The ADOT Quiet Pavement Pilot Program

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ADOT

ILLINGWORTH & RODKIN, INC.
Acoustics • Air Quality

ADOT Situation Pre-2002

- 150 miles of new freeways to be added in the Phoenix area, 1985 to 2007
- Existing and new freeways are Portland Cement Concrete (PCC) with transverse tining
- Community complaints in areas where freeways added – sound walls not preferred
- Knowledge of quieter pavement application in it's infancy

US Federal Policy

- Pavement can not be considered as traffic noise abatement in FHWA funded projects
- FHWA Traffic Noise Model (TNM) only allows of an “average” pavement type
- FHWA noise abatement requirements:
  - Feasible reduction – 5 dB
  - Reasonable cost
- New possibility of “pilot projects” which account for pavement based on previous state research

Arizona Quiet Pavement Pilot Program

- 115 miles of freeway to be overlaid with ARFC ($34 million)
- 4 dB “credit” allowed for pavement by FHWA relative to TNM predicted noise level
- Long term research project to measure performance over 10 years ($3.8 million)
- Multiple Measurements Types (or “Sites”)

Pre & Post Overlay

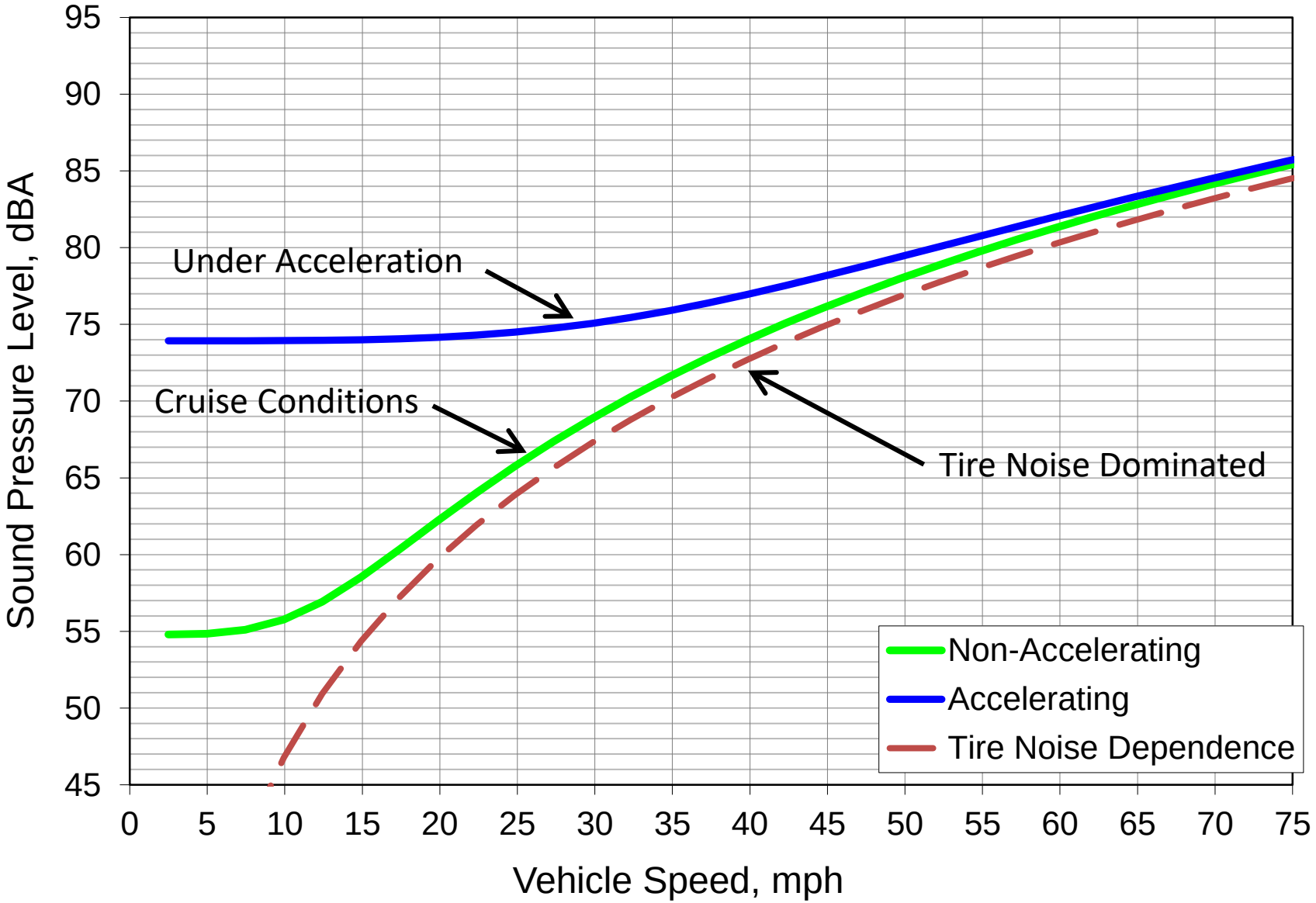
ARFC Overlay (25mm Thick)

Random Transverse Tined PCC

QPPP ARFC Specifications

- 18 to 22% crumb rubber particles
- Asphalt rubber binder of 9.1 to 9.6% by weight
- Aggregate gradations:
  - 95% 9.5mm chips
  - 5% fine aggregate
- Void content typically 20 to 21%
- However, no indication of being a porous pavement

Light Vehicle Pass-by Level



Source: FHWA REMELs Data Base

Caltrans Quieter Pavement Research on I-80 near Davis

Arizona Quiet Pavement Program: Preliminary Work

- Development of measurement methods
- Construction and evaluation of pavement test sections
- Pavement selection – ARFC with almost 30 years of history
- Evaluation of pavement age and noise performance
- Investigations of alternative PCC surface textures

Isolating the Pavement Performance

No big deal, just go out and measure it before and after

BUT

It depends on

- Traffic speed
- Traffic Volume
- Traffic mix

Measurement Methods

Traffic Noise

CTIM TP 99

Isolate Vehicle Noise then Tire Noise

Individual Vehicle Noise Pass-by Noise

SIP TP 98
SPB ISO 1189-1

Tire Noise

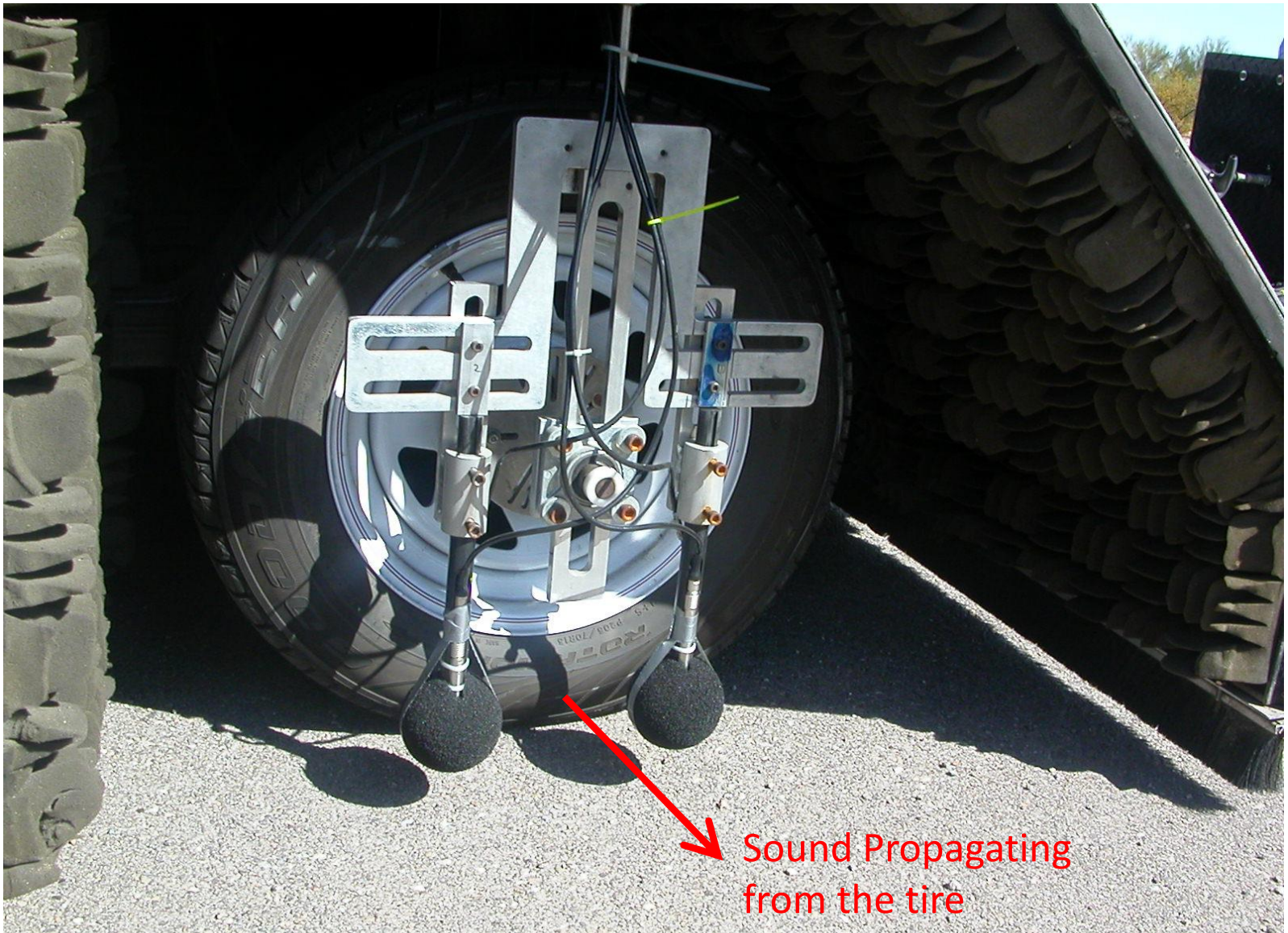
OBSI AASHTO T360
CPX ISO 11819-2

CPX Trailer – ISO Procedure

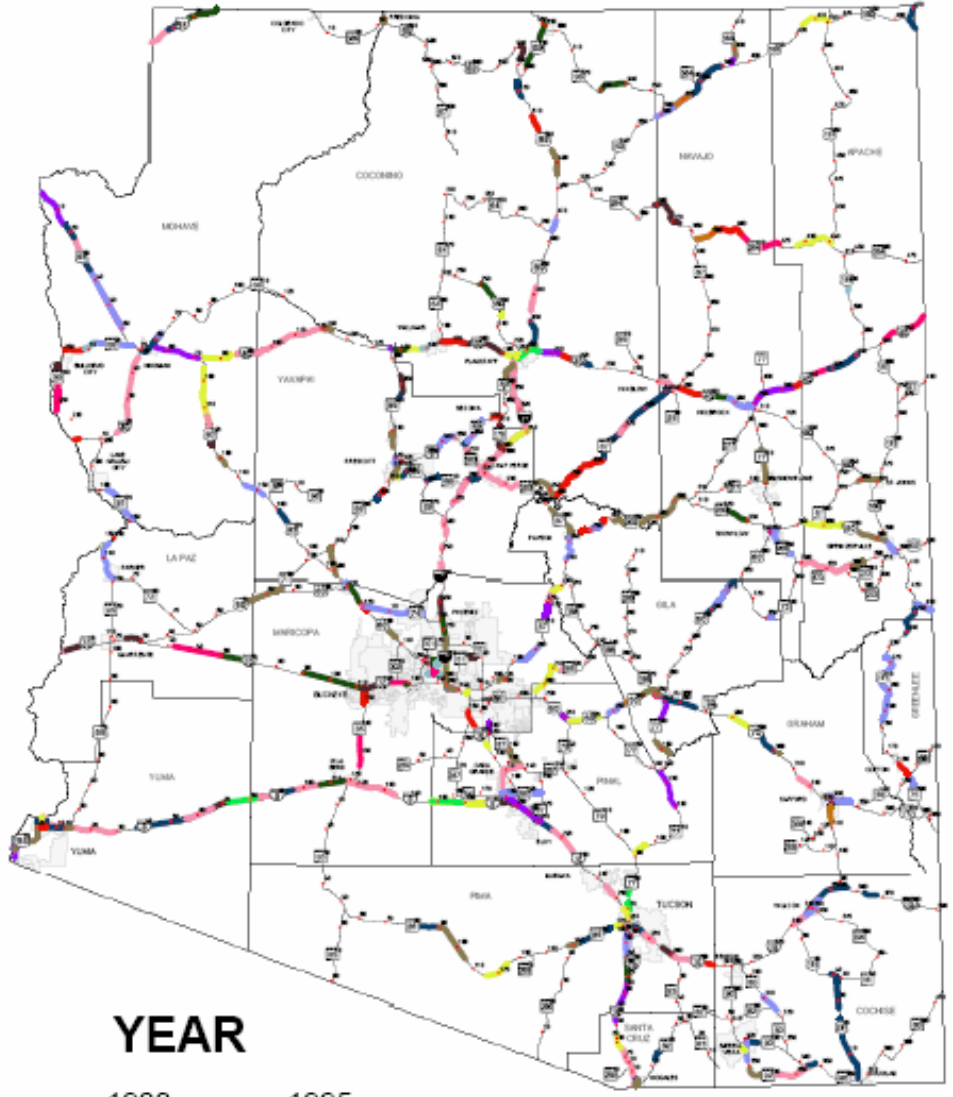
CPX Mics

Acoustical Enclosure

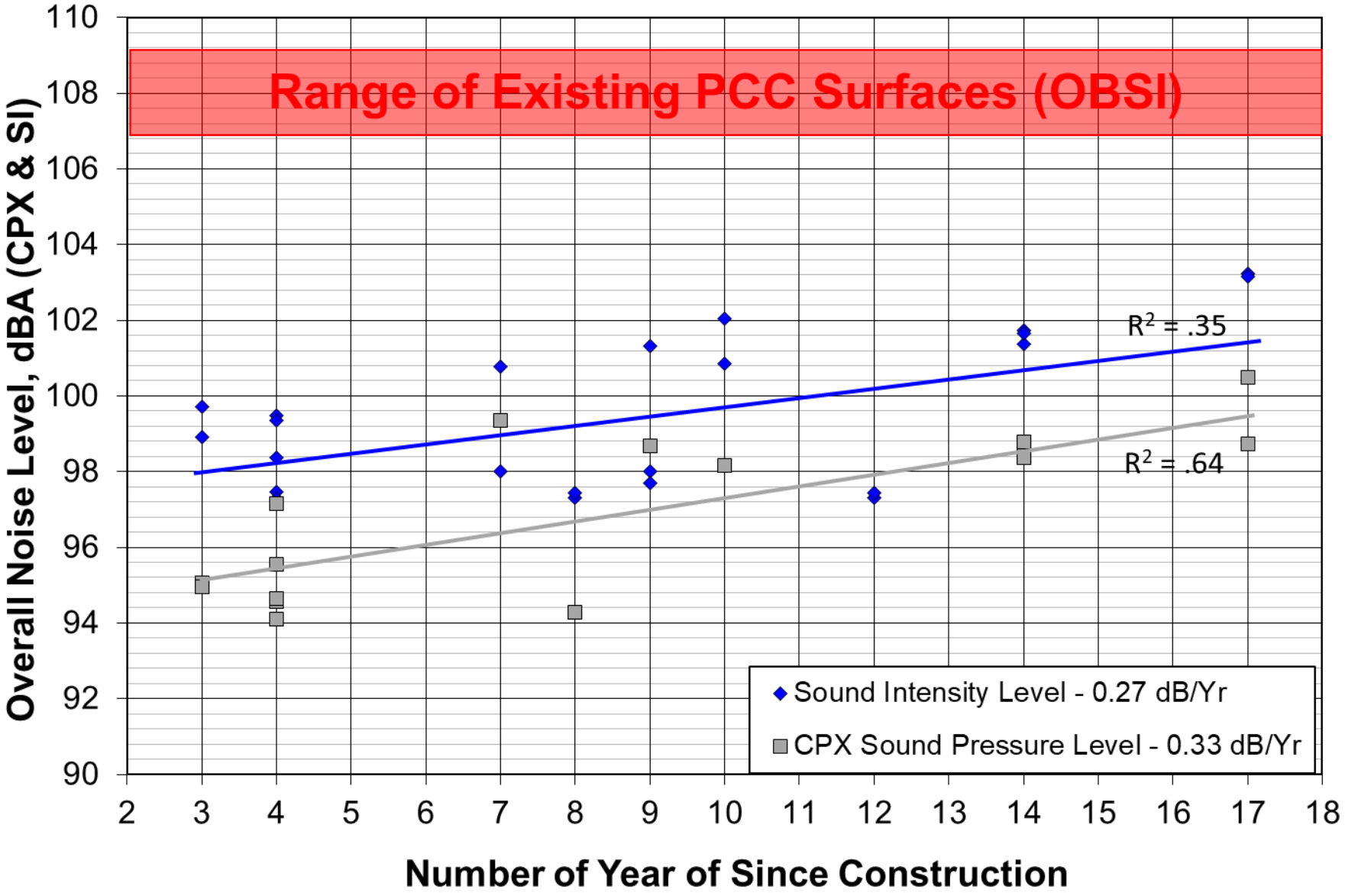
ADOT Two Sound Intensity Probe Concept



ARFC Applications



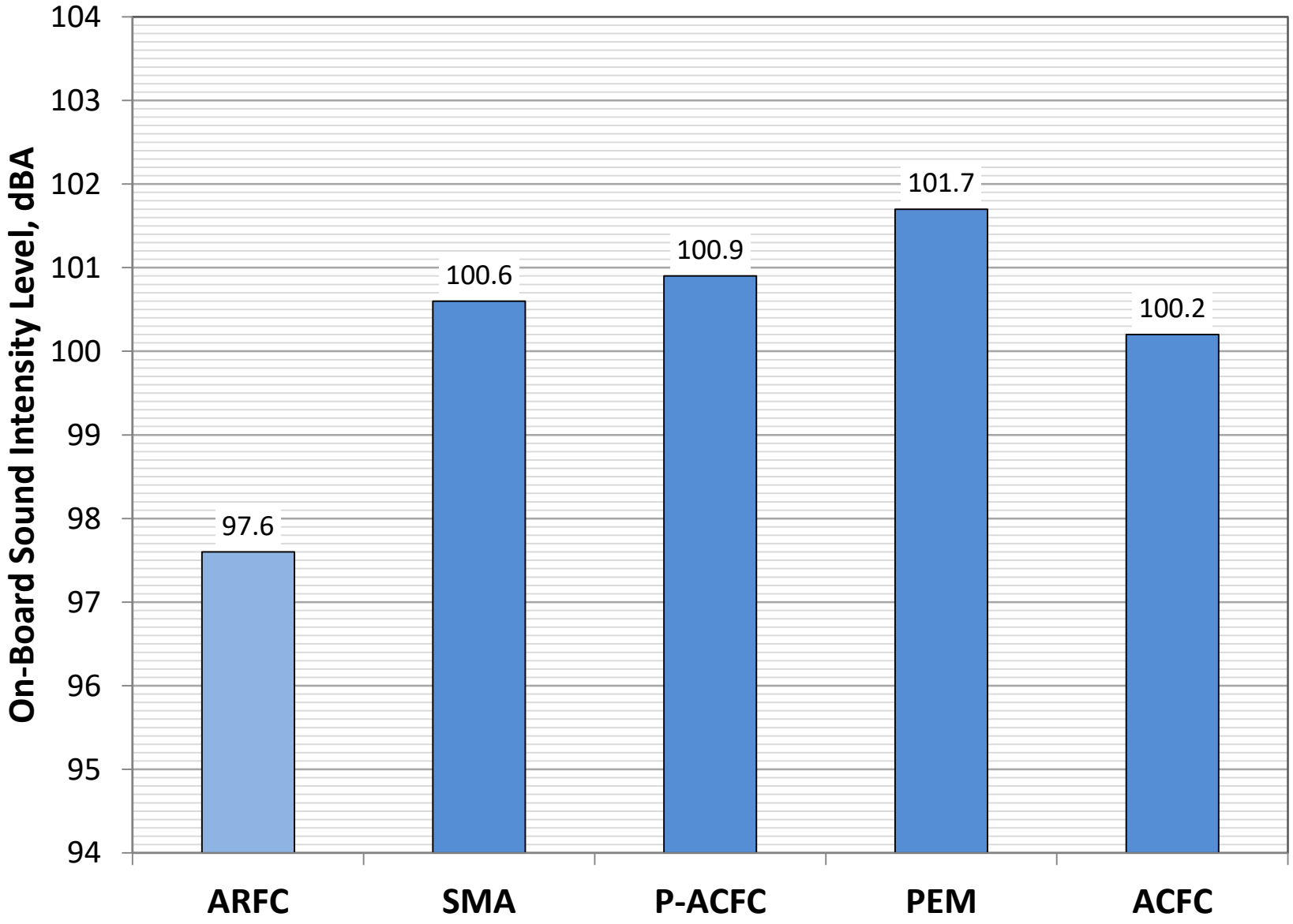
Difference in Noise with Pavement Age



Arizona I-10 Casa Grande AC Research Test Sections

- Constructed in 2000
- First tested in 2002
- Pavements – 6 of each:
  - Asphalt rubber AR-ACFC
  - Conventional ACFC
  - Stone mastic SMA
  - Porous ACFC
  - Porous European PEM

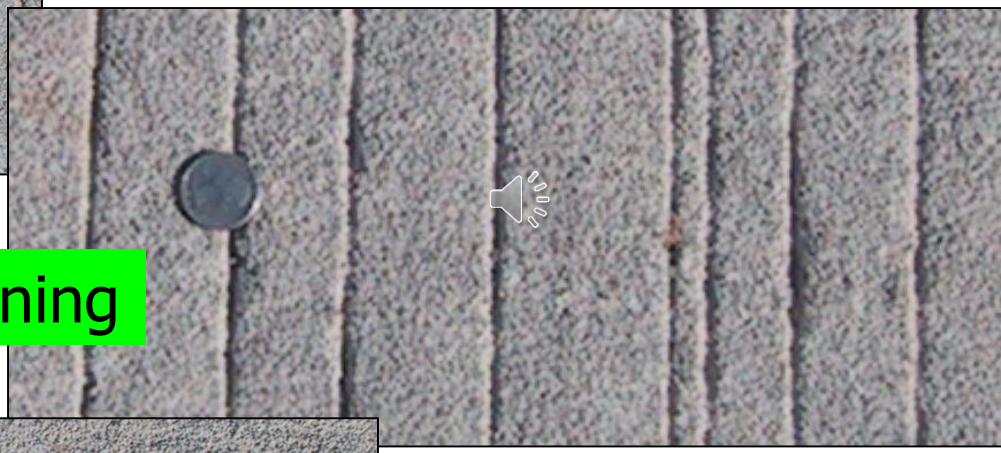
Casa Grande Research Test Sections



SR 202 Test Surfaces

Uniform Transverse Tining

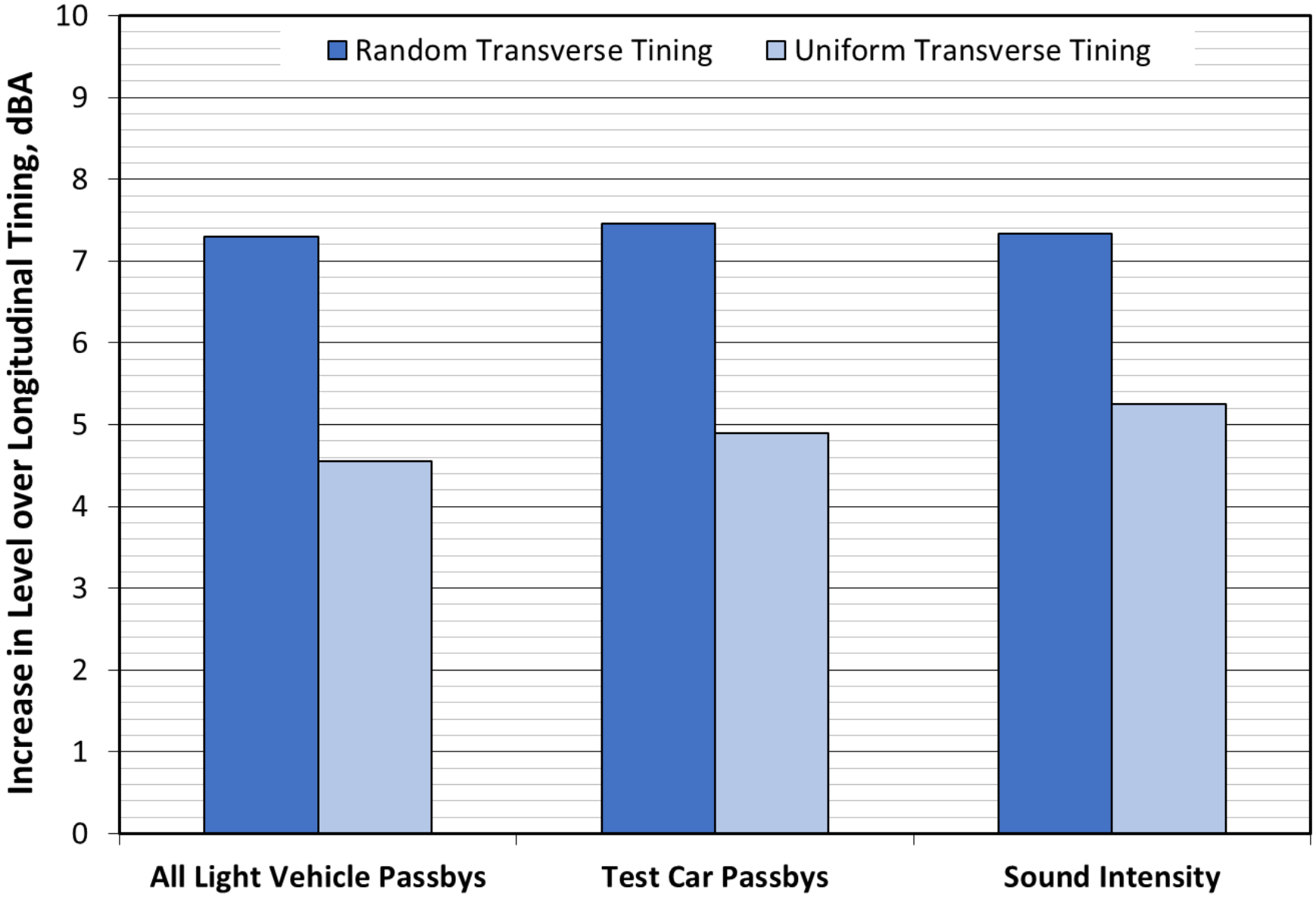
Direction of Travel



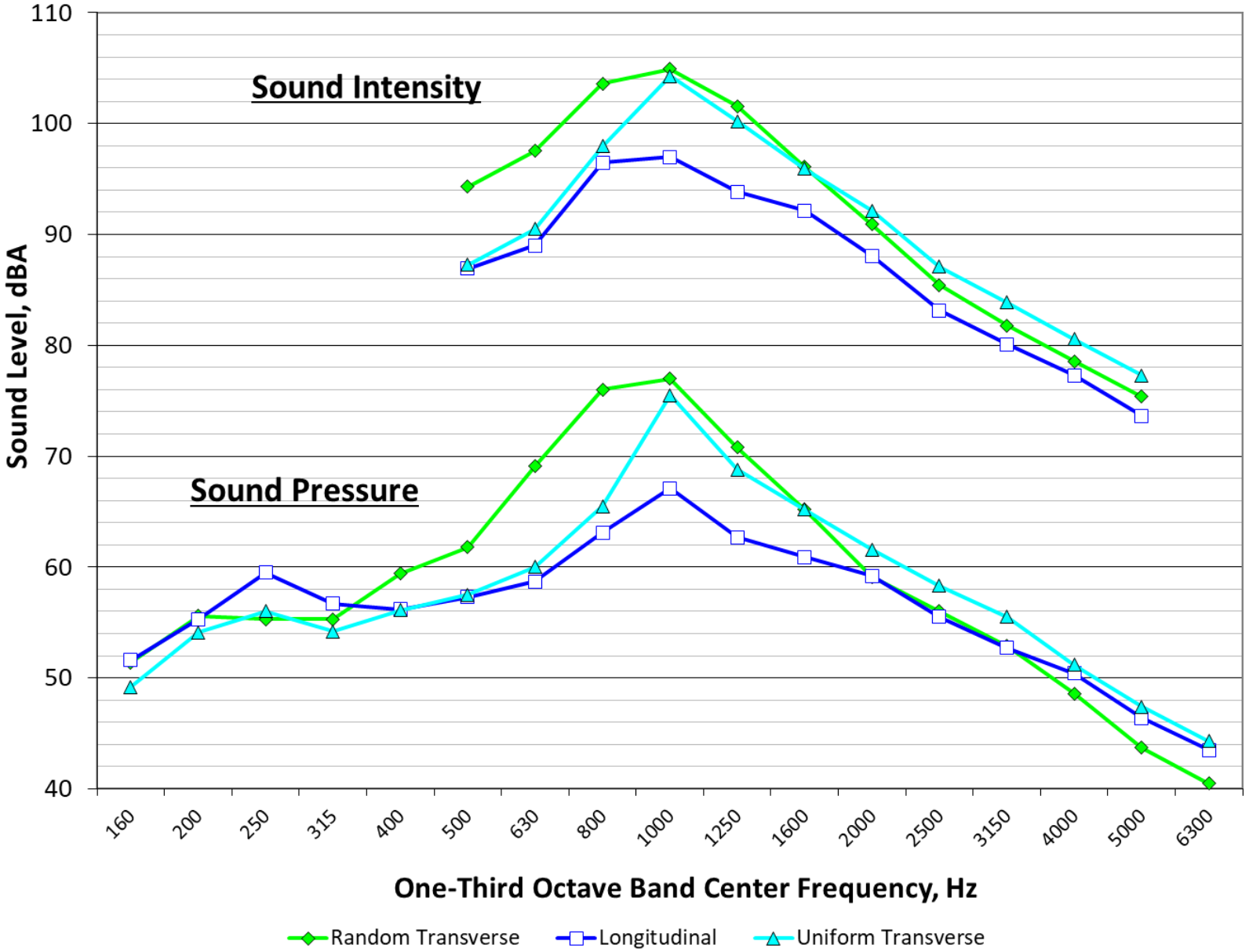
Random Transverse Tining

Longitudinal Tining

SR 202 Test Surface Results



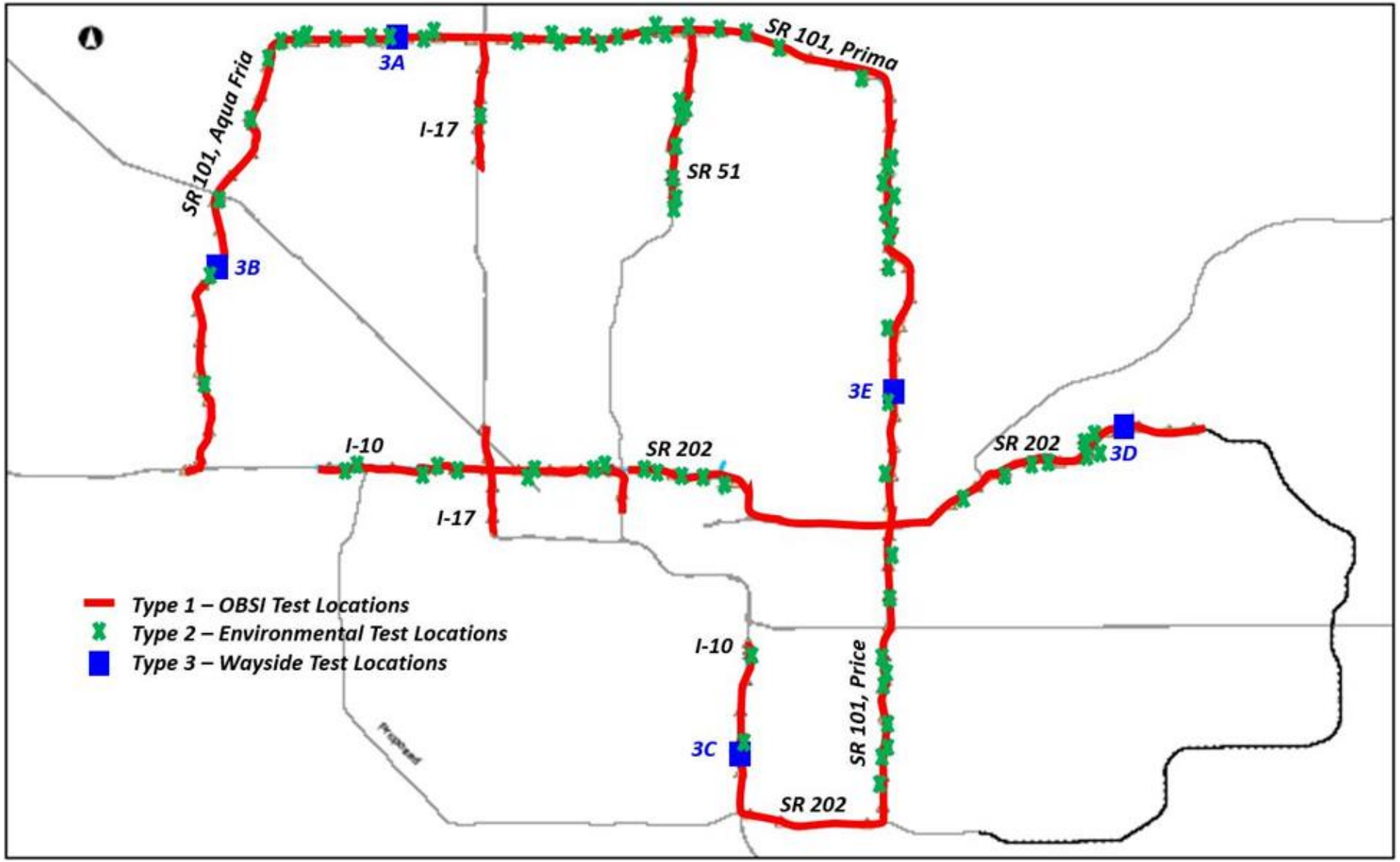
SR 202 Test Surface Results



Definition of the QPPP

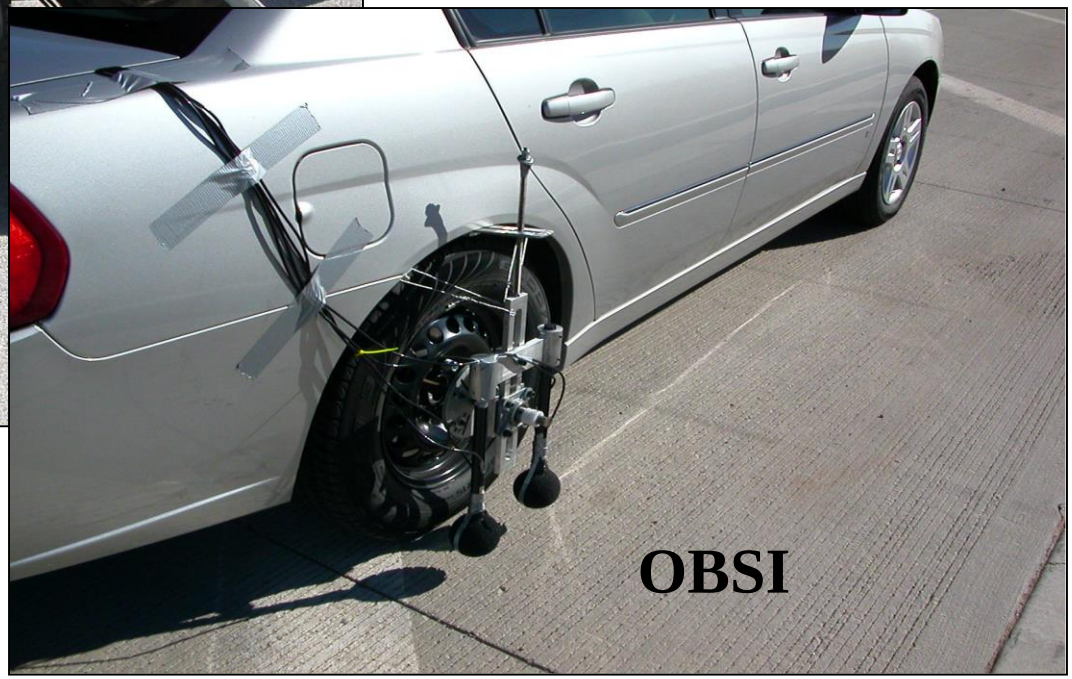
- Originated as a cooperative research project between ADOT & FHWA in April 2003
- 10-year project with 3 components
  - Type 1 measurements of tire/pavement noise
  - Type 2 noise measurements in residential settings
  - Type 3 noise measurements in “research grade” sites
- Additional pavement characteristic measurements

Measurement Types & Locations



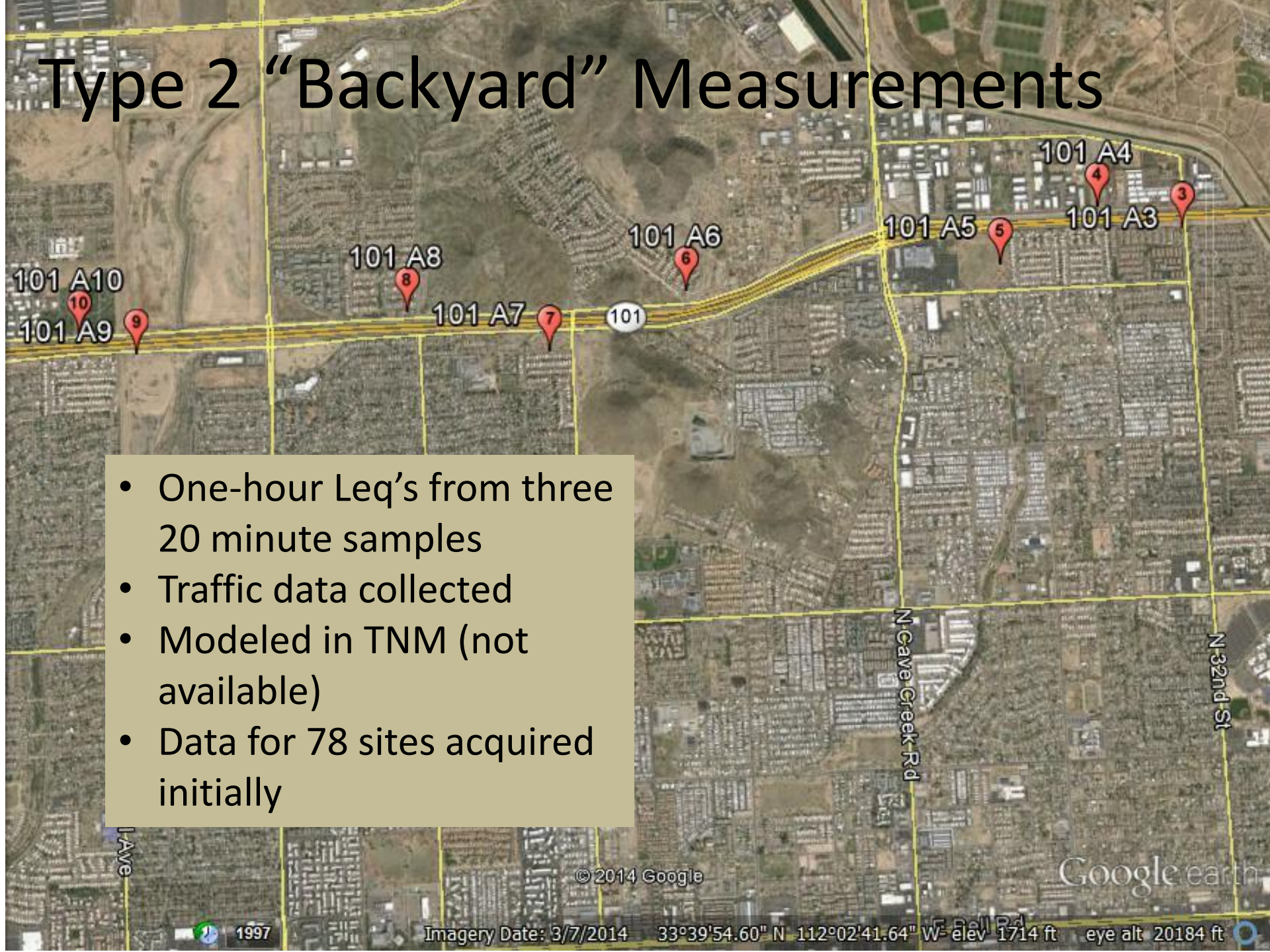
Tire/Pavement Source Levels
Type 1 Measurements

- Consistent with AASHTO T360
- Goodyear Aquatred 3 tire
- 60 mph, 5 second average
- Outside lane both directions at 115 mileposts



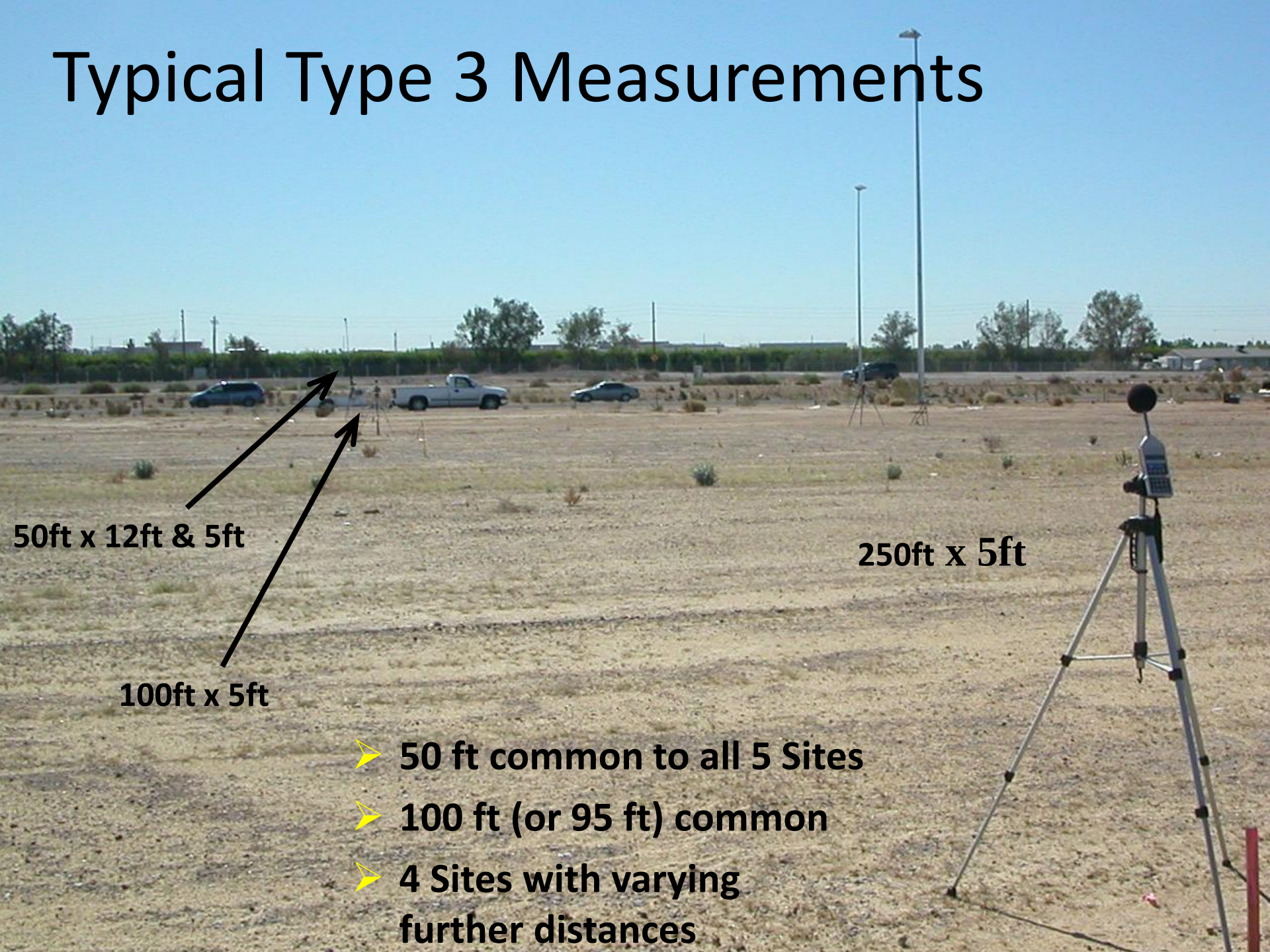
- Developed correlation for CPX to OBSI
- Initially 2 times per year, later once

Type 2 “Backyard” Measurements



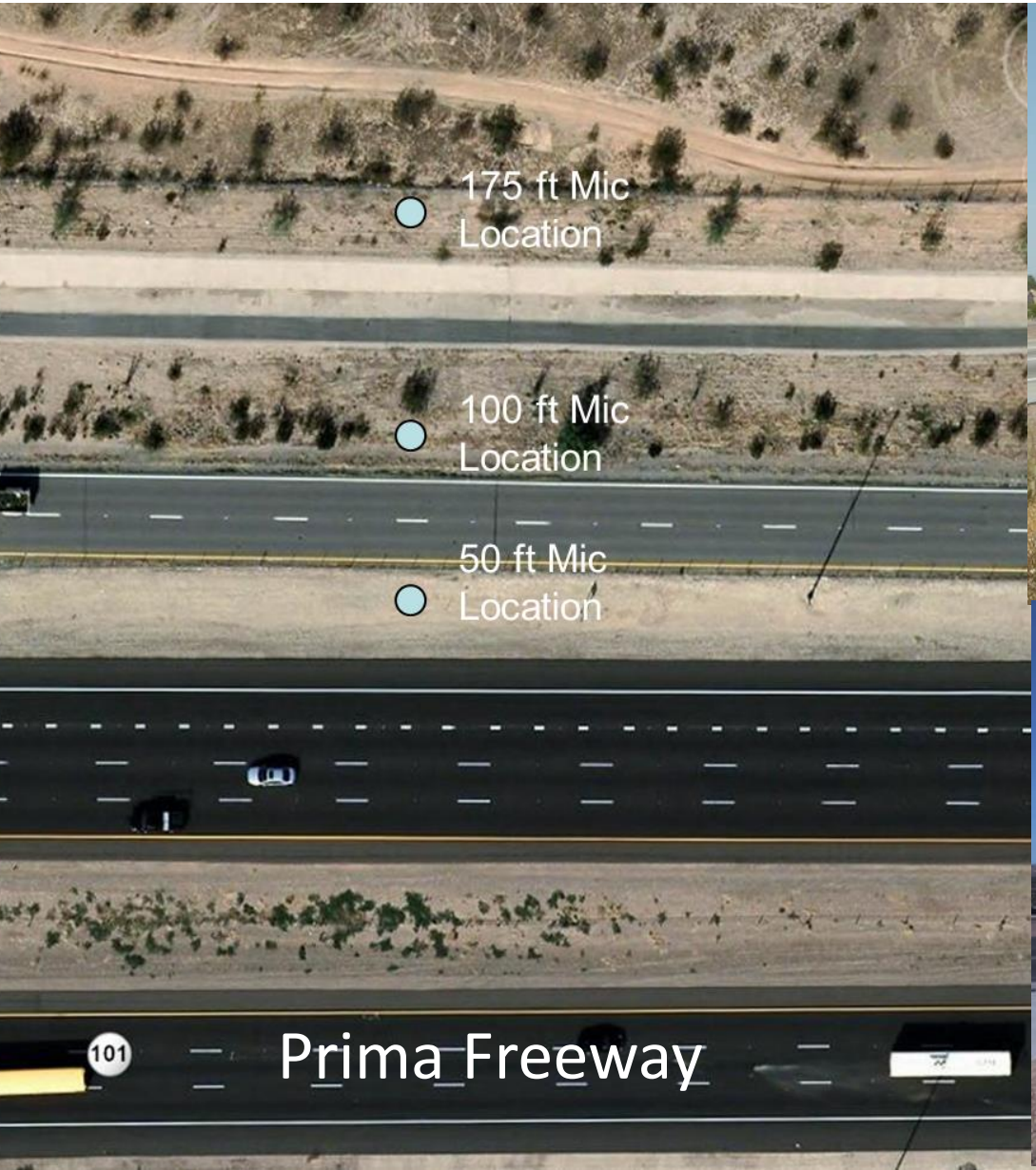
- One-hour Leq’s from three 20 minute samples
- Traffic data collected
- Modeled in TNM (not available)
- Data for 78 sites acquired initially

Typical Type 3 Measurements

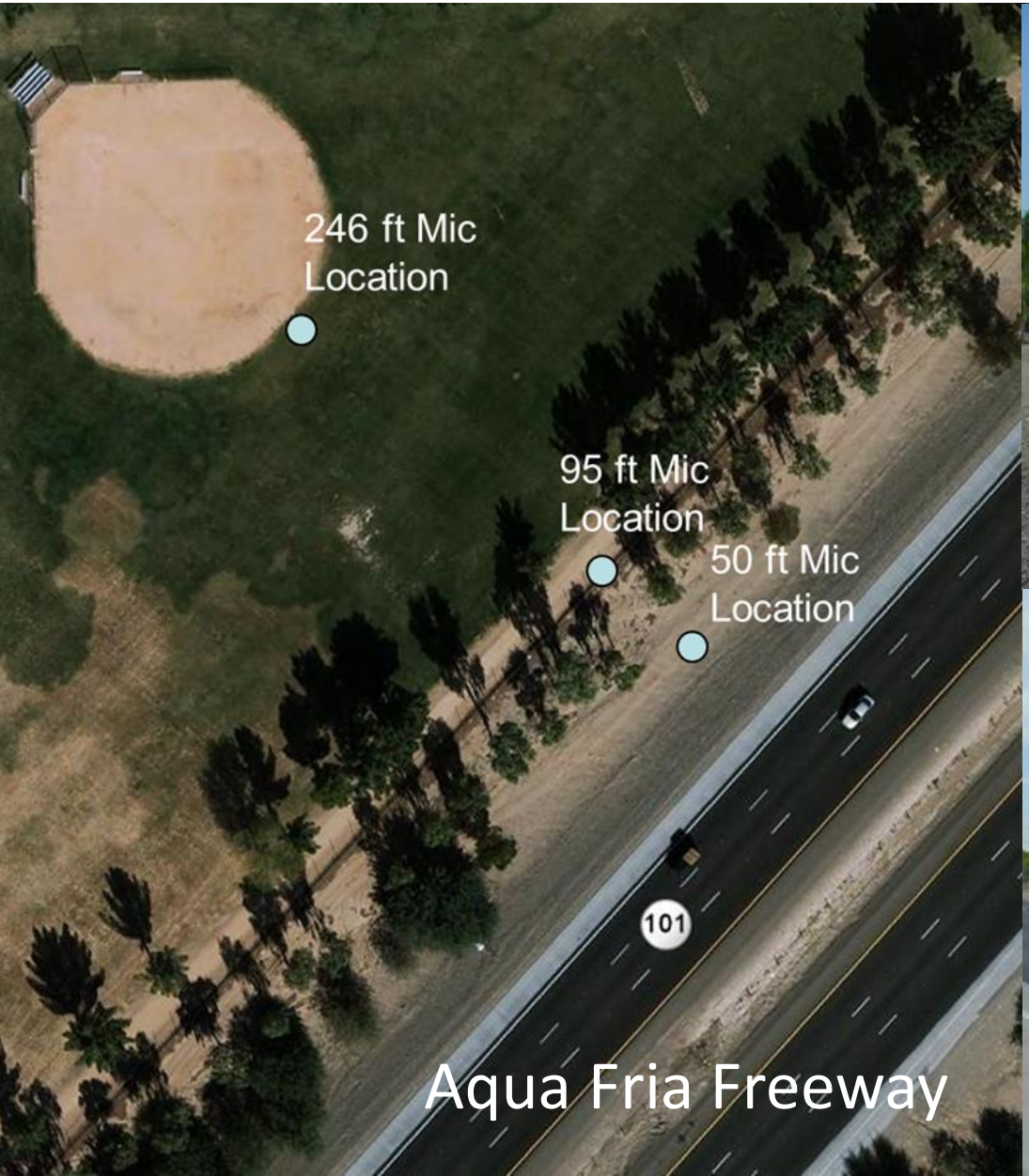


- 50 ft common to all 5 Sites
- 100 ft (or 95 ft) common
- 4 Sites with varying further distances

Type 3 Measurements at Site 3A on SR 101

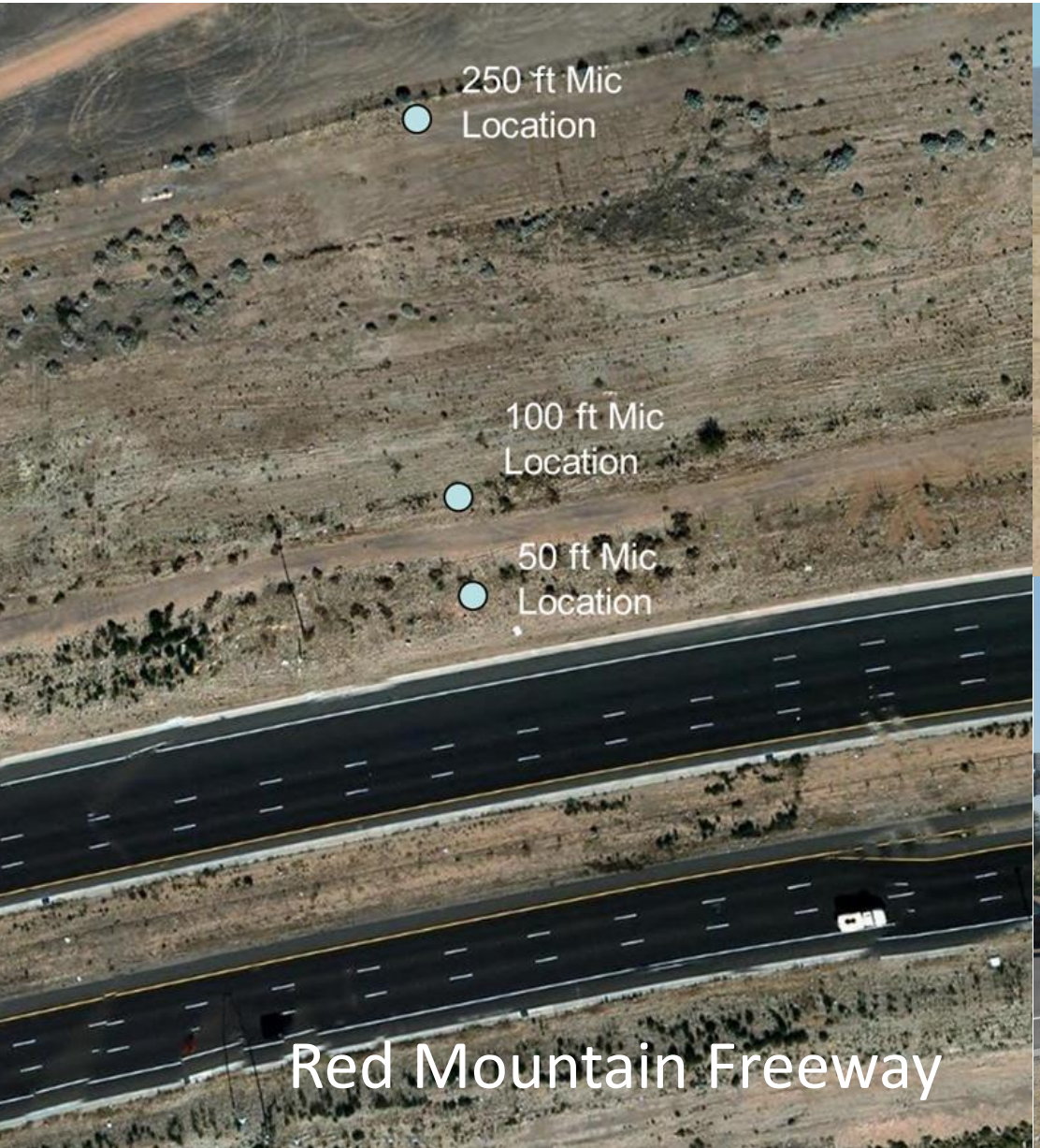


Type 3 Measurements at Site 3B on SR 101

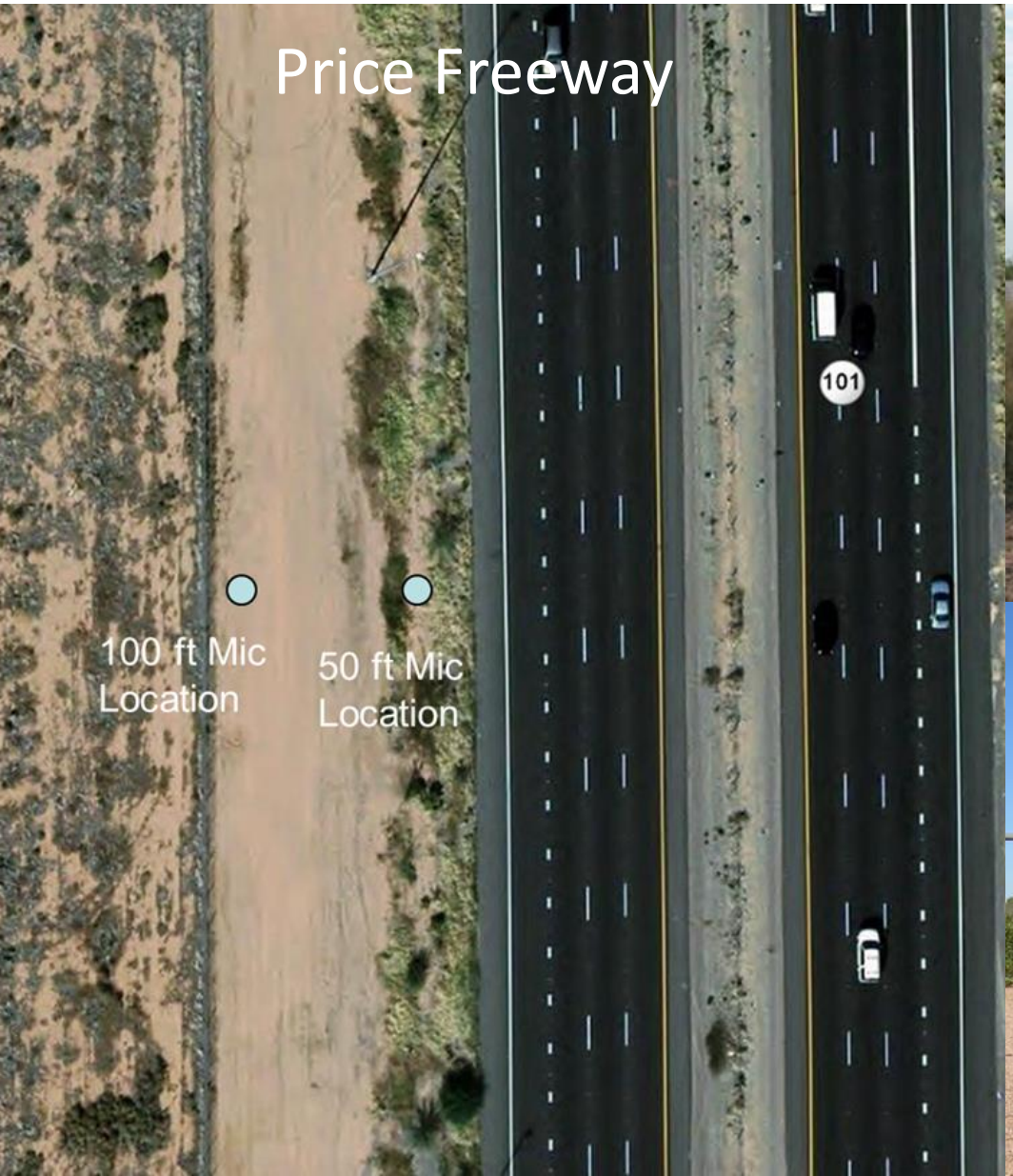


Type 3 Measurements at Site 3C on I-10

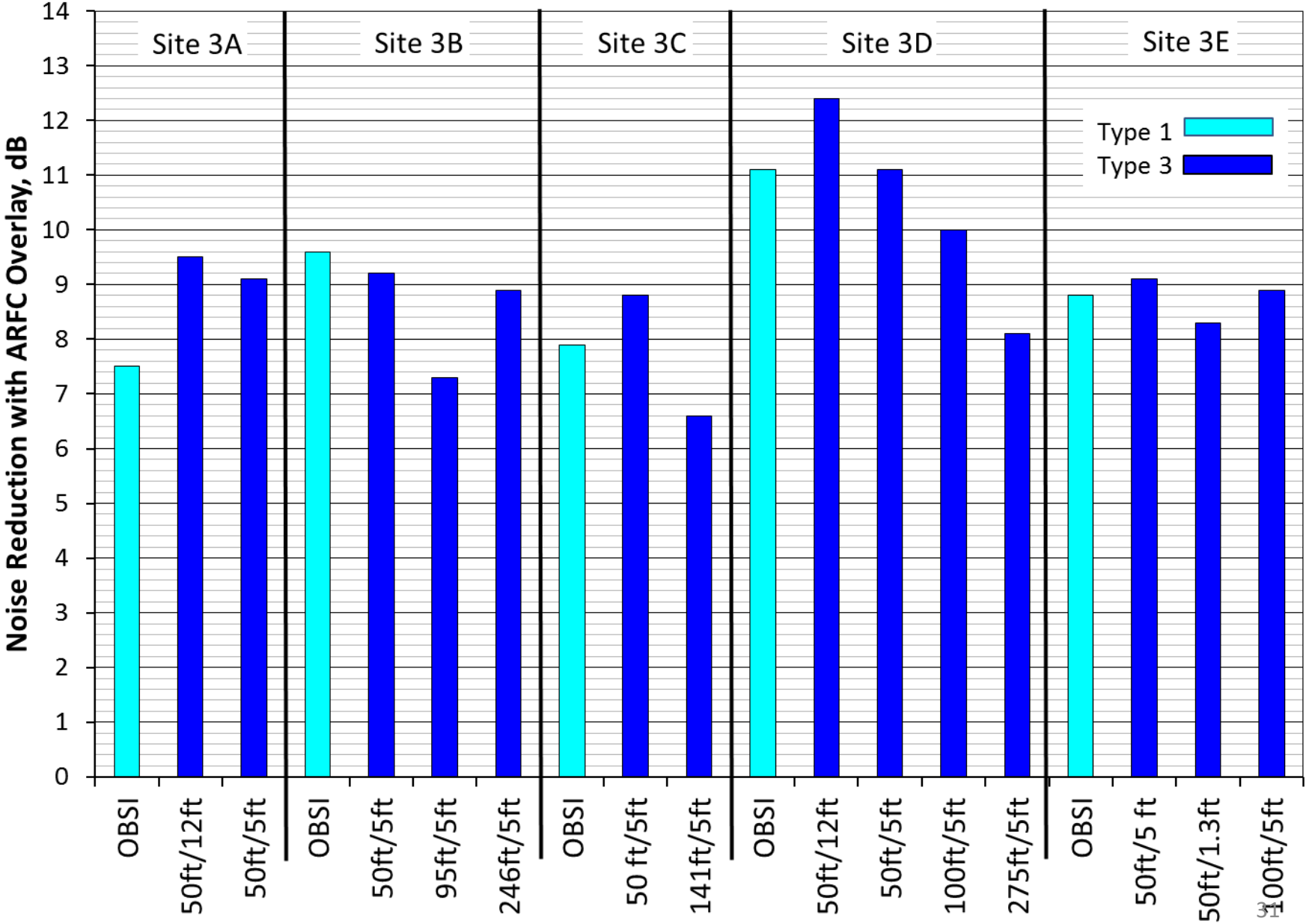
Type 3 Measurements at Site 3D on SR 202



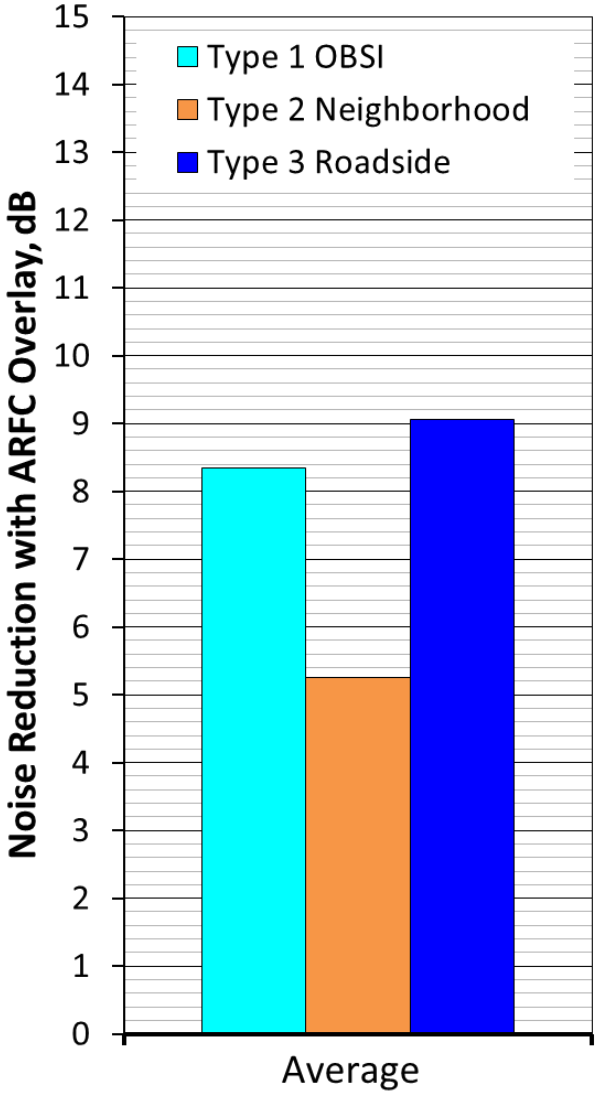
Type 3 Measurements at Site 3E on SR 101



Initial Type 3 Measurement Results



Comparison of Noise Reductions for Measurement Types



- Type 1 & 3 noise reductions within ½ dB at 50 ft distance & ¾ dB averaged over distance
- Type 2 noise reductions 3 to 4 lower than Type 1 & 3
- Why didn't they "correlate"?

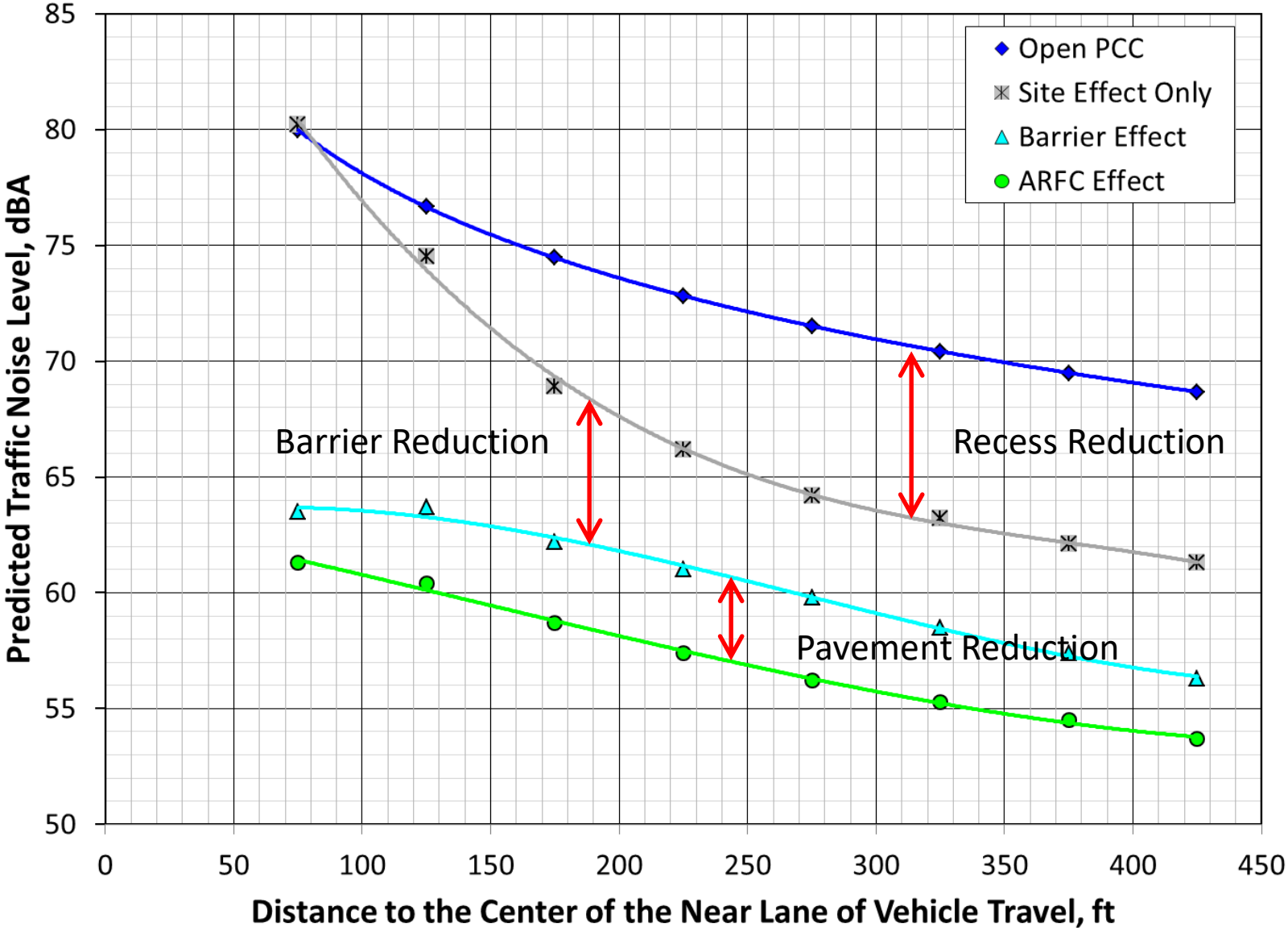
Common Type 2 Measurement Site

Freeway Opposite of Measurement Site

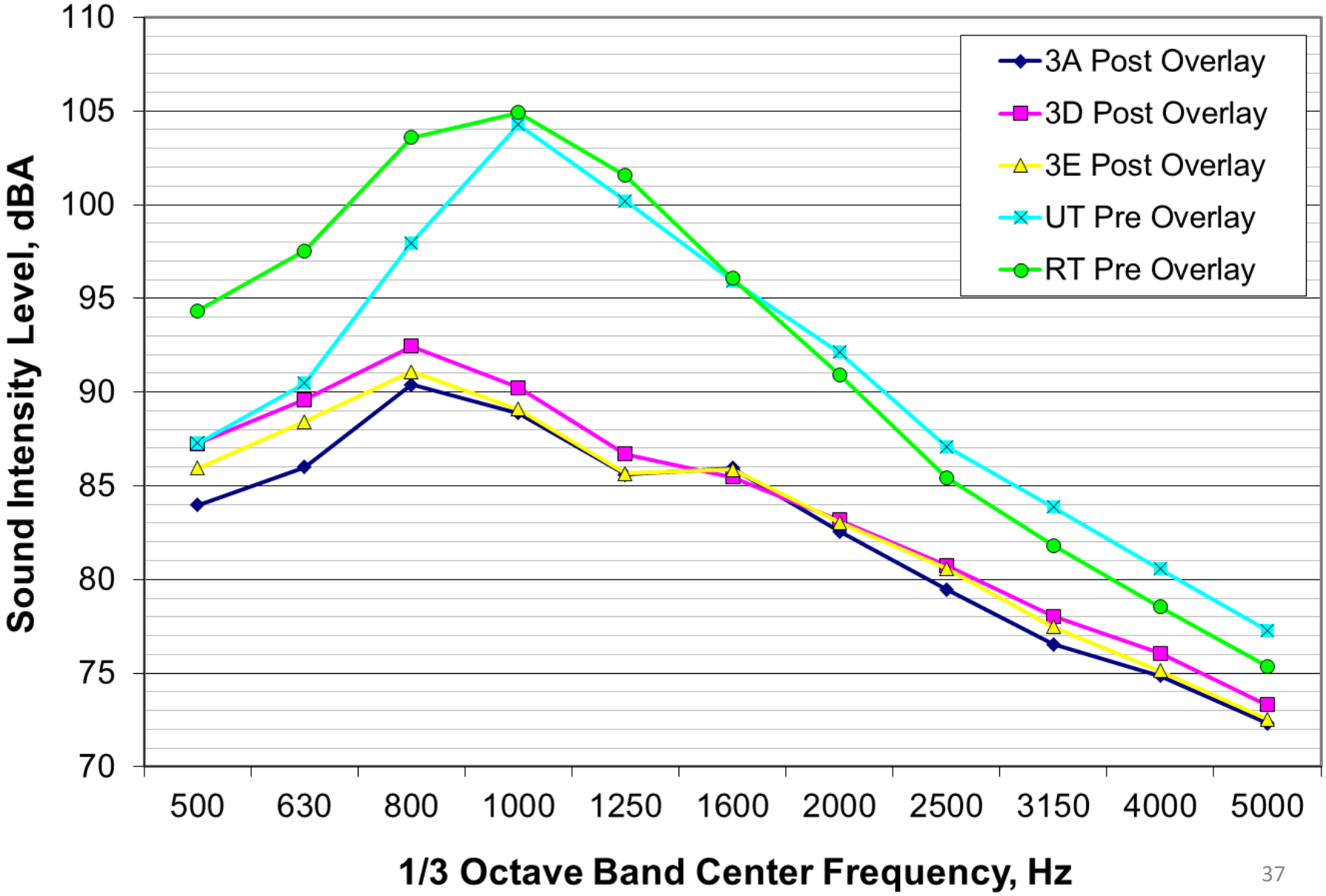
Analysis of Type 2 Sites

- Categorized site geometries
- Modeled in TNM
- Applied additional reduction due to ARFC
  - Research version of TNM
  - Use OBSI levels to adjust for actual pavement

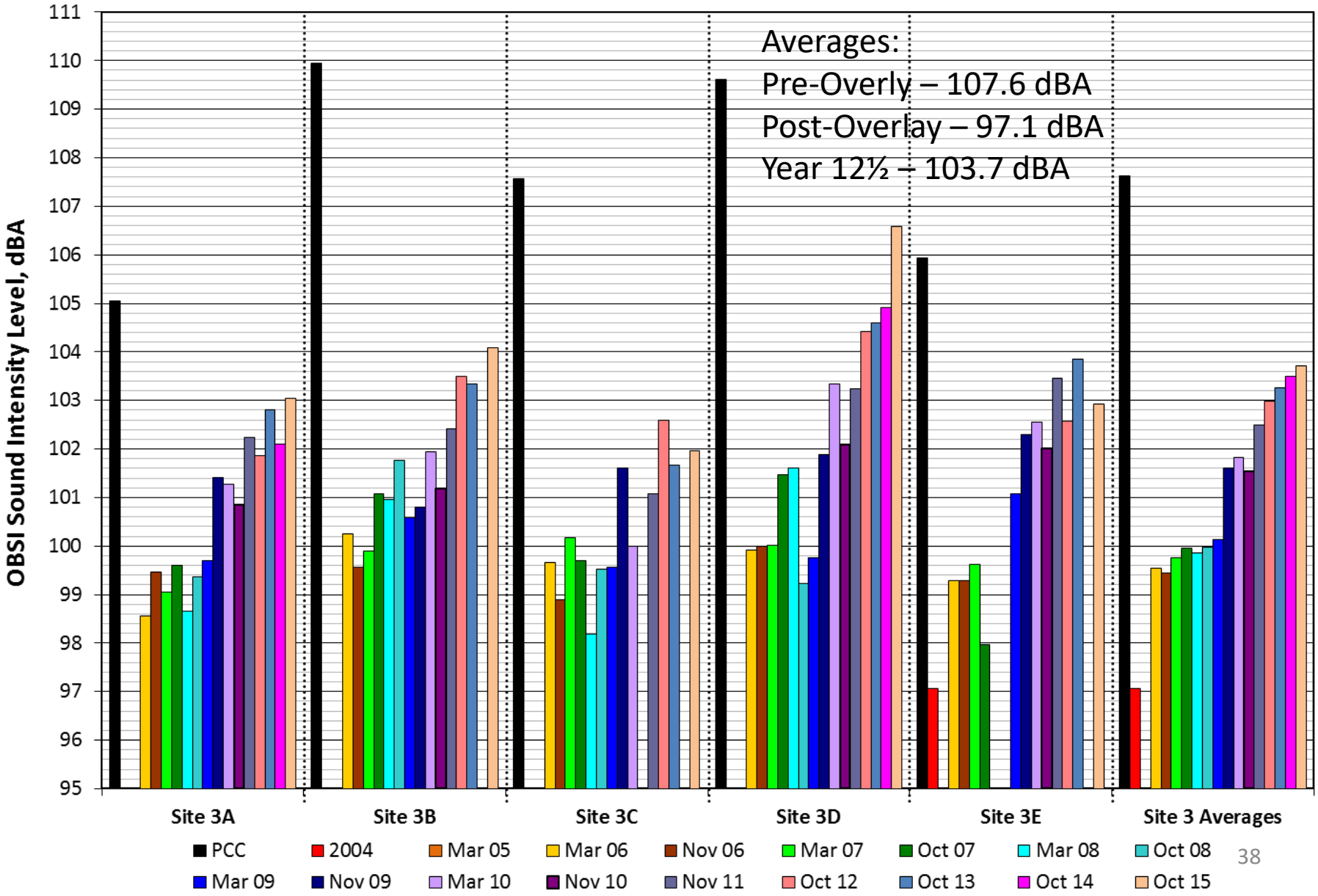
Freeway Recessed 12ft with 12ft Barrier Located 70ft from Near Lane



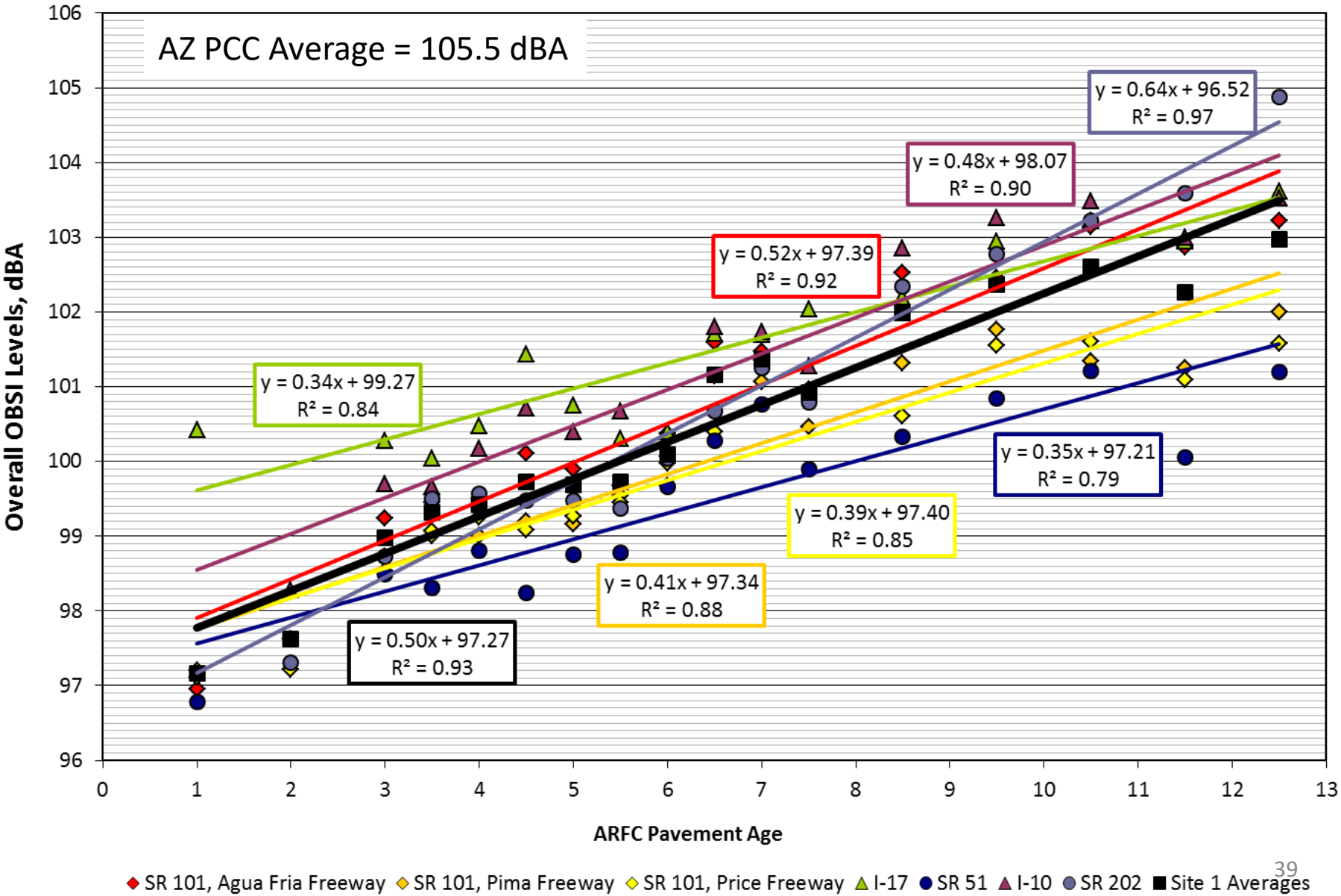
Initial Type 1 Results



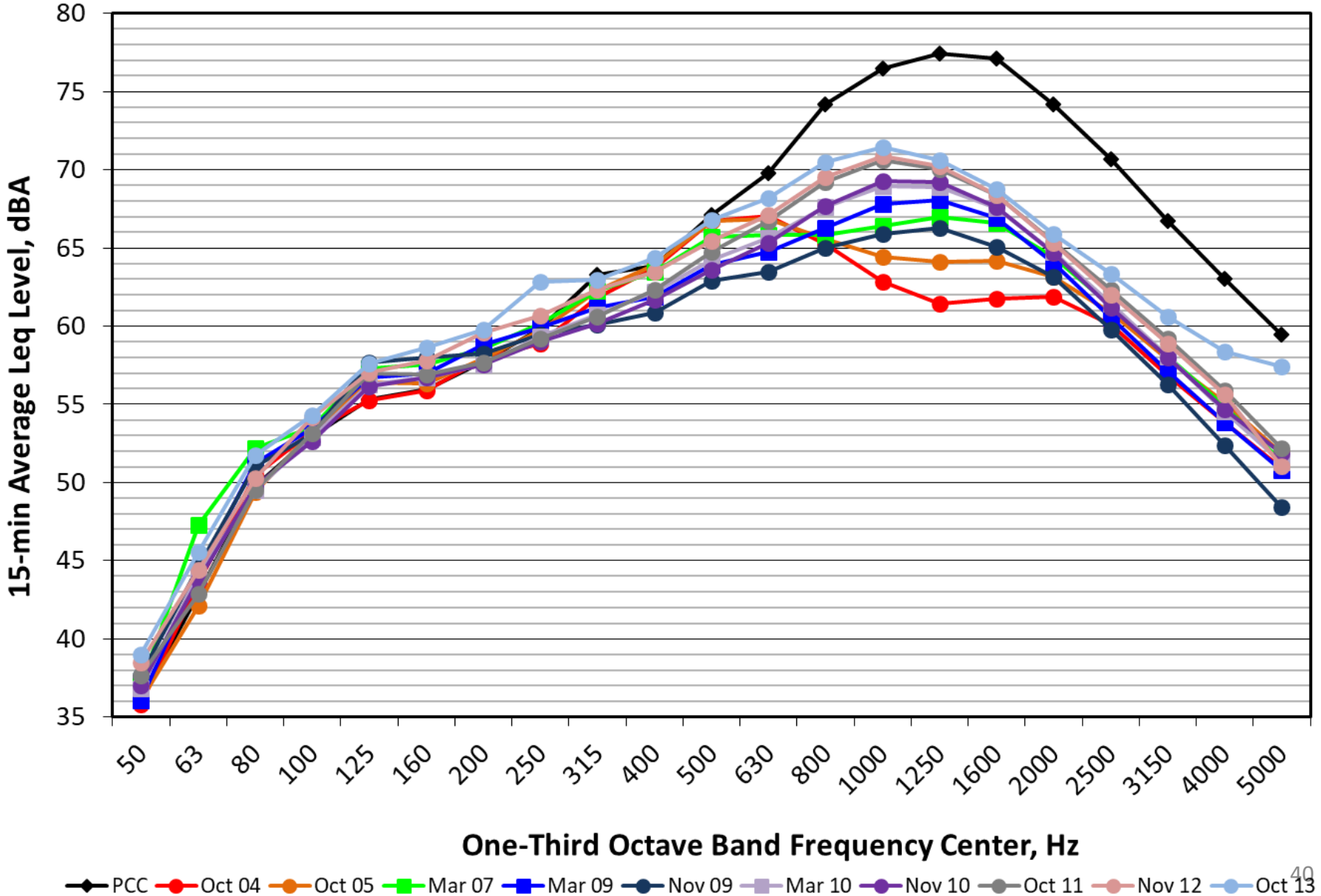
Type 1 Results at Type 3 Sites



Type 1 Results – All Freeways

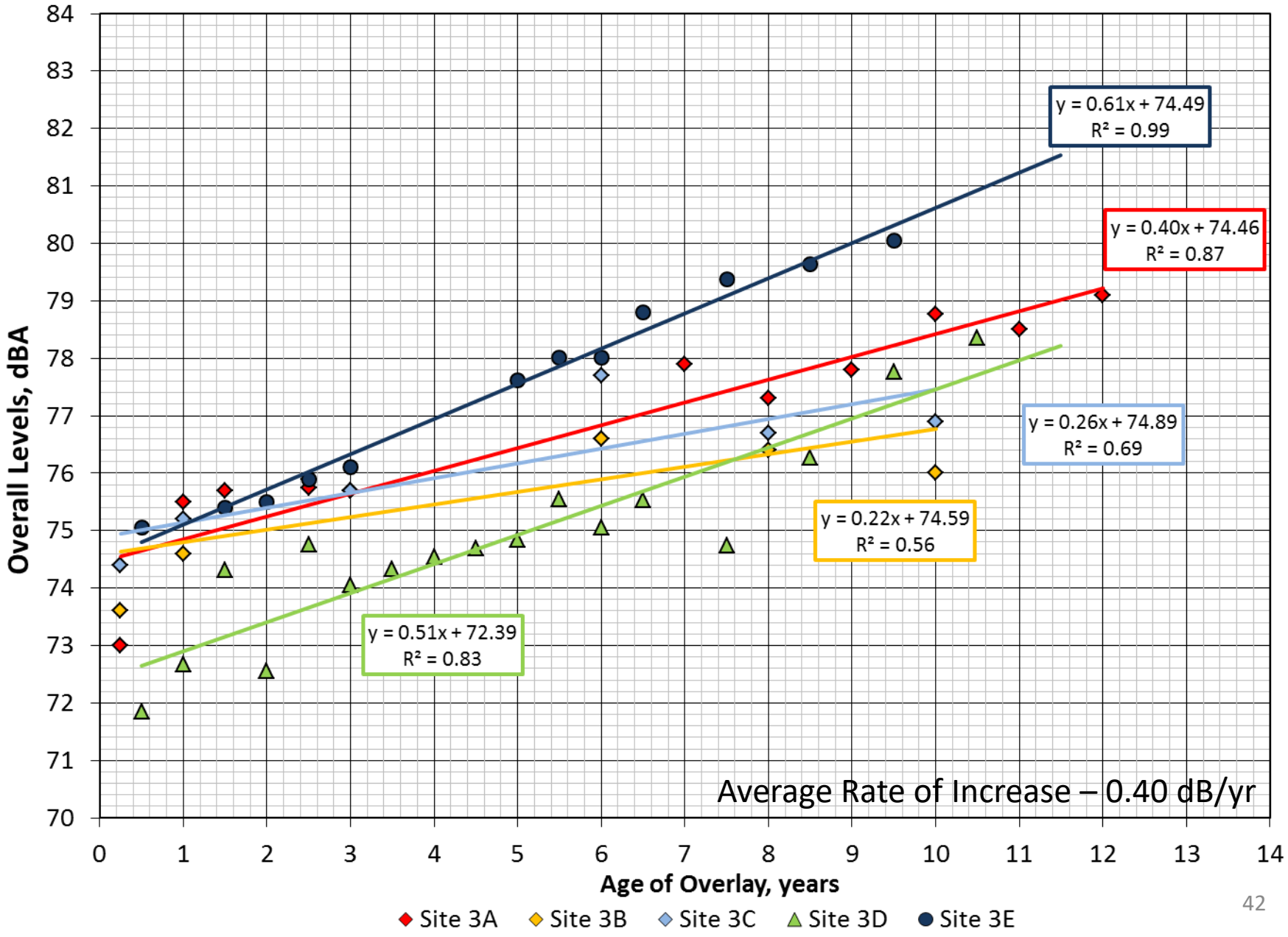


Site 3E Results

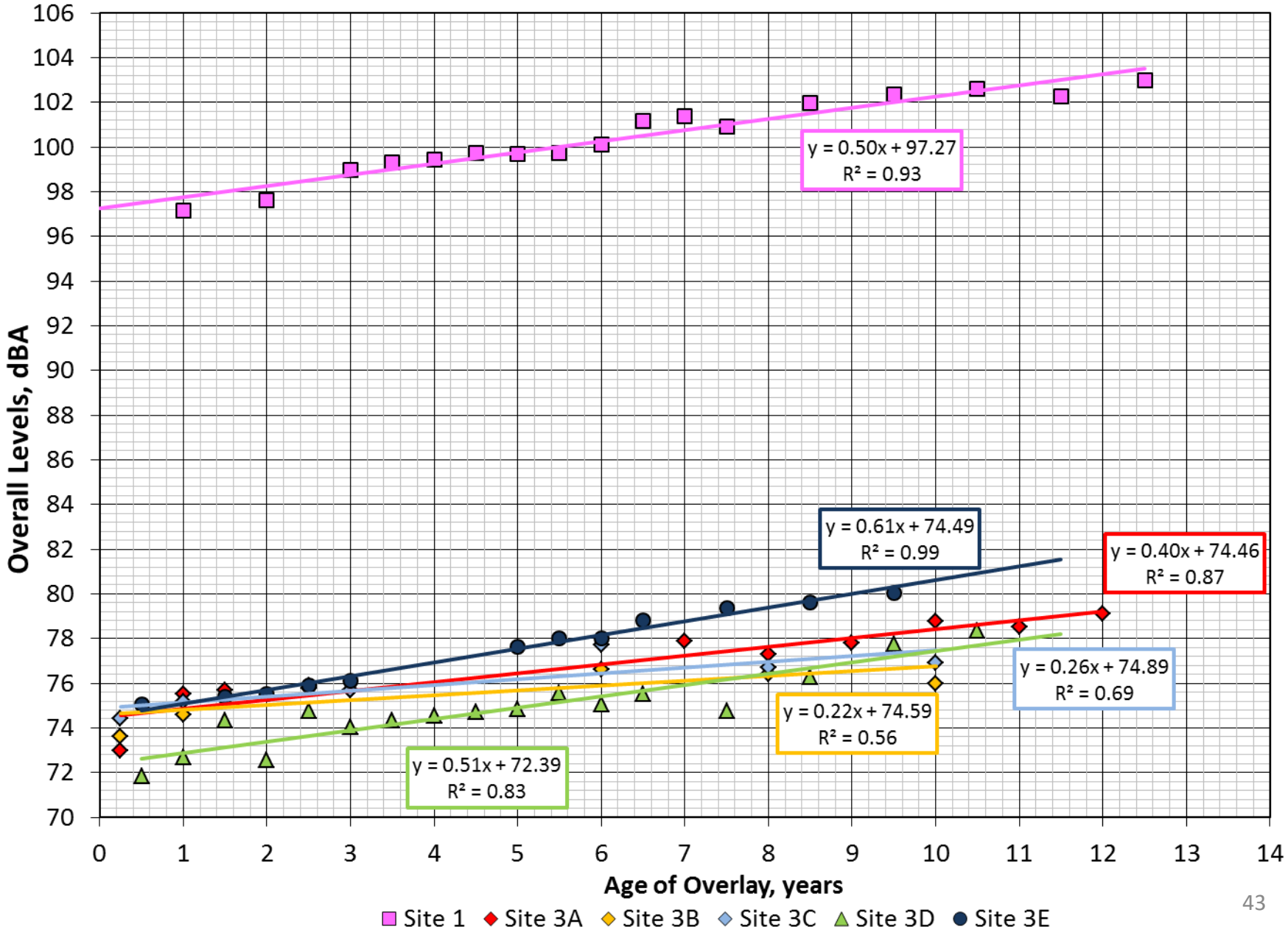


Traffic Noise & Pavement

Type 3 Site Noise Levels with Age



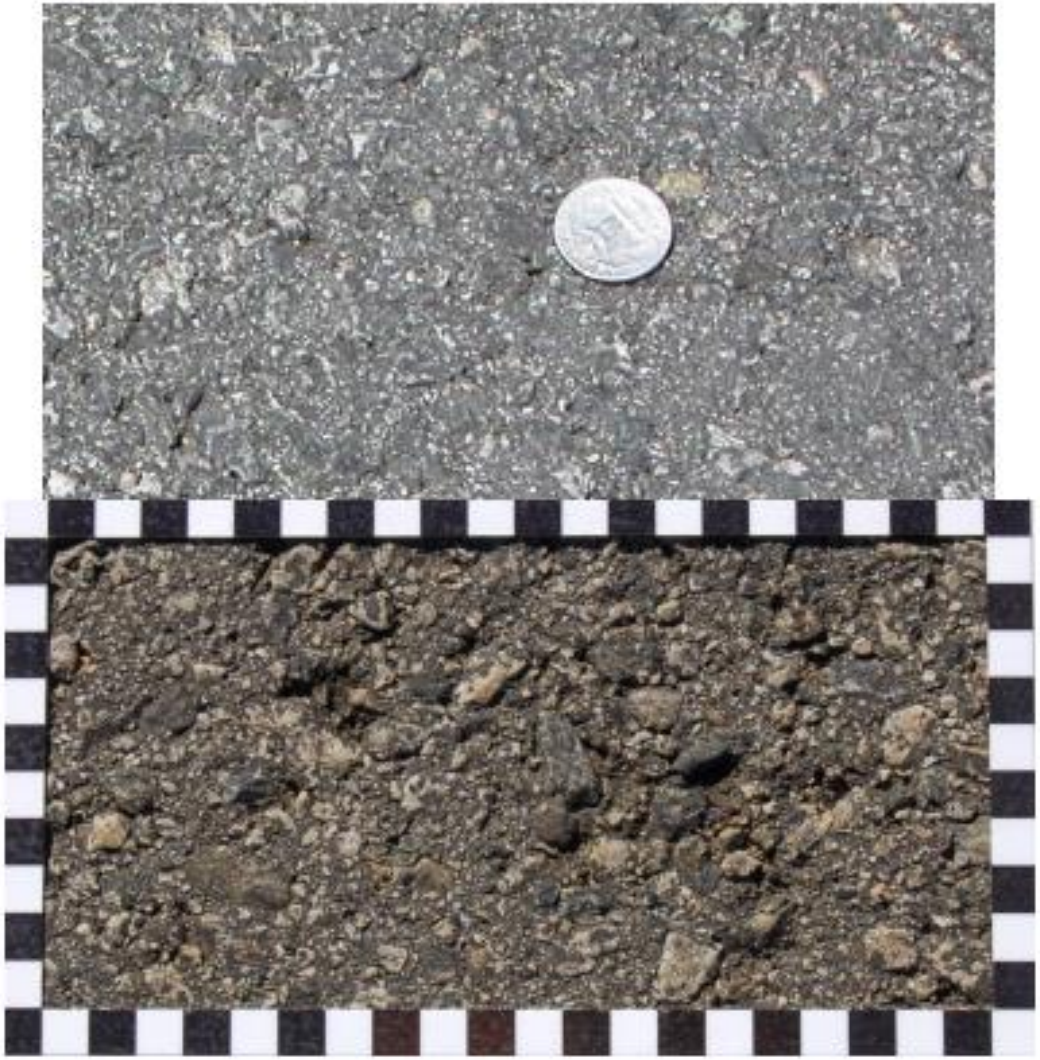
Type 1 & Type 3 Site Noise Levels with Age



Type 3 Site Noise Reductions

	Site 3A	Site 3B	Site 3C	Site 3D	Site 3E
Initial Noise Reduction	9.3 dB	9.2 dB	8.8 dB	11.4 dB	9.1 dB
Final Noise Reduction during final testing period	3.2 dB after 12 years	6.8 dB after 10 years	6.3 dB after 10 years	4.8 dB after 10.5 years	4.2 dB after 9.5 years
Final Noise Comparison to TNM average at 10 years	1.1 dB	4.1 dB	3.2 dB	-1.6 dB	0.2 dB

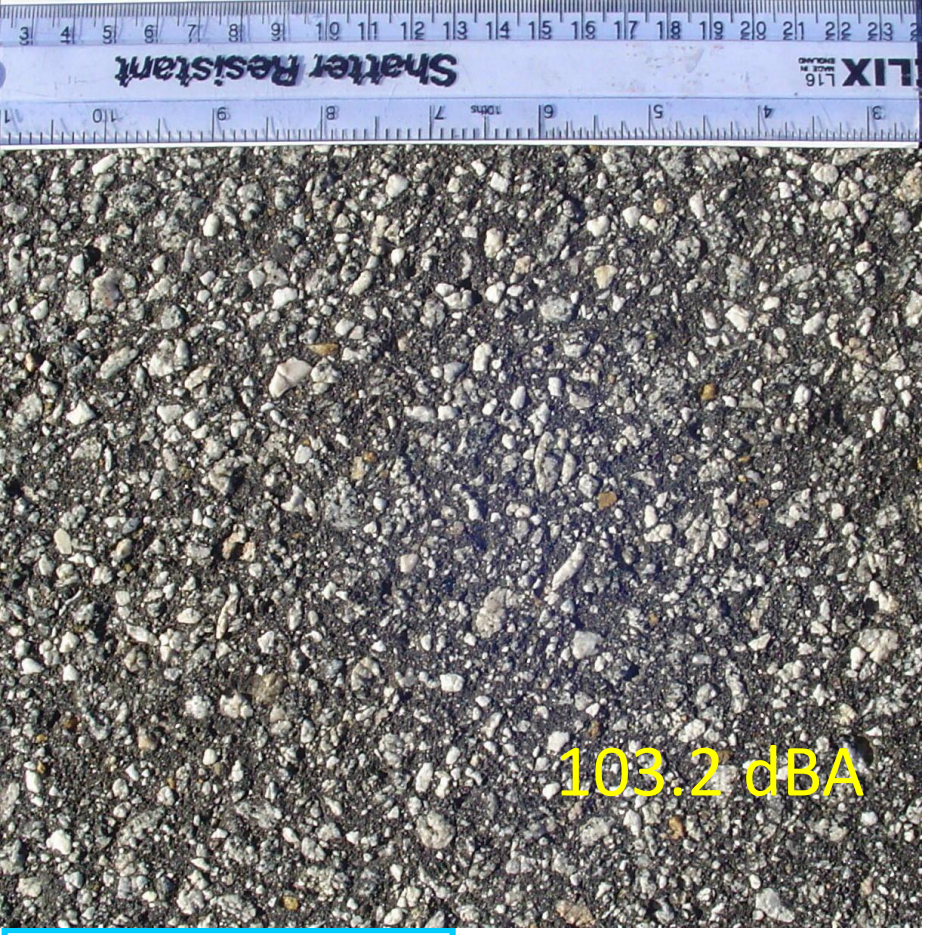
Acoustic Longevity – Why Do Pavements Get Noisier?



2002
100 dBA

2008
102 dBA

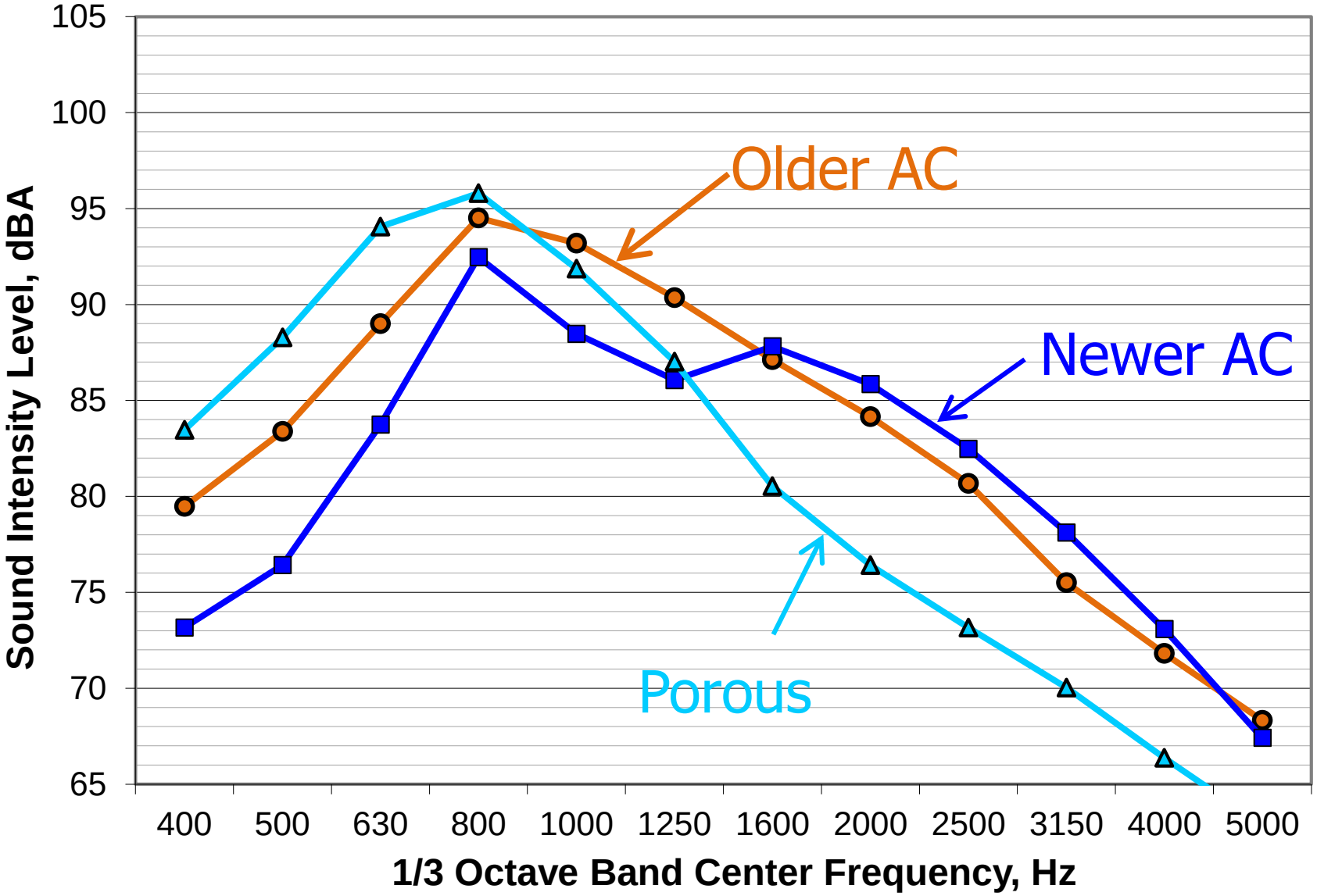
Different?



The Old
9.5 mm Max
Aggregate

The New
9.5 mm Max
Aggregate

9.5mm AC Pavement Aging



Worn Pavements

Accelerated Wear

Natural Wear

Worn Pavements

Accelerated

Natural Wear

QPPP Site 3D After 8 Years

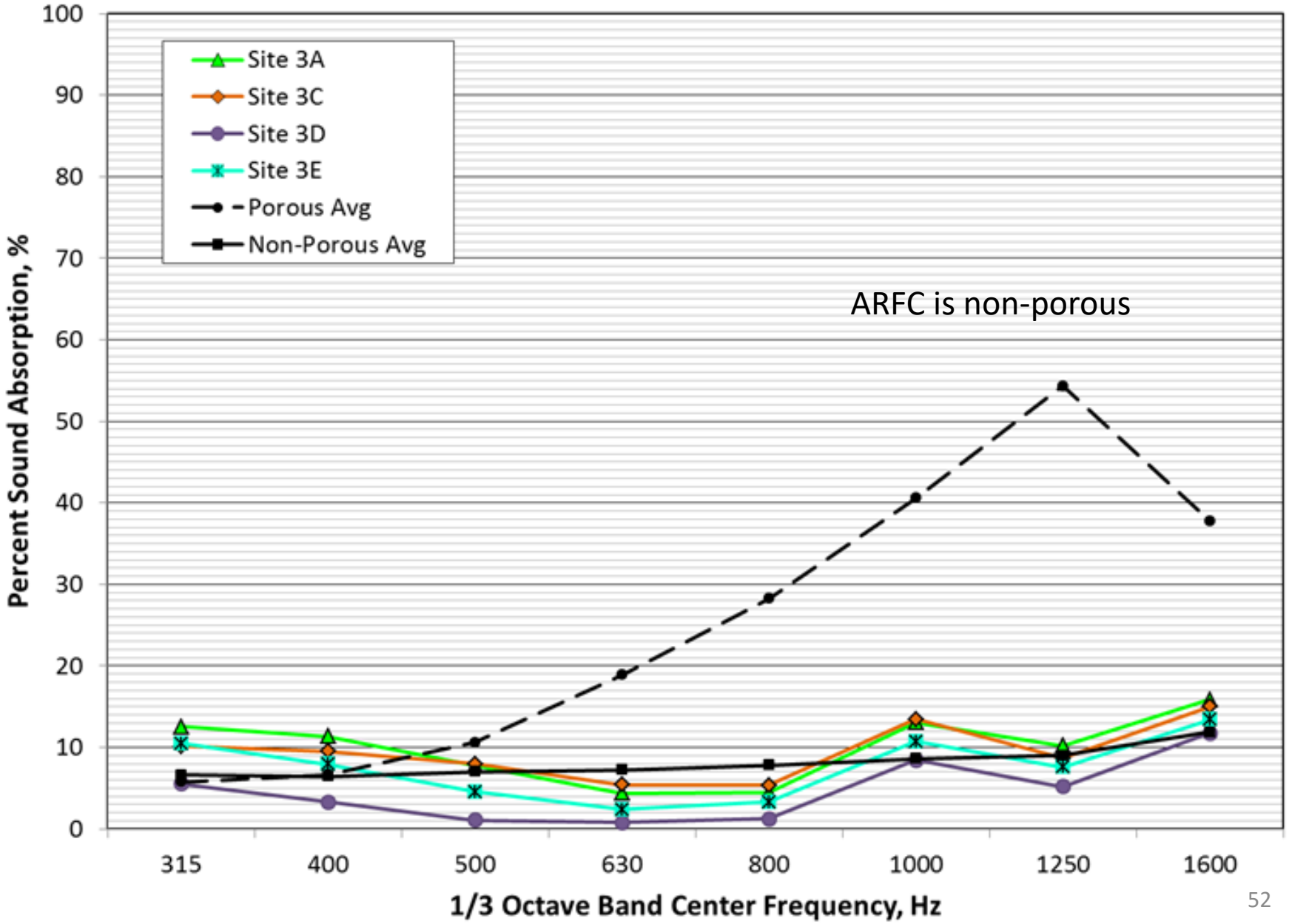
2004

2012

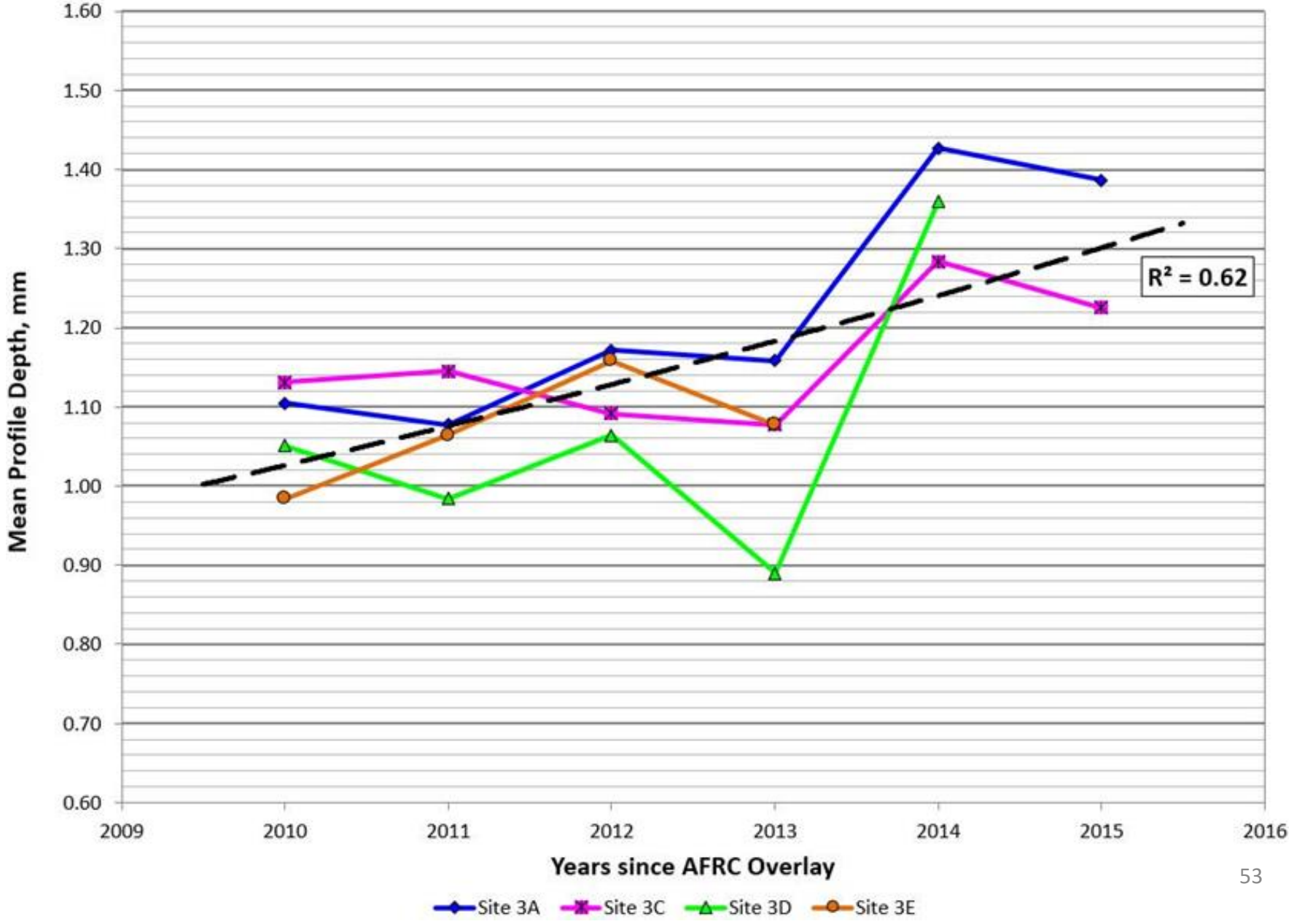
Other Topics Covered in Final Report

- Pavement sound absorption
  - Effective flow resistance (EFR)
  - Acoustic impedance measurement
- Mean profile depth
- Acoustic longevity of Casa Grande Asphalt Test Sections
- Measurement Performance of PCC textures
  - Random Transverse Tine
  - Uniform Transverse Tine
  - Longitudinal Tine
  - Diamond “Whisper” ground

Sound Absorption



Mean Profile Depth vs Age



Summary

- The QP3 produce significant reduction in wayside traffic noise – 9.6 dB on average
- At the end of monitoring, the reduction was still averaging 5.1 dB
- Wayside noise increase at an average rate of 0.4 dB/year & tire/pavement source levels at 0.5 dB/year
- At the end, levels averaged 1.4 dB lower than TNM predictions

https://apps.azdot.gov/files/ADOTLibrary/publications/project_reports/pdf/spr577-2.pdf

Quieter Pavement

- Lower initial cost than barriers
- Larger area of reduction
- Can be used anywhere
- Noise levels increase over time
- Maintaining performance requires periodic rehabilitation

How Do You Trade These Off?

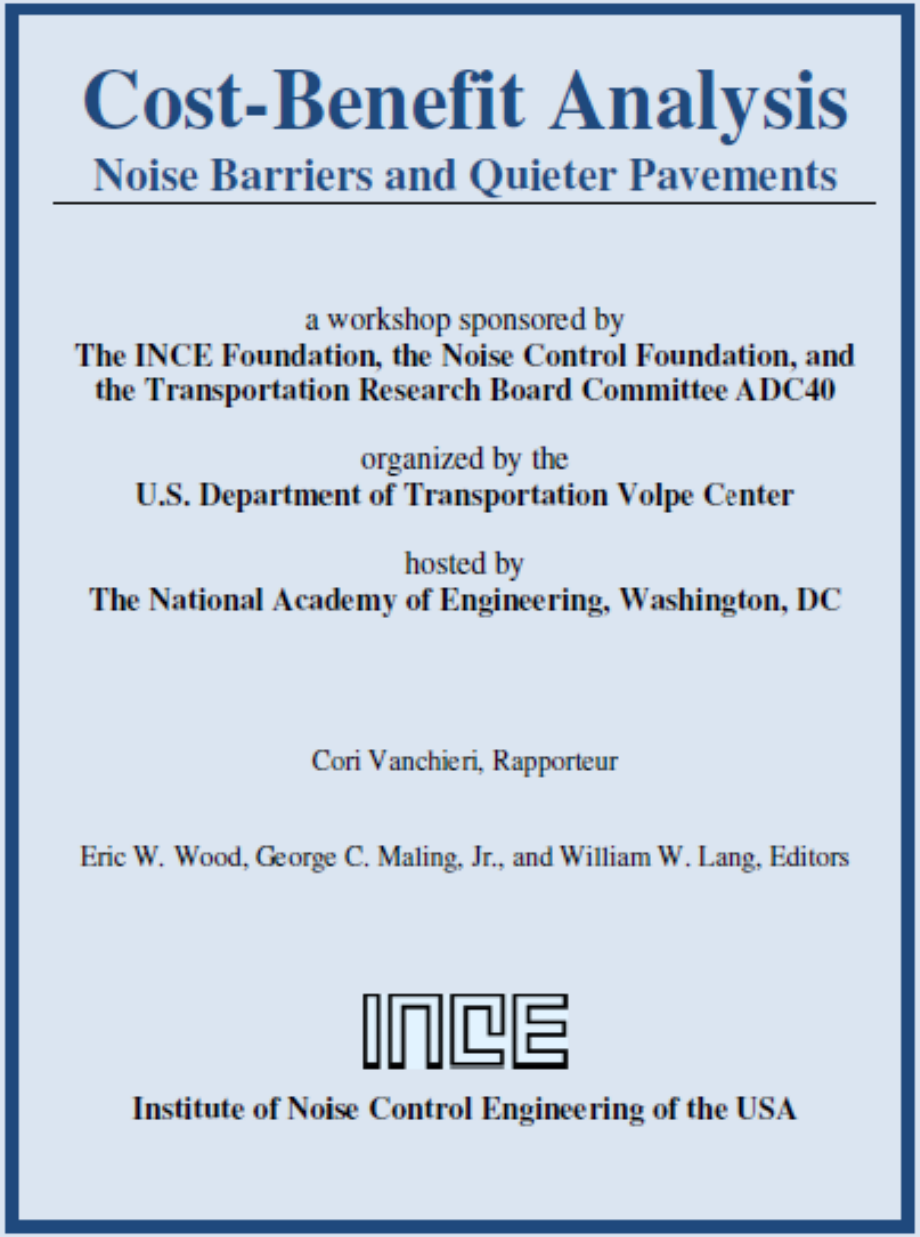
- Pavement noise data
  - Initial expected performance
  - Longevity performance
- Barrier performance
  - How high (& square meters)
  - Extent of reduction
- Cost data
  - Initial
  - On-going

Goals & Analysis

- Determine the noise reduction goal
- Model the acoustic performances of all approaches
  - Barrier or pavement
  - Combined
- Apply Life Cycle Cost Analysis
- Select the lowest overall cost with the most reduction & impact

Example Implementation Approach

https://inceusa.org/publications/technology-for-a-quieter-america/#cost-benefit



Cost-Benefit Analysis

Noise Barriers and Quieter Pavements

a workshop sponsored by
The INCE Foundation, the Noise Control Foundation, and the Transportation Research Board Committee ADC40

organized by the
U.S. Department of Transportation Volpe Center

hosted by
The National Academy of Engineering, Washington, DC

Cori Vanchieri, Rapporteur

Eric W. Wood, George C. Maling, Jr., and William W. Lang, Editors

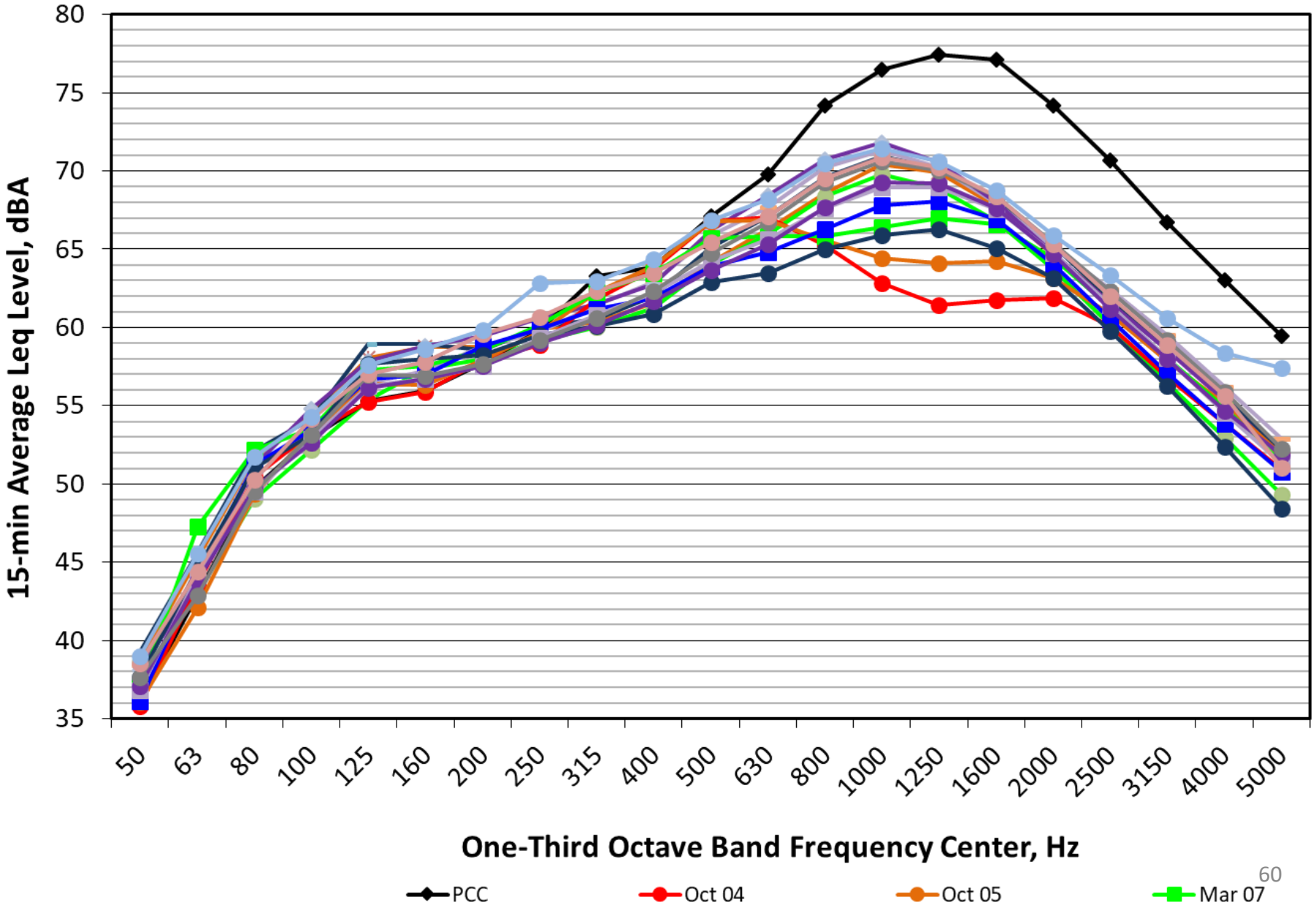
INCE

Institute of Noise Control Engineering of the USA

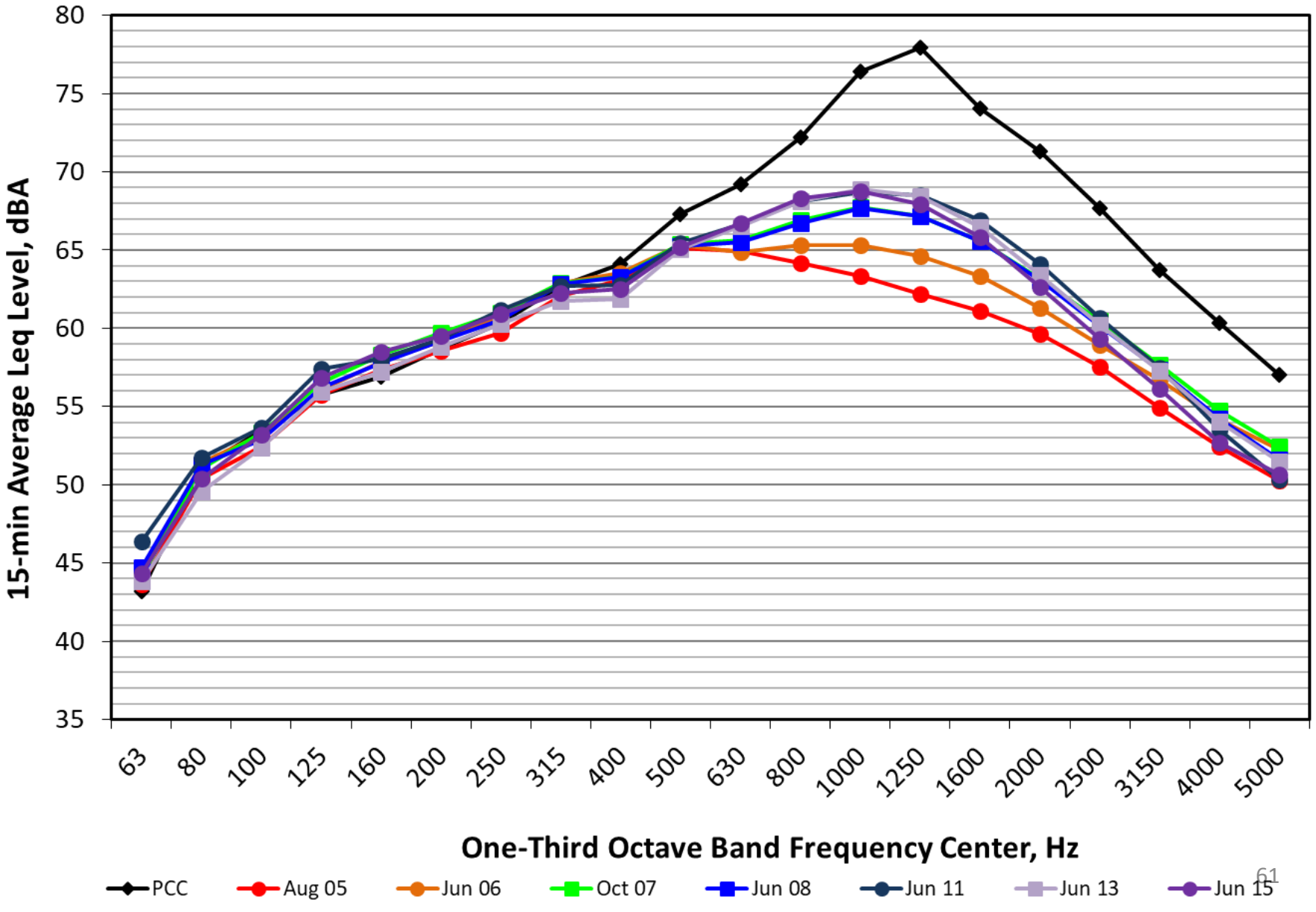
Thank You

For Your Attention

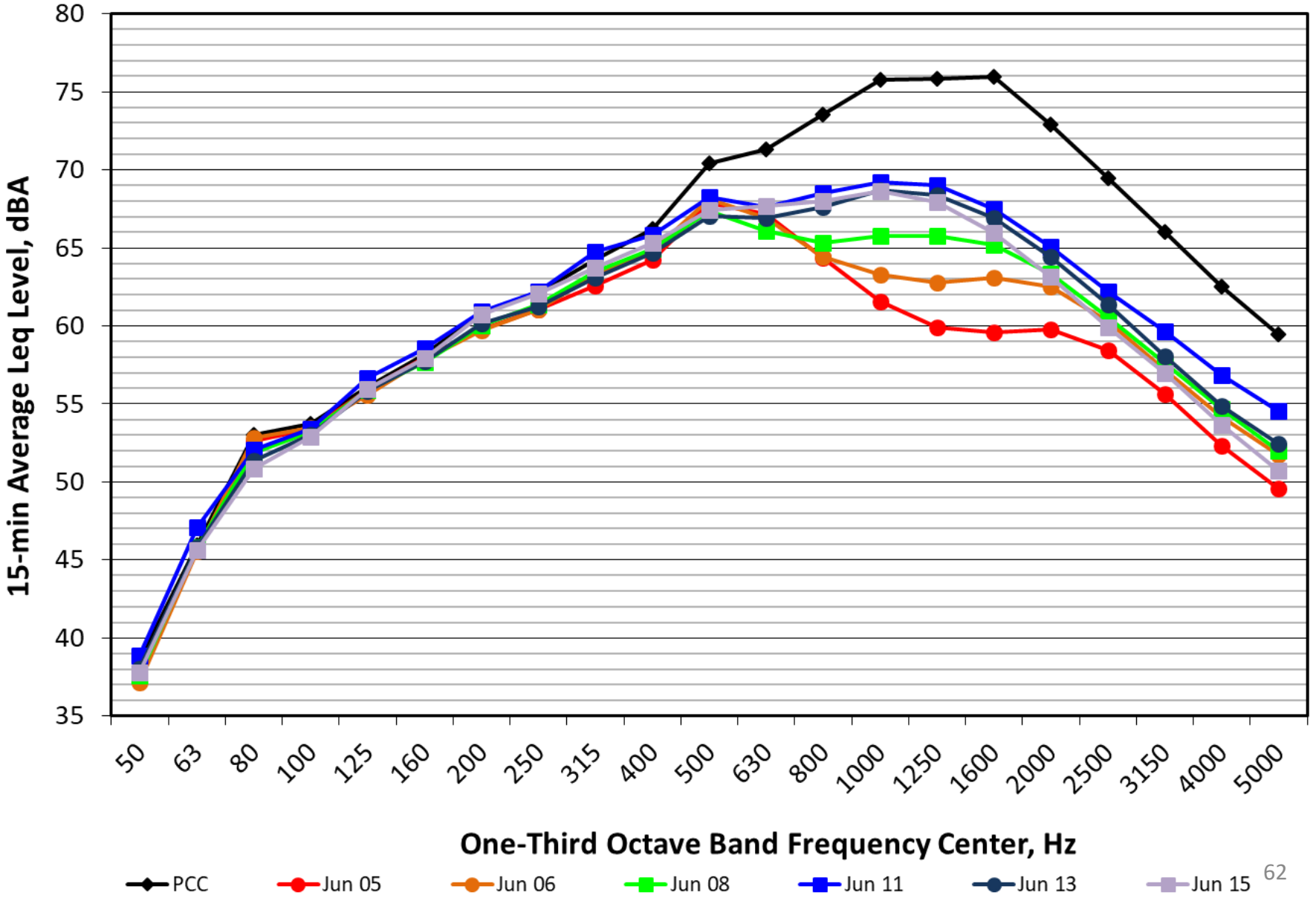
Site 3A Results



Site 3B Results



Site 3C Results



Site 3D Results