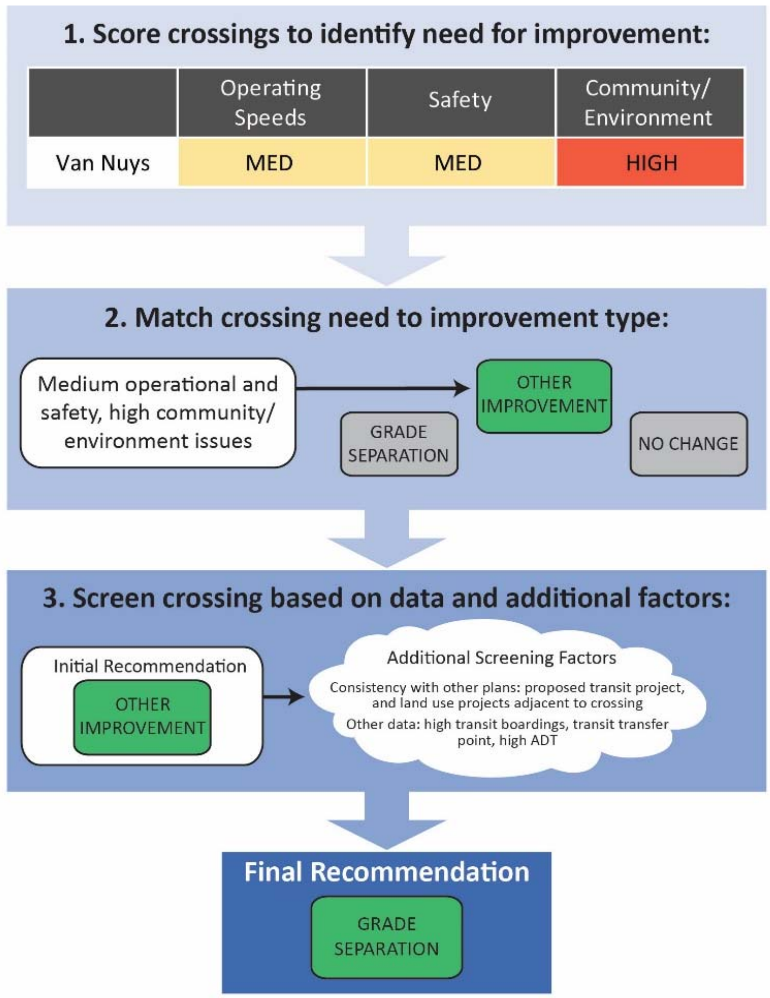
3.4 Ensuring Cost Effectiveness

The evaluation criteria and performance metrics were used to screen all crossings to identify the need for potential improvements. The specific improvements for each crossing, as identified in the needs analysis are detailed in **Section 4.0**. The team explored options to "package" crossings and improvements together. The packages presented in **Section 7.0** also take into account constrained and unconstrained funding scenarios.

4.0 METHODOLOGY

This section describes the methodology used to conduct the needs analysis and to screen the potential improvements for each crossing. The team drew upon a range of data sources and reports, including: the Metro Orange Line Speed Evaluation Study Final Report (2015), this project's Existing Conditions Technical Memorandum, Southern California Association of Governments (SCAG) land use information, Metro weekday ridership, SWITRS, and raw bus run data collected by the team. The methodology is summarized in **Figure 4**.

Figure 4 – Needs Analysis and Screening Methodology



4.1 Score Crossings to Identify Need for Improvement

The team used a two-step process to assign a need score to each crossing for each of the three goals. The first step of the process started with analyzing the quantitative measures and ranking the list of crossings into percentiles to receive a score of "high", "medium", or "low". These scores correspond with the severity of the issue at each crossing and thus its need for an improvement in that category. The scoring system is shown in **Table 6.**

Table 6 – Needs Analysis Scoring System

SEVERITY LEVEL OF ISSUE	CROSSING MUST MEET THE CORRESPONDING CRITERION
HIGH	Scores in top percentile; demonstrates a high need for improvement
MEDIUM	Scores in middle percentile; demonstrates some need for improvement
LOW	Bottom percentile or not applicable; demonstrates little or no need for improvement

Table 7 provides a sample for the first step of the process, for how the data would translate into need scores within the matrix. For example, crossings with low bus speeds would score as having a higher need for improvement relative to crossings with fast bus speeds.

Table 7 – Step 1: Score Performance Measures

CROSSING	AVERAGE BUS SPEED (MPH)	SCORE
Goodland Ave (ped Xing)	35.5	LOW
Coldwater Canyon Ave	3.6	HIGH
Chandler Blvd	1.6	HIGH
Ethel Ave	18.7	MED
Fulton Ave/Burbank Blvd	0.6	HIGH

Note: All information shown is for discussion purposes only and does not reflect actual analyses conducted in this Section. Analyses is done in other Sections.

After all of the individual performance measures were scored, they were summed within their respective categories to obtain an overall score for each goal. **Table 8** provides a sample for one crossing that demonstrates a high need for improvement with regards to MOL operations.

Table 8 – Step 2: Summarize Measures for Overall Score

CROSSING	NEED TO IMPROVE OPERATING SPEEDS				
	Average Bus Speed (mph)	Red Light Delay (sec)	Total Rider Delay (sec)	Average Speed Previous Crossing to Next (mph)	Summary Score
Sepulveda Blvd	HIGH	HIGH	HIGH	HIGH	**HIGH**

Note: All information shown is for discussion purposes only and does not reflect actual analyses conducted in this Section. Analyses is done in other Sections.

The summary scores for each of the three goals provided a high-level picture of the type of need present at each crossing.

4.2 Match Crossing Need to Improvement Type

After looking at a variety of operating, safety, and community/environmental measures, the team was able to identify the key issues at each crossing that describe the need to improve bus operations, safety, and the surrounding community. With a better understanding of the need at each crossing, the team used the scores and matched each crossing to a proposed improvement tailored to each crossing's need. For example, crossings with high traffic volumes, slow bus speeds, and a high number of collisions would be good candidates for grade separations, while crossings with little cross-traffic, fast bus speeds, and low surrounding population/employment density might not need any improvements.

Table 9 describes the universe of potential improvements, which include: grade separations, other improvements (including minor capital and operational improvements), and street closures/no changes.

Table 9 – Proposed Improvements to Address Need

EXISTING CONDITIONS	PROPOSED IMPROVEMENT TYPE
• Complex operational issues • High safety conflicts • High potential for community benefits	Grade Separation

EXISTING CONDITIONS	PROPOSED IMPROVEMENT TYPE
• Medium to complex operational issues • Medium to high safety conflicts • Medium to high potential for community benefits	Other improvements (minor capital improvements such as quad gates; operational improvements such as signal changes; and/or closure)
• Low to medium operational issues • Low to medium safety conflicts • Low to medium potential for community benefits	No Change

4.3 Screen Crossings Based on Additional Factors

The final step of the process was to further screen the crossings and initial proposed improvements, by adding additional qualitative measures to relevant crossings, such as the presence of other transportation or land use plans at that crossing. Some crossings had unique circumstances in its geometry or performance, while other crossings were completely screened out for any improvements due to low need in all categories. This final screening step resulted in a set of final recommendations for improvements for the crossings, which is described in greater detail in **Section** Error! Reference source not found..

5.0 NEEDS ANALYSIS MATRIX

Using the process outlined in **Section 4.0**, the team was able to identify the key issues at each crossing and match them with a potential improvement. **Table 10** is the needs analysis matrix, which is organized by the initial proposed improvement that was matched with the need score. The matrix provides the summary score for each goal and highlights some of the key issues at the crossings, with the crossings arranged by improvement type and by east to west. Crossings listed in bold indicate the presence of a MOL station.

Table 10 – Needs Analysis Matrix: Initial Improvement Based on Needs Analysis Findings

CROSSING	NEED FOR IMPROVEMENT			KEY ISSUES	INITIAL PROPOSED IMPROVEMENT
	Improve Operating Speeds	Address Safety Concerns	Benefit Surrounding Community		
Laurel Canyon Blvd	HIGH	MED	HIGH	- High impacts on average bus speeds - High numbers of collisions - Visibility restrictions - High cross-traffic volumes	Grade Separation
Woodman Ave	HIGH	HIGH	HIGH		
Sepulveda Blvd	HIGH	HIGH	HIGH		
Balboa Blvd	HIGH	HIGH	MED		
Reseda Blvd	HIGH	HIGH	HIGH		
Tujunga Ave	HIGH	LOW	LOW	- Impacts on average bus speeds - Red light delay - Presence of current collisions or near misses - Varying levels of cross-traffic volumes	Other Improvements (Minor Capital, Operational, and/ or Closure)
Colfax Ave	HIGH	LOW	LOW		
Corteen Pl	MED	LOW	MED		
Whitsett Ave	MED	LOW	MED		
Coldwater Canyon Ave	HIGH	LOW	MED		
Chandler Blvd	HIGH	LOW	LOW		
Fulton Ave/Burbank Blvd	HIGH	LOW	MED		
Oxnard St	HIGH	LOW	MED		
Hazeltine Ave	MED	LOW	MED		
Tyrone Ave	LOW	MED	MED		
Van Nuys Blvd	MED	MED	HIGH		
Kester Ave	MED	HIGH	MED		

CROSSING	NEED FOR IMPROVEMENT			KEY ISSUES	INITIAL PROPOSED IMPROVEMENT
	Improve Operating Speeds	Address Safety Concerns	Benefit Surrounding Community		
Sepulveda Station (ped Xing)	MED	LOW	MED		
Woodley Ave	HIGH	MED	MED		
White Oak Ave	MED	LOW	MED		
Lindley Ave	LOW	MED	MED	- Impacts on average bus speeds - Red light delay - Presence of current collisions or near misses - Varying levels of cross-traffic volumes	Other Improvements (Minor Capital, Operational, and/or Closure)
Wilbur Ave	HIGH	LOW	LOW		
Tampa Ave	MED	MED	MED		
Corbin Ave	MED	MED	LOW		
Victory Blvd	HIGH	LOW	MED		
Winnetka Ave	MED	LOW	MED	- Impacts on average bus speeds - Red light delay - Presence of current collisions or near misses - Varying levels of cross-traffic volumes	Other Improvements (Minor Capital, Operational, and/or Closure)
Mason Ave	LOW	HIGH	LOW		
De Soto Ave	LOW	MED	HIGH		
Agnes Ave (ped Xing)	MED	LOW	LOW	- Limited impacts on average bus speeds - Limited red light delay - Low numbers of collisions - Low levels of visibility restrictions - Low volumes of cross-traffic - High LOS performance for cross-streets	No Change
Bellaire Ave	LOW	LOW	MED		
Goodland Ave (ped Xing)	LOW	LOW	MED		
Ethel Ave	MED	LOW	LOW		
Vesper Ave	LOW	LOW	MED		
City of LA (private Xing)	LOW	LOW	LOW		
Densmore Ave (gated driveway)	LOW	LOW	LOW		
Driveway (private)	LOW	LOW	LOW		
Hayvenhurst Ave (ped Xing)	LOW	LOW	LOW		
Zelzah Ave (ped Xing)	LOW	LOW	LOW		

Note: Crossings listed in **bold** indicate the presence of a MOL station.

5.1 Screening Results

Table 11 and **Figure 5** show the refined recommendations as a result of the screening process described above. Crossings are organized by improvement, and secondarily by location, from east to west.

Table 11 – Recommended Improvements

CROSSING	INITIAL PROPOSED IMPROVEMENT
Laurel Canyon Blvd	Grade Separation
Fulton Ave/Burbank Blvd	
Woodman Ave	
Van Nuys Blvd	
Sepulveda Blvd	
Balboa Blvd	
Reseda Blvd	
Tujunga Ave	Other Improvements (Minor Capital, Operational, and/or Closure)
Colfax Ave	
Corteen Pl	
Whitsett Ave	
Coldwater Canyon Ave	
Chandler Blvd	
Oxnard St	

CROSSING	INITIAL PROPOSED IMPROVEMENT
Hazeltine Ave	
Tyrone Ave	
Kester Ave	
Sepulveda Station (ped Xing)	
Woodley Ave	
White Oak Ave	
Lindley Ave	
Wilbur Ave	
Tampa Ave	
Corbin Ave	
Victory Blvd	
Winnetka Ave	
Mason Ave	
De Soto Ave	
Agnes Ave (ped Xing)	No Change
Bellaire Ave	
Goodland Ave (ped Xing)	
Ethel Ave	
Vesper Ave	
City of LA (private Xing)	
Densmore Ave (gated driveway)	
Driveway (private)	
Hayvenhurst Ave (ped Xing)	
Zelzah Ave (ped Xing)	

Note: Crossings listed in **bold** indicate the presence of a MOL station.

Figure 5 – Recommended Improvement for Each Crossing

Detailed technical analyses were completed for the following aspects of each identified improvement alternative, for each selected location:

- Potential minor street closures
- Conceptual design and cost estimates
- Operating plans
- Traffic impacts
- Traffic management and construction staging plans
- Parking impacts
- Right-of-way survey and maps
- Conceptual geotechnical investigation
- Utility investigation
- Conceptual hydraulics and hydrology study
- Four quadrant gate system feasibility

A number of detailed technical studies were prepared to address specific aspects and improvements. The results of these technical studies are documented in independent technical memoranda.

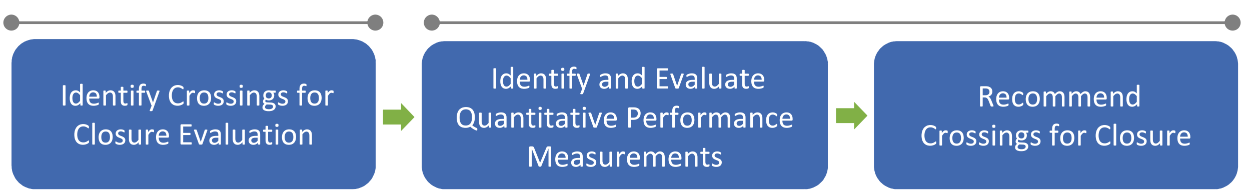
5.1.1 Potential Minor Street Closures

Crossings along the MOL were evaluated to determine if they could be permanently closed to cross-traffic in order to benefit MOL operations without negatively and disproportionately impacting the surrounding community.

5.1.1.1 Methodology for Identifying Closures

Section 3.0 and **4.0** of this document focused on identifying crossings which would benefit from grade separations. The analysis also found that many other crossings could benefit from some other forms of improvement, as well as crossings which affected bus operations so little that they could remain unchanged. As illustrated in **Figure 6,** additional quantitative performance measures for closure are identified.

Figure 6 - Methodology for Evaluation Closures



These new performance measures are specifically relevant to identifying crossings for closure, and include: street continuity, street classifications, traffic redistribution, emergency access, and neighborhood character. Similar to the methodology described in **Section 4.0**, each crossing received a score of “high”, “medium”, or “low” in the quantitative analysis for each performance measure, with a final overall summary score for the crossing. High scores indicate better candidates for closure. Only crossings with overall summary scores of “high” were recommended for closure. The additional performance measures and the methods to derive the measurements are as follows:

- **Street Continuity**: the shortest distance from the crossing to the end of the street in question. Shorter distances mean fewer miles of road would be cut off by a closure, making a crossing with a short distance a better candidate for closure.

- **Street Classification**: cross-street's classification, based upon the City of Los Angeles's Complete Streets Design Guide, published in 2014. A non-arterial street hosts less traffic, as it is less likely to connect activity centers and as a result is a better candidate for closure.
- **Traffic Redistribution:**
    - Vehicle miles diverted (the average daily traffic at each crossing multiplied by the distance to the next-nearest signalized crossing), which is the combined VMT of diverted traffic vehicle if the crossing was closed. Fewer vehicle miles diverted means less traffic would be affected, making such a crossing a better candidate for closure.
    - Adjacent crossing capacity rates the ability of both crossings on either side to absorb diverted traffic from a closure based on the adjacent crossing's own traffic volumes, LOS, and street classifications. This assumes a 50%-50% split of the closed crossing's traffic to the crossings on either side. A crossing surrounded by major roadways with C or better levels of service and reasonable daily volumes are better candidates for closure.
- **Emergency Access**: the difference in distance an emergency vehicle would have to travel from a fire station if a crossing was closed, compared to how far it would travel with the crossing open. The smaller the difference in distance required to travel, the less likely a closure of that crossing would impact emergency services.
- **Neighborhood Character**: the number of schools and Jewish religious institutions within a quarter-mile of each crossing. Schools indicate pedestrian activity, and discussions with Metro have revealed the importance of timed, signalized crossings for the area's religious Jewish communities who according to faith can neither press the pedestrian call buttons nor drive on the Sabbath. The fewer the number of such institutions around a crossing, the better candidate it is for closure.

5.1.1.2 Summary of Crossings under Consideration

Table 12 lists the crossings identified in the screening results as meriting some type of improvement other than grade separations, as well as those marked for no change. Crossings listed in bold denote the presence of an Orange Line station.

Table 12 – Crossings Marked for Improvements Other than Grade Separation

CROSSING	CD	CROSSING	CD	CROSSING	CD
Tujunga Ave	2	Hazeltine Ave	2 & 6	Lindley Ave	3 & 5
Colfax Ave	2	Tyrone Ave	6	Wilbur Ave	3
Corteen Pl	2	Vesper Ave	6	**Tampa Ave**	3
Whitsett Ave	2	Kester Ave	6	Corbin Ave	3
Bellaire Ave	2	City of LA (private)	6	Victory Blvd	3
Coldwater Canyon Ave	4	Densmore Ave (gated)	6	**Winnetka Ave**	3
Chandler Blvd	4	Driveway (private)	6	Mason Ave	3
Ethel Ave	4	**Woodley Ave**	6	**De Soto Ave**	3
Oxnard St	2	White Oak Ave	5		

Note: Crossings listed in **bold** indicate the presence of a MOL station. CD = LA City Council District

5.1.1.3 Results of Analysis and Recommendations

The results of the quantitative analysis are listed in **Table 13**.

Table 13 – Summary Scores of Crossings Considered for Closure

CROSSING	SUMMARY SCORE	CROSSING	SUMMARY SCORE	CROSSING	SUMMARY SCORE
Tujunga Ave	MED	Hazeltine Ave	MED	Lindley Ave	LOW
Colfax Ave	MED	Tyrone Ave	HIGH	Wilbur Ave	LOW
Corteen Pl	HIGH	Vesper Ave	HIGH	Tampa Ave	LOW
Whitsett Ave	LOW	Kester Ave	MED	Corbin Ave	MED
Bellaire Ave	HIGH	City of LA (private Xing)	LOW	Victory Blvd	LOW
Coldwater Cyn Ave	LOW	Densmore Ave (gated driveway)	HIGH	Winnetka Ave	MED
Chandler Blvd	LOW	Driveway (private)	HIGH	Mason Ave	MED
Ethel Ave	HIGH	Woodley Ave	LOW	De Soto Ave	LOW
Oxnard St	MED	White Oak Ave	LOW		

Note: Crossings listed in **bold** indicate the presence of a MOL station.

Corteen Place, Bellaire Avenue, Ethel Avenue, Tyrone Avenue, Vesper Avenue, Densmore Avenue, and a private driveway all scored well enough to be considered for closure. Some of the key reasons that these crossings scored "high" for closure candidacy include:

- Classification as non-arterial streets;
- Few vehicle miles diverted from traffic redistribution if closed;
- Adjacent crossings capable of absorbing additional traffic from closure;
- Insignificant differences in travel distance for emergency services access if closed.

Detailed quantitative information for each crossing evaluated is available in *Task 6.3 Potential Minor Intersections for Closure Memorandum*. Each crossing potentially closed to cross-traffic will improve MOL bus operations, as buses will no longer lose time from dwelling at red lights or slowing down and speeding up while approaching and departing intersections.

5.1.1.4 Other Considerations

In addition to quantitative technical analysis, qualitative and community considerations may impact the selection of recommended crossings for closure, as opposed to no change or alternative improvements. The considerations that follow have been gathered from Metro outreach and operations teams.

Community Considerations

- **Ethel Avenue:** Ethel Avenue is a key access point from Chandler Boulevard to the adjacent neighborhood. If closed, the only entrance to residents would be from Burbank Boulevard, limiting emergency service access to a single point. Additionally, the Ethel Avenue crossing is used by people frequenting the Chabad of North Hollywood, a Jewish institution at the corner of Ethel Avenue and Chandler Boulevard. Closing Ethel Avenue would cut off access for members of this community south of Chandler Blvd.
- **Bellaire Avenue:** Bellaire Avenue is a major thoroughfare for local travel and is used by neighborhood shuttles to transport children to school outside of the San Fernando Valley. Closing Bellaire Avenue would create local community impacts.
- **Valley Eruv:** The Jewish community within the study area maintains the Valley Eruv. An *eruv* is a portion of an urban area enclosed by a wire boundary that symbolically extends the private domain of Jewish households into public areas, permitting activities within it that are normally forbidden in public on the Sabbath. On the Sabbath and holidays, religious Jews follow a tradition of resting which

limits the types of activities performed that day. The Valley Eruv is bounded by the 101, 170, 5, 118, and 405 freeways. Metro has reviewed the boundaries of the Valley Eruv for impacts from potential crossing closures, particularly around the crossings under consideration within the Chandler Boulevard corridor of the Orange Line.

Operational Considerations
Densmore Avenue serves as the entrance to the Donald C. Tillman Water Reclamation Plant, and is a potential entry point for other buses which may require access to the busway at that location. Final decisions should consider these potential impacts.

5.1.2 Conceptual Design and Cost Estimates

This subsection presents an overview of conceptual design and constructability issues for these grade separations. The information gained during the course of this study, along with the conceptual drawings produced, provide all of the essential information, including cost and construction timelines, needed to begin to progress these improvements through the funding and design process. This is an essential step in laying the groundwork for an enhanced Metro Rail system to support the next decades of mobility in Los Angeles County.

A Cost Database has been developed based upon the five percent conceptual plans for the identified Grade Separation Analysis and Operational Improvements Technical Study, and summarizes the basic cost estimating methodology used to develop capital cost estimates.

5.1.3 Operating Plans

Operational plans were presented in *Task 6.6 MOL Detour Routing Memorandum*. These operational plans are primarily developed to maintain operations during the most intensive potential project improvements – the construction of grade separations at five priority locations: Fulton/Burbank, Woodman, Van Nuys, Sepulveda and Reseda. These crossings, and the busway corridor in the immediate vicinity of the crossing, would be out of service and buses would not be able to utilize various segments of the MOL busway right-of-way (ROW) during the construction period. The proposed detour route is designed to achieve the following goals:

- Maintain bus service during the construction period
- Maintain convenient passenger access to MOL service and connecting bus routes
- Avoid bus operations in construction zones
- Keep MOL service as close to the current ROW as possible
- Provide safe and efficient bus service operation during construction

The bus detour routes consider several issues found during the review of the current service operation, preliminary construction alternatives, and field investigation of the ROW. The following are items that have been identified during the review:

- **The ability of MOL articulated buses to enter and exit the busway ROW** – Because several ROW segments would be impacted during construction, MOL buses would have to enter and exit the ROW at several points for on-street operations. The detour routes consider locations where 60-foot articulated buses would need adequate space for turning movements and the ability to merge with automobile traffic.
- **Safe turning movements and service operations** – In development of the detour routing, the operation of MOL articulated buses along the major roadway was considered. Sepulveda Boulevard between the Woodley and Sepulveda Stations was reviewed due to concerns regarding the ability of eastbound buses to serve the Sepulveda Station from the bus stop located on Sepulveda Boulevard. This station located

immediately north of the ROW would require buses to safely cross traffic and turn left onto Oxnard Street. This route alternative was not recommended due to these predicaments.

- **Construction alternatives that would reroute the existing busway ROW** – One point of contention is to reroute the MOL Busway immediately south of the current ROW through existing automobile parking area. For example, the proposed detour routing for the Reseda Station includes an alternative routing if this construction alternative is implemented.

5.1.4 Traffic Impacts

Traffic analyses were conducted for various improvement alternative scenarios for the Metro Orange Line Grade Separation Analysis and Operational Improvements Technical Study. The VISSIM microsimulation software was used for the traffic analysis. The VISSIM model originally developed for the MOL Speed Evaluation Study (2015) was used as the base model for further evaluations. This model was updated to reflect existing 2016/2017 conditions. One of the major updates in the VISSIM model was bus speeds at intersection crossings, which changed after Metro implemented the immediate recommendations listed in the MOL Speed Evaluation Study.

5.1.4.1 Alternatives

A traffic operations analysis was conducted for each of the following alternatives:

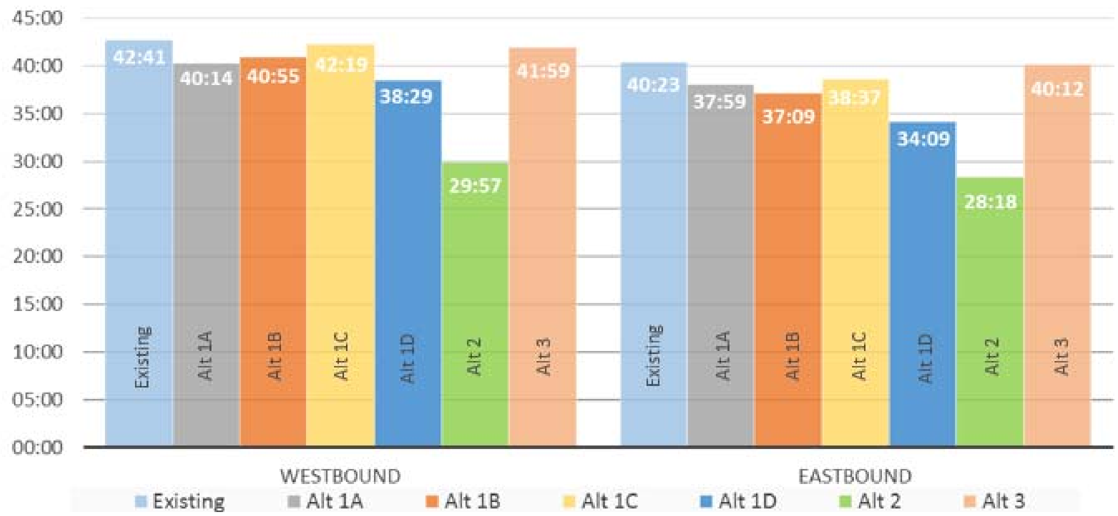
1. Alternative 1 - Grade Separation
    a. Alternative 1A – Grade separation of only Reseda and only Sepulveda
    b. Alternative 1B – Grade separation from Sepulveda to Van Nuys only
    c. Alternative 1C – Grade separation from Woodman to Valley College
    d. Alternative 1D – Grade separation at Reseda, Sepulveda to Van Nuys, and Oxnard-Woodman-Fulton-Valley College
2. Alternative 2 – Four Quad Gate System Deployment at all Crossings (31 total crossings, not including private and/or pedestrian-only crossings)
3. Alternative 3 – Signal Improvements at all Crossings

In addition to the alternatives listed above, a simulation was conducted for potential construction detours. It is important to note that the alternatives evaluated as a part of the traffic operations analysis reflect a sample of potential improvements that were determined to be applicable to crossings via the initial screening conducted earlier in the project process. The findings of this analysis were used to develop potential packages of improvements, and the packages ultimately developed were different from the alternatives evaluated in this task.

5.1.4.2 Traffic Operation Simulation Results

Utilizing the data and findings collected in previous tasks, Iteris prepared a computer simulation, using VISSIM, of the operation of the MOL. **Figure 7** shows a comparison bus travel times under all alternatives: existing, Alternative 1A-1D, Alternative 2 and Alternative 3 conditions. Alternative 2 would have the maximum improvement, with travel time reduction of 12 minutes in both directions. Alternative 1D would reduce bus travel time up to six (6) minutes and Alternative 3 would reduce travel time by less than one minute.

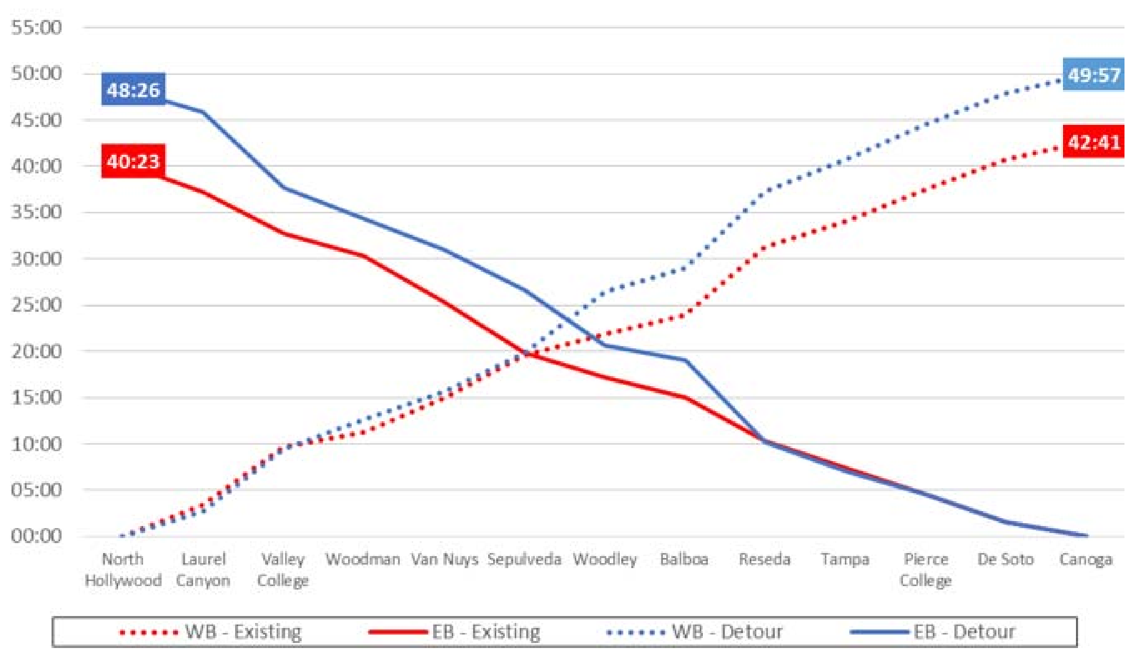
Figure 7 – Bus Travel Time – Alternative Comparison



5.1.4.2.1 Construction Stage Detour Analysis

The proposed routing plans, presented in *Task 6.6 MOL Detour Routing Memorandum*, would detour buses off the busway temporarily during construction of grade separation alternatives, to adjacent local roads. **Figure 8** shows the existing bus travel times between the bus stops. It should be noted that the travel times are calculated using VISSIM which includes bus speeds and traffic operational conditions.

Figure 8 – Eastbound and Westbound Travel Time Plots (by Bus Stops) – Existing Vs Detour



As shown in **Figure 8** the travel times would increase by approximately seven (7) minutes in both westbound and eastbound directions.

5.1.5 Traffic Management and Construction Staging Plans

A preliminary construction staging/detour plan, construction phasing, traffic management strategies, and identification of potential construction impacts, including the operation of the MOL, street and parking lot closures, and pedestrian and bicycle circulations was prepared as part of the *Task 6.8 Construction Staging Report*. The report, however, does not serve as the official Traffic Management Plan (TMP) as required by City of Los Angeles Department of Transportation (LADOT) for construction activities within LADOT's jurisdiction. Construction staging details such as exact street crossing locations, length, width, curve radii, signage, and closure period will be identified and analyzed in the next phase of the project when engineering design is further refined. Detailed TMP will be prepared in the later stages in accordance with LADOT specifications and requirements.

5.1.6 Parking impacts

A parking analysis was performed for the MOL, as detailed in *Task 6.9 Parking Impact Analysis Memorandum*. Potential parking impacts were assessed based on the conceptual design (up to 5% level of engineering) of the three (3) grade separation alternatives. These alternative segments include: 1) Yolanda Avenue to Texhoma Avenue (Reseda Boulevard Grade Separation), 2) I-405 to Ranchito Avenue (Sepulveda Boulevard to Van Nuys Boulevard Grade Separation), 3) Ranchito Avenue to Leghorn Avenue (Woodman Avenue to Fulton Avenue/Burbank Boulevard Grade Separation). For the purposes of the parking analysis, each of the alternative segments are divided into sections based on existing parking that would be affected by the alternatives, particularly near the MOL station sites.

5.1.7 Right-of-Way Survey and Maps

A thorough investigation of parcels and property ownership along the right-of-way required for MOL improvements is available in *Task 6.10 Technical Memorandum: Right of Way Requirements*.

5.1.8 Geotechnical Analysis

The detailed results of the evaluation of geotechnical and hazardous material conditions that could adversely impact the development of grade separating the Orange Line are presented in *Task 6.11 Geotechnical Analysis Report* and summarized in this document.

5.1.9 Utility Investigation

Within the study area, various utilities along the project will be impacted during construction. The Utility Matrix indicates all known utilities that are impacted at the time of the study. The utilities that are indicated as major impacts fall into the following categories:

- Overhead utility lines near or crossing the project alignment
- Gas lines larger than 24" in diameter
- Storm drain lines that are larger than 36" in diameter
- Water lines that are larger than 24" in diameter
- Sewer lines that are larger than 30" in diameter
- Oil lines near or crossing the project alignment

The overhead utility lines are generally electrical, communication, or cable services. Gas lines larger than 24" generally serve a regional population. Typically, these third party utilities require a long lead time for removal and/or relocation. Oil lines are also owned by third party utilities and will require the long lead time as well.

At this level of study, it was decided to use the above criteria to determine the categorical impacts for storm drain, water, and sewer lines. As the design progresses, additional utilities will be identified to be removed and/or relocated based on the final design.

5.1.10 Conceptual Hydraulics and Hydrology Study

The detailed results of existing drainage conditions and potential drainage impact caused by grade separating the priority locations of the Orange Line is presented in *Task 6.13 Preliminary Drainage Study Report*.

5.1.11 Four Quadrant Gate System Feasibility

The potential application of railroad-type four quadrant gate systems as an additional traffic control and safety feature at MOL busway crossing intersections is presented in *Task 11 Four Quadrant Gate System Phase II* and summarized in this document. Two primary aspects of potential gate systems are the focus of the analysis:

- Conceptual schematics, operations, and equipment for gate system applications along the MOL corridor; and
- A summary of traffic operations for both vehicular traffic crossing the MOL corridor and Metro buses using the MOL corridor with the addition of potential gate systems.

A preliminary Concept of Operations memorandum was completed, as part of Task 11, to document the feasibility of gate systems applied to a BRT corridor. The Concept of Operations document noted that gate systems are common along at-grade rail lines throughout Los Angeles County, and the technology used to activate and operate these systems is proven and reliable. Gate systems have never been deployed for BRT systems in California, and there are inherent differences between rail and bus operations that necessitate specific design and operational considerations in order to serve as a viable traffic control and safety feature for at-grade BRT corridor crossings. The Concept of Operations memorandum concluded that a four quadrant gate system can be considered feasible for application and operation on the MOL BRT Corridor, under the following specific conditions:

1. Vehicle detectors (loops or video detection systems) can and should be used.
2. Maximum approach speeds of buses should be used to develop the timing plans and sequence for gate operation.
3. The four quadrant gate system would replace the existing traffic signal at a crossing that controls the bus movements. Traffic signals controlling vehicular movements on crossing streets would be modified or remain, consistent with traffic signal installations adjacent to other Metro rail crossings. An Operator Signal or modified light rail transit (LRT) signal would be required to alert the approaching bus operator to the current gate status (e.g., for an operator signal – dark when the gates are up, solid when the gates have been activated and are descending, and flashing when the gates are down).
4. The system would only be feasible if the MOL right-of-way was exclusively used by Metro buses, and use by all other vehicles is restricted and only authorized by Metro, with strict regulations for safety adherence.

5.2 Travel Demand Forecasting Model Summary

Preliminary travel demand model forecasts were developed to determine potential ridership and VMT changes that would result from potential grade separations. The complete detailed analysis is available in the *Task 8.0 Travel Demand Forecasting Methodology Report* and summarized here. Metro's travel demand model was used to develop forecasts for the opening year of potential grade separations, anticipated as the year 2025 (based on the most recent Measure M funding plan). The project team reviewed detailed model inputs for accuracy and correctness, running the model stream and comparing the results to existing conditions for the modeling area. Changes were made in the model code to reflect current conditions and the 2025 horizon year, including modifications to socioeconomic data and updated transit information. Ridership forecasts were prepared for potential combinations of grade separations, and the results are presented on **Table 14**. The majority of the growth is forecast to occur during peak periods, with additional growth forecast in the off-peak periods. Maximum passenger loads are forecast for the Sepulveda station, consistent with current ridership.

Table 14 – Summary of Ridership Forecasts

FORECAST SCENARIO	RIDERSHIP			CHANGE			GROWTH		
	Peak	Off-Peak	Total	Peak	Off-Peak	Total	Peak	Off Peak	Total
Base Year 2012	16,200	8,300	24,500	-	-	-	-	-	-
Year 2025 (No Build)	18,200	7,700	25,900	-	-	-	12%	-7%	6%
Year 2025 Package A	18,900	8,000	26,900	700	300	1,000	4%	4%	4%
Year 2025 Package B	19,200	8,100	27,300	1,000	400	1,400	5%	5%	5%
Year 2025 Package C	18,900	7,900	26,800	700	200	900	4%	3%	3%
Year 2025 Package D	20,900	8,400	29,300	2,700	700	3,400	15%	9%	13%
Year 2025 Gate Systems	26,100	9,900	36,000	7,900	2,200	10,100	43%	29%	39%

5.3 Summary Needs Analysis

The **Table 15** presents a general summary of the needs analysis findings, which then lead to the development of project alternatives. These potential improvements are also displayed in **Figure 9**.

Table 15 – Summary of Potential Improvements and Associated Technical Analysis Findings

Improvement	Bus Travel Time Change	Change in Cross-Street Traffic Delays	Safety Benefit	Cost[1]	Other Issues
Grade Separation	• Reduction of approx. 1 min per bus per grade separation	• Reduction in average peak hour delay of approximately 5 seconds per vehicle per grade separation • Note that the reduction in delay is directly related to adjacent traffic signals, and is greatest in those locations where the existing MOL crossing is adjacent to other traffic signal controlled intersections	• Removes potential for bus/ vehicle/bike/ped conflicts for buses within the MOL corridor	• $50 M -$100 M per grade separation	• Potential interruption of existing bus/bike path operations • Potential reduction of Metro-owned parking • Potential utility conflicts
Improved TSP	• Reduction of less than 1 min per bus for the entire corridor	• Increase in average peak hour delay of approximately 1-2 seconds per vehicle per crossing	• Reduced potential for short stops by bus vehicles	• $50 K per crossing • Note that costs could increase if additional communication links are required	• Maintenance/deployment challenges with in-vehicle transponders
Improved Bus-Signal Communication[2]	• Reduction of less than 1 min per bus for the entire corridor	• Increase in average peak hour delay of approximately 1-2 seconds per vehicle per crossing	• Reduced potential for short stops by bus vehicles	• $50 K per crossing	• Accuracy of real-time traffic signal information
Minor Street Closures	• Reduction of approx. 40 sec per bus per closure	• N/A (no cross traffic movements)	• Removes potential for bus/ vehicle/bike/ped conflicts for buses within the MOL corridor	• $25 K - $100 K per closure (or higher)	• Interruption of direct walking/bicycling paths in residential neighborhoods • Reduced access for public safety vehicles
Four Quadrant Gate Systems	• Reduction of approx. 48 sec per bus per gate system	• Increase in average peak hour delay of approximately 7-8 seconds per vehicle per gate system location • Note that gates would only operate when a bus is present, and changes in bus operations – such as platooning vehicles or operating at increased headways – could reduce the overall average delay experienced	• Virtually removes potential for bus/vehicle/bike/ped conflicts for buses within the MOL corridor	• $1.3 M per gate system (or higher)	• May require further coordination with regulatory agencies, as the application of gates for a BRT system is unique • Implementation challenges for fail-safe operation

Note:
[1]Costs do not include ongoing operations and maintenance costs.
[2]This improvement would likely be implemented as a part of a systematic update for all signals along the MOL corridor.

Figure 9 – Potential Improvement at Each Crossing

6.0 RECOMMENDED BASE ALTERNATIVE

Initially four packages of improvements were developed for consideration, reflecting different combinations of grade separations and other operational improvements. An additional package was added, in order to consider the deployment of gate systems at all crossings. When these five packages were discussed with Metro staff during the course of recurring project meetings, it was ultimately determined that a hybrid package combining a variety of improvement measures would provide the maximum benefit and address the stated purpose and need to the greatest extent. Therefore, Package A-1 was developed as presented as follows:

Package A-1: Hybrid Solution (Grade Separations + Gate Systems)

Package A-1 (shown in **Figure 10**) proposes aerial grade separations at the Van Nuys and Sepulveda stations. The busway would be elevated the entire length from Van Nuys Station to Sepulveda Station, including the pedestrian crossing at Sepulveda Station and the station would be relocated over Sepulveda Boulevard. All roadway crossings between the Van Nuys and Sepulveda stations would remain open. Tyrone Avenue is the only roadway proposed to be closed. No changes are proposed to the other four pedestrian-only crossings located along the study segment, and the remaining 27 crossings would have gate systems installed.

Figure 10 – Recommended Base Alternative (Package A-1)

The recommended base alternative, Package A-1, assumes that the majority of busway crossings along the 12.7-mile study segment would be protected by gate systems, as described previously in **Section 5.1.11**. As the gate systems require additional advance warning time, the recommended base alternative also assumes changes to busway operations to minimize cross-traffic delays. The recommended base alternative assumes that during peak periods, buses would operate in two-vehicle platoons at eight-minute headways. This operation would allow the busway to carry the same amount of peak period riders at increased headways, thereby reducing the frequency of gate activation and reducing associated potential cross traffic delays. It should be noted that the eight-minute headway needs to be further evaluated and approved by Metro Operations department. The recommended base alternative also assumes that bus vehicles would operate at the maximum civil speed allowed by Metro operations, when traveling within the busway. With the increased protection of the crossings provided by the gate systems and grade separations, bus operators will be able to operate at higher speeds at the crossings, and will therefore be able to operate at higher speeds on busway segments between crossings.

Under Package A-1, bus travel times would decrease by approximately 12.6 minutes (average for both directions), and average cross street traffic delays due to gate activations during peak periods would reduce by approximately 1.6 seconds per vehicle. Daily vehicle miles travelled (VMT) would decrease by about 81,756 and the change in O&M costs would decrease by approximately 6.4 percent. The recommended base alternative assumes that the adjacent bike path would remain operational, and associated traffic signal controls for bike path crossings would be maintained. The signals controlling the bike path crossings would be connected to the busway crossings and gate systems, so that bikes could operate a push button to receive a signal to cross the intersecting streets, independent of gate system activation by MOL buses. This means that cross traffic would potentially face red lights due to bike crossings, assumed to be consistent with current levels of activation.

In terms of overall safety benefits, the hybrid package A-1 would provide the maximum potential improvement for the entire MOL corridor, as it allows for additional features that restrict and limit potential conflicting vehicular, pedestrian, and bicycle movements across the busway at the highest number of crossings. The combination of grade separations and gate systems would significantly impede the ability of cross-street traffic and pedestrians to illegally cross the busway while a bus was approaching or within the crossing, which would result in a significant reduction of bus-involved collisions.

It is important to note that although the focus of this feasibility study is the 12.7-mile east-west segment (from North Hollywood to Canoga), Metro seeks to provide improvements for the entire 18-mile MOL corridor (from North Hollywood to Chatsworth). Recognizing this, **Table 16** presents a summary of the recommended improvements and associated performance metrics for all segments of the MOL corridor. As noted on the table, performance metrics and costs for improvements for the segments not included in this current feasibility study were developed using information provided by Metro. Additional evaluations and refinements will likely occur during subsequent environmental clearance and design phases.

From a cost/benefit standpoint, the recommended base alternative would provide improvements at 33 MOL crossings at an average cost of $8.5 M per crossing. By increasing protections at 33 crossings, Package A-1 provides the maximum potential reduction for the 23 bus-involved collisions that occurred along the MOL corridor between 2015 and 2016. Compared to the other alternative packages described in the next section, the recommended base alternative provides greater improvements at more crossings, at nearly half the cost per crossings.

Table 16 – Recommended MOL Corridor Improvements

SEGMENT	RECOMMENDED IMPROVEMENTS & PERFORMANCE METRICS
East-West Segment (North Hollywood to Canoga)	• Hybrid Solution o 5 Grade separated crossings o 27 Gated crossings o 1 roadway crossing closures o $273 M (2017 $)[1] o Average 12.6-minute travel time decrease • Maintain existing bike path
North-South Segment (Canoga to Chatsworth)	• Gates only (Not included in current study) o 7 Gated crossings o $10 M[2] (2017 $) o Average 3.4-minute travel time decrease[2] • Maintain existing bike path
Entire Corridor (North Hollywood to Chatsworth)	• Hybrid Solution (Not included in current study) o 5 Grade separated crossings o 34 Gated crossings o 1 roadway crossing closure o Bike path grade separation o $283 M[2] (2017 $) o Average 16-minute travel time decrease[2] • Maintain existing bike path

Notes:
1. Cost estimates include elevated bike path (described below) as well as side platform station configurations.
2. Cost estimates and performance metrics presented are rough estimates, due to the preliminary nature of the feasibility analysis. Subsequent environmental clearance and design phases will require further evaluation and analysis.

As an optional component of the recommended base alternative, a preliminary feasibility analysis of potential grade separations for the adjacent bike path was conducted, so that bike path users could cross over the busiest cross streets – Sepulveda and Van Nuys. The results of the preliminary feasibility analysis are presented in **Table 17**. It is important to note that these results address only the engineering and operational feasibility, with a goal of identifying improvements that could be incorporated into the recommended base alternative to provide improved facilities for additional modes besides only buses and vehicles. There are many conceptual benefits of providing grade separations for the adjacent bike path over two of the most congested crossings along the MOL corridor, including safety and travel time benefits. There are also concerns regarding the feasibility of constructing, maintaining, and ensuring ongoing safety and security for grade separated bike path crossings. Therefore, additional evaluations and refinements will likely occur during subsequent environmental clearance and design phases.

Table 17 – Bike Path Grade Separation Alternatives

ALTERNATIVE	COST $ (2017)
Grade Separated bike path from Sepulveda to Van Nuys (No local access between these crossings) – Long Bike Path option	$22.7M
Grade separated bike path at Sepulveda crossing and Van Nuys crossing only – Short Bike Path option	$12.8M

7.0 ALTERNATIVE OPTIONS

Using the findings of the detailed technical analyses, the project team identified feasible improvements for further consideration. The improvements were then compared to the preliminary environmental checklist and travel demand modeling results, in order to arrive at a group of recommended improvements. These recommended improvements were then grouped together into potential packages for further study and potential implementation. Further details concerning these alternative packages can be found in the *Task 9.0 Grade Separation Alternatives Analysis and Structural Type Selections (GSAA&STS) Report*. The improvement packages for the east-west segment portion of the MOL are summarized in **Table 18** and described further, and depicted in **Figures 11a-11e**.

Table 18 – Summary of Potential Alternative Options (MOL North Hollywood to Canoga Segment)

Improvement / Benefit	Package A: Van Nuys & Sepulveda + Reseda	Package B: Valley College & Woodman + Reseda	Package C: Woodman + Sepulveda + Reseda	Package D: Valley College & Woodman + Van Nuys & Sepulveda + Reseda (Fiscally Unconstrained)	Package E: Gate Systems (Current operating speeds)	Package A- 1 (Hybrid) Van Nuys + Sepulveda + Gates Systems (with platooning & higher speeds & increased headways)[6]
# of Grade Separated Crossings (Priority Locations[1])	6 (3)	4 (3)	4 (3)	9 (5)	0	5 (2)
# of Permanent Closures	1	1	1	1	0	1
LA City Council Districts with Grade Separations	CD 3; CD 6	CD 2 & CD 4; CD 3	CD 2; CD 3; CD 6	CD 2; CD 3; CD 4; CD 6	-	CD 6
Existing Bus Travel Time (Average)[2]	Eastbound (EB - Canoga to North Hollywood): 40.3 mins Westbound (WB - North Hollywood to Canoga): 42.7 mins					
Change in Bus Travel Time (Between Canoga and North Hollywood)[2]	EB: -4.2 mins WB: -3.8 mins	EB: -2.5 mins WB: -2.3 mins	EB: -2.7 mins WB: -2.4 mins	EB: -6.3 mins WB: -4.2 mins	EB: -12.1 mins WB: -12.7 mins	EB: -12.3 mins WB: -12.9 mins
Existing Cross Street Traffic Delay[3] (PM Peak Hour, Average per Vehicle)	Northbound: 24.4 sec/veh Southbound: 22.2 sec/veh Average: 23.3 sec/veh					
Change in Cross Street Traffic Delay[3] (PM Peak Hour, Average per Vehicle)	NB: -0.3 sec/veh SB: -0.4 sec/veh AVG: -0.4 sec/veh	NB: -0.7 sec/veh SB: -0.9 sec/veh AVG: -0.8 sec/veh	NB: -0.6 sec/veh SB: -0.8 sec/veh AVG: -0.7 sec/veh	NB: -0.7 sec/veh SB: -1.6 sec/veh AVG: -1.1 sec/veh	NB: +9.6 sec/veh SB: +4.9 sec/veh AVG: +7.3 sec/veh	NB: -1.7 sec/veh SB: -1.4 sec/veh AVG: -1.6 sec/veh
Existing Ridership[4] (Weekday daily passengers)	24,500					
Change in Ridership, Year 2025 (Weekday daily passengers)	+1,000 (+4%)	+1,400 (+5%)	+900 (+3%)	+3,400 (+13%)	+10,100 (+39%)	+10,100* (+39%)
Change in VMT, Year 2025 (Daily)	-11,120	-13,202	-8,765	-29,159	-81,756	-81,756*
% Change in O&M Costs[5]	-2.5%	-1.4%	-1.4%	-1.9%	-6.4%	-6.4%*
Estimated Capital Cost of Grade Separations	$259M	$262M	$223M	$453M	-	$191M
Estimated Capital Cost of Permanent Closures	$0.08M	$0.08M	$0.08M	$0.08M	-	$0.08M
Estimated Capital Cost of Improved Bus-Signal Communications	$0.2M	$0.4M	$0.4M	$0.2M	-	-
Estimated Capital Cost of Signal Improvements	$1.3M	$1.4M	$1.4M	$1.2M	-	-
Estimated Capital Cost of Gate Systems	-	-	-	-	$40.3M	$35.1M
Estimated Capital Cost of Side Platform Locations	$15M	$10M	$10M	$20M	-	10M
Estimated Capital Cost of Elevated Bike Path (Van Nuys to Sepulveda)	$23M	$13M	$13M	$23M	-	$23M
Additional Overall Contingency (5.5%)[7]	$16.4M	$15.8M	$13.6M	$27.4M	$2.2M	$14.3
Estimated Total Capital Costs (2017 $)	**$315M**	**$303M**	**$261M**	**$525M**	**$43M**	**$273M**

Notes:
1. *Grade separations of the priority locations will require additional grade separations for adjacent crossings due to the proximity of roadways and design requirements for grade separations. Priority locations (shown as the number of grade separations in parenthesis) are those identified in Measure M – Reseda, Sepulveda, Van Nuys, Woodman/Oxnard, and Fulton/Burbank.*
2. *Does not include station dwell time, as dwell time is highly variable per station and time of day.*
3. *Average for all signalized crossings between North Hollywood and Canoga, and not indicative of specific crossings.*
4. *Travel demand model derived ridership; actual existing (Year 2016) ridership averages 25,090 daily passengers on weekdays.*
5. *O&M costs are rough estimates; see Appendix B for additional details.*
6. *Under Package A-1, buses are assumed to travel at the maximum civil speed authorized by Metro within the corridor, further reducing end-to-end travel times. Buses are also assumed to operate in two-vehicle platoons at increased headways (8-minute headways assumed for purposes of analysis). Last, gate systems would only operate when a bus is present, which would result in on overall decrease in gate activations throughout the course of a typical day.*
7. *A 5.5% contingency was added to all cost estimates, on top of individual contingencies for specific elements, to account for the preliminary nature of this technical study.*

* *Travel Demand Model results are preliminary in nature, due to the preliminary nature of this technical study. Since changes in ridership and VMT are related to increased bus travel speeds, it is assumed that the estimates of Ridership and VMT change would change slightly from what is currently shown with further refinements to the proposed alternatives. Similarly, O&M costs for Package A-1 were not provided. These items would be refined in subsequent environmental clearance and design phases.*

Package A: Van Nuys & Sepulveda + Reseda

Package A (shown in **Figure 11a**) proposes aerial grade separations at the Van Nuys, Sepulveda, and Reseda stations. The busway would be elevated the entire length from Van Nuys Station to Sepulveda Station, which is proposed to be relocated over Sepulveda Boulevard. All roadway crossings between the Van Nuys and Sepulveda stations would remain open. Tyrone Avenue is proposed to be closed as it is required for the grade separation ramp structure. The package also includes bus-signal communication systems at pedestrian crossings (Agnes Avenue, Goodland Avenue, Hayvenhurst Avenue, and Zelzah Avenue). These crossings do not significantly impact bus operations and could be good opportunities to pursue a bus-signal communications pilot program. The remaining crossings in the corridor would receive TSP improvements.

Under Package A, bus travel times would decrease by approximately six minutes (combined in both directions), and cross street traffic delays would decrease by an average of 0.4 seconds per vehicle. Daily VMT would decrease by about 11,100, and the change in O&M costs would decrease by approximately 2.5 percent.

Package B: Valley College & Woodman + Reseda

Package B (shown in **Figure 11b**) proposes two undercrossing grade separations at the Valley College and Woodman stations, and an aerial grade separation at Reseda Station. The Valley College and Woodman stations are proposed to be below-grade stations, and the busway would be lowered from at-grade to travel below-grade between the stations, crossing under Oxnard Avenue as well. Tyrone Avenue is proposed to be closed. The remaining crossings would receive the same bus-signal communication systems and signal improvements as recommended in Package A. In addition, the City of Los Angeles Bureau of Street Maintenance, Van Nuys District Yard driveway (referred to in this document as City of Los Angeles driveway), located just east of the Sepulveda Boulevard crossing, would receive bus-signal communication system improvement.

Under Package B, bus travel times would decrease by approximately four minutes (combined in both directions), and cross street traffic delays would decrease by an average of 0.8 seconds per vehicle. Daily VMT would decrease by about 13,200, and the change in O&M costs would decrease by approximately 1.4 percent.

Package C: Woodman + Sepulveda + Reseda

Package C (shown in **Figure 11c**) proposes an undercrossing grade separation at Woodman Station and aerial grade separations at the Sepulveda and Reseda Stations. The Woodman Station is proposed to be a below-grade station and the busway would be lowered from at-grade to travel below-grade in this area, crossing under Oxnard Street as well. Similar to Package A, the existing Sepulveda Station would be relocated to be over Sepulveda Boulevard. Tyrone Avenue is proposed to be closed. The remaining crossings would receive the same bus-signal communication systems and signal improvements as recommended in Package B.

Under Package C, bus travel times would decrease by approximately four minutes (combined in both directions), and cross street traffic delays would decrease by an average of 0.7 seconds per vehicle. Daily VMT would decrease by about 8,800, and the change in O&M costs would decrease by approximately 1.4 percent.

Package D: Fiscally Unconstrained (All Priority Grade Separations)

Package D (shown in **Figure 11d**) is fiscally unconstrained, and would grade separate all five priority grade separations identified in Measure M. Tyrone Avenue is proposed to be closed. The remaining crossings would receive the same bus-signal communication systems and signal improvements as recommended in Package A.

Under Package D, bus travel times would decrease by approximately six minutes (combined in both directions), and cross street traffic delays would decrease by an average of 1.1 seconds per vehicle. Daily VMT would decrease by about 29,100, and the change in O&M costs would decrease by approximately 1.9 percent.

Package E: Gate Systems

This alternative (shown in **Figure 11e**) proposes deploying railroad-style four quadrant gate systems at all crossings along the corridor, except for the City of Los Angeles driveway and pedestrian crossings, which would receive bus signal improvements. No crossings are proposed to be closed.

Under this alternative, bus travel times would decrease by 12 minutes (per direction), and cross street traffic delays would increase by an average of 7.3 seconds per vehicle. Daily VMT would decrease by about 82,000, and the change in O&M costs would decrease by approximately 6.4 percent.

Detour Routing

The technical evaluation also included an analysis of potential detour routes for buses, bicycles, and pedestrians during construction of any of the grade separation alternatives. For bicycle and pedestrian routes, including the adjacent multi-modal bike path, the detours would route users to adjacent surface streets and signalized intersections. The goals for potential bus detours include:

- Maintain bus service during the construction period
- Maintain convenient passenger access to MOL service and connecting bus routes
- Avoid bus operations in construction zones
- Keep MOL service as close to the current ROW as possible
- Provide safe and efficient bus service operation during construction

Figure 11a – Potential Improvement Package A

Figure 11b – Potential Improvement Package B

Figure 11c – Potential Improvement Package C

Figure 11d –Potential Improvement Package D

Figure 11e – Potential Gate Systems

8.0 OTHER CONSIDERATIONS

As the Measure M Expenditure Plan identifies future conversion of the MOL corridor to rail, stations at the proposed grade crossing locations would be designed to be convertible to future light rail transit (LRT) requirements. A feasibility study was conducted to evaluate the potential for temporarily raising the busway during BRT operations, and then lowering the guideway for future LRT operations, and this was determined to be infeasible. Other considerations regarding conversion of stations to LRT requirements include:

- Center platform design implemented for BRT operation (requires cross-over, similar to El Monte Busway)
- Platforms would be extended to three-car LRT length
- Platforms would be raised
- Canopies would be adjusted
- Escalators would be modified

9.0 FUNDING SUMMARY

Potential grade separations are included in the Measure M Expenditure Plan, as well as ultimate conversion of the MOL corridor to LRT. Funding is summarized in **Table 19**.

Table 19 – MOL Measure M Expenditure Plan

Project (Final Project to be Defined by the Environmental Process)	Notes	Schedule of Funds Available		Subregion*	2016 - 2067 Local, State, Federal, Other Funding 2015 $	Measure M Funding 2015 $	Most Recent Cost Estimate 2015 $**	Modal Code
Expenditure Plan Major Projects		Ground-Breaking Start Date	Expected Opening Date (3 Year Range) First Year of Range					
Orange Line BRT Improvements	n	FY 2019	FY 2025	sf	$0	$286,000	$286,000	T
Orange Line Conversion to Light Rail		FY 2051	FY 2057	sf	$1,067,000	$362,000	$1,429,000	T

Note: n. Critical grade separation(s) will be implemented early through Operation Shovel Ready.
Source: Los Angeles County Transportation Expenditure Plan – Fiscal Year 2018-2057
(http://theplan.metro.net/wp-content/uploads/2016/09/measurem_ordinance_16-01.pdf)

10.0 NEXT STEPS

Following completion of this technical study, Metro staff will initiate an environmental process and preliminary engineering design. Concurrently, Metro is pursuing a pilot study of potential gate systems to reduce the frequency of right-turn on red (RTOR) violations and collisions, and will be deploying new equipment along the north-south segment between Canoga and Chatsworth. A number of key issues will require further attention and analysis during subsequent project phases. The issues include:

- **Project-specific transportation and parking impacts** –Refined transportation and parking analyses should be conducted for the recommended base alternative, as a part of subsequent environmental clearance and design efforts.
- **Real estate/right-of-way impacts** - Metro may need to initiate negotiations for right-of-way acquisitions included as a part of the recommended base alternative.
- **Utility impacts** - Further utility investigations should be conducted to confirm potential conflicts for the recommended base alternative, as a part of subsequent environmental clearance and design efforts.

- **Ridership impacts** – Forecast ridership increases indicate continued crowding of buses during peak periods, particularly for stations between Sepulveda and North Hollywood. The Reseda (or Canoga) Shortline operation may address these issues, and Metro should continue to monitor peak bus loads to ensure bus capacity can meet ridership demand.
- **Ongoing operations** – Metro will continue to monitor and adjust bus operations to address issues related to bus speeds and safety.
- **Multi-agency coordination** – Metro will continue to coordinate with LADOT and other stakeholder agencies to ensure potential improvements along the corridor are integrated into other concurrent projects.
- **Public outreach** – Metro will continue to reach out to community stakeholders, to ensure this vital transportation link continues to meet the mobility needs of the San Fernando Valley.