Sensitivity Analysis: Highway Noise Level Differences between L_{eq} and L_{dn}

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Image Credit: Inhabitat.com

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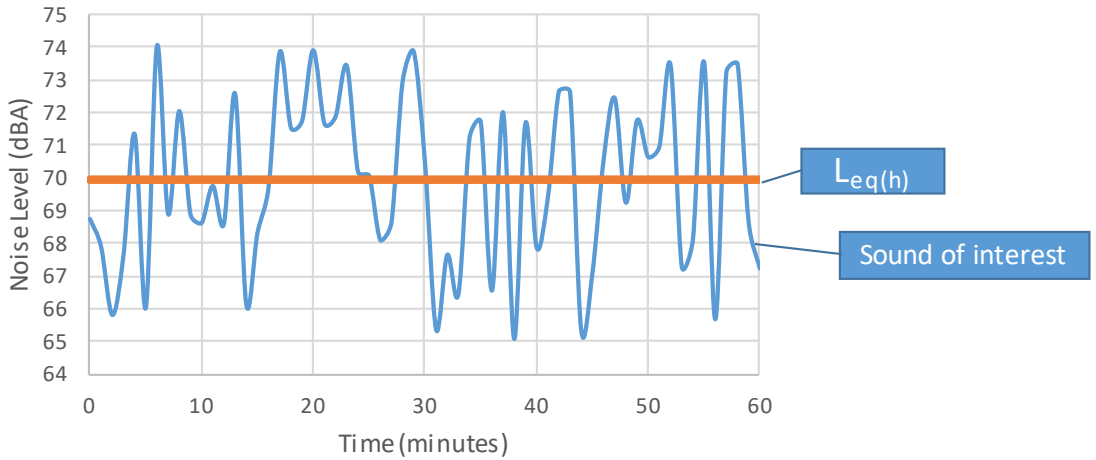
Background

- 23 CFR 772, "Procedures for Abatement of Highway Traffic Noise and Construction Noise" requires $L_{eq(h)}$ for peak noise hour
  - Protects against short term effects of noise
  - Practical for abatement and enforcement
  - Usually similar values to L_{dn} with less measurement burden
- **Question**: How different are peak hour $L_{eq(h)}$ and L_{dn}?
  - How big of a difference can we expect?
  - What factors affect the difference?

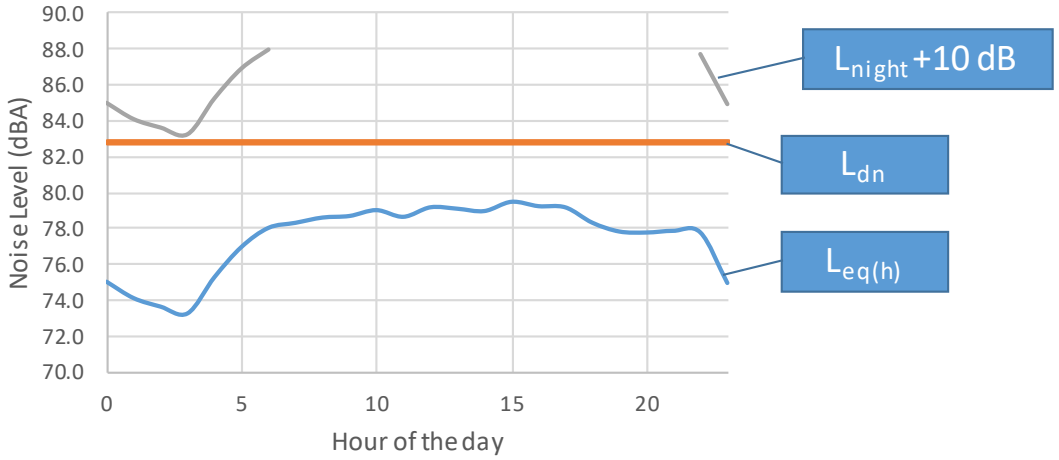
L_{Aeq} (peak hour) and L_{dn}

L_{Aeq} (peak hour)



- Describes only loudest hour of noise
- Lower level of effort for accurate measurements
- Good descriptor for short term noise impacts
- May not account for nighttime noise impacts

L_{dn}



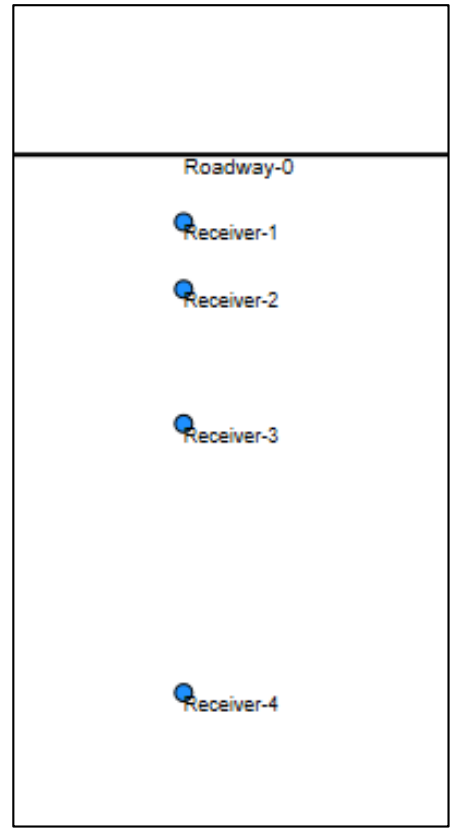
- Describes full day of noise exposure
- Requires longer duration measurements in day and night hours for accurate calculation
- Good descriptor for long term effects and land use planning
- May not account for significant peaks in hourly noise levels

Study Methodology

- Highway Noise Model: FHWA's Traffic Noise Model (TNM)
- Artificial Analysis:
  - Experimental traffic parameter inputs
  - **Initial Analysis**: Understand importance and trends with individual parameters
  - **In Depth Analysis**: Predict the difference for ranges of parameter values
- Real world traffic patterns
- Model metric difference that may be observed in different regions

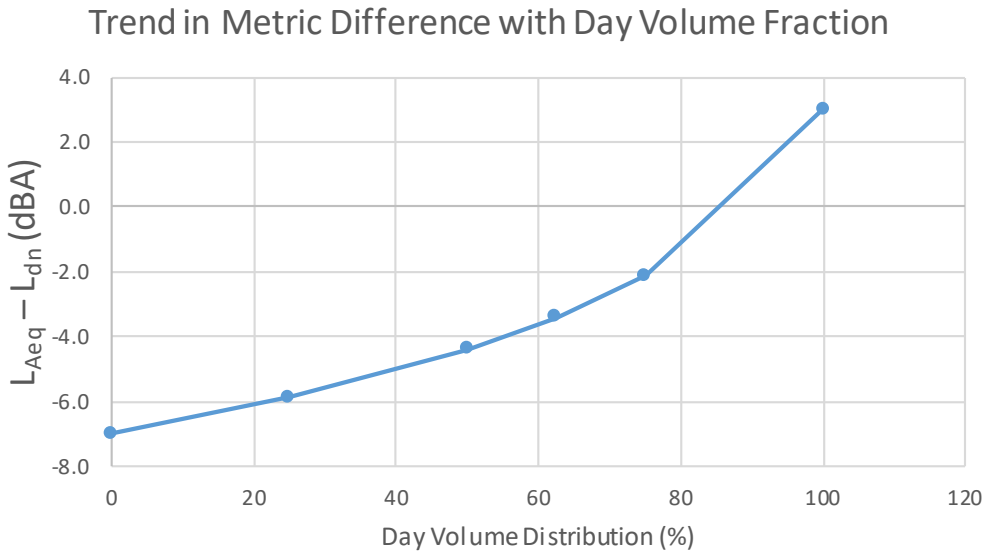
Noise Simulation in TNM – Initial Analysis

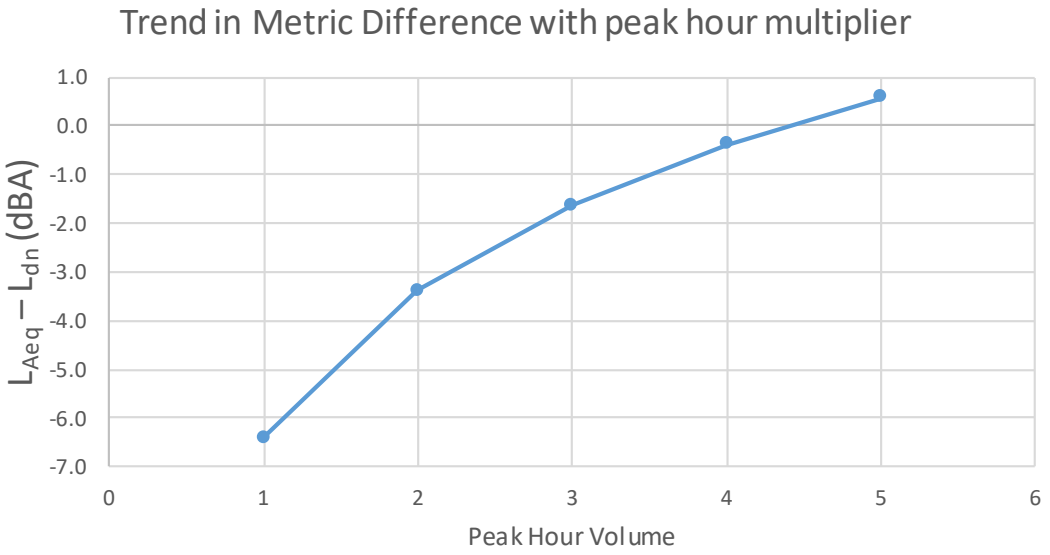
- Parameters Studied – changes from daytime to nighttime
  1. Day and night traffic distributions, P_{day}, P_{night}
  2. Peak hour volumes, X_{peak}
- Simple setup: Single lane highway, 55 mph average speed, 4 receivers
- Calculated L_{Aeq} (peak hour) and L_{dn} for all scenarios
- V_{eff}: Adjusts heavy duty and passenger vehicle traffic to equivalent noise levels with only passenger vehicles



Simple Highway with Receivers

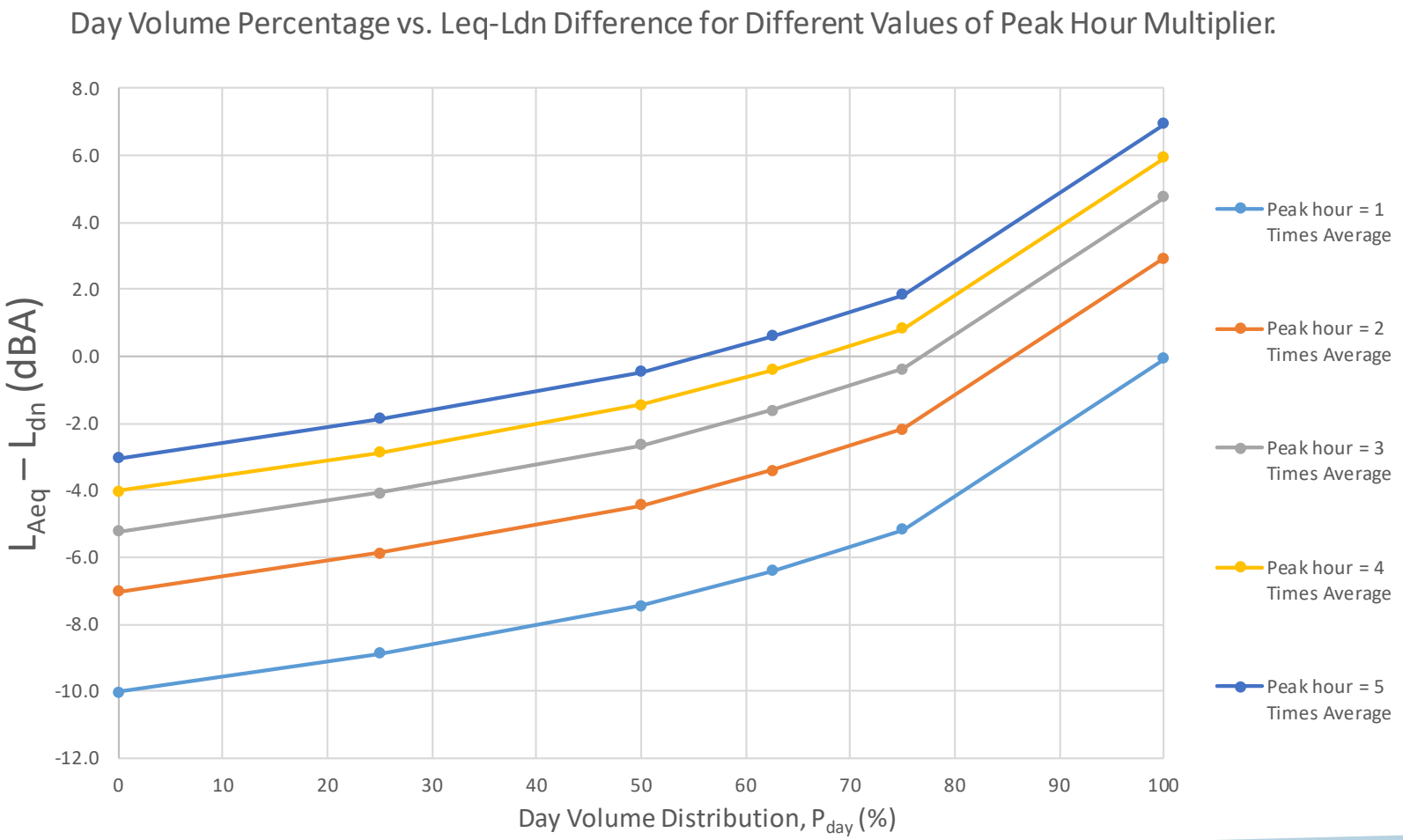
Noise Simulation in TNM – Results





- Overall difference is combination of both difference relationships: $\Delta_L = L_{Aeq(h)} - L_{dn}$ $\Delta_L = g(P_{day}) + v(X_{peak})$
- Peak hour and metric difference relationship is logarithmic: $v(X_{peak}) = 10 * \log X_{peak}$
- Obtain a more complete picture by generating $g(P_{day})$ through simulation and shifting using $v(X_{peak})$

In Depth Analysis Results



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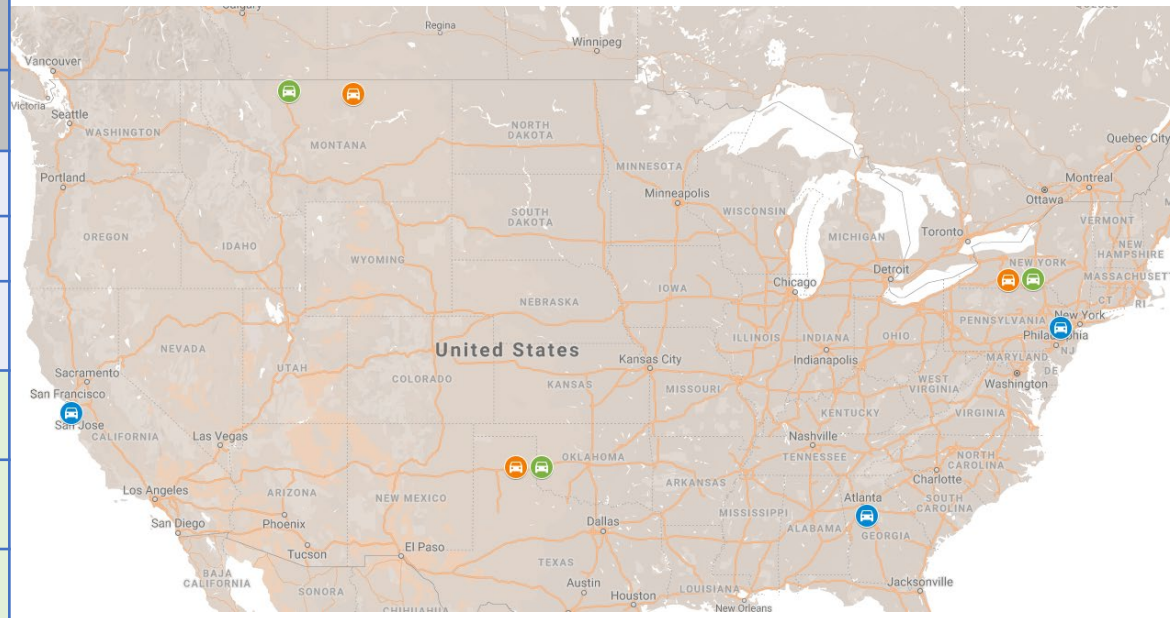
Real World Traffic Data – Traffic Monitoring and Analysis System (TMAS)

Location	Category	Hourly Volume (# veh)				Peak Hour Multiplier	Percent Daily Volume (%)	
		Peak	Average Daytime	Average Nighttime	Total		Daytime Hours	Nighttime Hours
NJ (NYC) I-80	Urban	4931	3990	1648	3112	1.58	80.1	19.9
Atlanta, GA I-20	Urban	7849	5756	2050	4367	1.80	82.4	17.6
San Francisco, CA US101 Near SFO	Urban	7547	6930	2598	5306	1.42	81.6	18.4
Waverly, NY I-86	Rural Highway	775	542	139	391	1.98	86.6	13.4
Shamrock, TX I-40	Rural Highway	412	335	137	261	1.58	80.3	19.7
Shelby, MT I-15	Rural Highway	100	75	16	53	1.89	88.8	11.2
Horseheads, NY RT 223	Rural Backroad	135	70	23	70	1.93	87.8	12.2
Shamrock, TX RT 83	Rural Backroad	106	75	11	51	2.08	91.6	8.4
Harlem, MT RT 241	Rural Backroad	17	11	1	7	2.38	97.0	3.0



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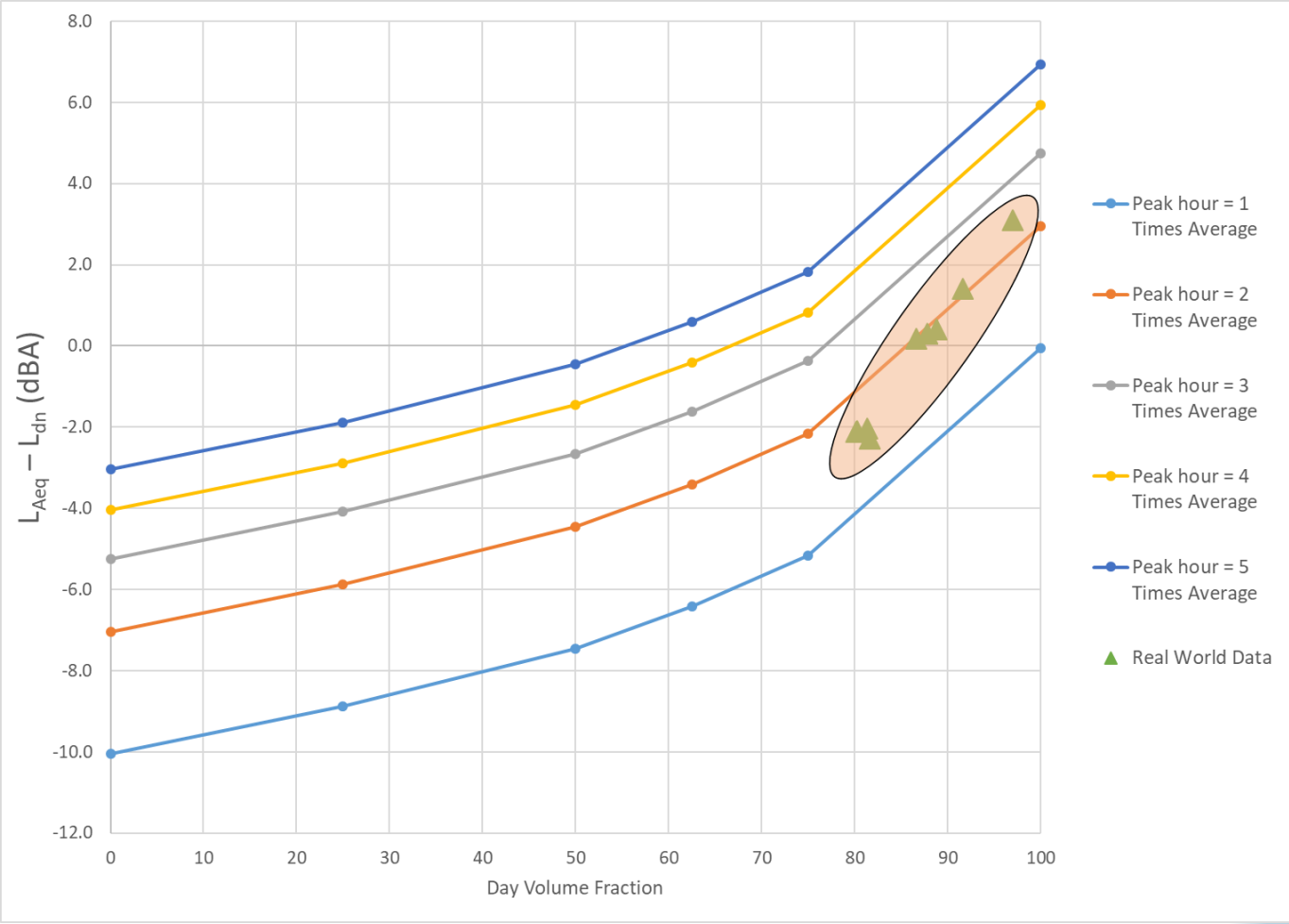
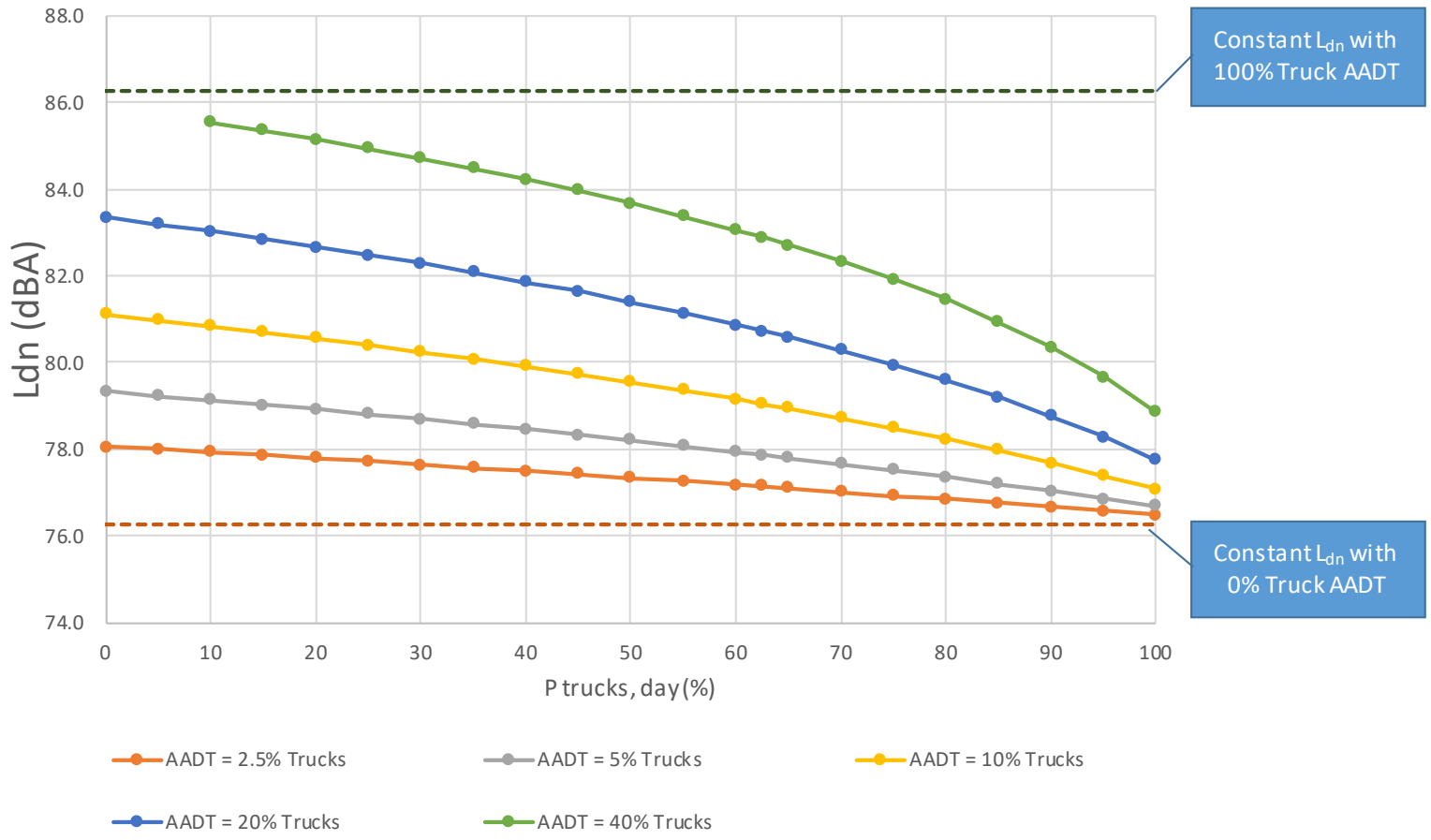
Projected Differences From Noise Modeling



- Resulting projected differences shown as green triangles
- Ranges between -2.3 dB and +3 dB
- Differences depend on location

Truck Traffic Distributions

- Can change from day to nighttime hours and in peak hour independently
- More difficult to analyze, shifts inherently affect other variables
- Hourly truck distribution affects any hour's noise level independently of day-night shifts in distribution
- Reduce Day–Night truck distributions to percent of overall truck traffic that occurs during the day
- Affects difference more or less depending on the percent of AADT that is trucks



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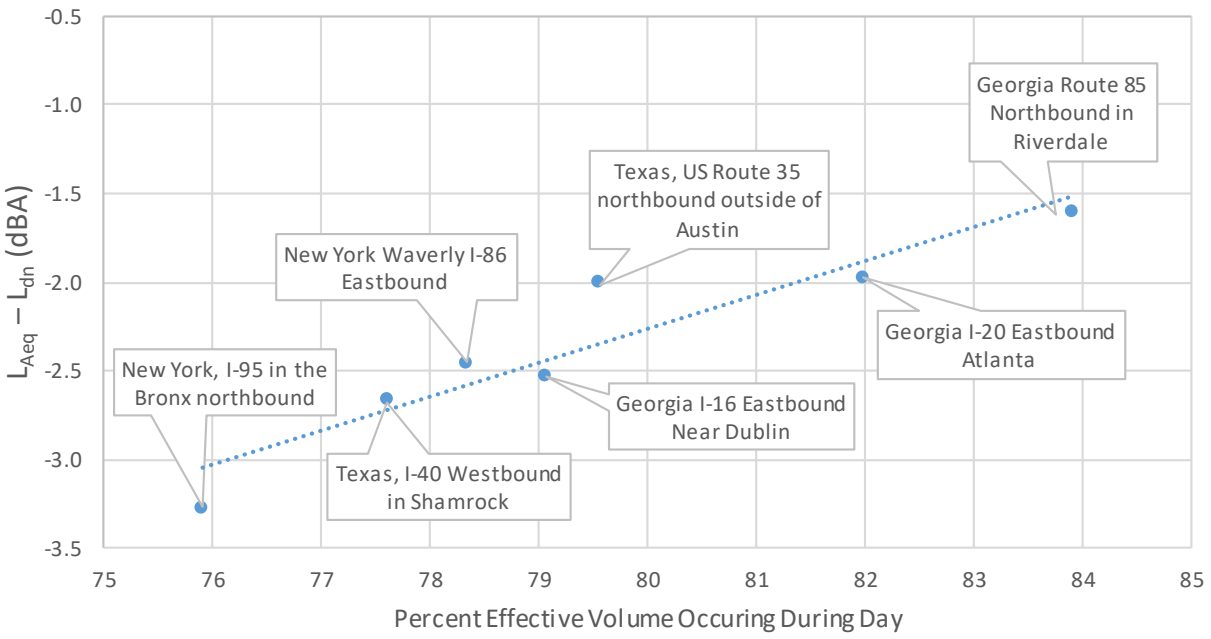
Real World Truck Traffic Data

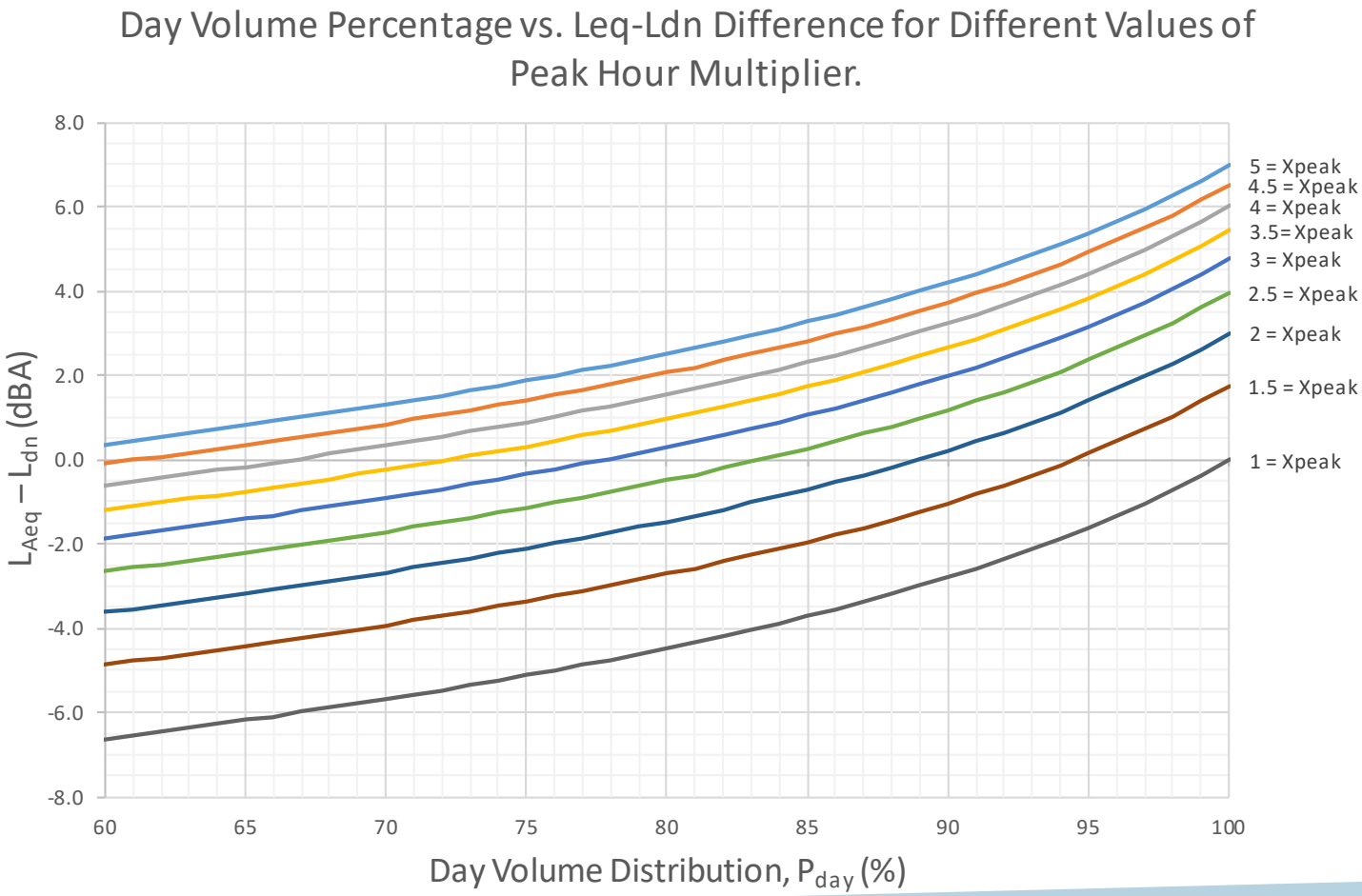
- Not from TMAS, from individual state databases (NY, GA, TX)
- Simulated L_{Aeq} (peak hour) and L_{dn} for 7 locations
- **Key Conclusion**: Difference depends mostly on P_{day} $(R^2 = 0.88)$



Location	X_{peak}	P_{day}	$P_{trucks,peak}$	$P_{trucks,day}$	$P_{trucks,aadt}$	L_{Aeq} (Peak Hour)	L_{dn}	L_{Aeq}-L_{dn}
New York, I-95 in the Bronx northbound	1.48	75.9	21.76	77.1	15.54	79.46	82.74	-3.28
New York Waverly I-86 Eastbound	1.65	78.33	24.31	75.16	28.5	72.38	74.84	-2.46
Georgia I-20 Eastbound Atlanta	1.66	81.97	3.58	80.89	3.97	79.14	81.12	-1.98
Georgia I-16 Eastbound Near Dublin	1.59	79.05	26.1	76.62	32.1	73.83	76.36	-2.53
Georgia Route 85 Northbound in Riverdale	1.7	83.89	3.09	88.24	3.17	71.08	72.69	-1.61
Texas, I-40 Westbound in Shamrock	1.62	77.6	59.76	76.94	61.34	72.66	75.33	-2.67
Texas, US Route 35 northbound outside of Austin	1.81	79.55	21.3	77.09	12.79	80.58	82.59	-2.01

Summary

- Use plot of differences for ranges of parameter values to estimate difference in specific situations
- Need hourly traffic data, including heavy duty classifications
- Calculate two parameters using V_{eff}:
  1. X_{peak}
  2. P_{day}



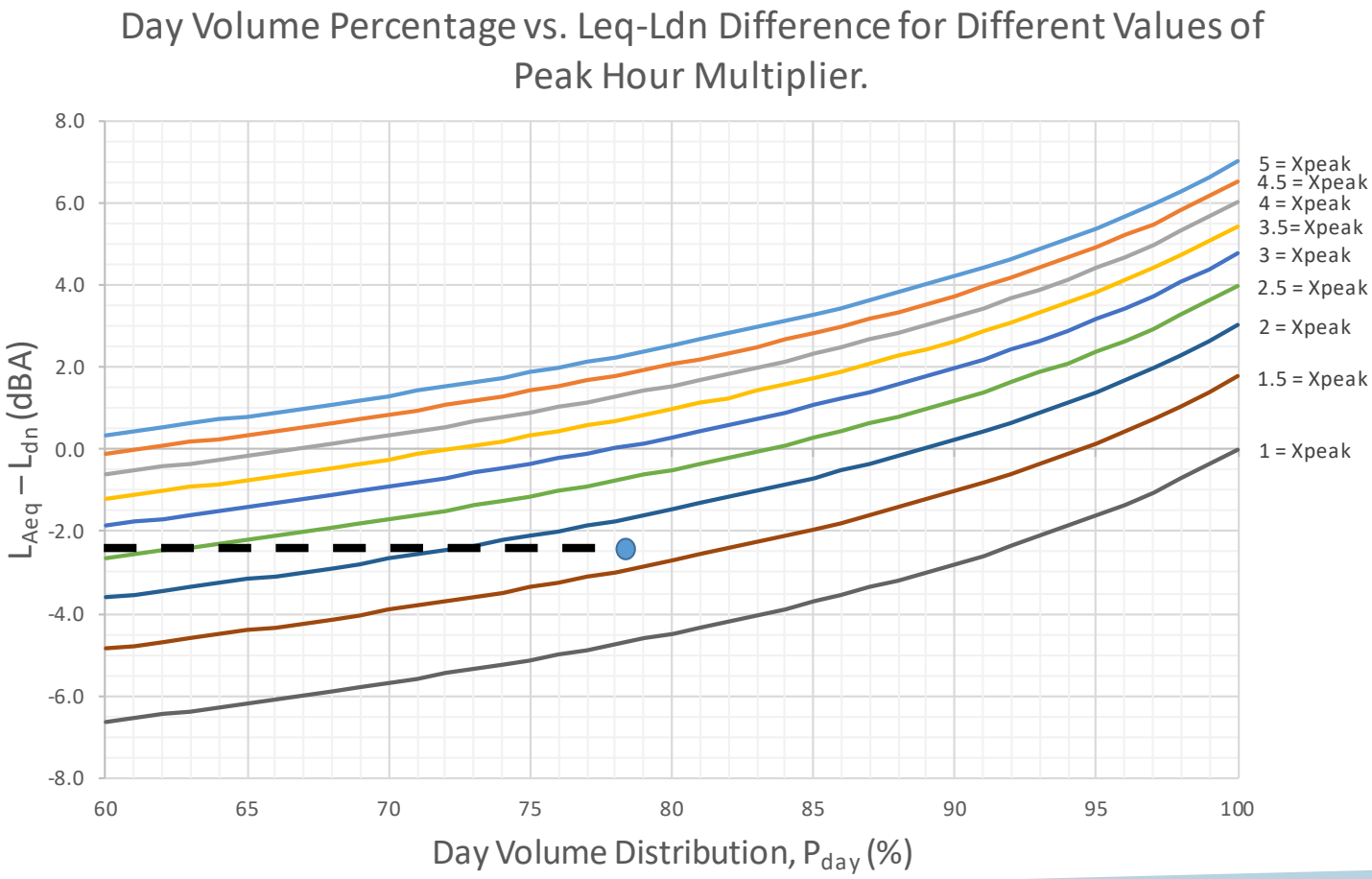
Example

- Example:

New York Waverly I-86 Eastbound

Parameter	Value
X_{peak} (V_{eff})	1.65
P_{day} (V_{eff})	78.33%

Result: Leq-Ldn = -2.5



Thank You!

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