Volpe Center Updates on Tire/Pavement Noise Studies

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Outline

- **Variability of pavement noise benefit by vehicle type**
  - **Caltrans LA 138 study**
- **Pavement effects as a function of distance**
  - **FHWA Traffic Noise Model® (TNM) analysis**
  - **ADOT QPPP data**
- **Current FHWA / Volpe projects**

VARIABILITY OF PAVEMENT NOISE BENEFIT BY VEHICLE TYPE

LA 138 Quiet Pavement Study

- **Asphalt Concrete (AC) study funded by Caltrans**

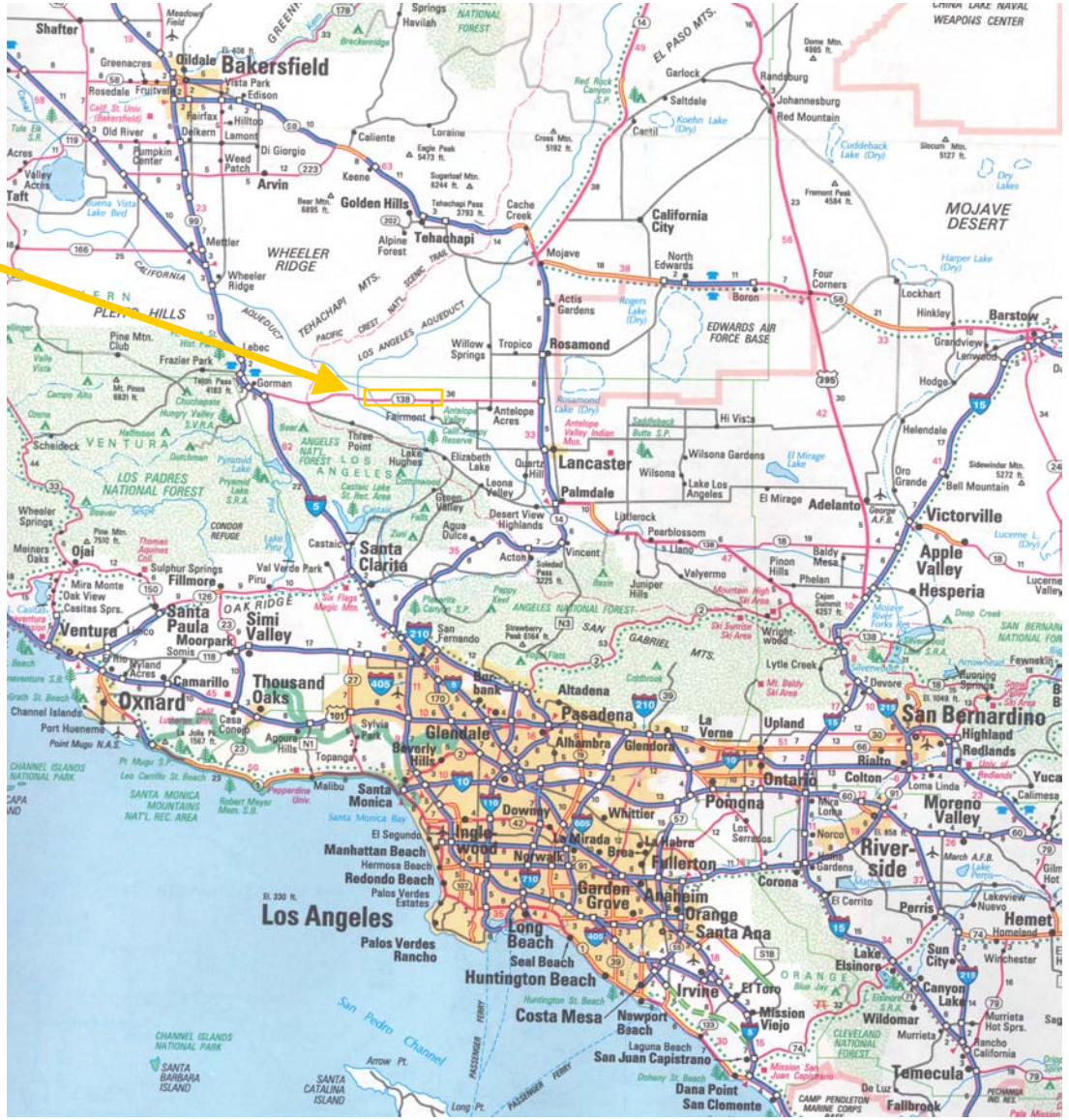
- **Primary sponsors:**
  - **Bruce Rymer**
  - **Jim Andrews**

Caltrans

LA 138 AC Pavement Study Location

- LA 138

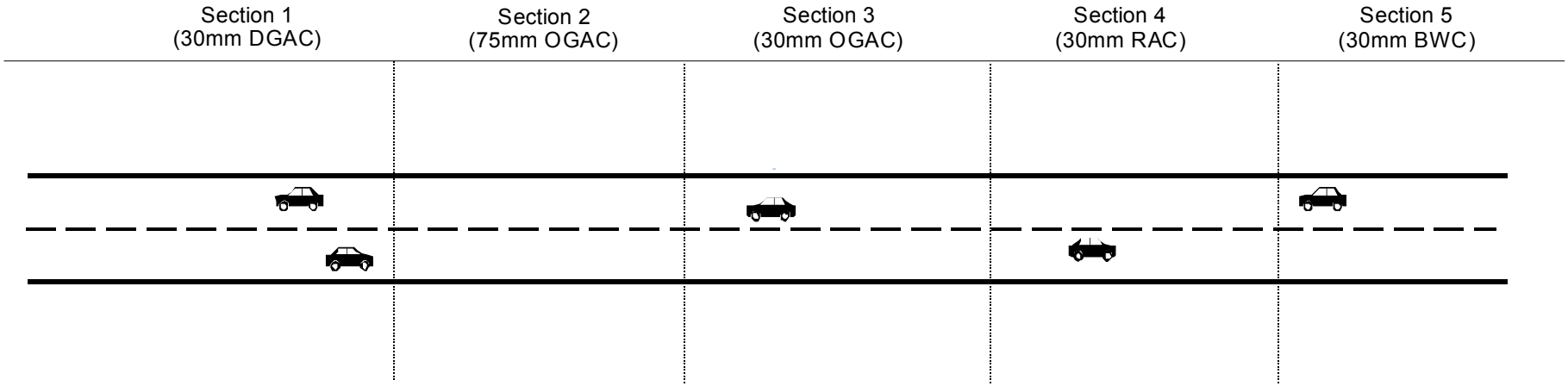
- ~4 mi (6.4 km) relatively flat desert area
- ~80 mi (~130 km) north of Los Angeles, CA



Study Overview

- **Long-term study examining 5 asphalt pavements for durability, safety, and noise**
- **Wayside Measurements**
  - **Side of highway measurements at multiple distances and heights applying the Statistical Pass-By Method**
- **Source Measurements (Illingworth & Rodkin)**
  - **On-Board Sound Intensity measurements at the tire**
- **Analysis**
  - **Compare reference and test sections over time**
  - **Observe degradation of individual sections over time**

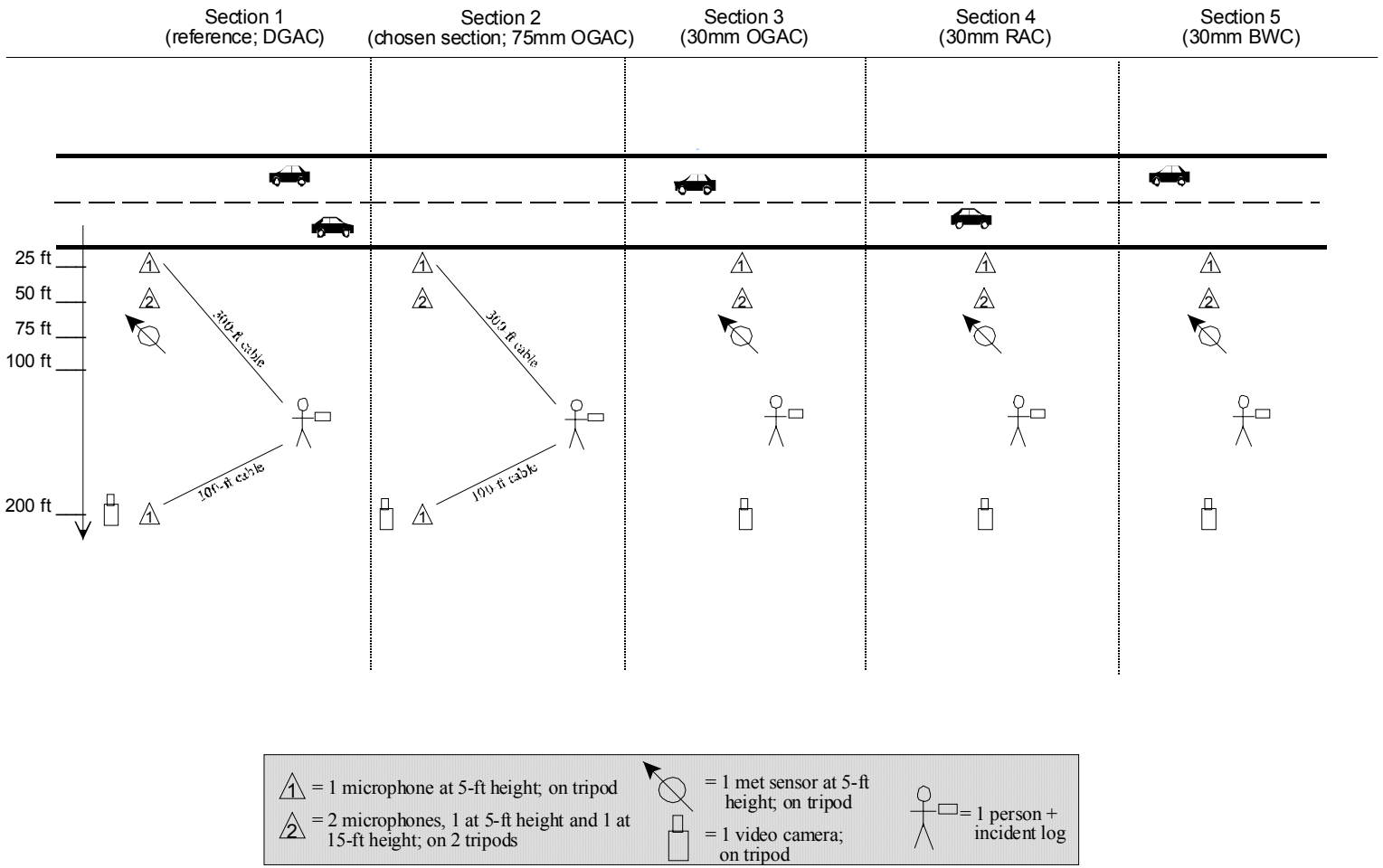
Pavement Sections



- **Five Pavement Types**
  - **S1 – Dense-Graded Asphalt Concrete (DGAC)**
  - **S2 – Open-Graded Asphalt Concrete (OGAC) 75 mm thickness**
  - **S3 – Open-Graded Asphalt Concrete (OGAC) 30 mm thickness**
  - **S4 – Rubberized Asphalt Concrete Type O (RAC type O)**
  - **S5 – Bonded Wearing Course (BWC)**

Wayside Measurements – instrumentation diagram

Caltrans Pavement Study: full set-up



Wayside Measurements – instrumentation

Data Collection

- **Baseline measurements (March 2002)**
  - Leveling course (DGAC in all sections) completed in December 2001
  - Allows for the determination of site bias
- **Subsequent measurements (with pavement overlays)**
  - October 2002 – pavement aged ~4 months
  - March 2003 – pavement aged ~10 months
  - October 2003 – pavement aged ~16 months
  - Planned for October 2006 – pavement aged ~ 52 months

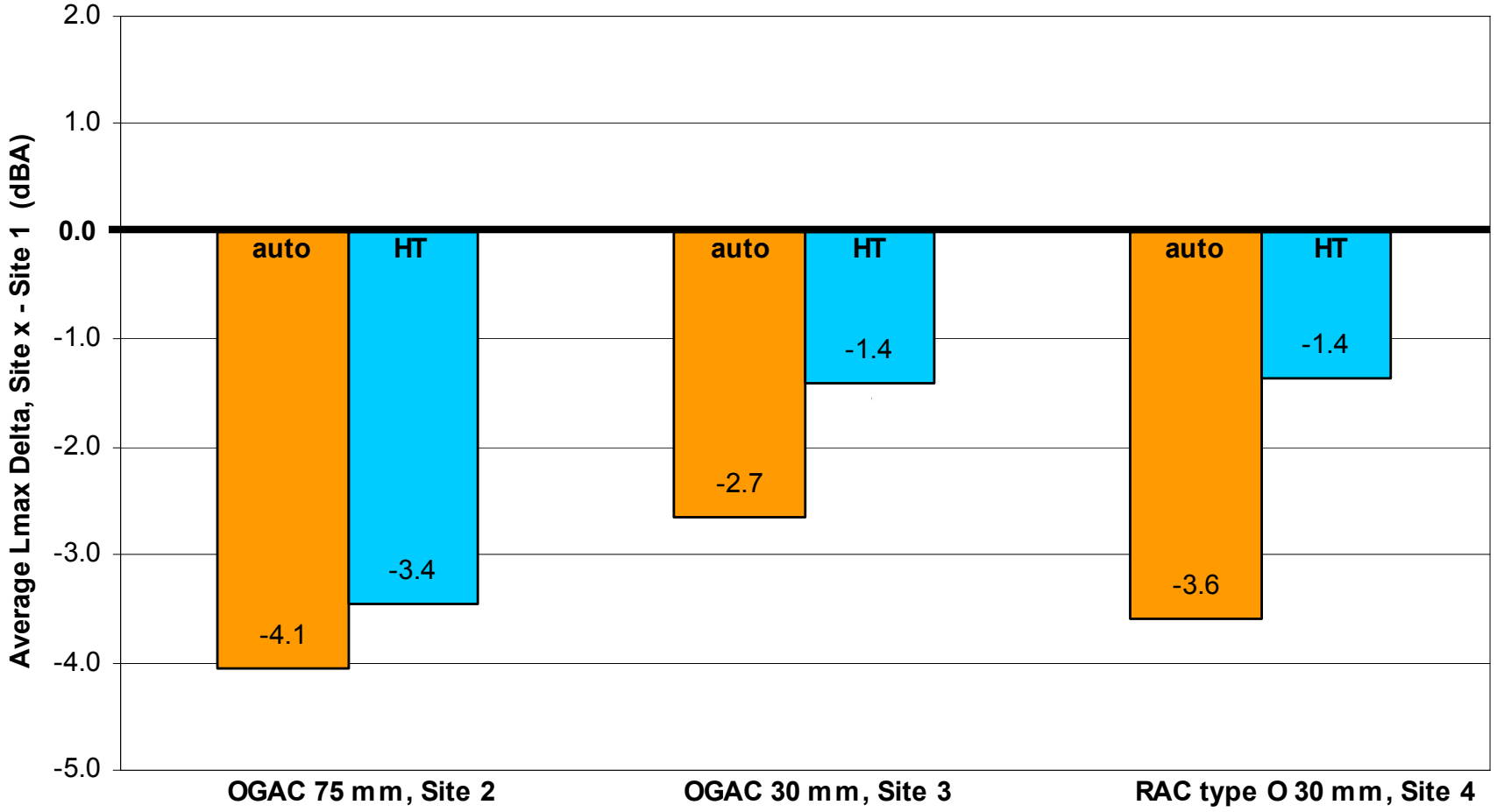
Data Analysis (part 1)

- **Modified Statistical Pass-By Method (ISO 11819-1)**
  - Accounts for autos, medium trucks, and heavy trucks
  - Calculate Lveh as average Lmax (dBA) for each vehicle type

- **Broadband paired pavement analysis**
  - Compares each of the quieter pavements to DGAC:
    - DGAC and 75mm OGAC
    - DGAC and 30mm OGAC
    - DGAC and RAC
  - Identical vehicle sets for paired data
  - Accounts for site bias
  - Will show paired noise reduction deltas for autos and heavy trucks (HT)

Results – broadband noise reduction by vehicle type

(comparing each of the quieter pavements to DGAC, 25 ft from road)



Results – broadband observations

For the pavements tested in this study …

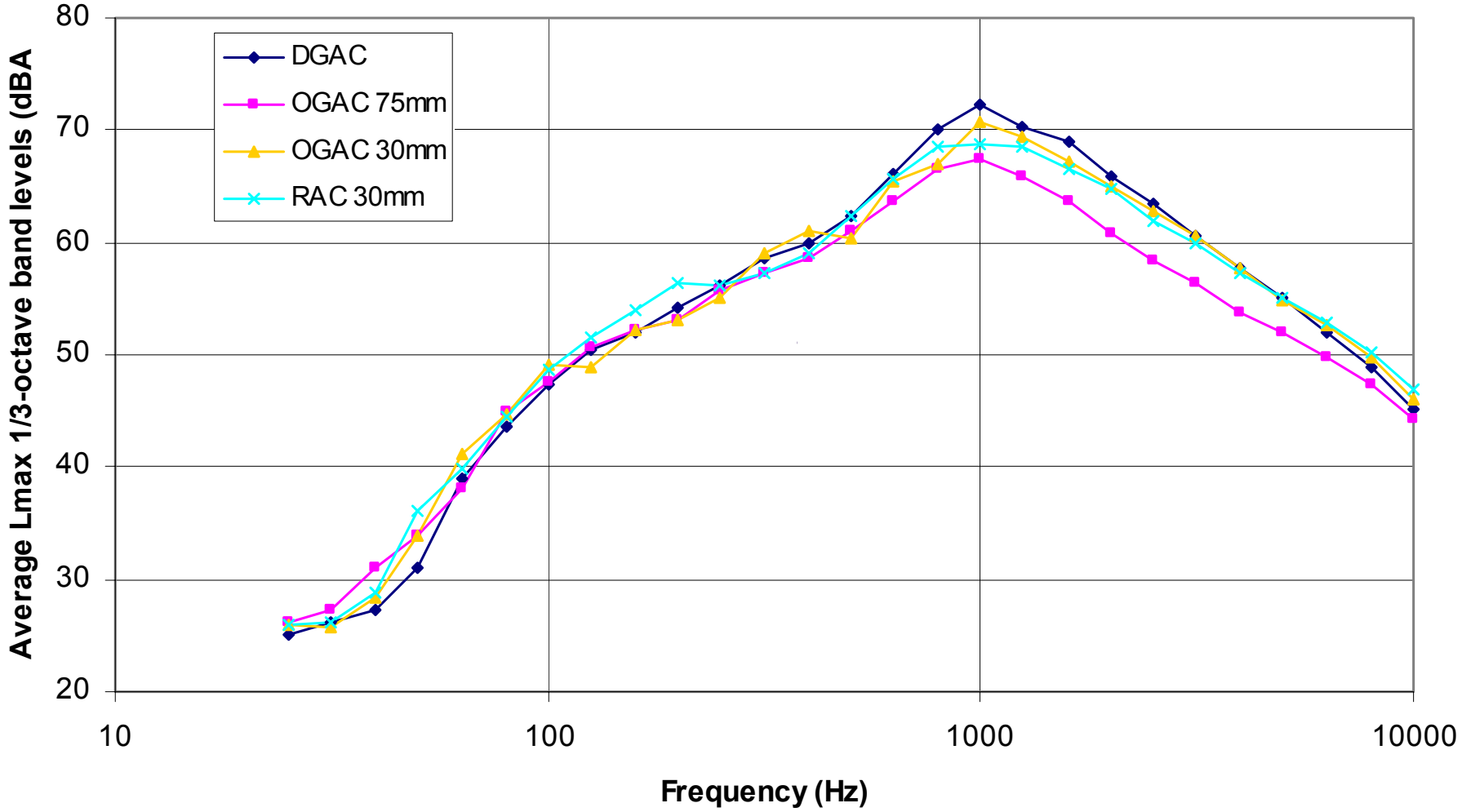
- **Quieter pavements provide a greater reduction for auto noise than heavy truck noise**
- **Increasing the thickness of OGAC overlay provides additional benefit for both autos and heavy trucks**
- **With the same thickness, RAC provides additional benefit over OGAC for autos**

Data Analysis (part 2)

- **Spectral "paired" pavement analysis**
  - **Directly compares four pavements:**
    DGAC, 75mm OGAC, 30mm OGAC, RAC
  - **Identical vehicle set for all sites**
  - **Does not account for site bias (too few baseline events)**
  - **Will show average measured levels for autos and heavy trucks (HT)**

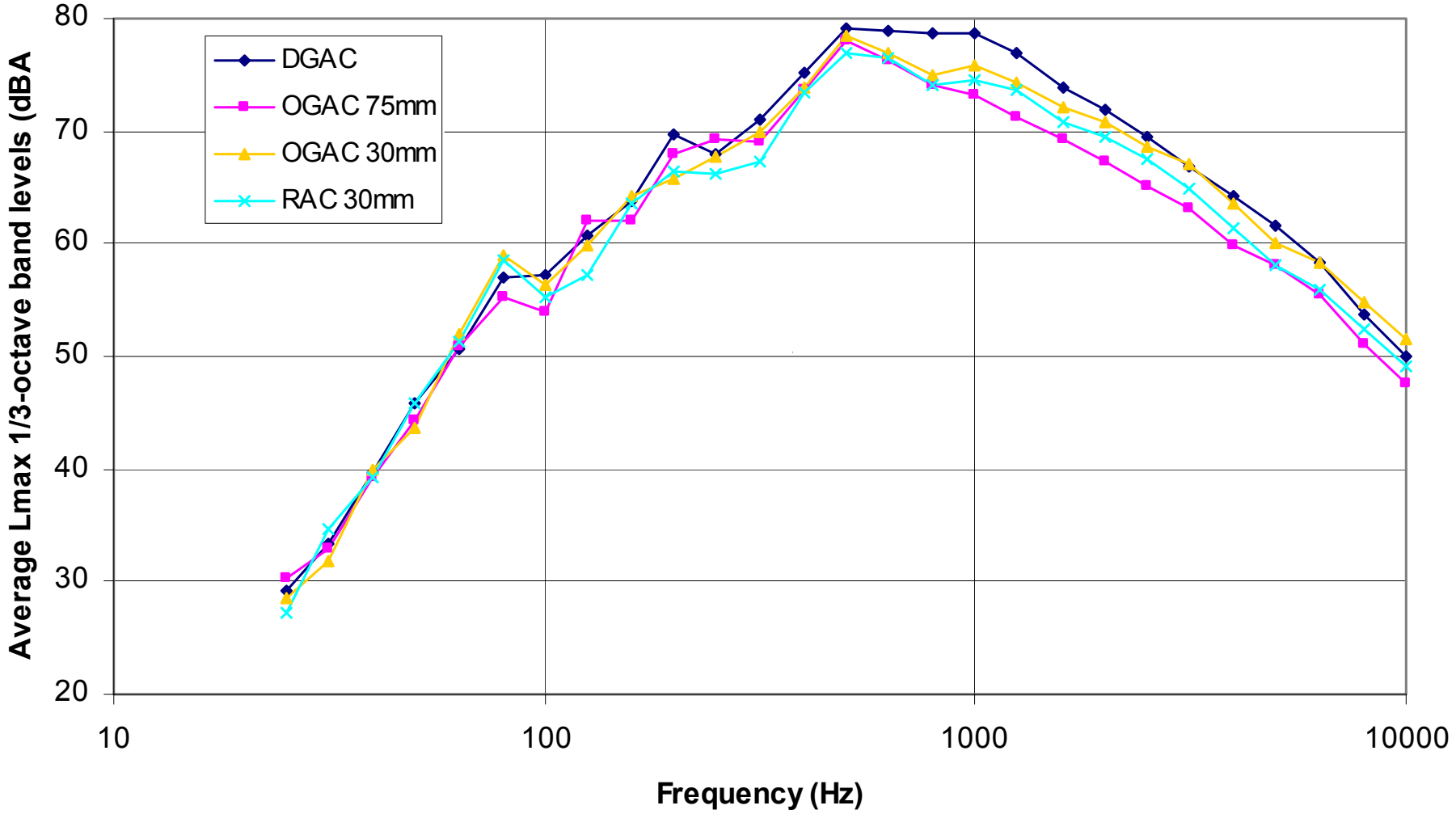
Results for Autos – spectral data by pavement type

(25 ft from road)



Results for Heavy Trucks – spectral data by pavement type

(25 ft from road)



Results – spectral observations

For the pavements tested in this study …

- **Quieter pavements provide noise reduction in a critical range around 1 kHz**
  - **Reduction range is more beneficial to autos than heavy trucks due to energy distribution**
- **Increasing the thickness of OGAC overlay provides additional benefit for frequencies ≥ 1 kHz for both autos and heavy trucks**
- **With the same thickness, RAC provides additional benefit over OGAC at 1 kHz for both autos and heavy trucks**

LA 138 AC Study Observations

- **Applying quieter pavement overlays can reduce wayside-measured sound levels**
- **Amount of noise reduction due to pavement is vehicle-type dependent**
  - **Longevity of noise reduction has yet to be determined**
- **Compared to DGAC …**
  - **OGAC 75 mm provided greatest noise reduction (~3-4 dBA)**

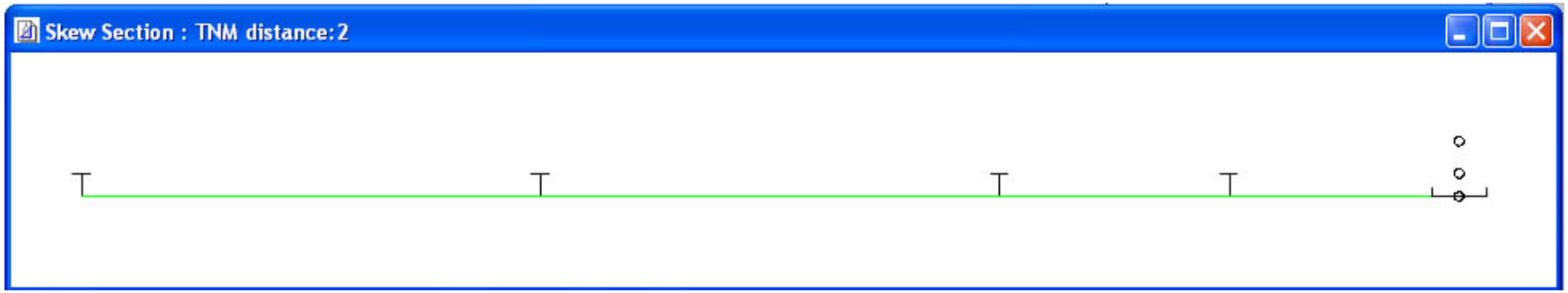
    Noticeably more reduction than thinner overlays at frequencies ≥ 1 kHz
  - **OGAC 30 mm and RAC also provided noise reduction**

    Rubberized provided extra reduction at some critical frequencies (~1 dBA for autos)
  - **Each of the quieter pavements provided greater noise reduction for autos than for heavy trucks**

    To further reduce heavy truck noise, pavements should be designed to reduce noise at 500 Hz

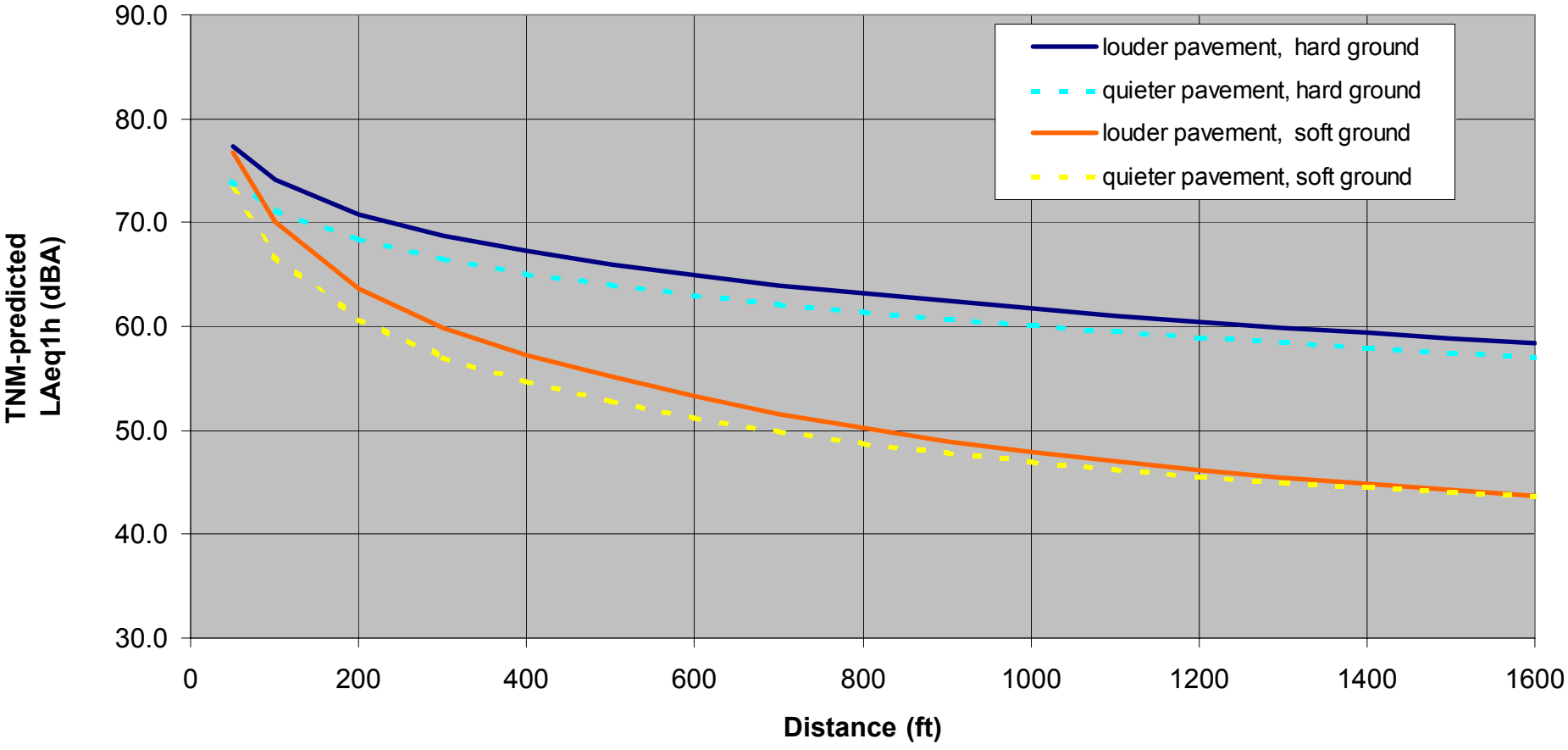
PAVEMENT EFFECTS AS A FUNCTION OF DISTANCE

FHWA TNM® Predictions

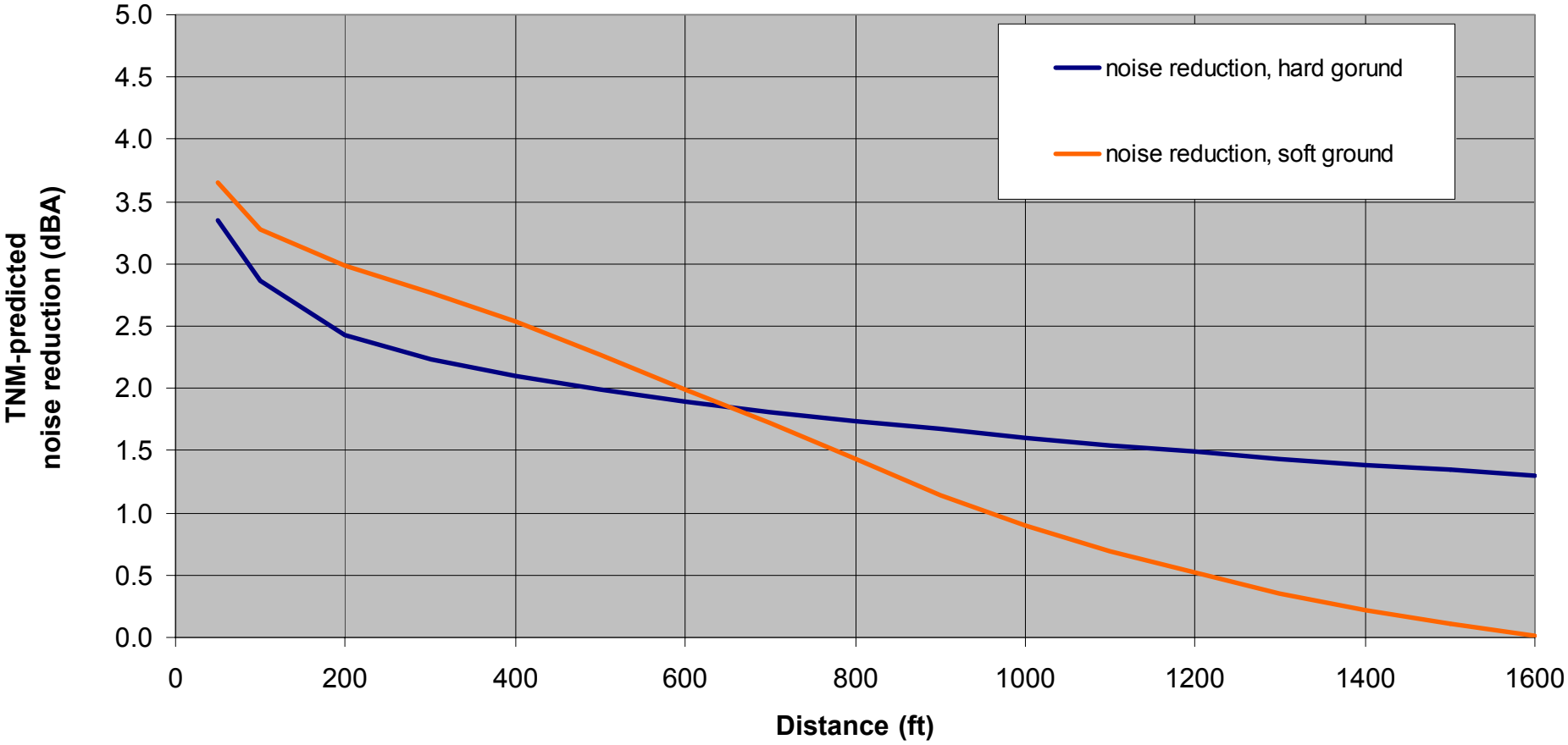


- Used TNM v2.5 to model flat, open site with mixed traffic
  - Receivers at multiple distances
  - 2 types of roadway pavements: louder and quieter (part of noise emission database in TNM)
  - 2 types of sites adjacent to road: acoustically hard and soft ground (soft is more sound absorptive)
- Calculated results on a 1/3-octave band basis

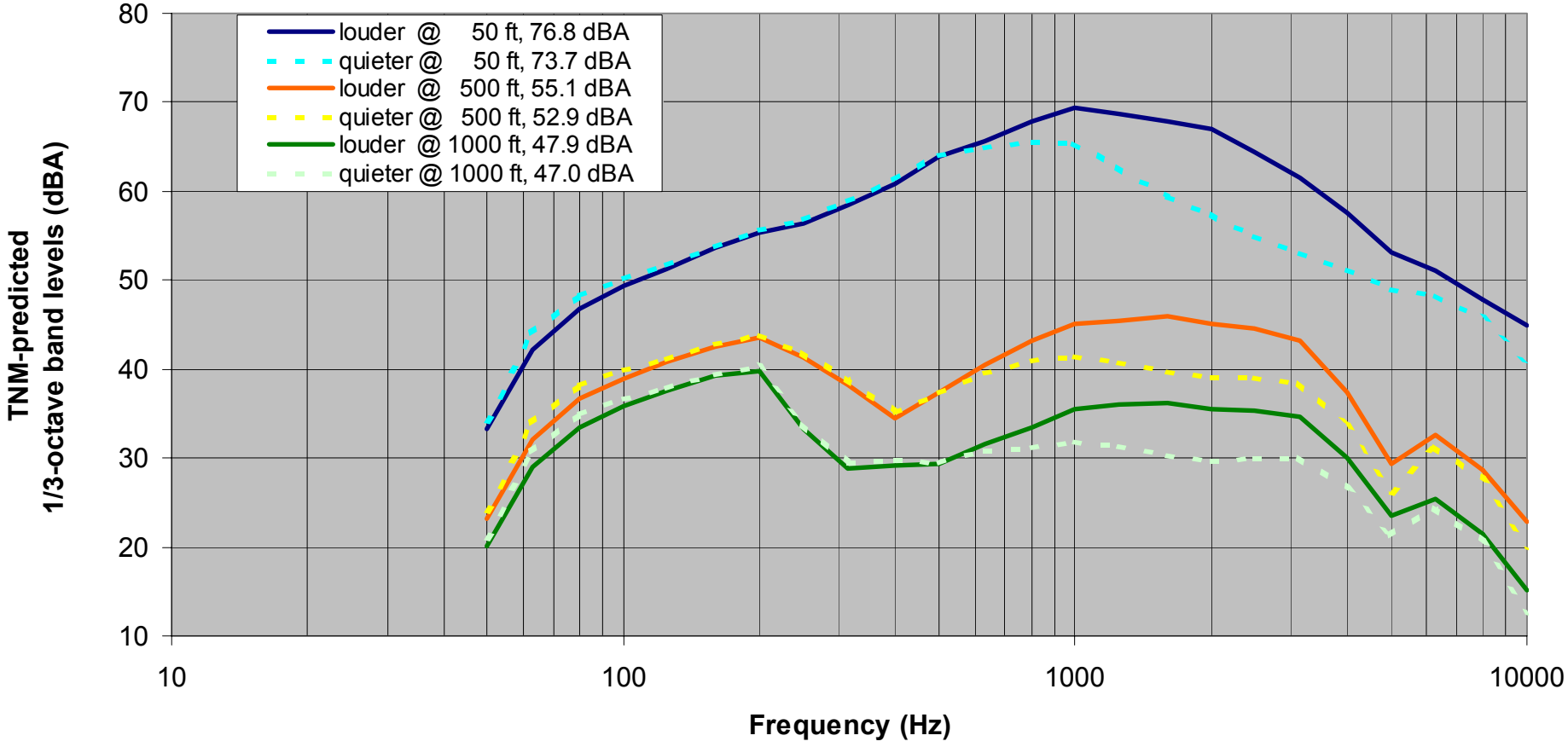
Sound Pressure Level over Distance



Effect of Pavement over Distance



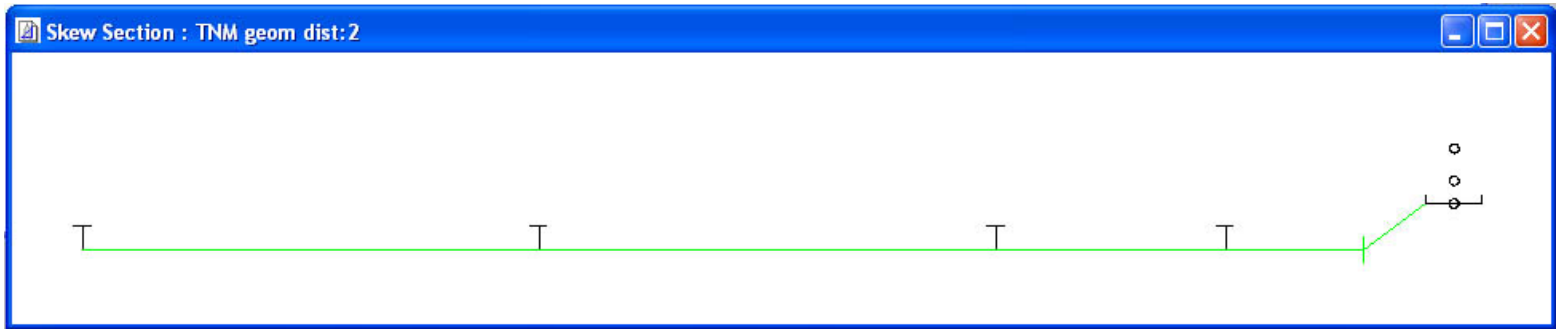
Spectral Examination at 3 Distances (soft ground)



Additional TNM Predictions

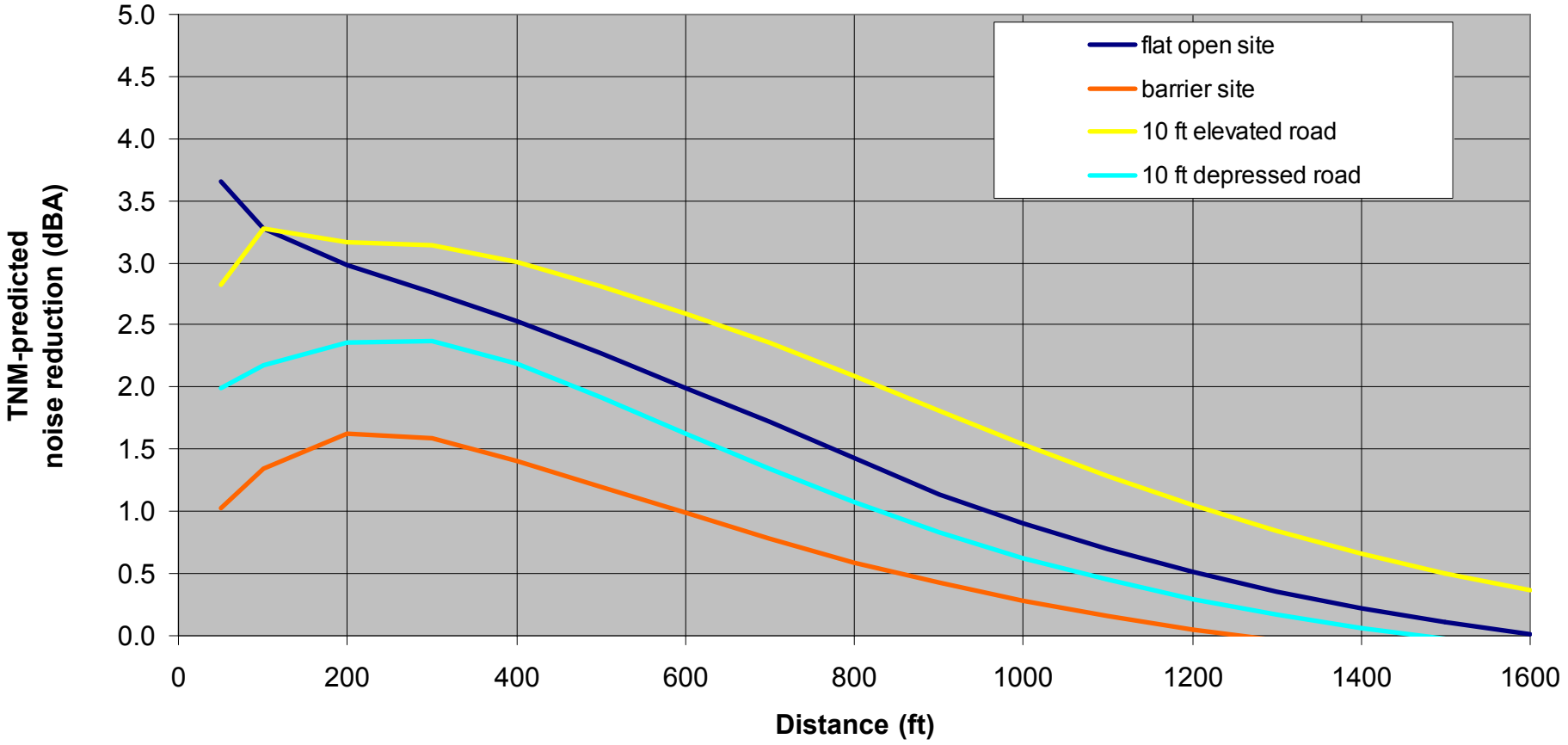
Added noise barrier to site

Elevated road 10 ft



Depressed road 10 ft

Effect of Pavement over Distance – 4 site types, soft ground



TNM Predictions – Observations

- The effect of pavement on noise levels is …
  - Distance dependent
  - Site dependent

    Ground type, intervening objects, and site geometry will affect the noise reduction due to pavement

- For predicting sound levels, the effect of pavement should be accounted for at or near the source to allow for propagation effects

- At farther distances, low frequencies …

  … are contributing more to overall sound level

  … are affected very little by pavement type

ADOT QPPP

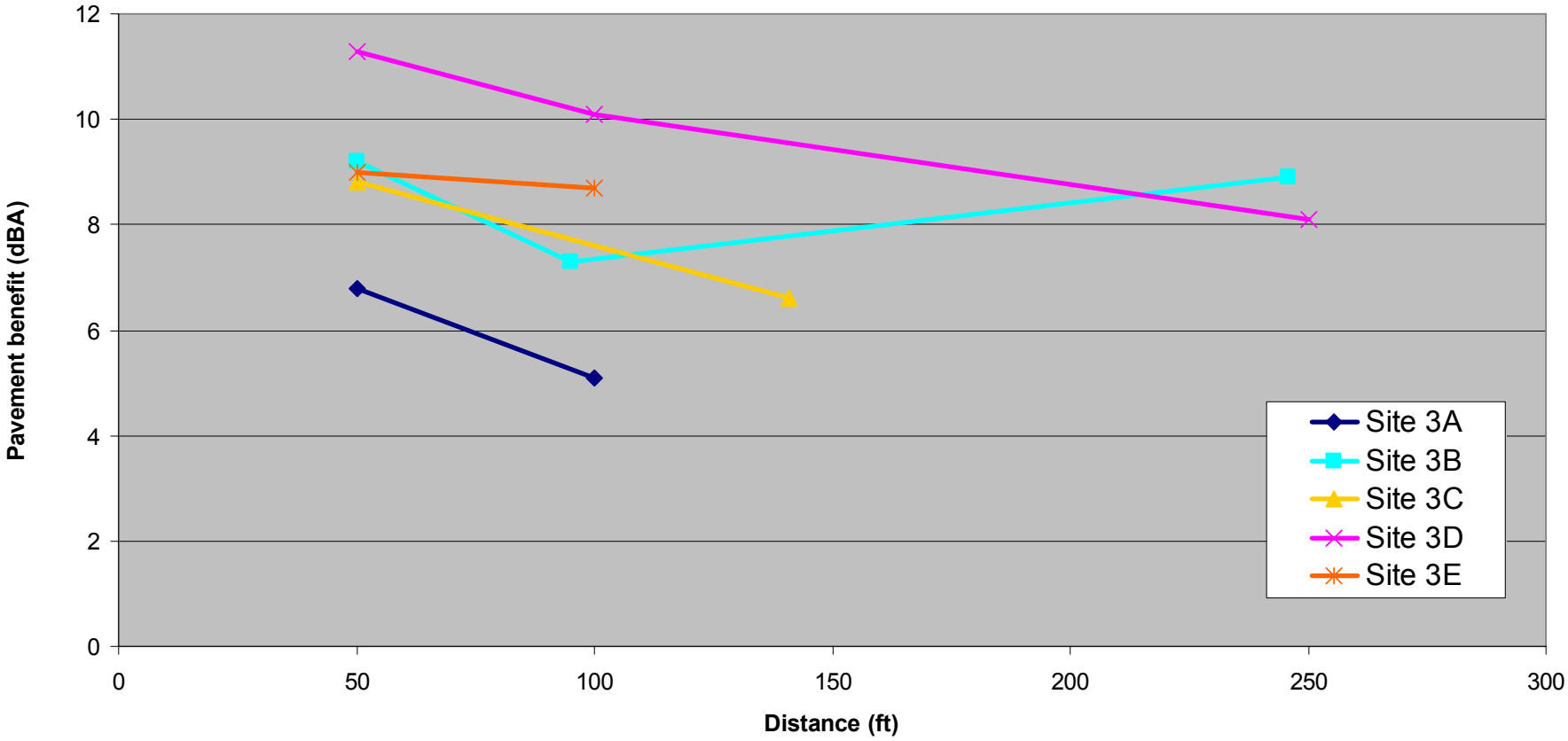
- **Study to evaluate the effectiveness of quiet pavement (ARFC), funded by ADOT**

- **Primary sponsors:**
  - **Christ Dimitroplos (ATRC)**
  - **Mike Dennis**

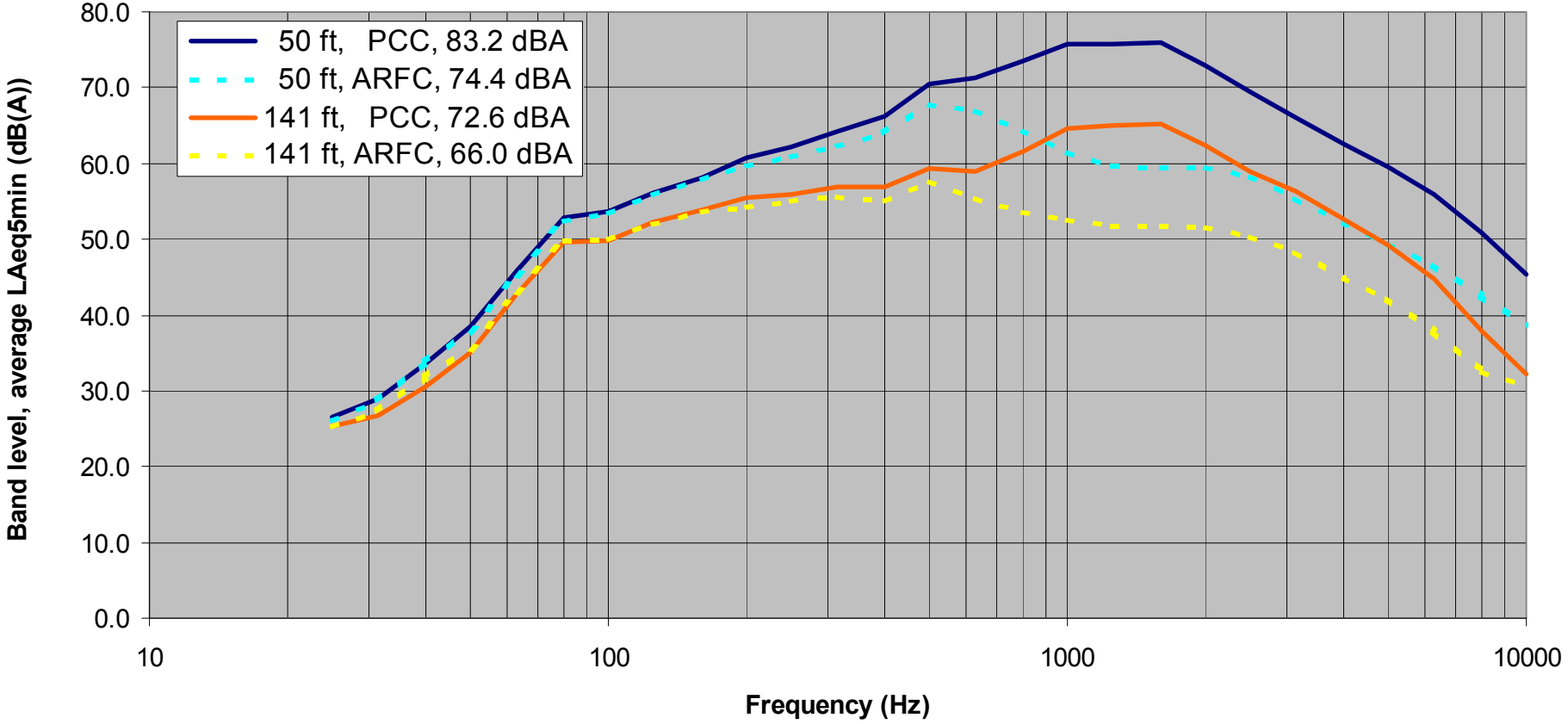
ADOT QPPP Data

- **Wayside time-averaged data at Type 3 sites**
  - **Collected continuously with free-flowing traffic**
  - **Pre-overlay: transversely tined PCC (variation by site)**
  - **Post-overlay: ARFC (rubberized asphalt)**

Benefit of ARFC over Distance



Spectral Examination of Site 3C Data



ADOT Data Observations

- There is variation of pavement noise benefit over area adjacent to highways
- General trend: less benefit with increasing distance from road (there are exceptions)
- At farther distances, low frequencies …
  - … are contributing more to overall sound level
  - … are affected very little by pavement type

Summary

- It is extremely important to examine the noise benefit of pavements in terms of autos and heavy trucks
- “Turning down the volume” at the source does not equate to the same “volume adjustment” throughout an area adjacent to a highway
- These types of examinations will help us to understand how communities adjacent to highways are affected by pavement type

Current FHWA / Volpe Projects

- **Investigate the implementation of pavement effects into TNM**

  (funded by FHWA Pavements, Mark Swanlund)

  - **Effective flow resistivity (EFR) measurements – determining sensitivity to pavements**

  - **Accounting for change in source noise – investigating possibilities**

    Trial adjustment of tire/pavement source noise using OBSI data

    Trial addition to vehicle noise database using "REMEL light" data (data for various pavement types)