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MEMORANDUM

DATE: April 2, 2019

TO: Gwen Owen, City of Vacaville

FROM: John Long and John Gibb

SUBJECT: Daily Travel Demand Model

This memorandum describes the development and validation of a daily travel demand model for the City of Vacaville.

Background

In 2016, DKS updated the City's "Local Transportation Model", which had been used by the City to provide peak hour traffic volume forecasts. In 2015, the City had collected a substantial amount of traffic count data that allowed the development and validation of a peak hour travel demand model. However, there was not enough daily traffic count data for the development of a daily travel demand model. Thus, during the scoping for the model update, it was decided to not create a model that would provide daily traffic volume forecasts but to 1) maintain a peak hour model and 2) structure the updated peak hour model in a manner that would accommodate future model enhancements that would provide daily volume forecasts.

The City's peak hour model provides AM and PM peak hour traffic volume forecasts, including turning movements at major intersections. This model allows the analysis of peak hour traffic operations and levels of service. However changes in State law will soon require the City to estimate changes in daily vehicle-miles of travel (VMT) due to proposed development and transportation projects.

Thus in 2018, the City contracted with DKS to enhance the City's Local Transportation Model to provide daily volume forecasts. DKS provided the City with a list of locations where daily traffic counts should be collected to create a daily travel model. These locations augmented the daily traffic counts that the City collected in 2015. Traffic counts at the new locations were collected in May and June 2018.

Daily Model Development

The Vacaville travel demand model developed by DKS Associates in 2016 began by estimating average weekday trip generation and distribution in terms of vehicle trips in six trip purposes, in production-attraction orientation. The AM and PM peak hour travel demand arises from the percentage and directionality of daily travel in those hours of the day, which vary among the trip purposes. A further factoring step is applied to match the resultant AM and PM trip-end totals to trip generation directly estimated from the land use.

A new daily version of the Vacaville travel demand model introduces four new time periods. Following best practices, each time period has a separate assignment and the volumes from each are totaled up to provide an average weekday volume. These are AM and PM peak periods, each of 3-hour length, a mid-day period for the intervening daytime interval, and an evening-overnight period for the rest of the day. These periods represent a division of the day distinguishing its major episodes of traffic intensity and dominant purposes.

Table 1 shows the hourly distribution of a collection of 116 directional counts taken in 2015 as reported by the City of Vacaville. From this distribution, the four periods are identified.

Table 1
24-hour Distribution of 2015 Vacaville Traffic Counts

Period	Hour Ending	Total of 116 directional traffic counts	Percentage
Evening-Overnight	01	1,459	0.3%
	02	750	0.2%
	03	550	0.1%
	04	593	0.1%
	05	1,335	0.3%
	06	4,583	1.0%
	07	12,563	2.7%
AM Peak Period	08	31,062	6.7%
	09	35,082	**7.6%**
	10	25,686	5.5%
Mid-day	11	24,002	5.2%
	12	27,845	6.0%
	13	28,301	6.1%
	14	28,500	6.1%
	15	32,140	6.9%
PM Peak Period	16	39,586	8.5%
	17	38,324	8.3%
	18	40,066	**8.6%**
Evening-Overnight	19	31,952	6.9%
	20	21,429	4.6%
	21	16,651	3.6%
	22	11,915	2.6%
	23	6,280	1.4%
	24	3,136	0.7%
Day	**Total**	**463,783**	**100%**

From **Table 1** are identified the AM peak period from 7 to 10 AM, midday from 10 AM to 3 PM, PM peak period from 3 PM to 6 PM, and the evening-overnight period from 6 PM to 7 AM. For purposes of calibration and validation, hourly traffic counts from the City of Vacaville, Caltrans, and other sources were combined into these time intervals.

For the four new time periods, the time-of-day factors applied to modeled production-to-attraction trips by purpose were initially selected or adapted (for compatibility) and averaged from three sources:

- The Alameda County adaptation of the Baycast model, originally from the Metropolitan Transportation Commission (MTC),
- Trips by hour from the Napa-Solano adaptation of MTC's newer Travel Model One (Cambridge Systematics, January 2017),
- Regional household travel survey data.

The time-of-day factors were adjusted for calibration. **Table 2** shows the resultant time-of-day factors.

Table 2
Time-of-Day Factors

Period	Home-Work	Work-Home	Home-Shop	Shop-Home	Home-Social/Rec	Social/Rec-Home
AM3	24.6%	0.6%	7.5%	2.3%	12.9%	2.9%
Midday	7.3%	8.3%	16.4%	20.6%	15.8%	13.9%
PM3	1.4%	24.1%	8.2%	17.7%	8.4%	12.1%
Evening-Night	17.6%	16.2%	8.3%	18.9%	12.2%	21.7%
Total	**50.9%**	**49.1%**	**40.4%**	**59.6%**	**49.3%**	**50.7%**

Period	Home-School	School-Home	Non Home-Based (P-A)	Non Home-Based (A-P)	Through (P-A)	Through (A-P)
AM3	41.3%	0.7%	5.1%	5.1%	9.6%	9.6%
MD	5.1%	20.6%	21.4%	21.4%	15.6%	15.6%
PM3	2.7%	16.5%	13.4%	13.4%	9.6%	9.6%
Evening-Night	5.3%	7.8%	10.1%	10.1%	15.2%	15.2%
Total	**54.4%**	**45.6%**	**50.0%**	**50.0%**	**50.0%**	**50.0%**

No factoring was performed to force any period's trip generation to conform to anything directly computed from land use, as was done for the two peak hours.

For traffic assignment, traffic capacity factors were estimated for the four periods of the day, using Vacaville traffic counts. The capacity factors apply to hourly link capacities, converting them to effective period capacities, for estimating link v/c ratios and congested speeds. If traffic were uniform throughout a

period, then the capacity factor would be that number of hours. However, since traffic varies somewhat during each period, the capacity factor is somewhat less than the number of hours. A vehicle-weighted averaging method was used, in which total hourly counts (Table 1) were the weights (so hours with more vehicles count more), and a non-linear increasing function of the hourly counts (representing congestion) was averaged. **Table 3** lists the capacity factors applied. (Note that traffic is almost equal among the three PM hours, so the factor is nearly 3, while the several lightly-traveled hours in the evening-overnight period account for a factor considerably less than its number of hours.)

Table 3
Period Capacity Factors for Traffic Assignment

Period	Duration (hours)	Capfac parameter
AM3	3	2.85
MD	5	4.84
PM3	3	2.96
Evening-Night	13	5.17

Model Validation

DKS used the traffic count data to validate the draft model described above. The validation required an iterative process of model adjustments and re-runs to improve model performance. DKS used national and state guidelines to compare model outputs to count data to validate the daily model.

The travel model was validated by testing its ability to replicate existing traffic counts. Estimates of base year (2015) land uses were used as inputs to generate model estimated traffic loadings on individual road segments. These were compared to recent traffic counts at the same locations.

Several system-wide comparisons were made as part of the validation process. The sum of the model's assigned volume for all roadway segments that have traffic counts is compared to the sum of the traffic counts for these links. Separate comparisons in the attached tables were made by roadway type (i.e., freeways, arterials, collectors, etc.) and by volume group.

Table 4 shows the validation of the model in terms of total model volumes versus total counts, at counted locations, for roadways grouped into four classes. **Table 5** similarly compares model totals to counts by ranges of counted traffic volume.

Figure 1 shows the model volume to count ratio on individual counted links and classifies them as follows:

- Model/count between 0.75 and 1.25 - blue
- Model/count greater than 1.25 - red
- Model/count less than.75 - green

Table 4
Model Validation by Roadway Class

AM Peak Period (3 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
Freeways	21	234,786	240,162	1.02
Major Arterials	362	388,214	395,225	1.02
Minor Art-Collectors	281	132,527	111,472	0.84
Ramps	34	16,552	19,163	1.16
Total	**698**	**772,079**	**766,022**	**0.99**
PM Peak Period (3 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
Freeways	21	272,982	276,226	1.01
Major Arterials	363	555,806	554,582	1.00
Minor Art-Collectors	282	192,908	168,634	0.87
Ramps	34	26,977	27,156	1.01
Total	**700**	**1,048,673**	**1,026,598**	**0.98**
Mid-Day Period (5 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
Freeways	8	198,503	190,563	0.96
Major Arterials	114	268,289	267,893	1.00
Minor Art-Collectors	108	100,793	83,855	0.83
Ramps	0	n/a		
Total	**230**	**567,585**	**542,311**	**0.96**
Evening-Overnight Period (13 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
Freeways	8	231,908	189,455	0.82
Major Arterials	114	254,602	256,609	1.01
Minor Art-Collectors	108	78,552	79,134	1.01
Ramps	0	n/a		
Total	**230**	**565,062**	**525,198**	**0.93**
Daily				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
Freeways	17	994,301	925,279	0.93
Major Arterials	114	866,198	875,909	1.01
Minor Art-Collectors	108	315,588	272,610	0.86
Ramps	54	235,970	291,107	1.23
Total	**293**	**2,412,057**	**2,364,905**	**0.98**

Table 5
Model Validation by Volume Range

AM Peak Period (3 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
1 to 199	178	17,209	21,956	1.28
200 to 499	180	58,444	53,178	0.91
500 to 999	142	103,279	91,089	0.88
1,000 to 1999	170	235,821	239,619	1.02
2,000 to 4,999	55	136,193	135,603	1.00
≥ 5,000	17	225,016	230,898	1.03
Total	**742**	**775,962**	**772,343**	**1.00**
PM Peak Period (3 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
1 to 199	116	11,458	17,794	1.55
200 to 499	177	59,086	57,555	0.97
500 to 999	118	84,855	72,319	0.85
1,000 to 199	169	248,712	235,194	0.95
2,000 to 4,999	147	391,544	388,537	0.99
> 5,000	17	261,589	265,473	1.01
Total	**744**	**1,057,244**	**1,036,872**	**0.98**
Mid-Day Period (5 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
1 to 499	38	14,813	12,159	0.82
500 to 999	52	37,222	29,736	0.80
1,000 to 1,999	55	82,496	77,711	0.94
2,000 to 19,999	77	234,551	232,142	0.99
> 20,000	8	198,503	190,563	0.96
Total	**230**	**567,585**	**542,311**	**0.96**
Evening-Overnight Period (13 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
1 to 499	52	17,129	17,683	1.03
500 to 999	50	34,628	31,431	0.91
1,000 to 199	54	80,719	89,639	1.11
2,000 to 499	64	189,307	186,963	0.99
5,000 to 19999	2	11,371	10,027	0.88
> 20,000	8	23,1908	18,9455	0.82
Total	**230**	**565,062**	**525,198**	**0.93**
Daily (24 hours)				
Link Class	Number of Locations	Total Count	Total Model	Model/Count
1 to 999	23	13,965	13,684	0.98
1,000 to 1,999	51	73,945	68,747	0.93
2,000 to 4,999	82	265,252	248,391	0.94
5,000 to 9,999	82	592,424	613,348	1.04
10,000 to 1,9999	43	541,976	556,318	1.03
> 20,000	12	924,495	864,417	0.94
Total	**293**	**2,412,057**	**2,364,905**	**0.98**

Legend

- Model/Count 0.75 to 1.25
- Model/Count >1.25
- Model/Count <0.75

Figure 1
Daily Model to Count Ratio on Counted Links

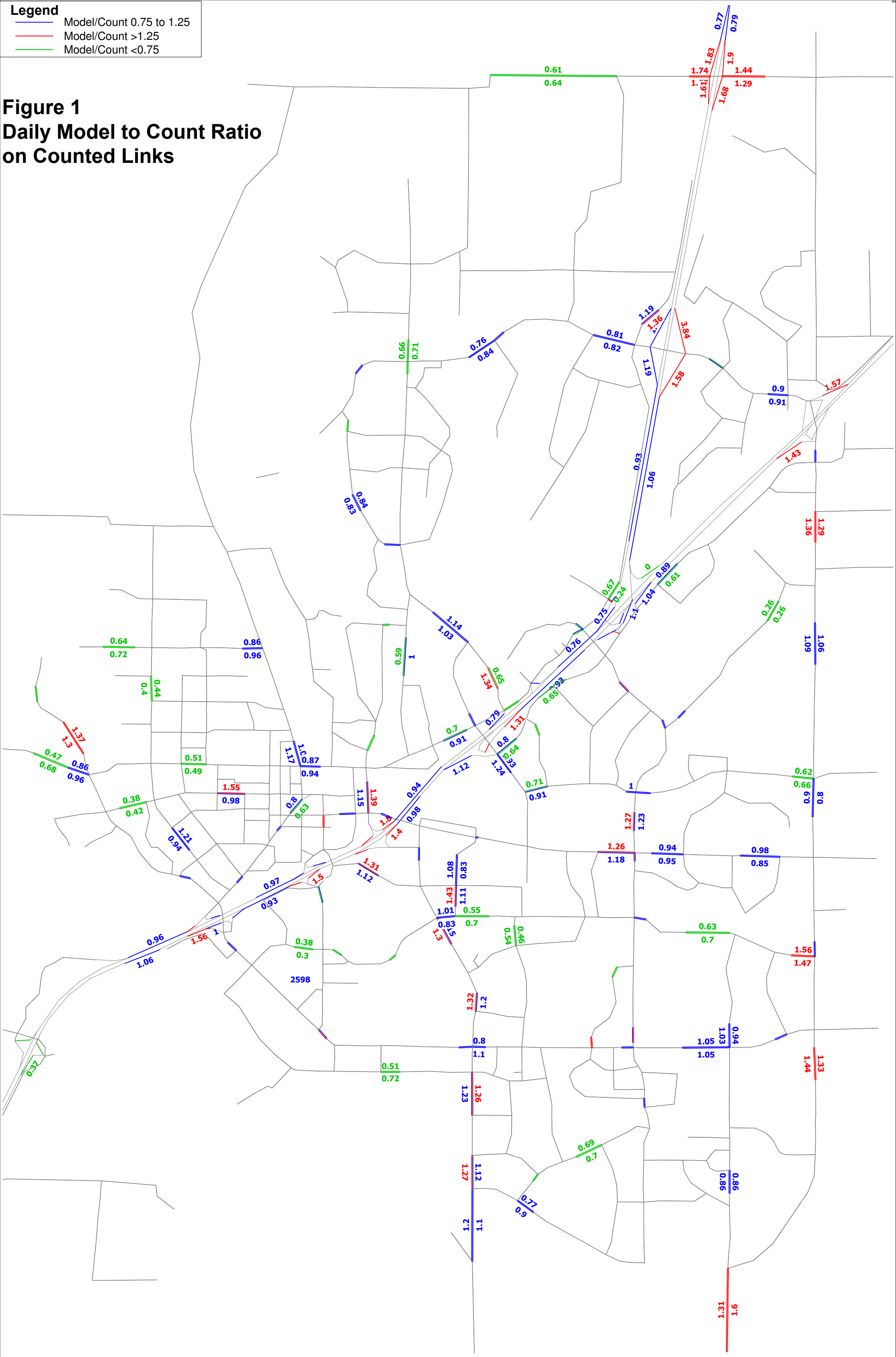
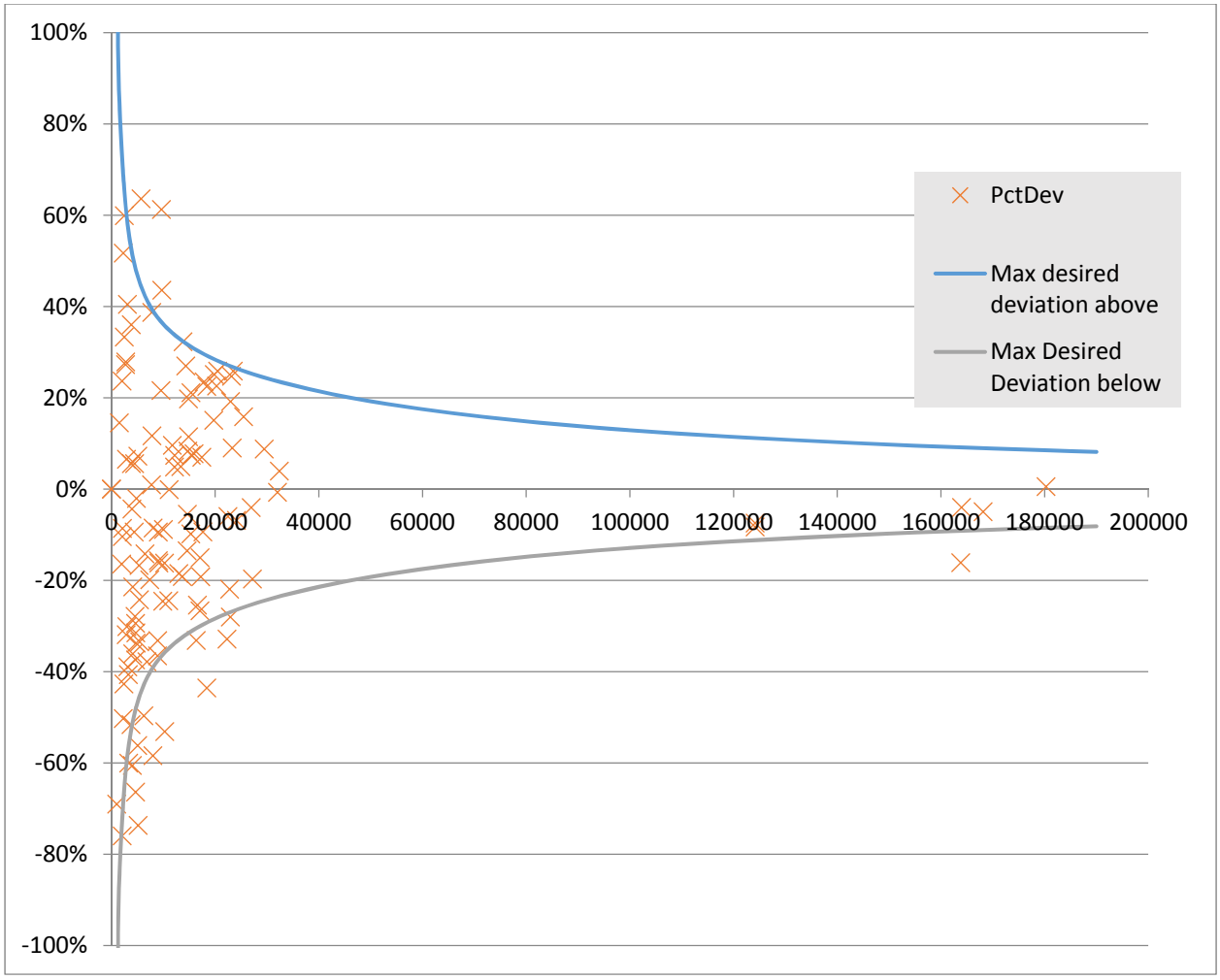


Figure 2 shows points for the percentage error of modeled daily traffic relative to the daily traffic count, in comparison to the "maximum desirable deviation" indicated by the 1990 FHWA publication "Calibration and Adjustment of System Planning Models". (The FHWA graph ranged from about 4,000 to 90,000 ADT; a fitted formula is shown with extrapolation.)

Figure 2: Daily Model Volume Deviation from Desirable Thresholds



Caltrans guidelines for model validation calls for at least 75 percent or more of the model volumes to be within the desirable deviation threshold. The City of Vacaville Daily Travel Demand model has 86 percent of its model links within the desirable threshold.

The analysis summarized above demonstrates that the daily model meets accepted validation criteria and will provide reasonable daily volume forecasts if best practices are used when applying the model. A key best practice is to use the model to forecast the change in traffic volumes rather than using the forecast volume directly from the model. To account for model error, future year forecasts will be developed using the "delta method" which accounts for error between base year model estimates and observed counts.