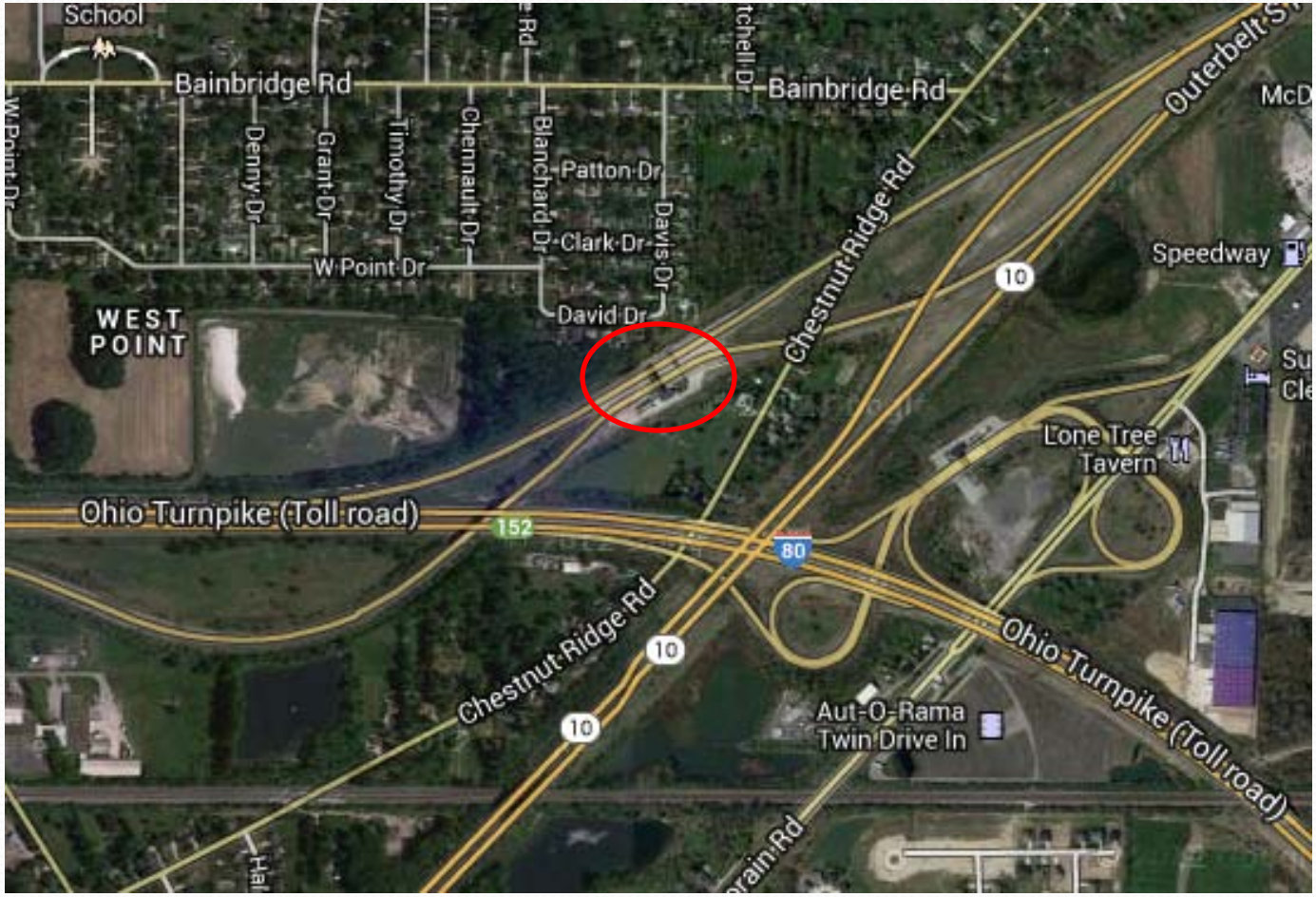
Toll Plaza Rumble Strip Noise

Geoffrey Pratt - Bowlby & Associates, Inc.
William Bowlby - Bowlby & Associates, Inc.
Kim Burton - Burton Planning Services, LLC
Elvin Pinckney - Burton Planning Services, LLC
Noel Alcala - Ohio Department of Transportation

July 29, 2013

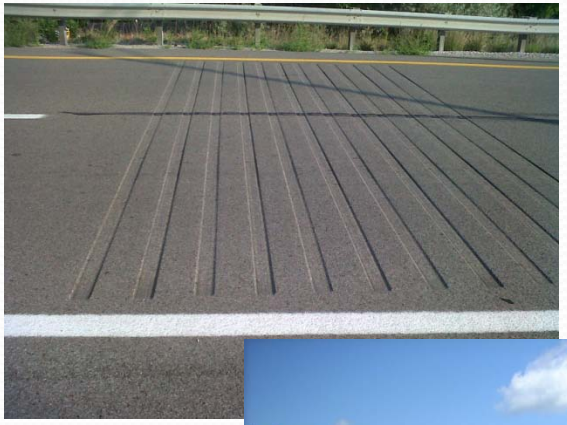
Project Location



I-80 Toll Plaza at I-480/I-80 Interchange, Lorain County, Ohio

Bowlby & Associates, Inc.

Rumble Strips for Safety at the Toll Plaza



Bowlby & Associates, Inc.

Problem Statement Questions

- Can rumble strip noise be mitigated with a noise wall of any type or size?
- Can *anything* can be constructed to mitigate rumble strip noise (i.e., specialized noise wall design features, such as a T-top, etc.)?
- Is a noise wall feasible and reasonable from a traffic noise standpoint?
- What is the most acoustically effective noise wall that can be constructed regardless of cost reasonableness, although probable construction costs should be included?

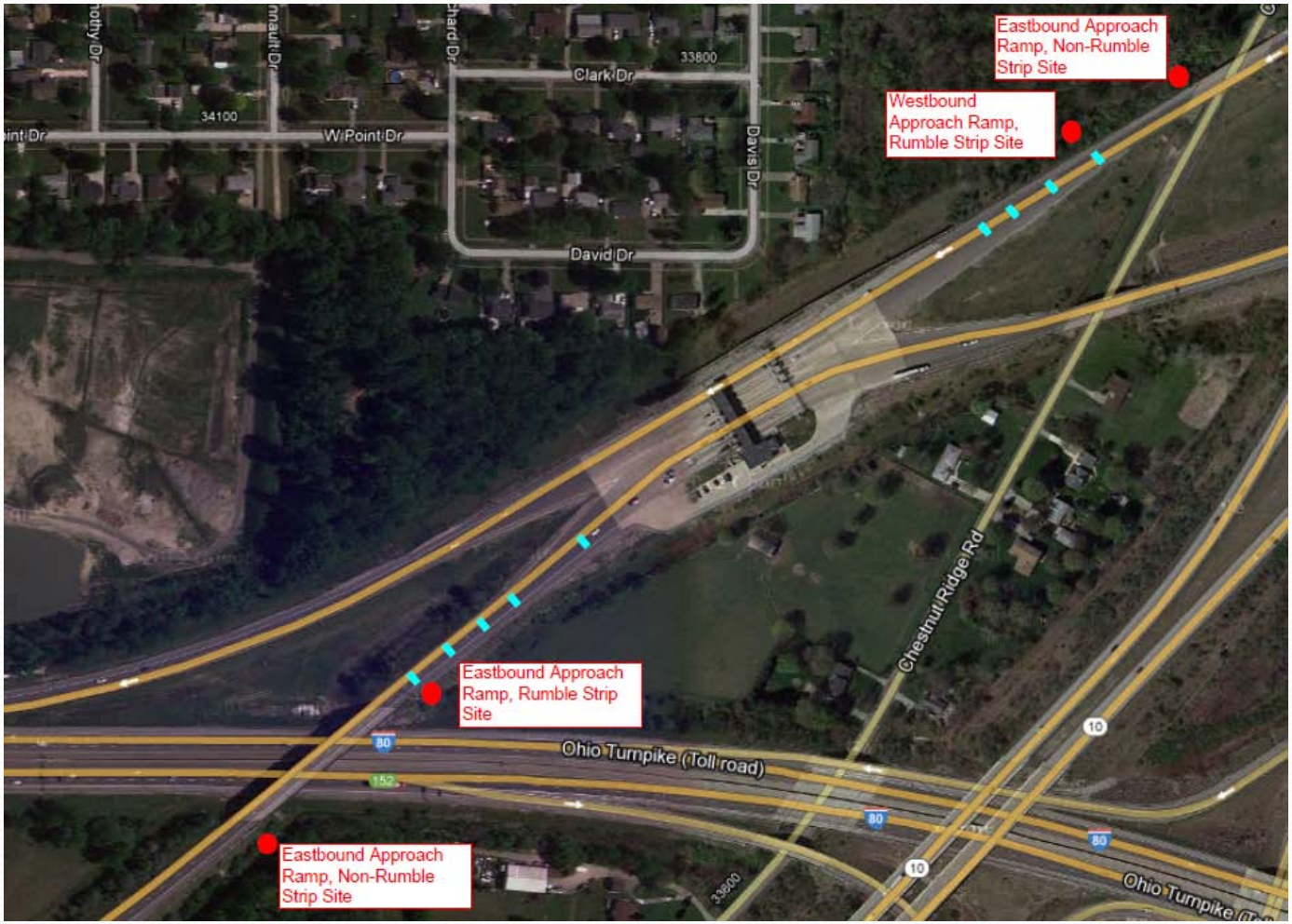
Challenges

- Residents were annoyed, yet preliminary ODOT measurements showed minor increase in $L_{eq}(h)$
- While TNM was used on this project originally, the problem statement asks questions that cannot be answered solely in TNM
- Modeling was to be done in CadnaA, but some additional data was needed
- Needed to consider existing 16-ft high safety wall

Safety Barrier

Bowlby & Associates, Inc.

Vehicle Pass-by Measurement Plan



Bowlby & Associates, Inc.

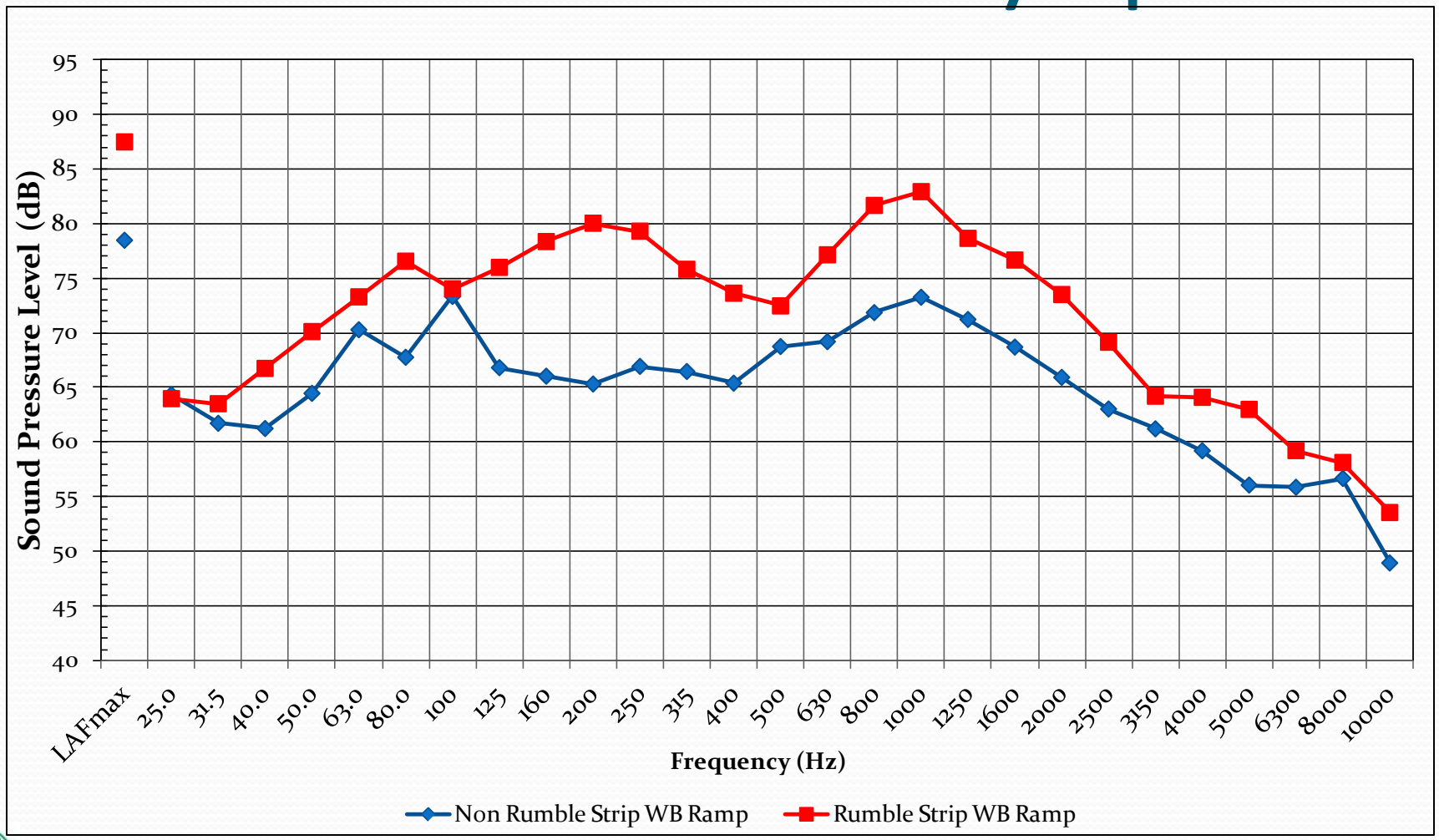
Vehicle Pass-by Measurement Sites

Bowlby & Associates, Inc.

Vehicle Pass-by Results

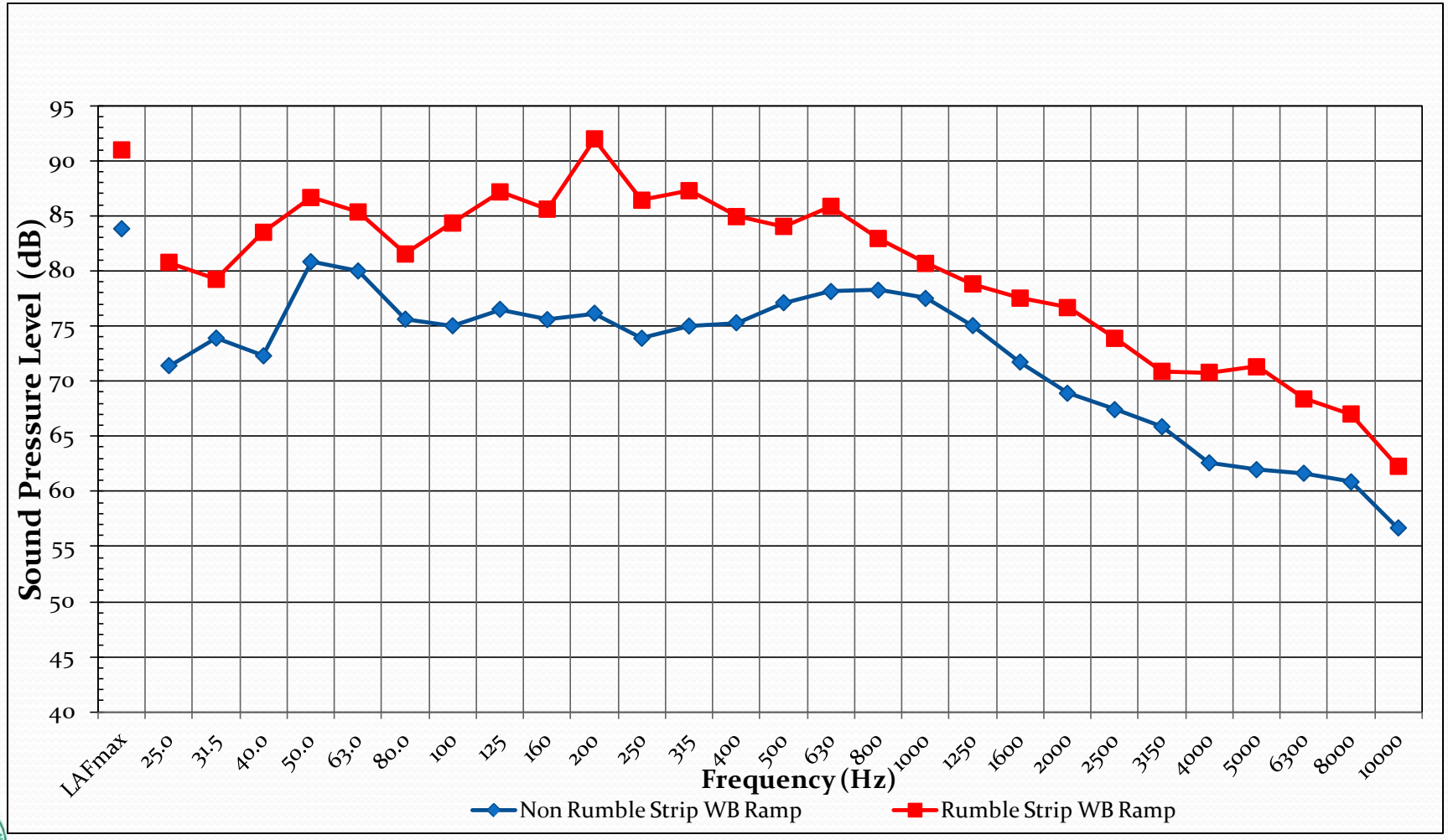
Site	Rumble Strips	Vehicle Type	Average L_{max}, dBA	Difference, dB	# Samples
WB Ramp	No	Auto	78.5		27
WB Ramp	Yes, RS 1	Auto	87.5	9.0	106
WB Ramp	No	HT	83.8		51
WB Ramp	Yes	HT	91.0	7.2	53
EB Ramp	No	Auto	78.4		15
EB Ramp	Yes, RS 1	Auto	90.8	12.3	127
EB Ramp	No	HT	84.8		34
EB Ramp	Yes, RS 1	HT	92.3	7.4	39

WB Automobile Pass-by Spectra



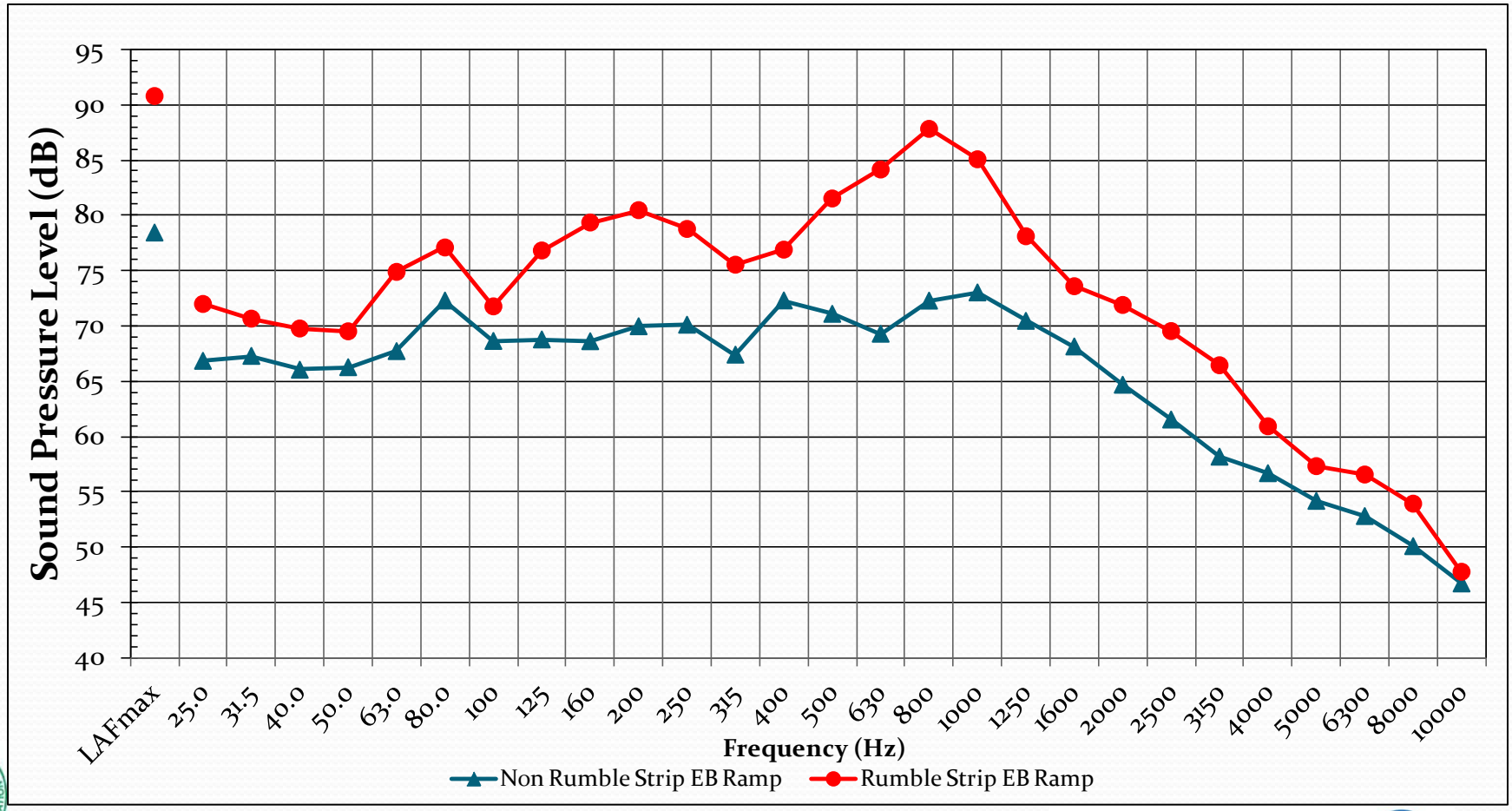
Bowlby & Associates, Inc.

WB Heavy Truck Pass-by Spectra



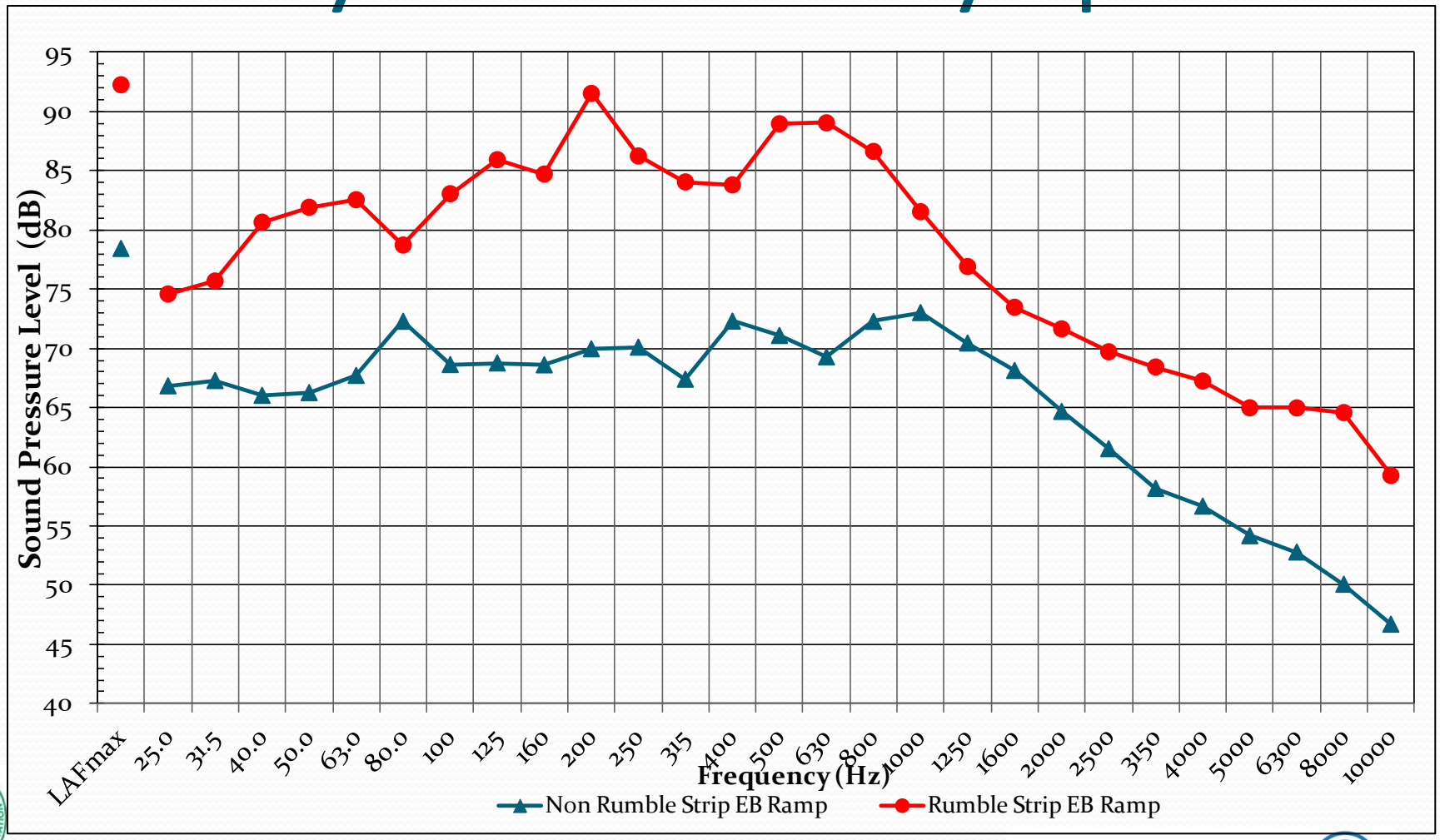
Bowlby & Associates, Inc.

EB Automobile Pass-by Spectra



Bowlby & Associates, Inc.

EB Heavy Truck Pass-by Spectra



Bowlby & Associates, Inc.

Community Measurements

Bowlby & Associates, Inc.

Noise Measurement Summary –

- Reference sound level measurements at 25 feet from center of travel lane: levels increased by 9 and 7 dB, respectively, for autos and HTs for WB approach ramp rumble strips, and 12 and 7 dB, respectively, for autos and HTs for EB approach ramp rumble strips.

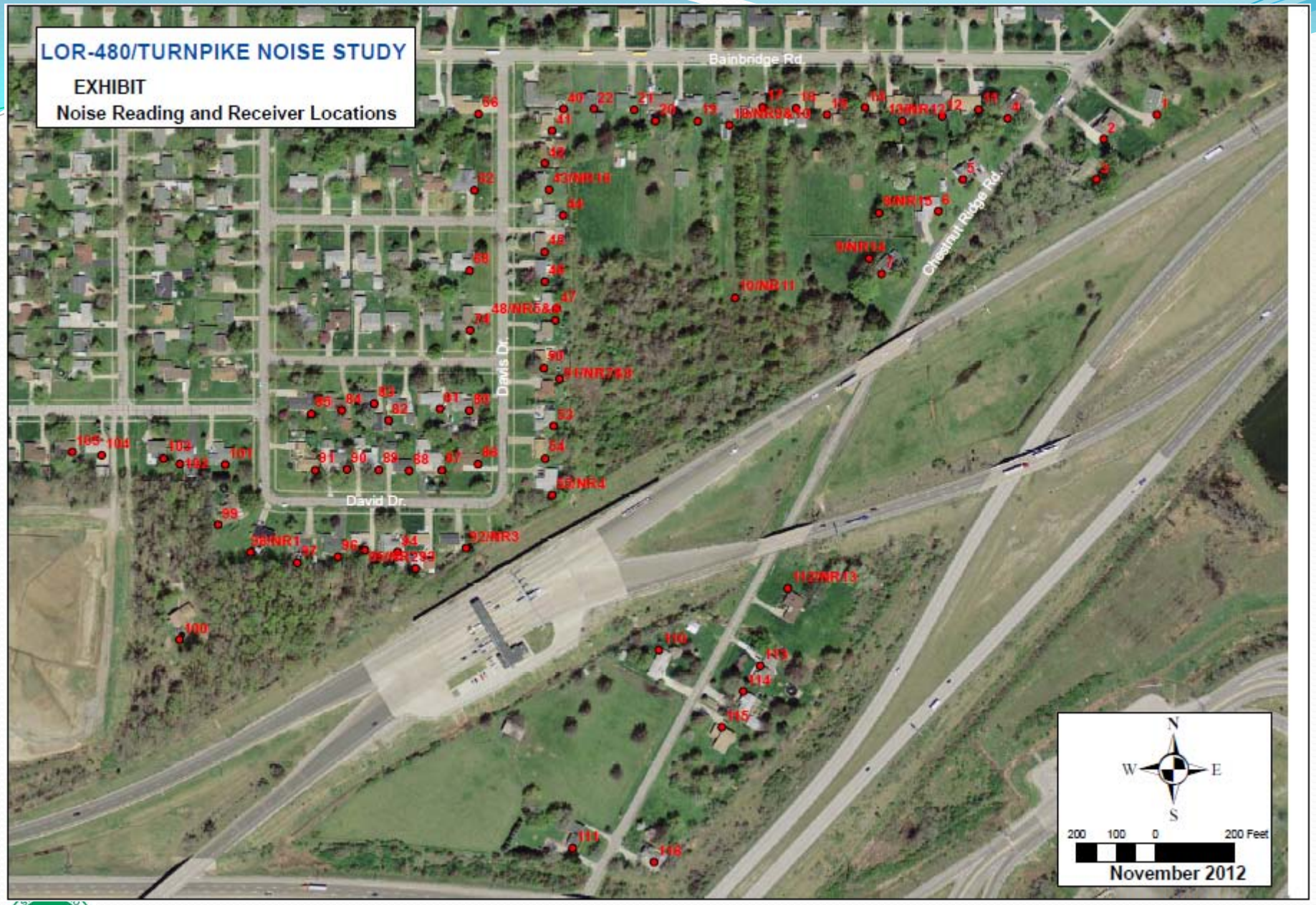
- WB ramp rumble strip sound pressure level peaks were in 200, 800 and 1,000 Hz bands for autos and, for HTs, in 1,000, 200 and 80 Hz bands, in that order.

- EB ramp rumble strip peaks are in 1,000, 200 and 80 Hz bands, in that order, for autos, and 200 Hz and 500-630 Hz for HTs.

- The community noise level measurements showed 15-20 minute L_{eq} values to be in 48-62 dBA range. Rumble strip noise was clearly audible, but did not raise A-weighted levels appreciably.

Traditional TNM Modeling

- 71 single-family residences modeled
- Each rumble strip modeled as a short roadway segment in TNM with and without Adjustment Factors
- Three abatement options considered:
  - 16 ft tall wall
  - 24 ft tall wall
  - Refined height wall



Bowlby & Associates, Inc.

TNM Modeling Results

- In model validation, 13 of the 16 noise measurement points were within +/- 3 dB
- Using adjustment factors for the rumble strips only increased the modeled $L_{eq}(h)$ by an average of 0.5 dB – dominance of rest of highway
- Six of the 71 modeled locations had noise levels that approached or exceeded the NAC
- None of the analyzed barrier options met ODOT's traffic noise policy criteria

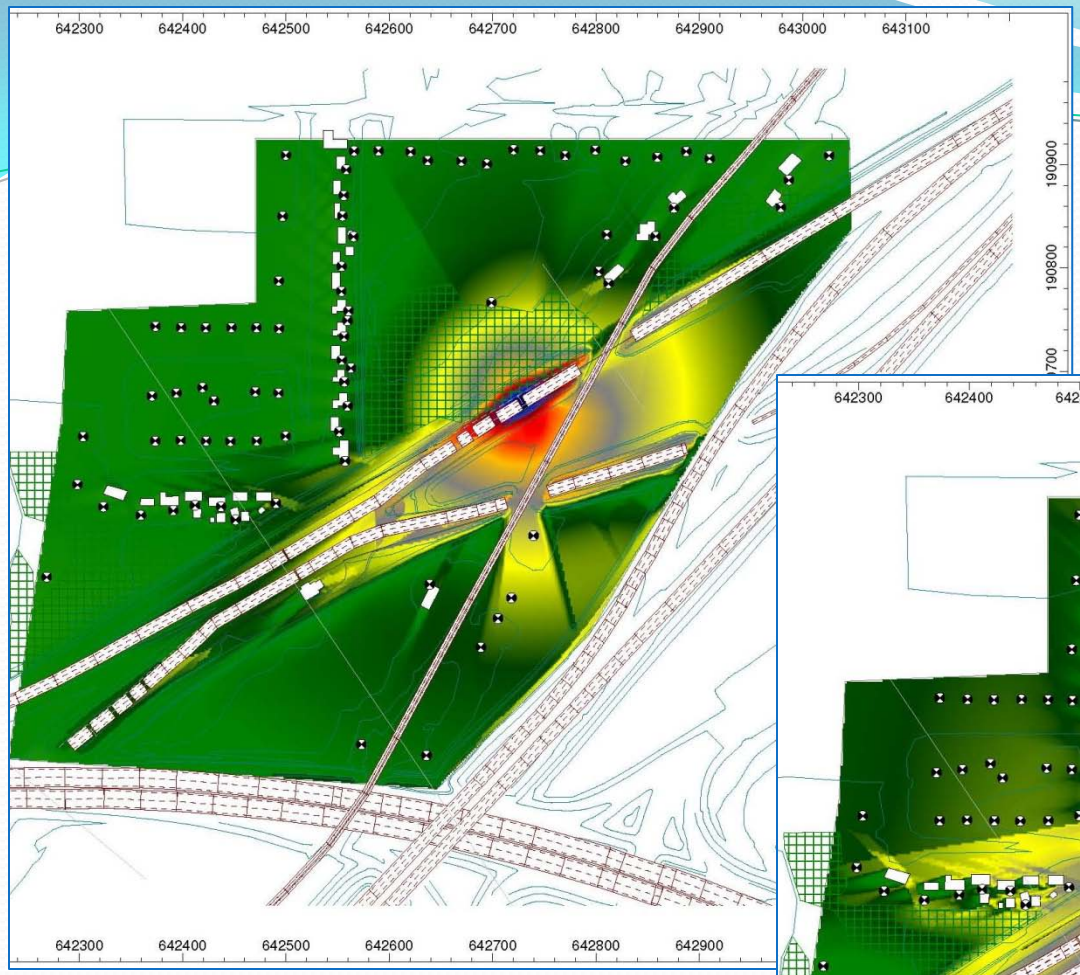
CadnaA Modeling

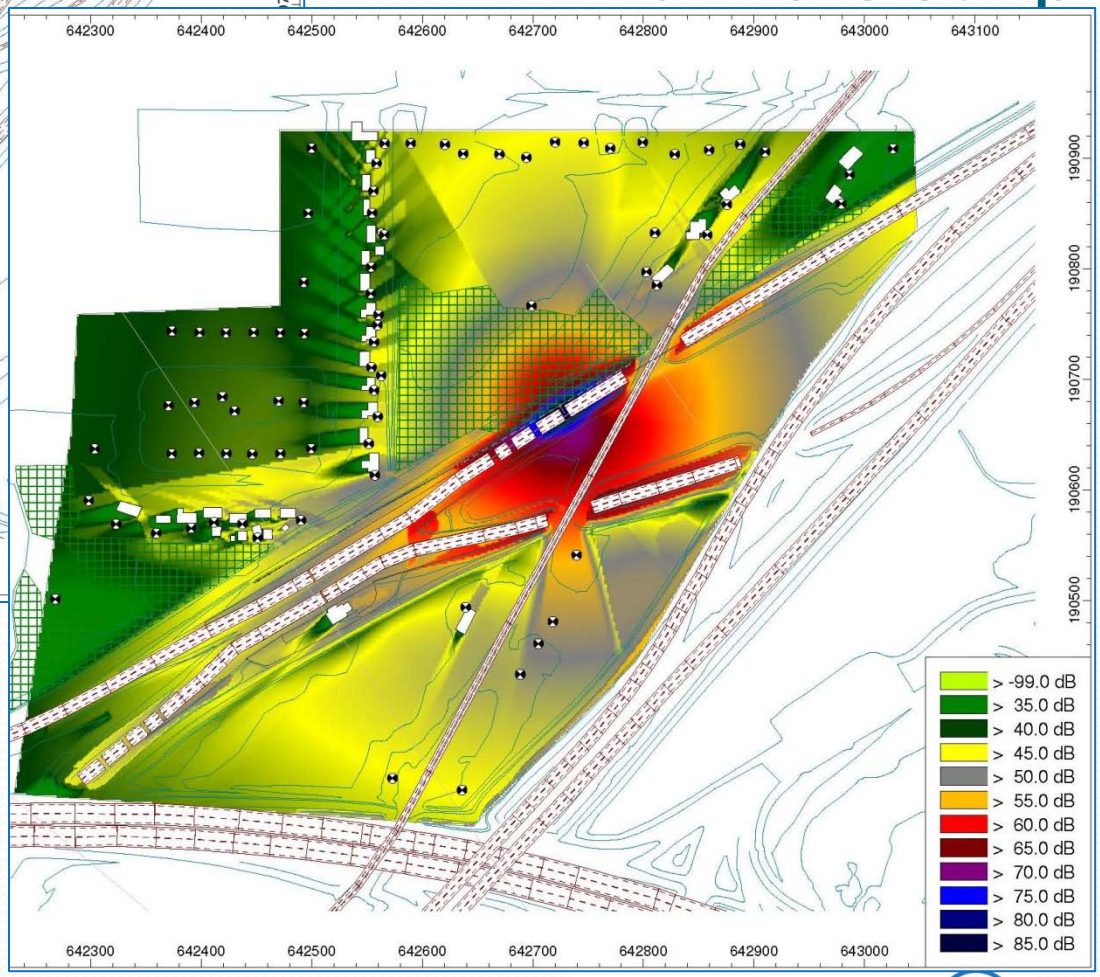
- Rumble strips were the only sources included
- Spectral data from pass-by measurements used to create the source spectra
- Modeled as both “no rumble strip” and “with rumble strip”
- Maximum sound levels from the rumble strips predicted at the receivers

Cases Modeled

EB	RS 1	Auto "no rumble strip"	Auto "with rumble strip"	HT "no rumble strip"	HT "with rumble strip"
WB	RS 1	Auto "no rumble strip"	Auto "with rumble strip"	HT "no rumble strip"	HT "with rumble strip"

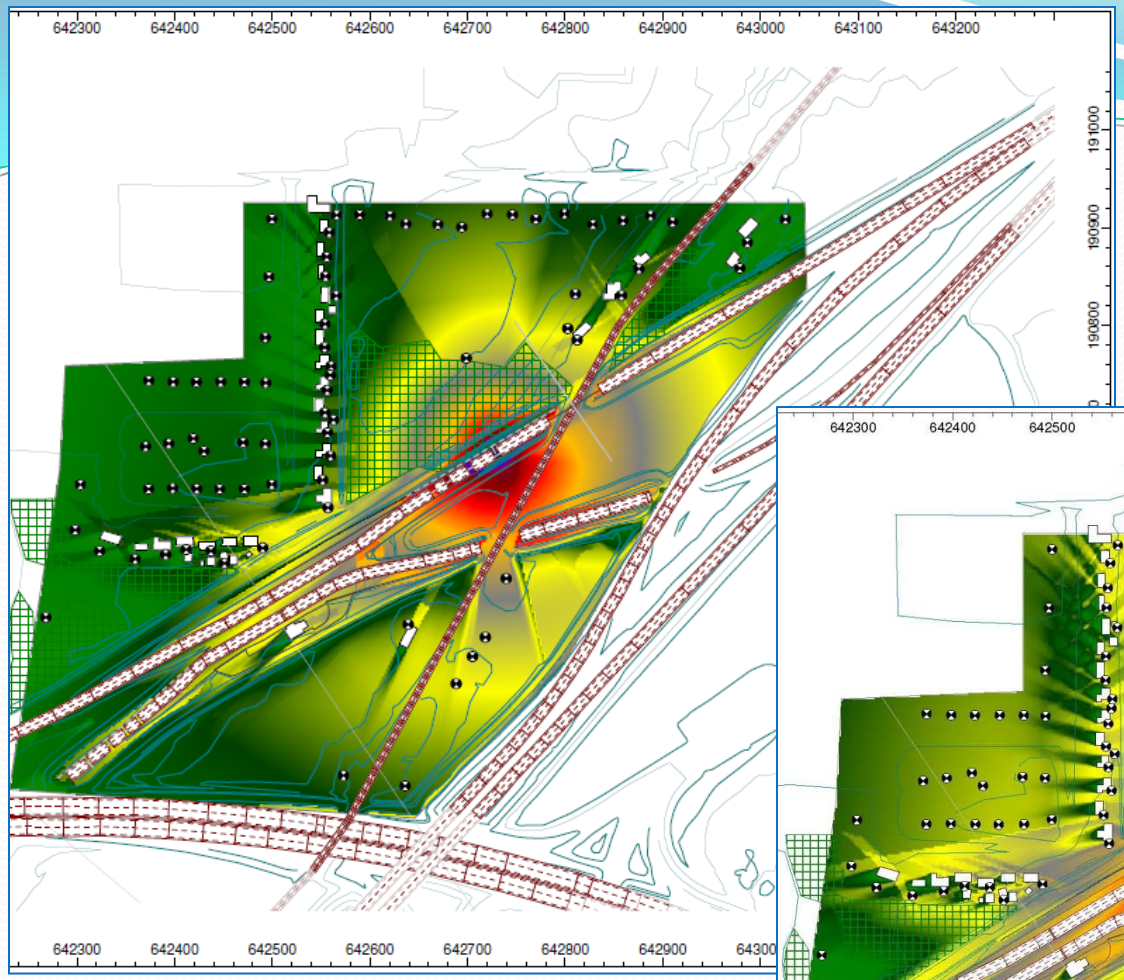
WB Auto: with rumble strip



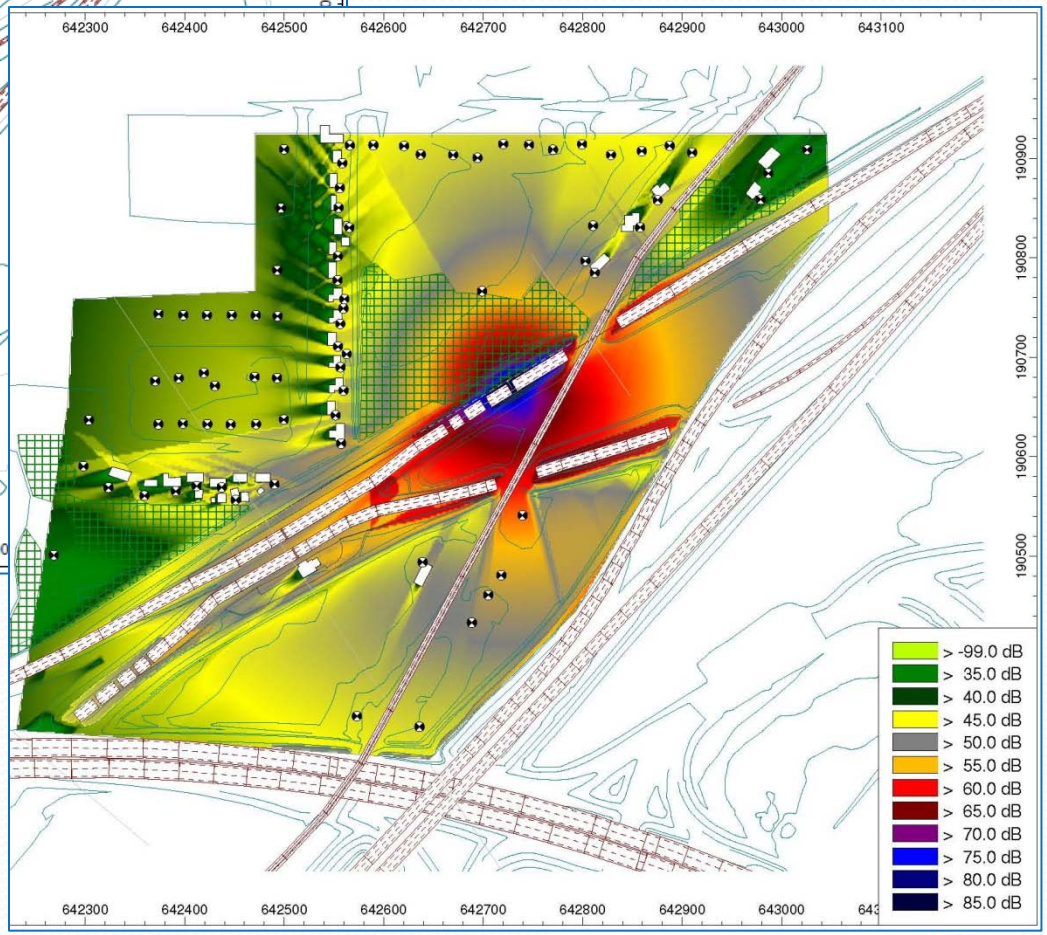


WB Auto: no rumble strip

Bowlby & Associates, Inc.



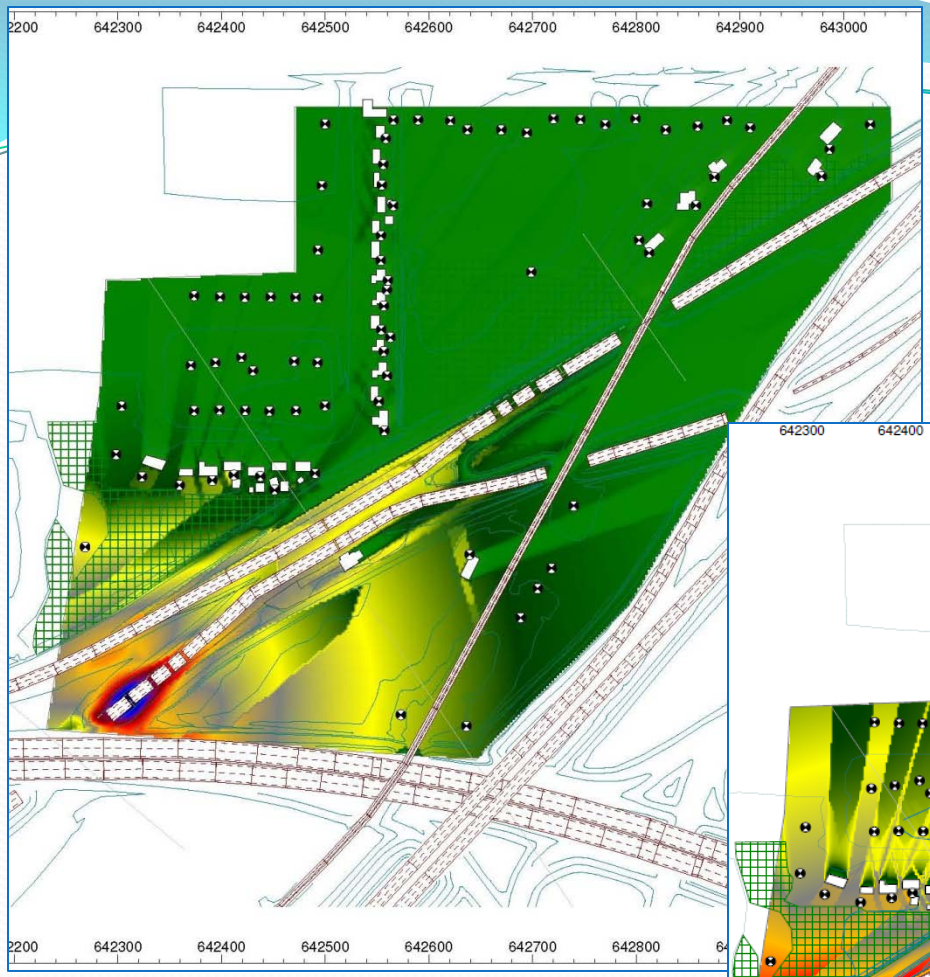
WB HT: with rumble strip

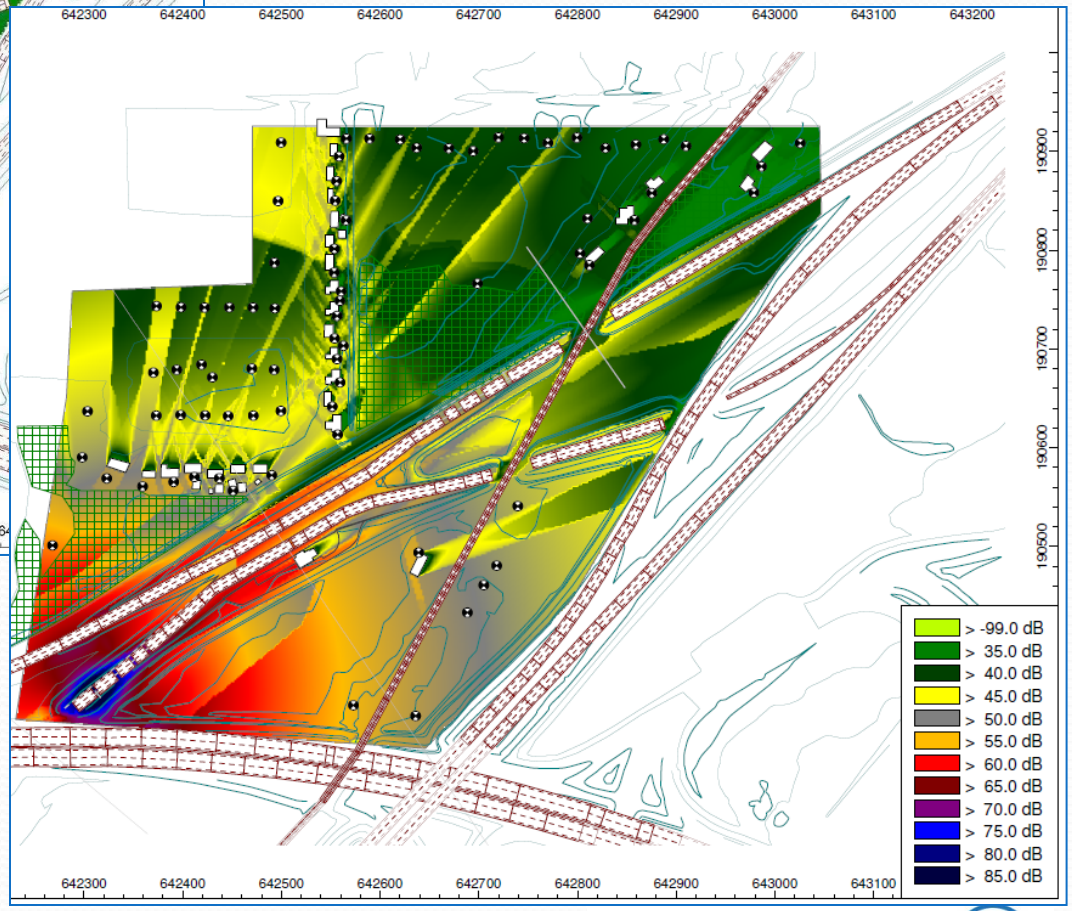


WB HT: no rumble strip

Bowlby & Associates, Inc.

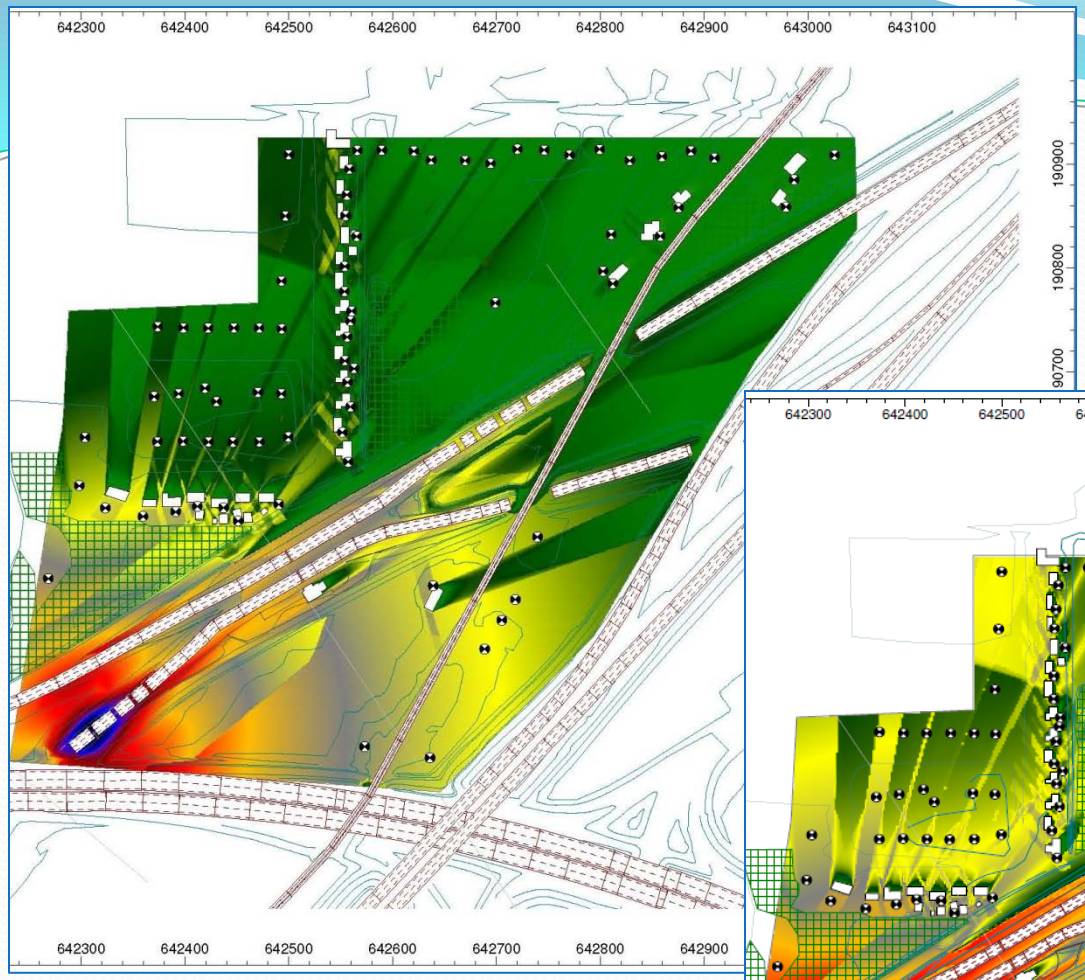
EB Auto: with rumble strip



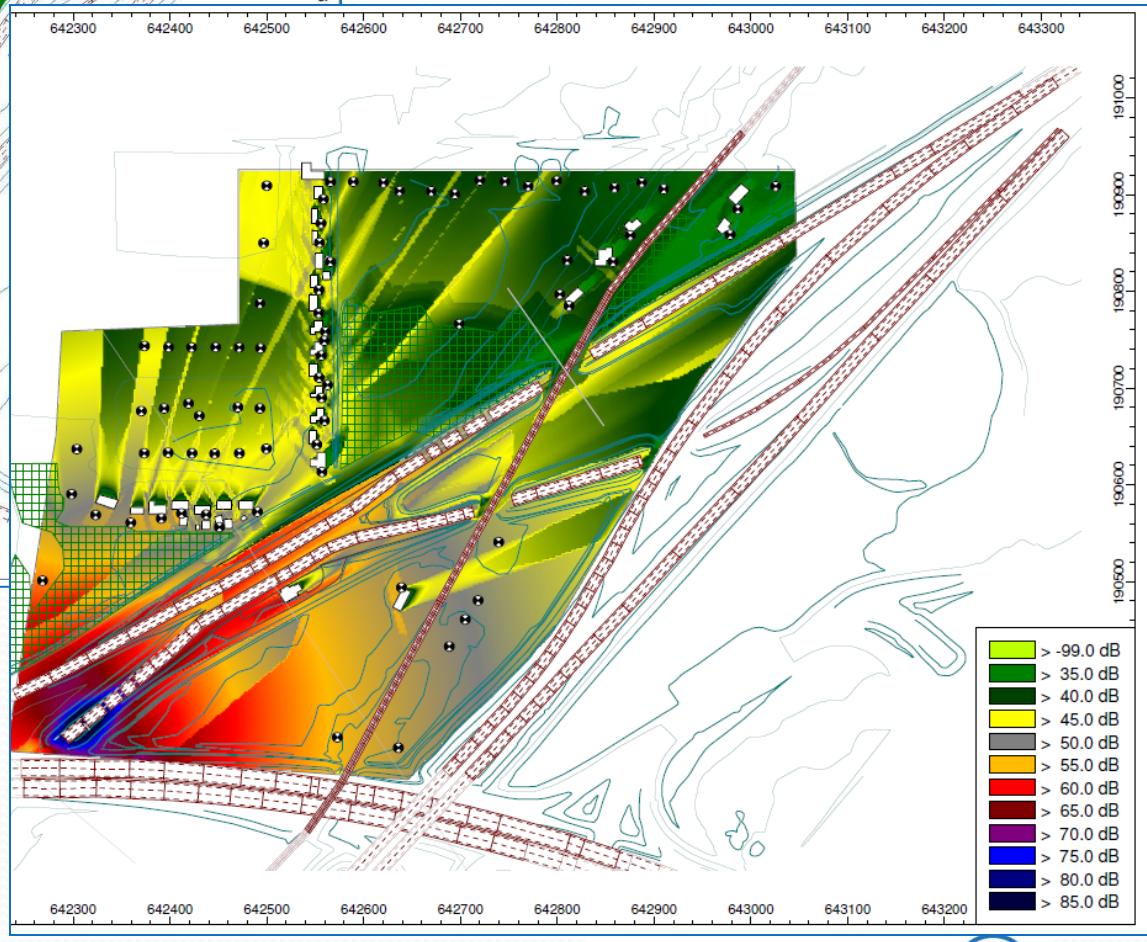


EB Auto: no rumble strip

Bowlby & Associates, Inc.



EB HT with rumble strip



EB HT no rumble strip

Bowlby & Associates, Inc.

Abatement Design in CadnaA

- Abatement design goal: reduce rumble strip noise down to "no rumble strip" level
- No barrier and with barrier sound levels calculated on an L_{max} basis
- No attempt to determine effect on overall $L_{eq}(h)$
- Both standard and T-Top walls were considered

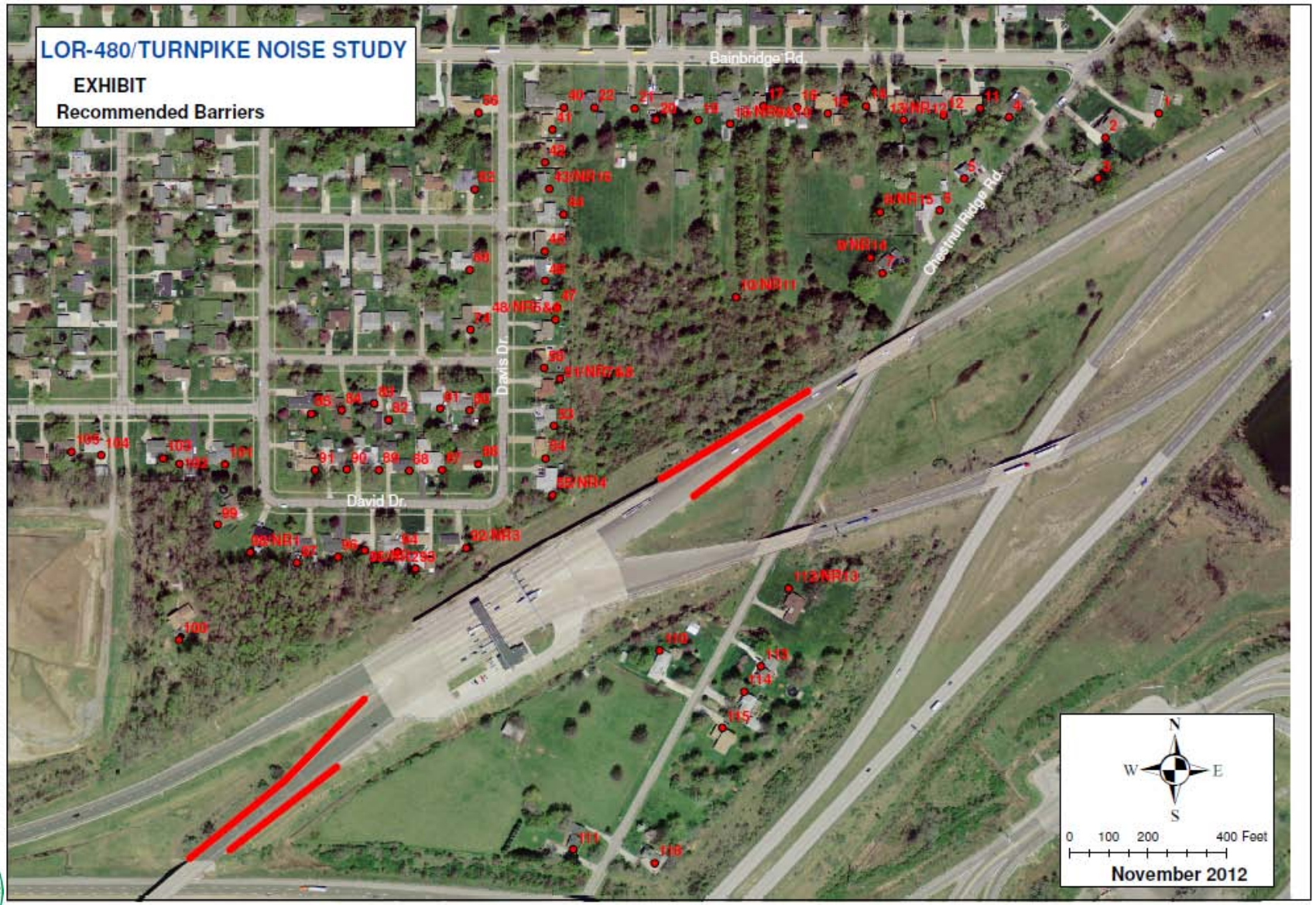
Example T-Top Walls from Berea, OH on the Ohio Turnpike

Bowlby & Associates, Inc.

Noise Barrier Design Options

- Reflective barrier unit cost of $25 per sq ft, provide by ODOT
- Extra cost for sound-absorption on the roadway side of $4 per sq ft, based on discussions with the manufacturers
- Extra cost for a sound-reflecting T-top of $30 per linear ft, based on discussions with the City engineer and design consultant
- A cantilever barrier was modeled in CadnaA to represent a T-Top barrier

Recommended Barriers



Bowlby & Associates, Inc.

Summary of Barrier Design Recommendations

Location	*Type*	*Height (feet)*	*Length (feet)*	*Estimated Cost*
Northside Westbound Approach	T-top	12-14	430	$175,300
Northside Eastbound Approach	T-top	10	600	$192,000
Southside Westbound Approach	Vertical top	10	340	$98,600
Southside Eastbound Approach	Vertical top	14	340	$138,040

- The T-Top offers similar or slightly improved performance on the Northside at a lower cost.

Answers to Problem Statement

- Can rumble strip noise be mitigated with a noise wall of any type or size? **It can be.**
- Can *anything* can be constructed to mitigate rumble strip noise (i.e., specialized noise wall design features, such as a T-top, etc.)? **Yes.**
- Is a noise wall feasible and reasonable from a traffic noise standpoint? **No.**
- Determine what is the most acoustically effective noise wall that can be constructed in this area regardless of cost reasonableness, although probable construction costs should be included **Done.**

Questions?

Study funded by the Ohio Department of Transportation, District 3 Office, Ashland, OH

Bowlby & Associates, Inc.