

Controlling Highway Noise at the Source

January 5 & 6, 2005

Little Rock, AR

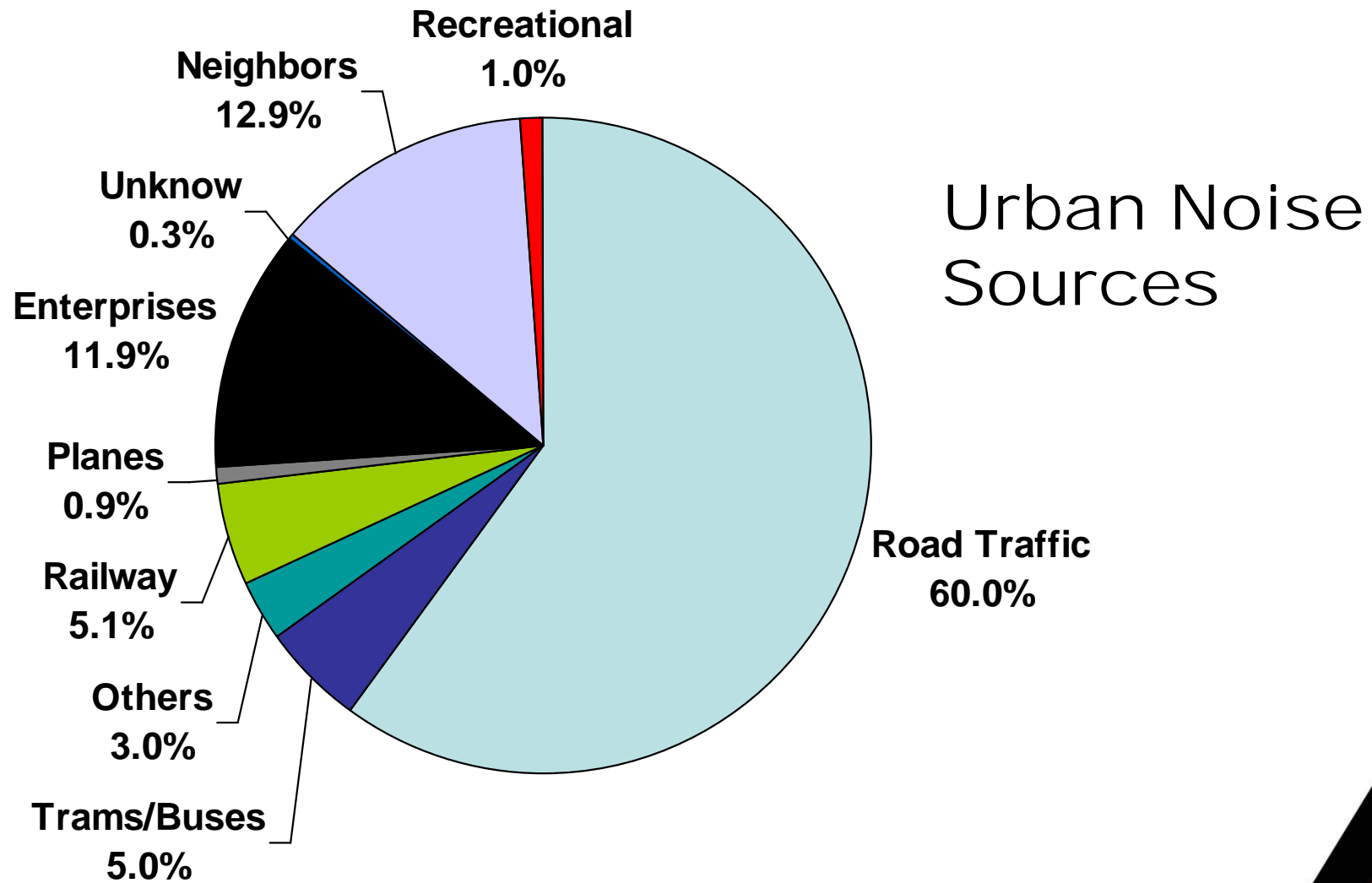


Controlling Highway Noise at the Source

- Sound
 - mechanical energy transmitted by pressure waves (**sound waves**) that is the stimulus to hearing
- Noise
 - one that lacks agreeable musical quality or is noticeably unpleasant

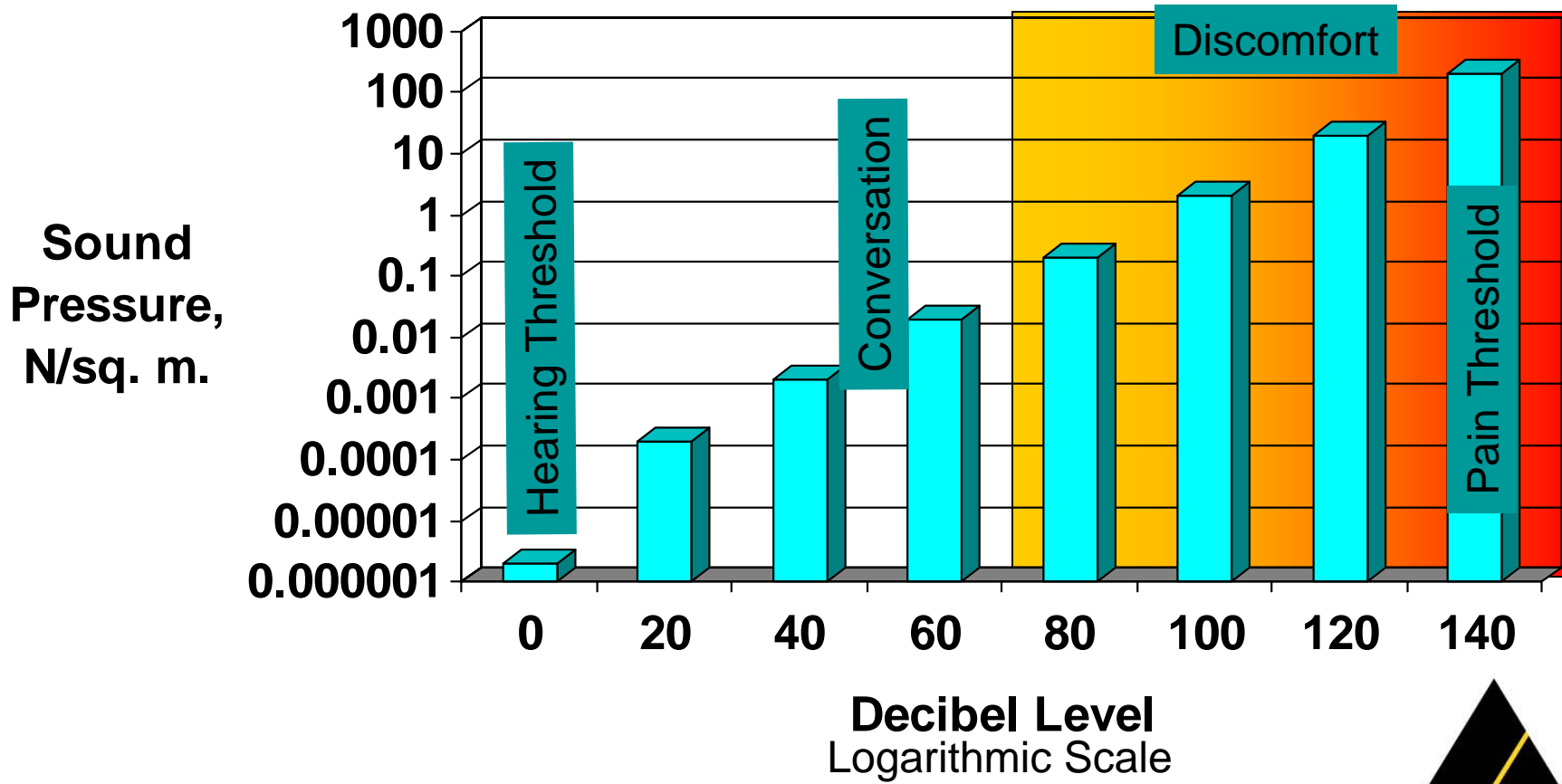


Controlling Highway Noise at the Source



Controlling Highway Noise at the Source

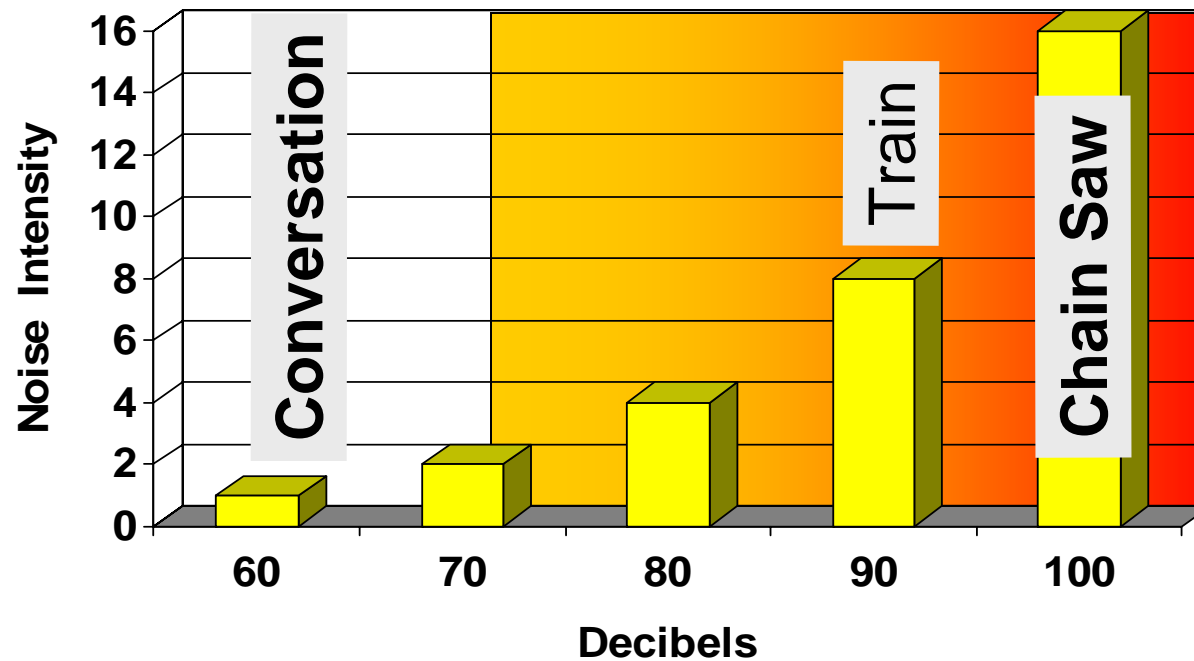
The Decibel Scale



Controlling Highway Noise at the Source

The Decibel Scale

Increasing the decibel level by 10 doubles the noise intensity!



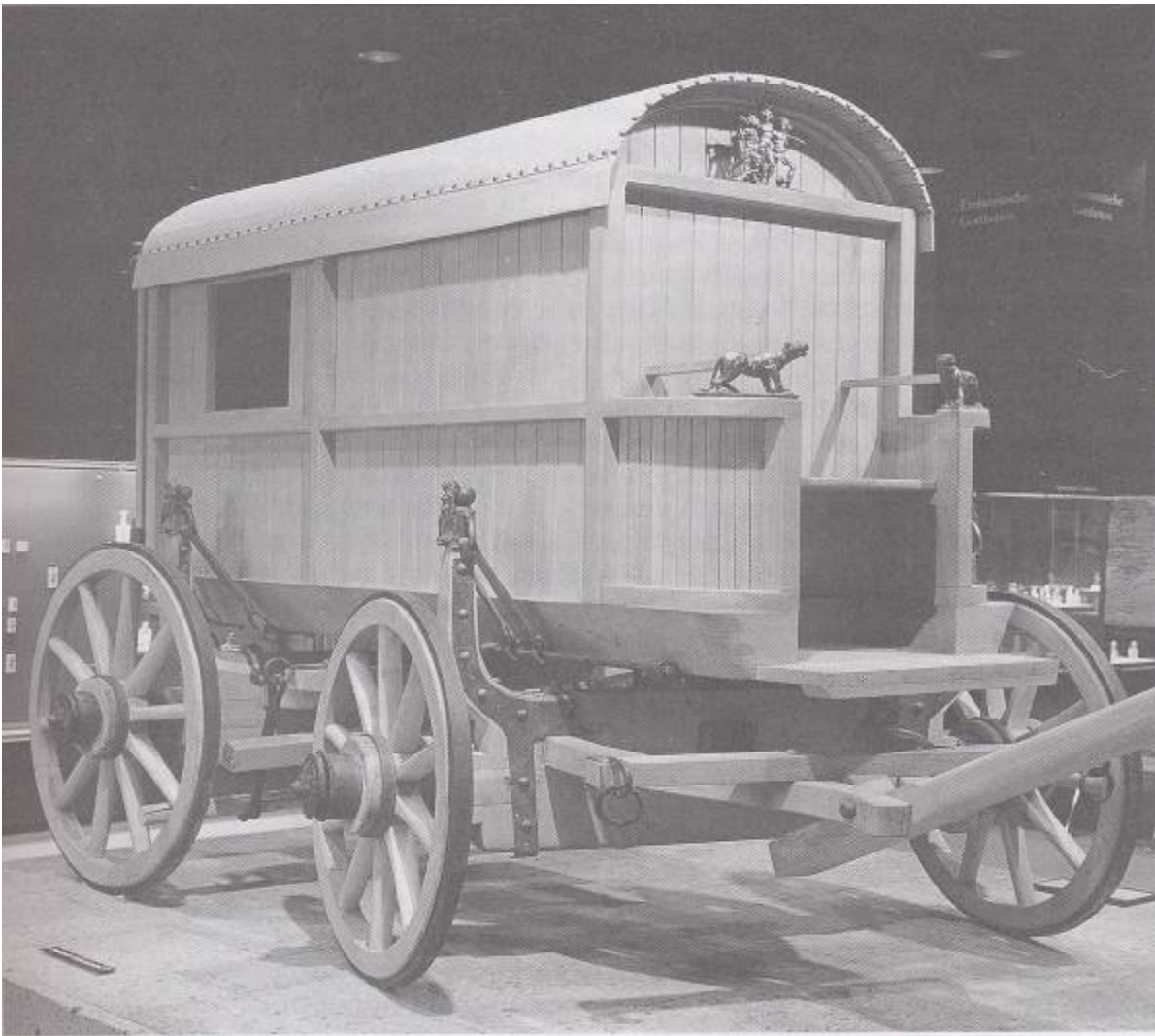
Controlling Highway Noise at the Source

Common Outdoor and Indoor Noises			
Outdoor Noises	Sound Pressures (uPa)	Sound Pressure Levels (dB)	Indoor Noises
Jet Flyover at 300 m	6,324,555	110	Rock Band at 5 m
Gas Lawn Mower at 1 m	2,000,000	100	Inside Subway Train (New York)
Diesel Truck at 15	632,456	90	Food Blender at 1 m
Noisy Urban Daytime	200,000	80	Garbage Disposal at 1 m Shouting at 1 m
Gas Lawn Mower at 30 m	63,246	70	Vacuum Cleaner at 3 m Normal Speech at 1 m
Commercial Area	20,000	60	Large Business Office
Quiet Urban Daytime	6,325	50	Dishwasher Next Room
Quiet Urban Nighttime	2,000	40	Small Theatre, Large Conference Room (Background)
Quiet Suburban Nighttime	632	30	Library
Quiet Rural Nighttime	200	20	Bedroom at Night Concert Hall (Background)
	63	10	Broadcast and Recording Studio
	20	0	Threshold of Hearing



Controlling Highway Noise at the Source

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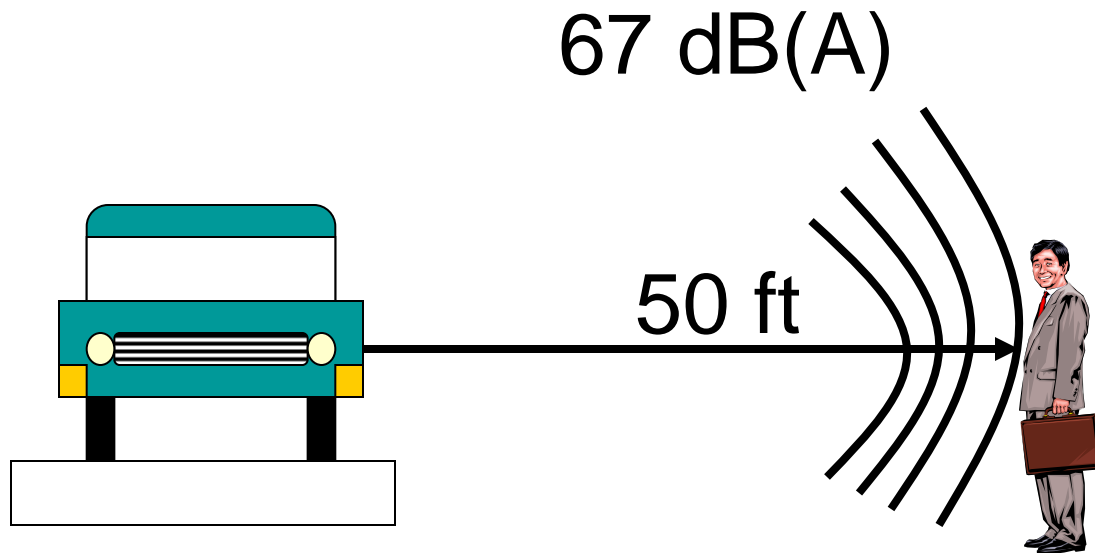


Roman Wagon
Circa 100AD



Controlling Highway Noise at the Source

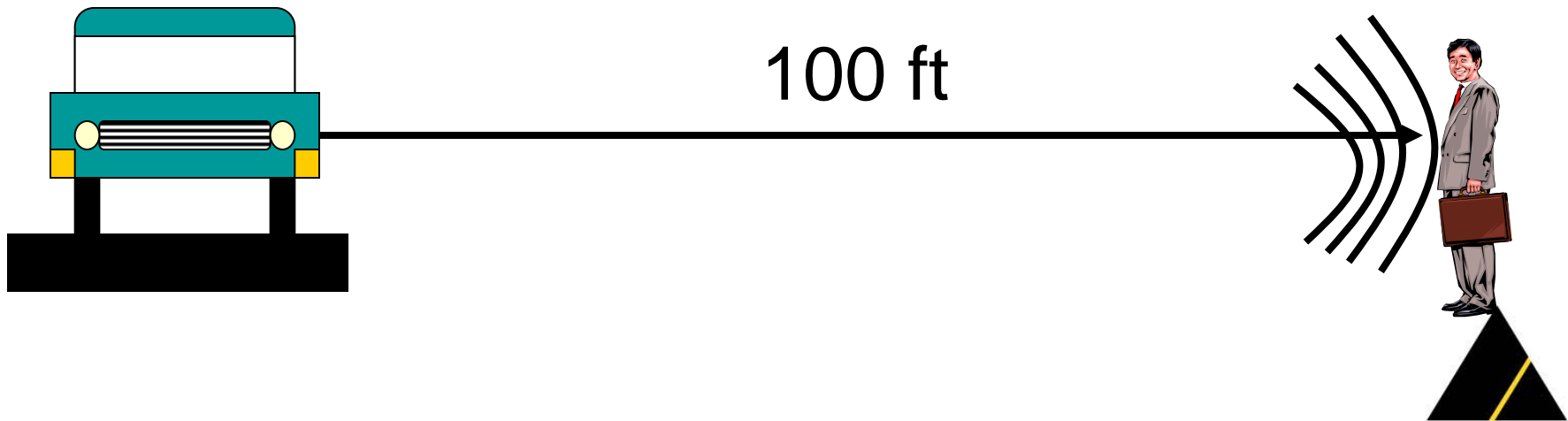
The Decibel Scale



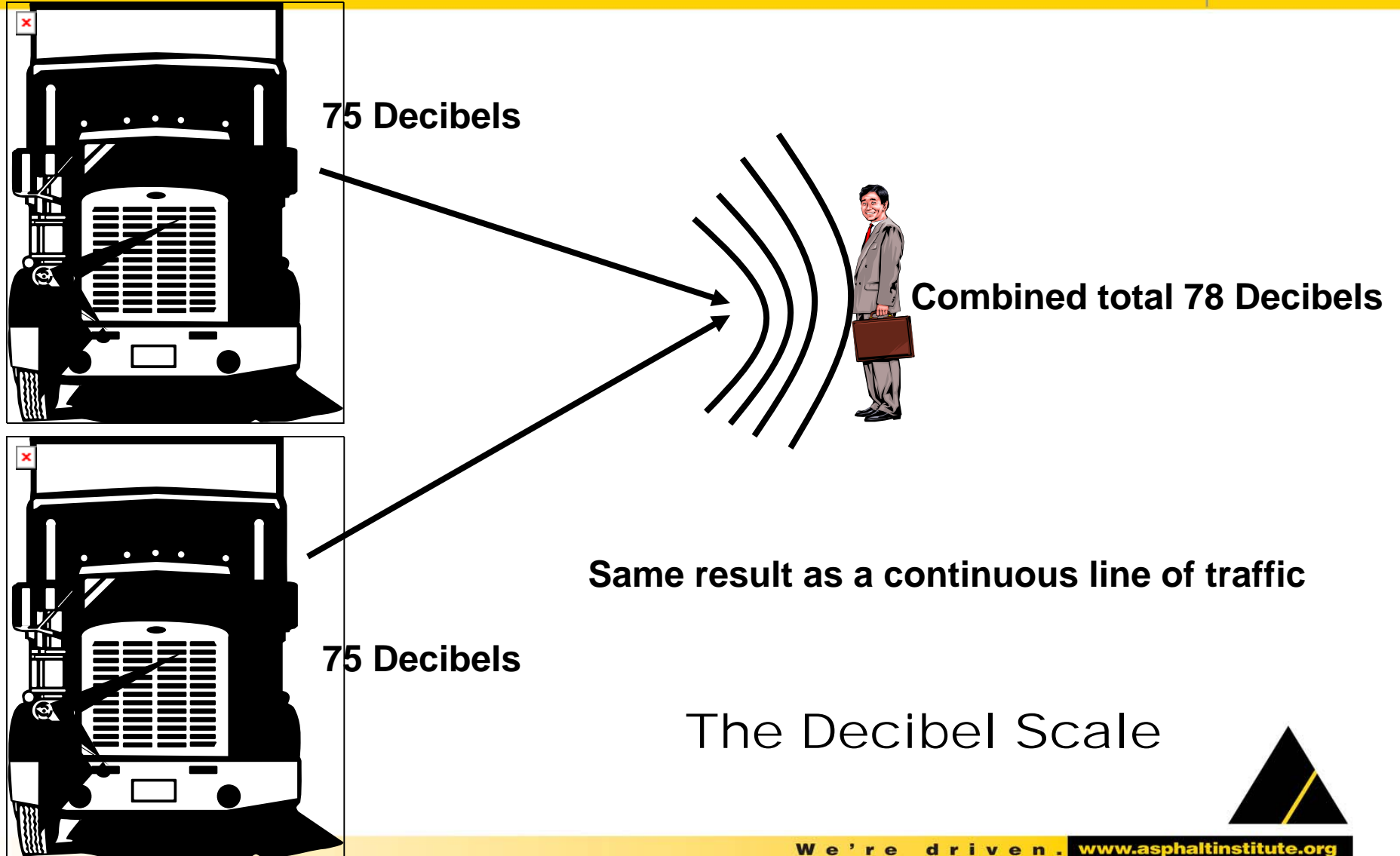
Controlling Highway Noise at the Source

Doubling the distance from the source produces a 3 dB(A) reduction

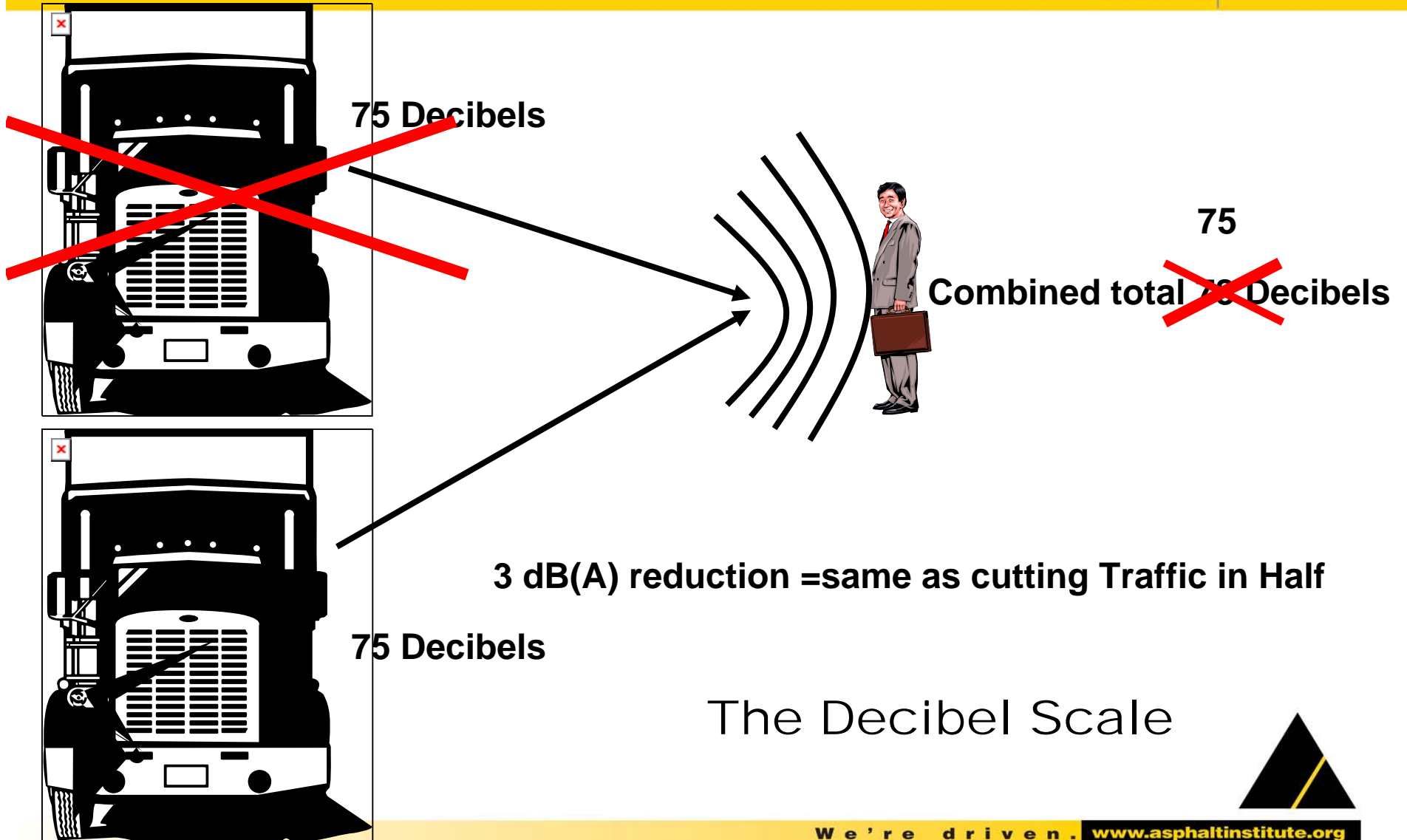
$$67 \text{ dB(A)} - 3 \text{ dB(A)} = 64 \text{ dB(A)}$$



Controlling Highway Noise at the Source

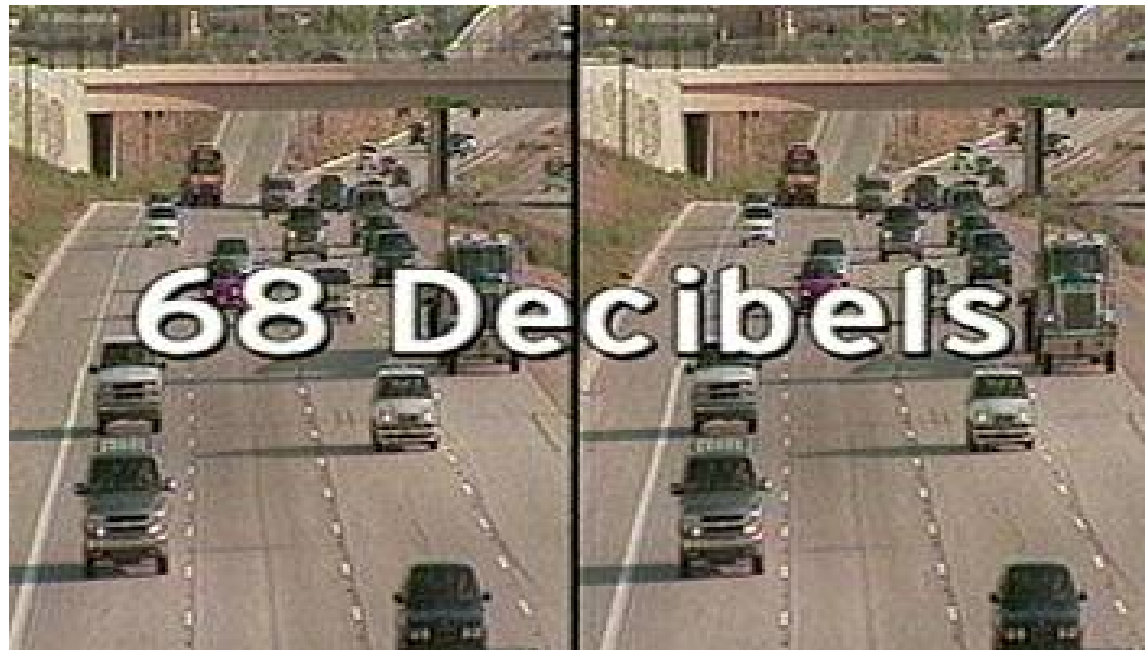
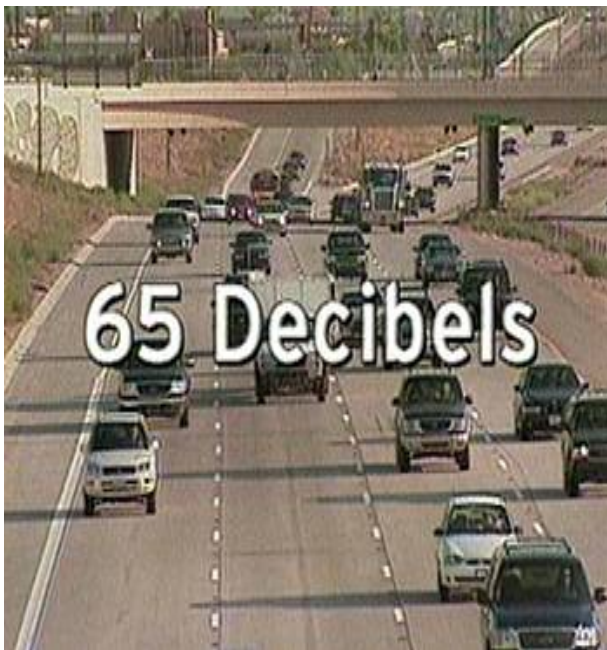


Controlling Highway Noise at the Source



Controlling Highway Noise at the Source

Doubling Traffic adds 3dBA



Controlling Highway Noise at the Source

Side-Line Measurements



- Microphones at 5 & 50m
- Measures all Sources
- Requires Flat, Open Terrain
- Statistical Pass-By
 - Existing Traffic
- Controlled Pass-By
 - Control Vehicles



Controlling Highway Noise at the Source

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**Close
Proximity
Method
CPX**



Controlling Highway Noise at the Source

FHWA - Noise Abatement Criteria

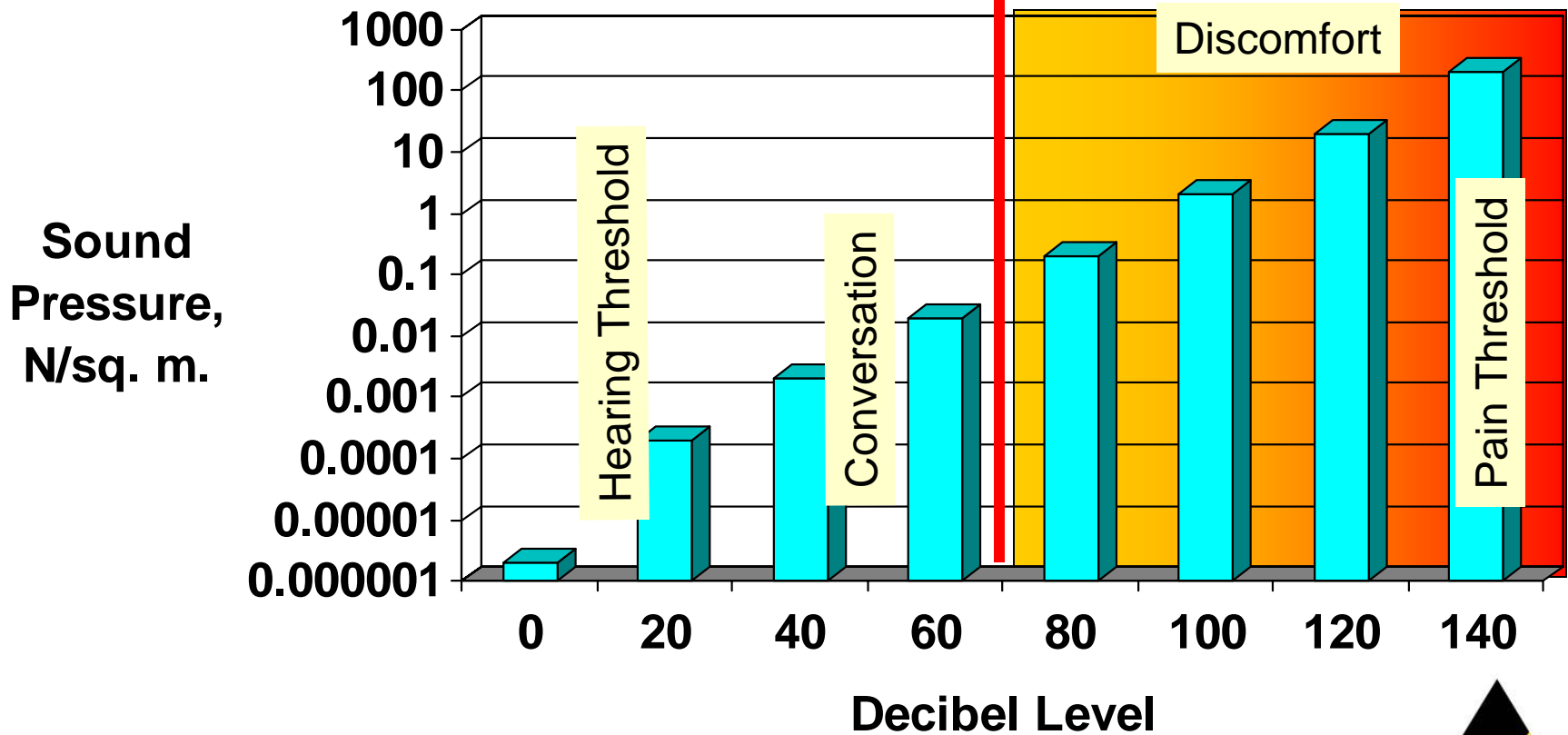
- Projects that Require Evaluation
 - Increase Capacity
 - New Alignments
- Maximum level = 67 dB(A)
- Maximum Change = 10 dB(A) change

“this is not an absolute value or design standard, only a level where noise mitigation must be considered”



Controlling Highway Noise at the Source

FHWA Guideline = 67 dB(A)



Controlling Highway Noise at the Source

Control Options

- Source
- Distance
- Obstructions



Controlling Highway Noise at the Source

Control Options

- Source
 - Eliminate
 - Reduce
- Distance
 - Lengthen Path/Relocate Receiver
- Obstructions
 - Obstacles in Path
 - Insulate



Controlling Highway Noise at the Source

Control Options

- At the Source
 - Vehicles
 - Smaller, Lighter
 - Quieter Less Aggressive Tread Patterns
 - Traffic
 - Lower Speeds
 - Traffic Calming (avoid Starting & Stopping)
 - Pavement Surfaces
 - More on this later



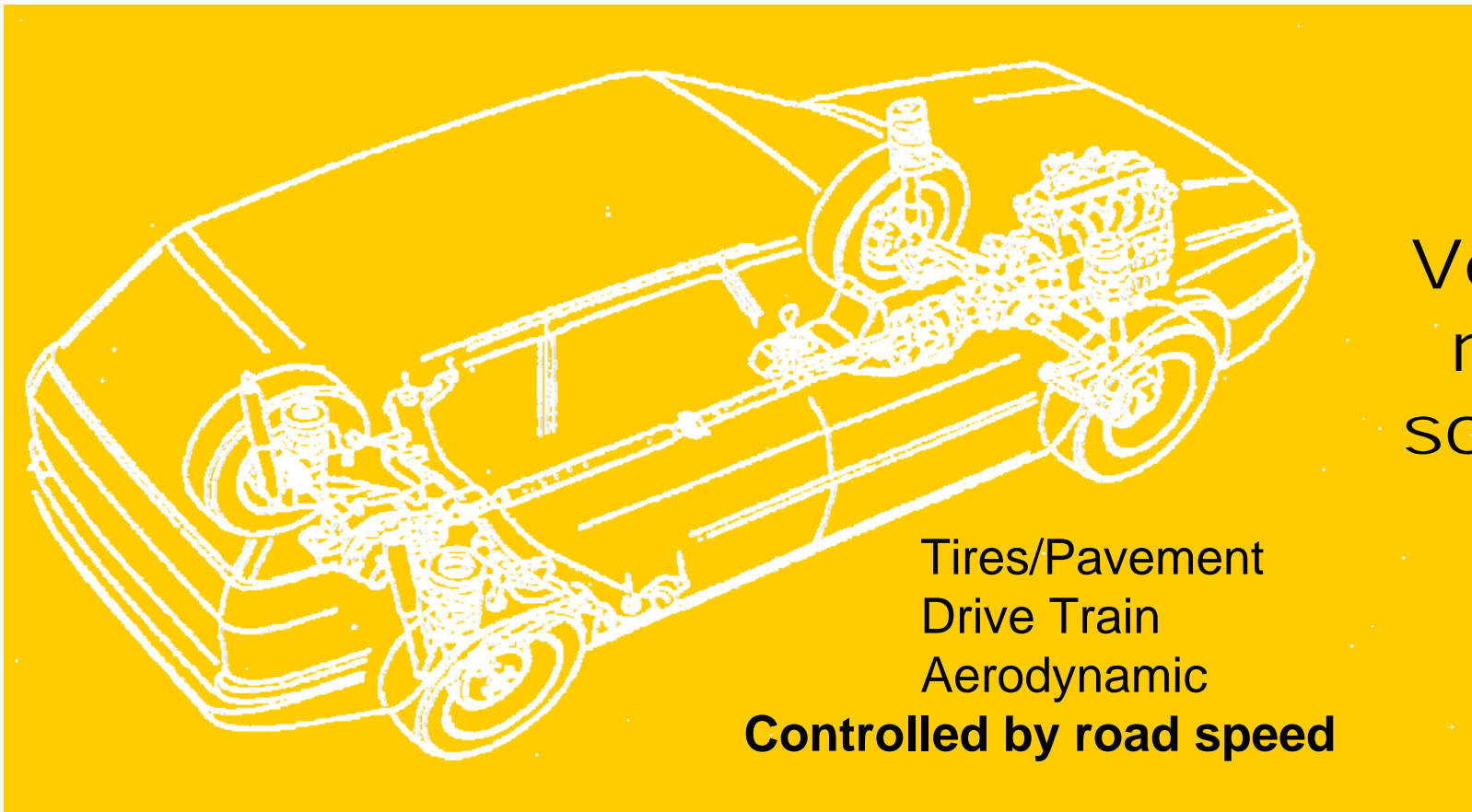
Controlling Highway Noise at the Source

- Vehicle-generated noise comes from:
 - engine,
 - exhaust system,
 - aerodynamic noise
 - tire noise.
- } **Power train noise**
- } **Coast- by noise**
- For ≥ 35 mph, pavement/tire noise dominates.



Controlling Highway Noise at the Source

Controlled by engine speed engine structure, air intake
exhaust etc

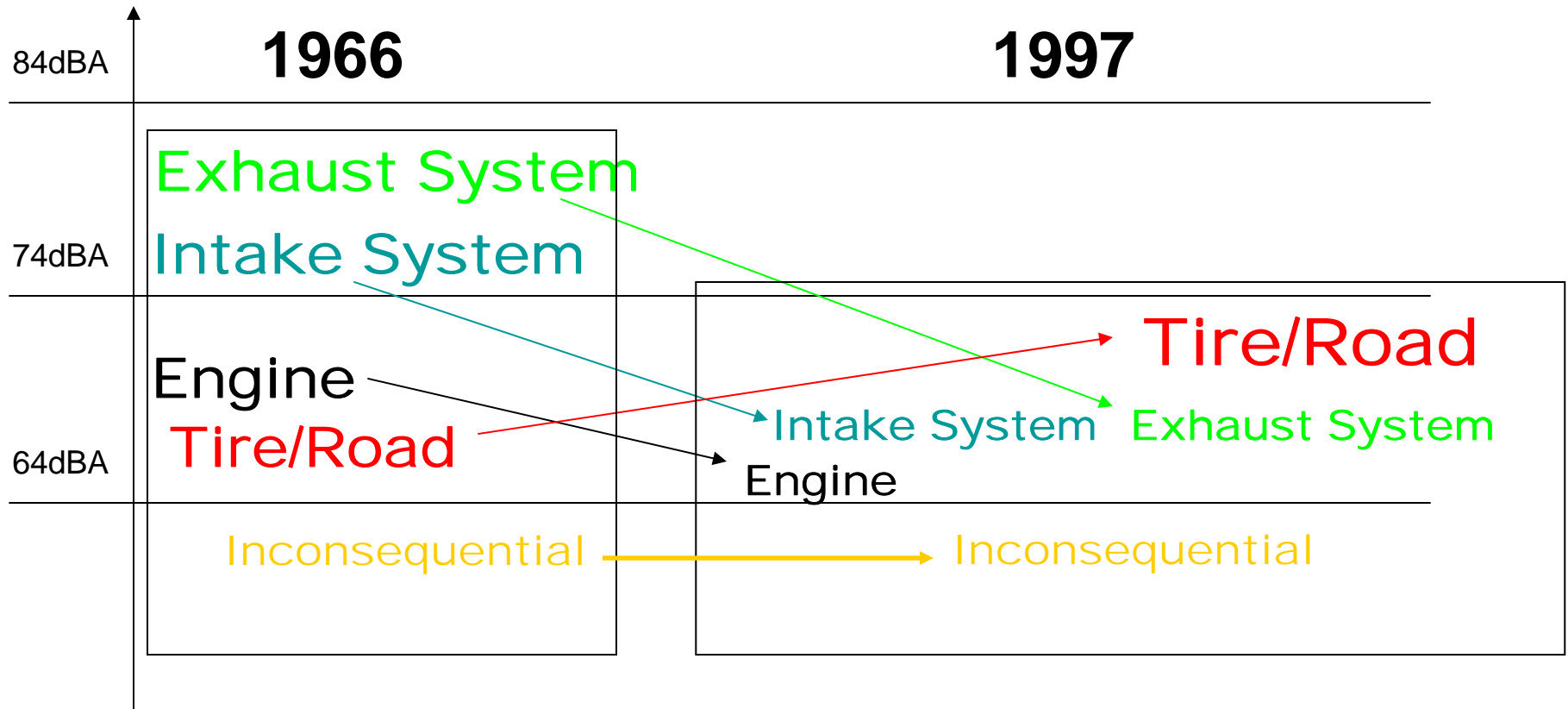


Vehicle
noise
sources

Tires/Pavement
Drive Train
Aerodynamic
Controlled by road speed



Controlling Highway Noise at the Source



Vehicle Noise Components



Controlling Highway Noise at the Source

Control Options

- **Source**
 - Eliminate
 - Reduce
- **Distance**
 - Lengthen Path/Relocate Receiver
- **Obstructions**
 - Insulation at Receiver
 - Obstacles in Path



Controlling Highway Noise at the Source

Lengthen Path



- Land Use Planning

- Type of Use

- Location

- Orientation

- Existing Buildings/Subdivisions

- New Routes Only

- No Outdoor Reduction

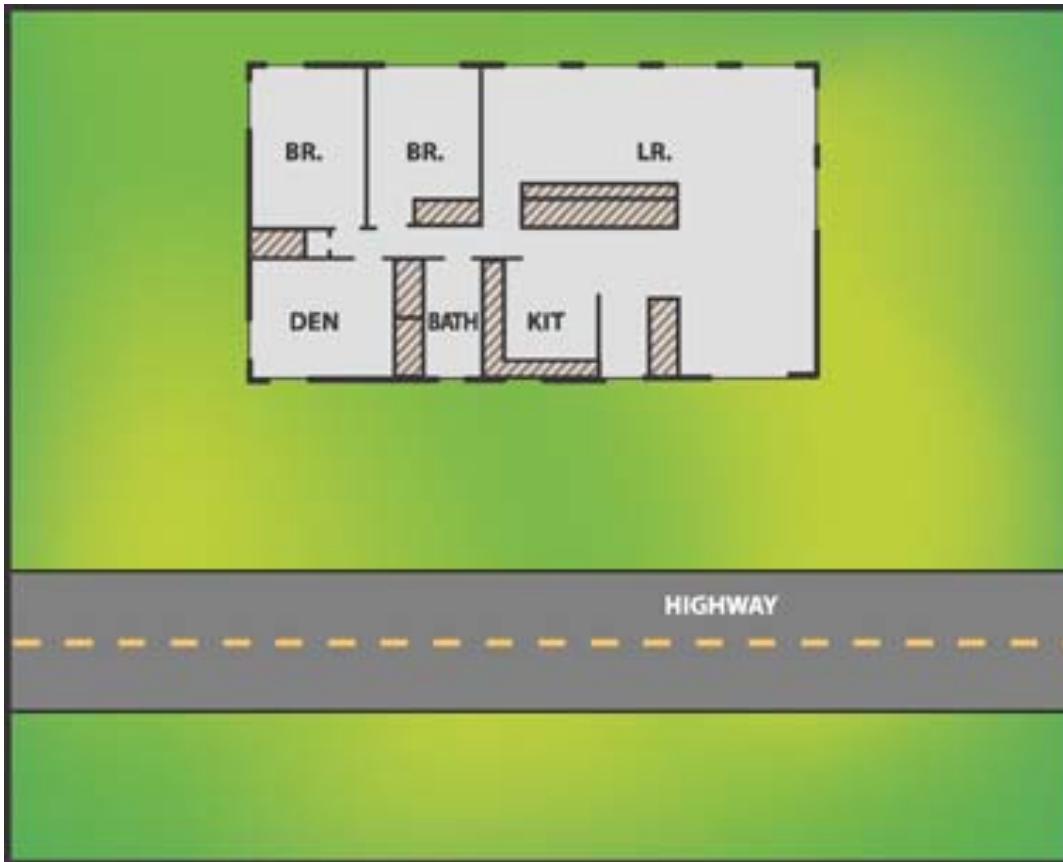
Controlling Highway Noise at the Source

Control Options

- **Source**
 - Eliminate
 - Reduce
- **Distance**
 - Lengthen Path
 - Relocate Receiver
- **Obstructions**
 - Insulation at Receiver
 - Obstacles in Path



Controlling Highway Noise at the Source



- Insulate Buildings/Windows
 - Effective for interiors only
- Impractical & Expensive
- Public Buildings Only
- No Outdoor Reduction



Controlling Highway Noise at the Source

Control Options

- **Through Obstructions**
 - Vegetation
 - Berms
 - Barrier Walls
 - Combination of both



Controlling Highway Noise at the Source

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Vegetation

-Trees and Shrubs

- 10 dB(A) Reduction
- 250 FT of Dense Growth
- No line of sight

•Additional ROW

•Psychological Effect Only

•No overall Noise Reduction



Controlling Highway Noise at the Source

- Berms

- Effective only where no line of sight exists

- Require a large amount ROW

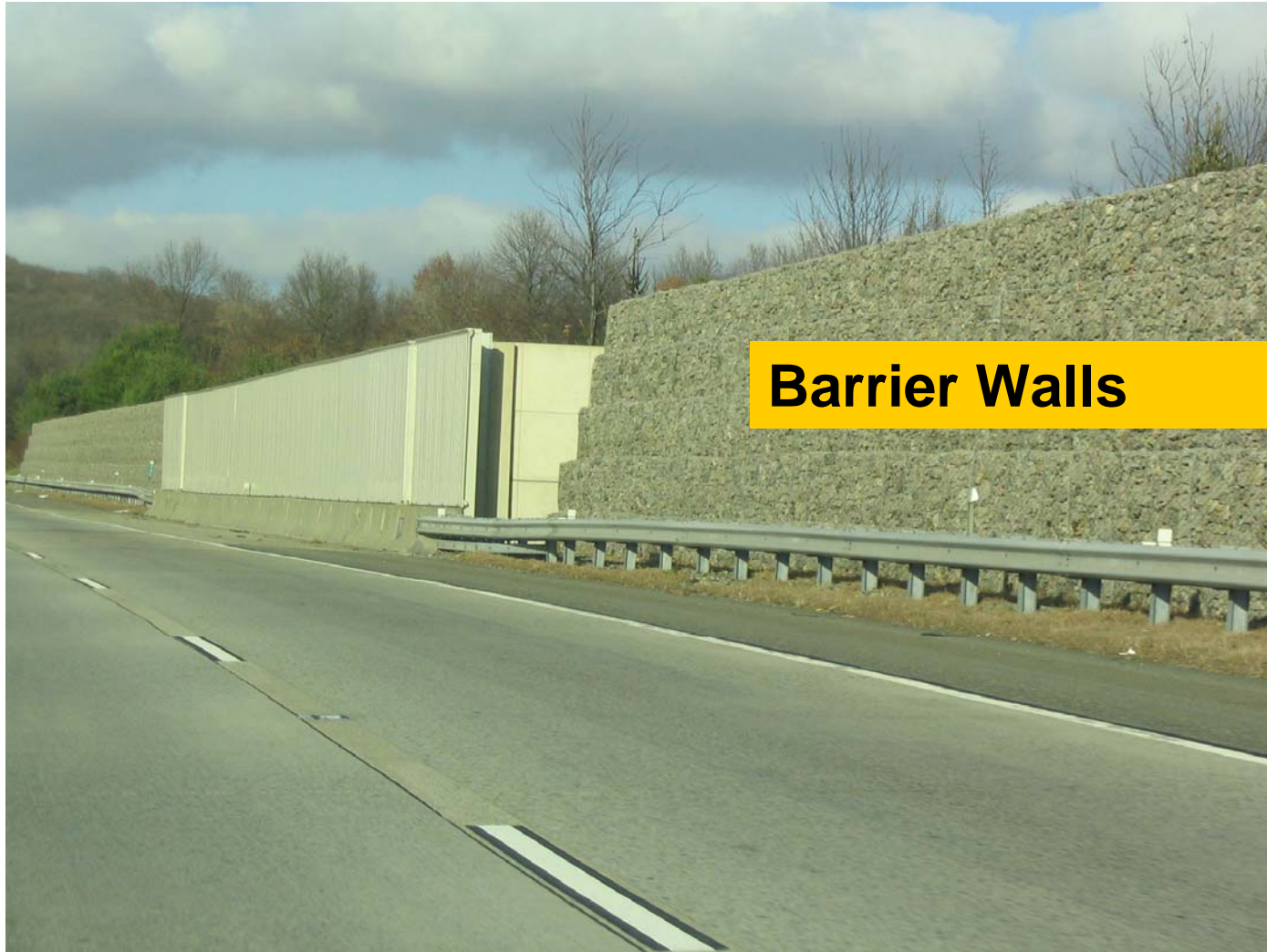
- Massive amounts of earthwork

- May not be an Option in Urban Areas

- No Overall Noise Reduction



Controlling Highway Noise at the Source



Barrier Walls



Controlling Highway Noise at the Source

Barrier Walls

- Only Method Approved for FHWA \$\$ Participation
- 5-8 dB(A) Effective Reduction

- Expensive
- Effective Only if no line of sight
- Limited Mitigating Effect
- Reflected Noise Problem
- Eliminates Scenic Vistas
- No Overall Noise Reduction



Controlling Highway Noise at the Source

Berms & Walls

- Require a large amounts ROW
- Massive amounts of earthwork
- May not be an Option in Urban Areas
- No Overall Reduction from Source

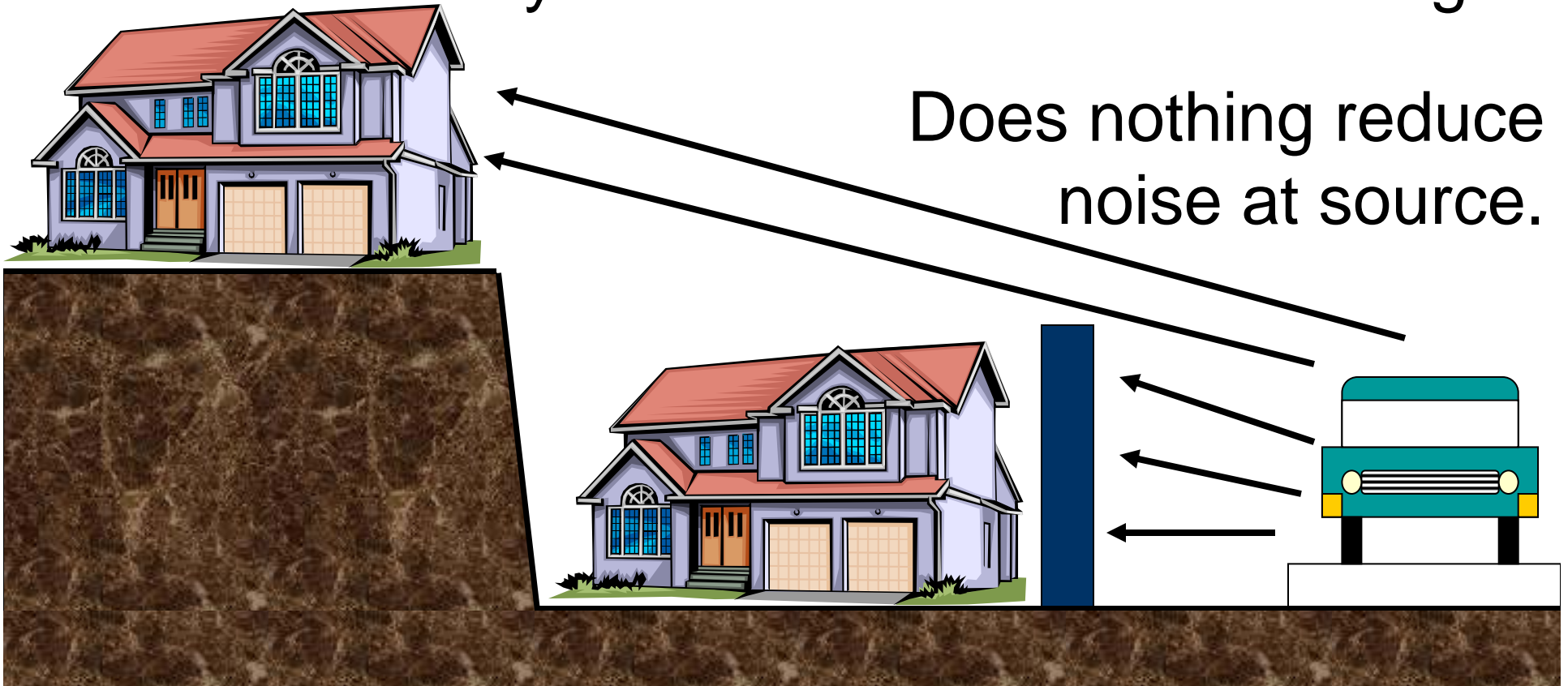


Controlling Highway Noise at the Source

Noise Walls

Effective only for those not in the line-of-sight.

Does nothing reduce noise at source.



Controlling Highway Noise at the Source

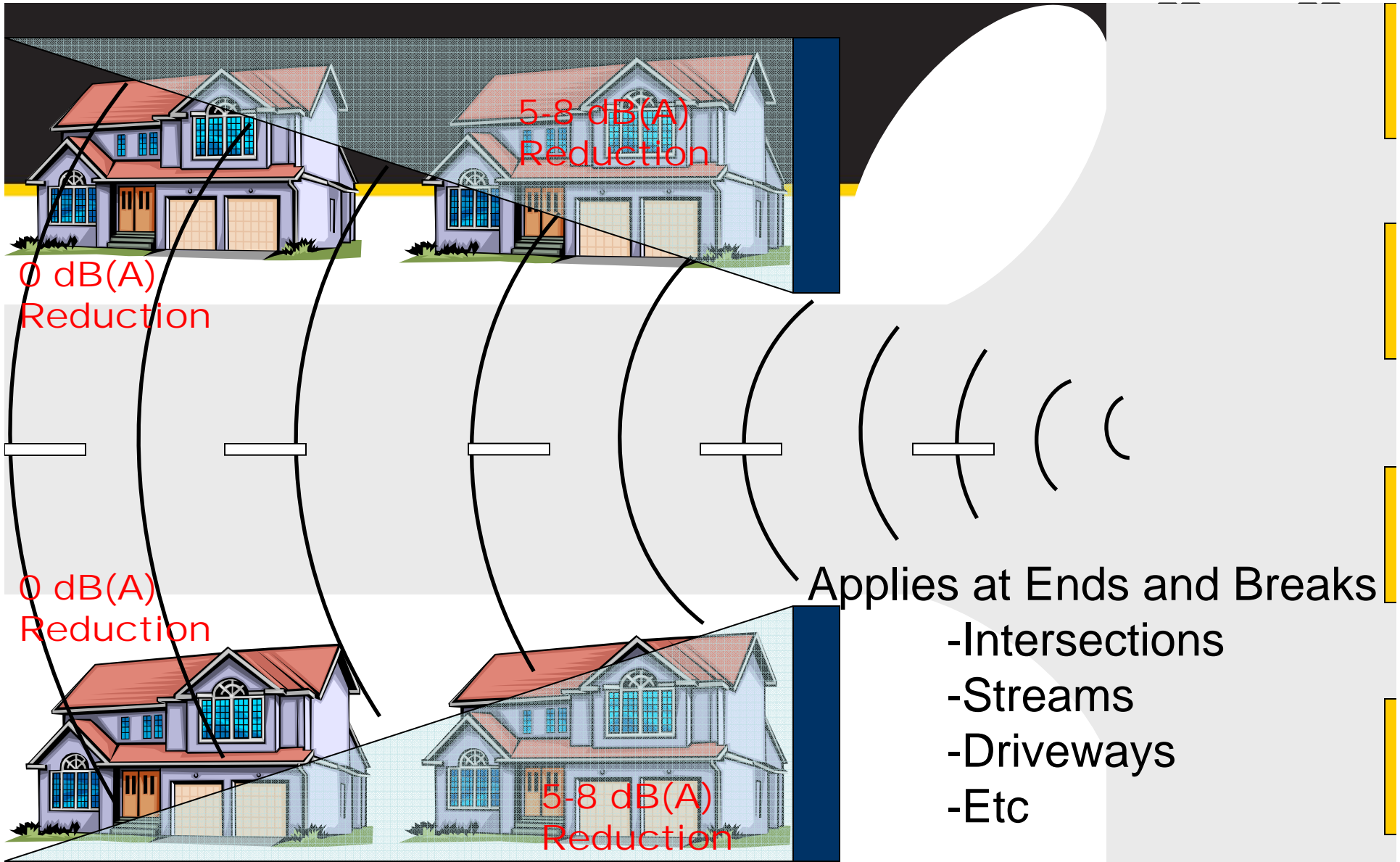
Not as Effective
For second
And Third
Tier Homes

Noise Walls
Shadow Effect

0 dB(A)
Reduction

5-8 dB(A)
Reduction





Noise Wall - Shadow Effect

Controlling Highway Noise at the Source

Noise Walls

- Effectiveness must justify expense.
- Cases:
 - I-285, Atlanta: Requirements of ≥ 69 dB(A) and $\leq \$50,000$ /home
 - U.S. 441, West Boca, FL: > 67 dB(A), $< \$30,000$ /home, reduction of ≥ 5 dB(A)
 - Maryland $< \$47$ k/Home, Type 2= $\$94$ k/Home
 - Nationwide (FHWA, 2001): $> \$1.18$ M/mile



Controlling Highway Noise at the Source

- Noise walls
 - They are expensive.
 - They don't work in all types of terrain.
 - Effective for first tier
 - Reflected noise may compound problem
 - Source of noise is still there.



Controlling Highway Noise at the Source

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European Experience

- Dense Population
- Limited ROW
- Historical Vistas
- Need to Reduce Overall Noise Level



Controlling Highway Noise at the Source

European CPX Trailers

Almost all European Countries have their own Noise measuring equipment

FIGE/BAST Trailer
Germany

DWW Trailer
Netherlands

M+P Trailer
Netherlands

TRL Vehicle
United Kingdom

TUG Trailer
Poland/Sweden

Arsenal Trailer
Austria

JARI/J-SAE Vehicle
Japan

TUB Trailer
Berlin, Germany



TRITON
Tyre/Road noise test vehicle



Controlling Highway Noise at the Source

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Review of skidding resistance standards

Pavement Friction Tester

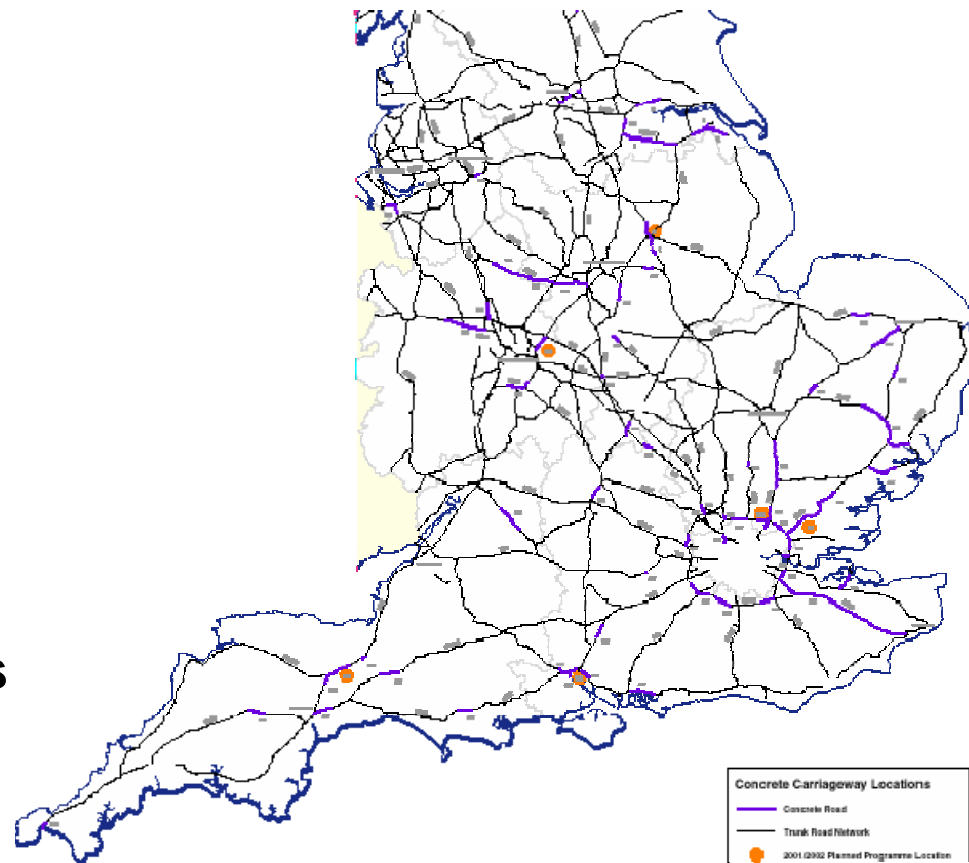


Controlling Highway Noise at the Source

United Kingdom's 10-year plan.

Highway Agency announce that quieter (asphalt) surfaces will be installed on over 60% of the network by 2010.

- OGFC & SMA Type Mixes



Controlling Highway Noise at the Source



Hot Mix Asphalt Technology – SEPTEMBER/OCTOBER 2004 • 23

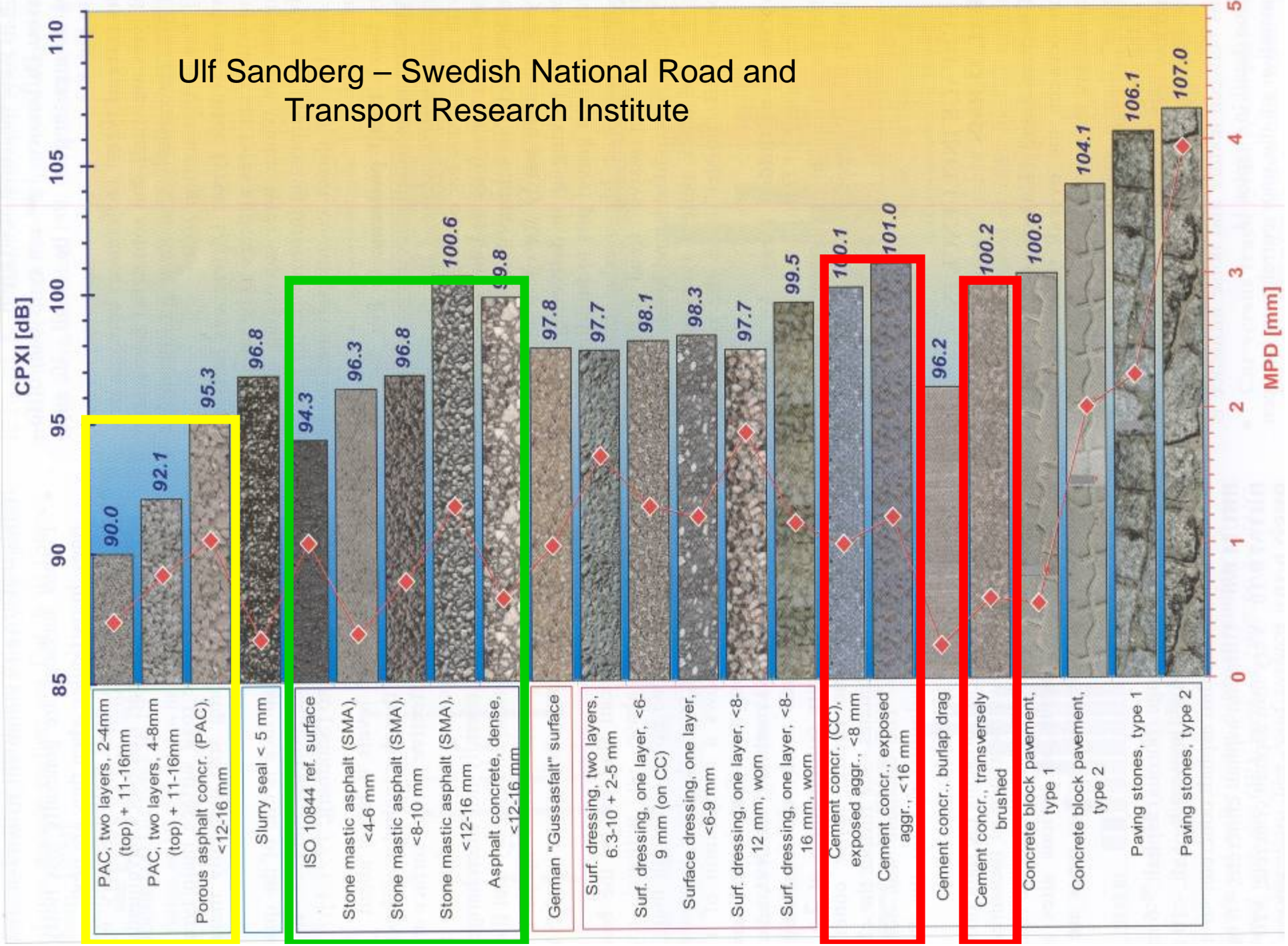
France

Two layer Open Graded Friction Course

- Expedite Drainage
- Prevent Clogging
- Aggregate Lift / Thickness
 - Bottom 11-14/40-50 mm
 - Top 6-8/25-30 mm
- Won an Environmental Award for Quiet Pavement

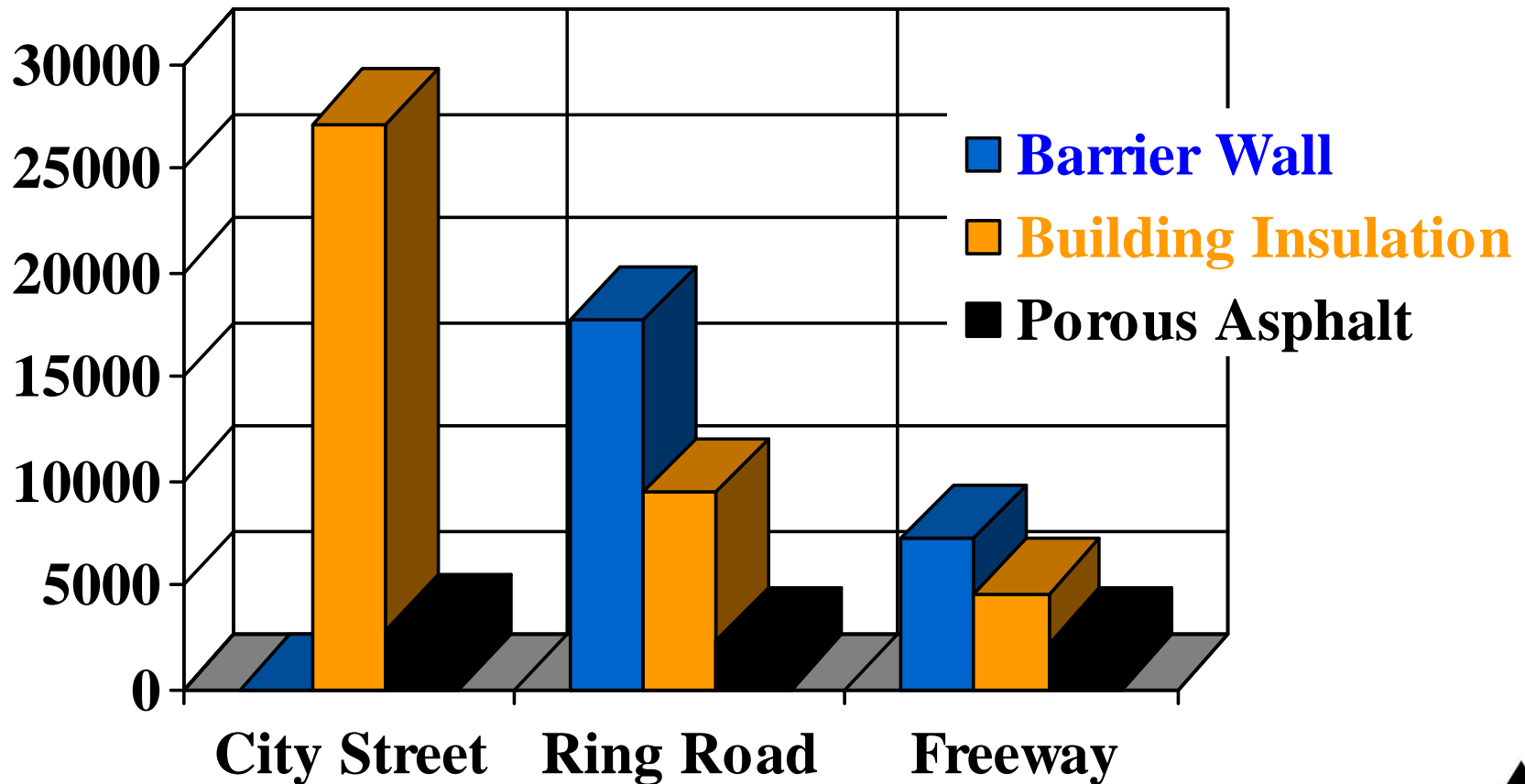


Ulf Sandberg – Swedish National Road and Transport Research Institute



Controlling Highway Noise at the Source

Danish 30 Yr Life Cycle Cost vs. Noise Reduction

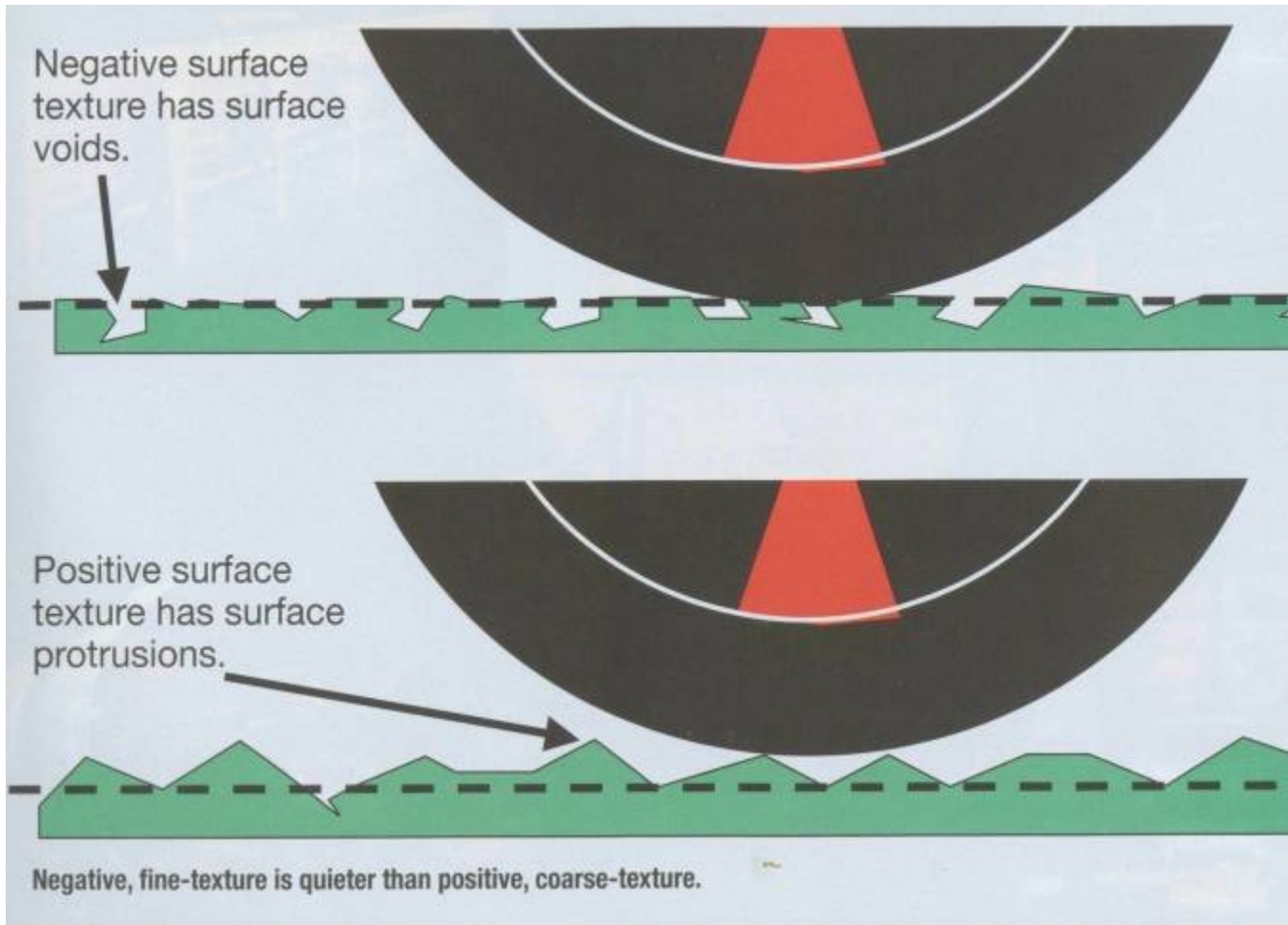


(a)

Roadway Type



Controlling Highway Noise at the Source



- Fine Graded Negative Textured Surfaces with Voids
- Course Graded Positive Textured Surfaces with Protrusions



Controlling Highway Noise at the Source

Netherlands

- 65% National Road System is OGFC
- To Reduce Clogging
 - Confined to High-speed Routes
 - Experimenting with High pressure washing and vacuuming.



Controlling Highway Noise at the Source

Noise Makes News in the USA!

- Families lobbied the Michigan DOT for noise abatement after surface on I-275 was changed
- Residents in Northern Ohio plead with ODOT Director for Noise Relief after sections of I-77 were rebuilt
- TX Dot reports an 1 ½ inch overlay on I-35 at San Antonio:
 - Improved ride by 61%
 - Improved Skid resistance by 200%
 - Reduced Noise readings an average of 14 dB(A)



Controlling Highway Noise at the Source

What Can Be Done?

- DOT's indicate a strong need for more pavement noise control strategies.
- The proper selection of pavement surfacing can have a profound impact on the primary source of highway noise, the pavement/tire interface.



Controlling Highway Noise at the Source

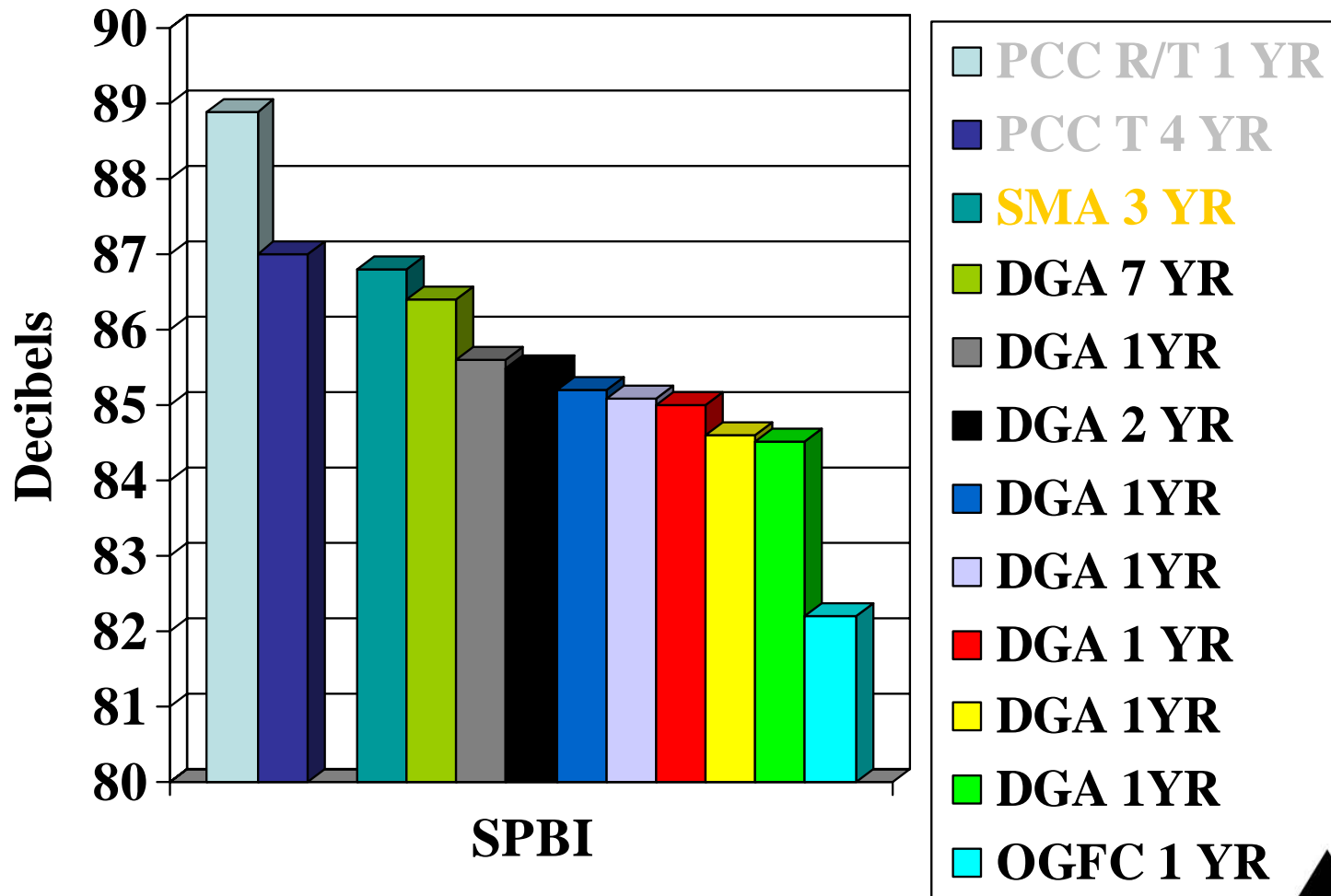
Effect of Pavement Surface

- OGFC is the quietest surface type. *(Wayson, NCHRP Synthesis 268)*
- SMA has also proven to be a quiet surface. *(Wisconsin DOT, 1993)*
- Dense graded HMA surfaces are quieter than PCC pavements. *(Hibbs and Larson, Report FHWA-SA-96-068, May 1996)*



Controlling Highway Noise at the Source

Ohio Study



Found a difference of 7 Decibels from the loudest to the quietest



NCAT Close Proximity Noise Trailer



Controlling Highway Noise at the Source



**AZDOT
CPX
Trailer**



Controlling Highway Noise at the Source

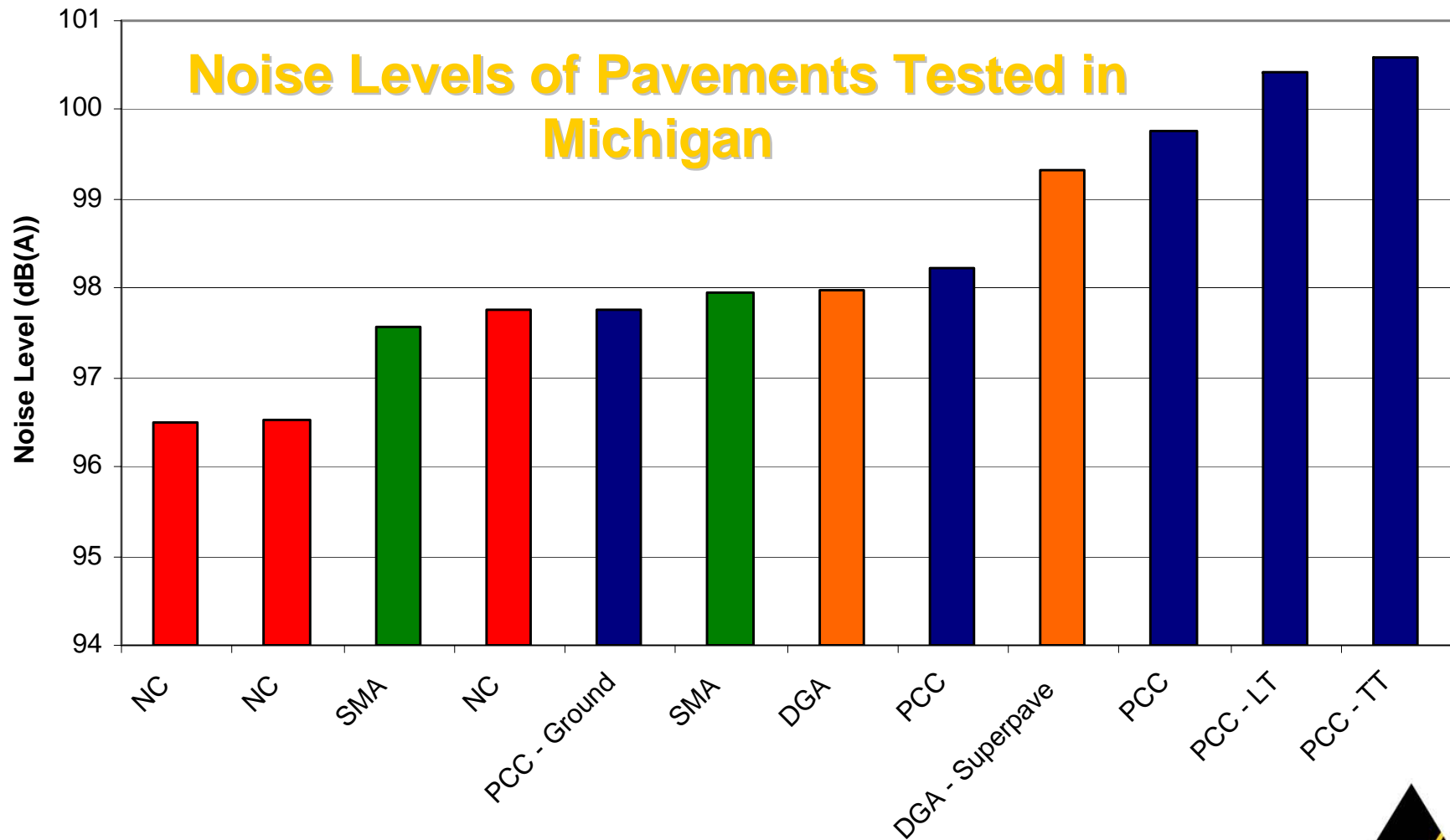
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**CalTran
Sound
Pressure
Level
Method**



Controlling Highway Noise at the Source



Controlling Highway Noise at the Source

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Noise Levels By Surface Type

104.9	Random Transverse (Wisconsin)
102.5	Uniform Transverse (ADOT-3/4")
95.5	Whisper Grind
95.9	SMA
95.0	ARFC
96.0	PEM



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Open Grade Friction Course's

- Improve Skid Resistance
- Reduced Hydroplaning
- Reduce Noise
- Improve Visibility



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Controlling Highway Noise at the Source

AZDOT's Use of Open Graded Friction Courses

- Development of OGFC for Use in Snow Country (1970s-80s)
- Improved OGFC to Resist Reflective Cracking (1980s-90s)
- Improved OGFC Used as PCCP Overlay (1980s-2000s)
- Benefit For Smoothness (1990s)
- Benefit for Noise (1990s-2000s)





JUL 8 2003

Controlling Highway Noise at the Source

Development of the Arizona Quiet Pavement Pilot Program

- ADOT Receives a 4 dB(A) Credit for ARFC
- Ten Year, Multi Million Dollar Research Program Underway
 - Composite
 - Flexible
 - Rigid
- Program Intended to Evaluate the Efficacy of Quiet Pavement Solutions



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SR 101W ARFC
11/6/03 91 dB(A)



Controlling Highway Noise at the Source

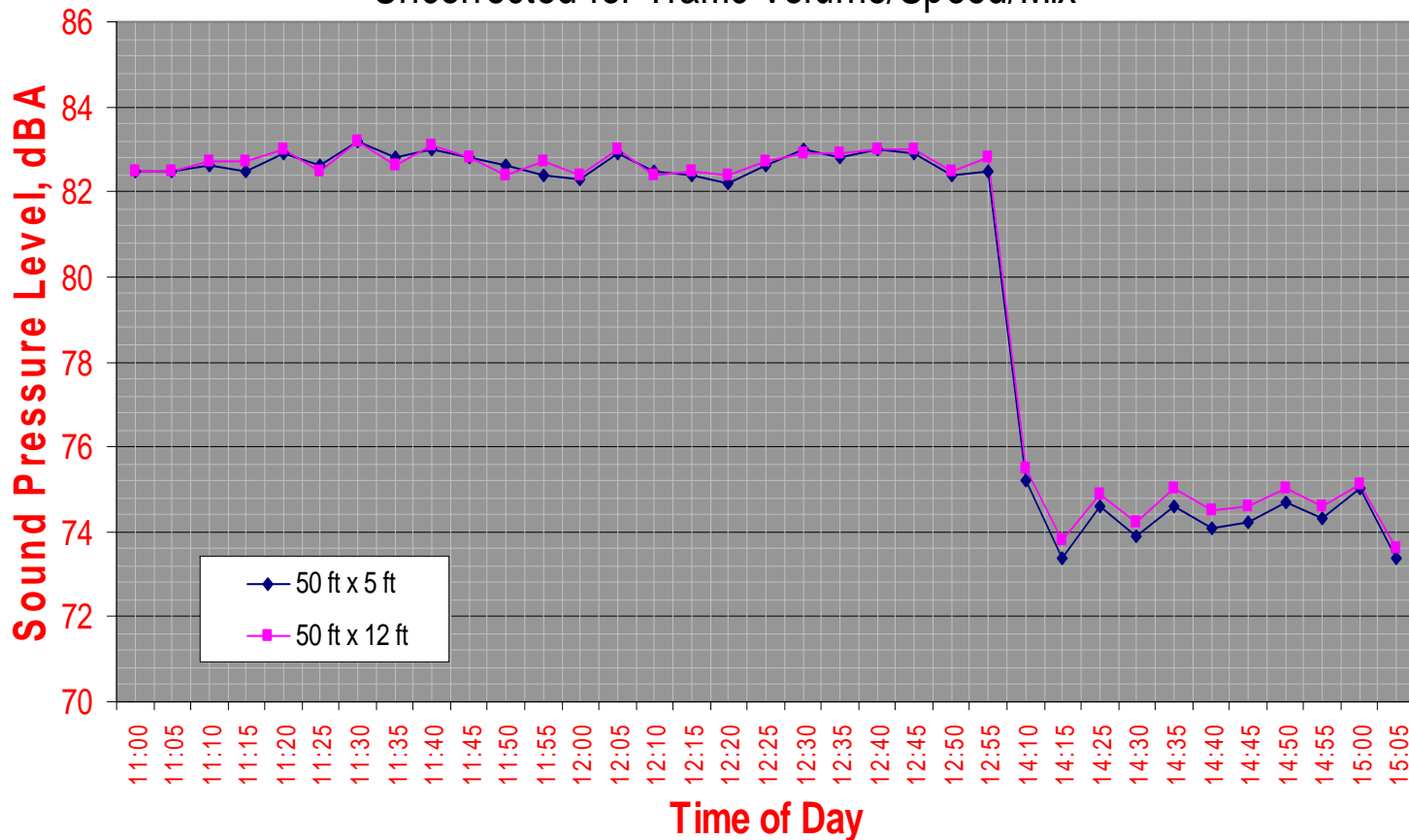
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Controlling Highway Noise at the Source

Sound Levels at 50 ft - AZ 101 Pre & Post Project

Uncorrected for Traffic Volume/Speed/Mix

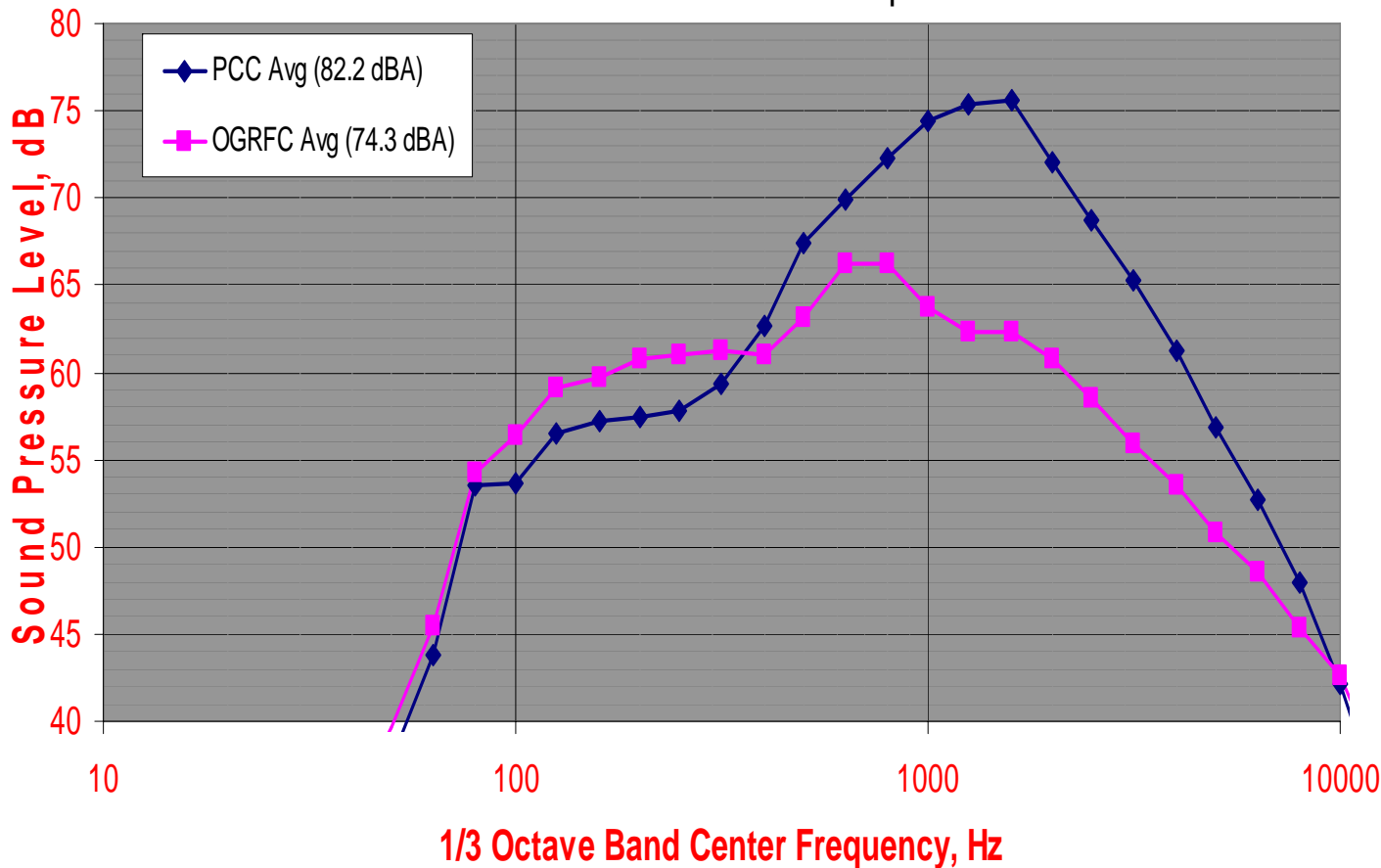


Before and After Comparison Site 3A

Controlling Highway Noise at the Source

Arizona 101 Wayside Data at 50 ft - Pre & Post Project OGFC

Uncorrected for Traffic Volume/Speed/Mix



Before and
After
Comparison
Site 3A

Controlling Highway Noise at the Source

Noise is Important to the Public.

Current Mitigation Techniques

- Expensive

- No Overall Reduction



Controlling Highway Noise at the Source

A Decrease of 3 dB(A)
-Equals Doubling Distance
-Cutting Traffic in Half



Controlling Highway Noise at the Source

Decrease of 10dB(A):
-Perceived as a 50%
reduction in volume



Controlling Highway Noise at the Source

Changing Surface Texture:

- Improves Smoothness
- Improves Skid-Resistance
- Reduces Overall Emissions
- Uses Existing Technology



Controlling Highway Noise at the Source

Changing Surface Texture:

- Routine Overlay Program
 - No need to wait
 - Done as Maintenance
- SMA & OGFC Mixes
 - Designed for Hi-Stress



Questions?



Controlling Highway Noise at the Source

Asphalt Information on the Web

- Asphalt Institute:
 - www.asphaltinstitute.org
- Asphalt Pavement Alliance
 - www.asphaltalliance.org
- National Center for Asphalt Technology
 - www.ncat.com

