

# Curious Challenges: Controlling Construction Noise

Wentworth Institute of Technology, 11/14/16



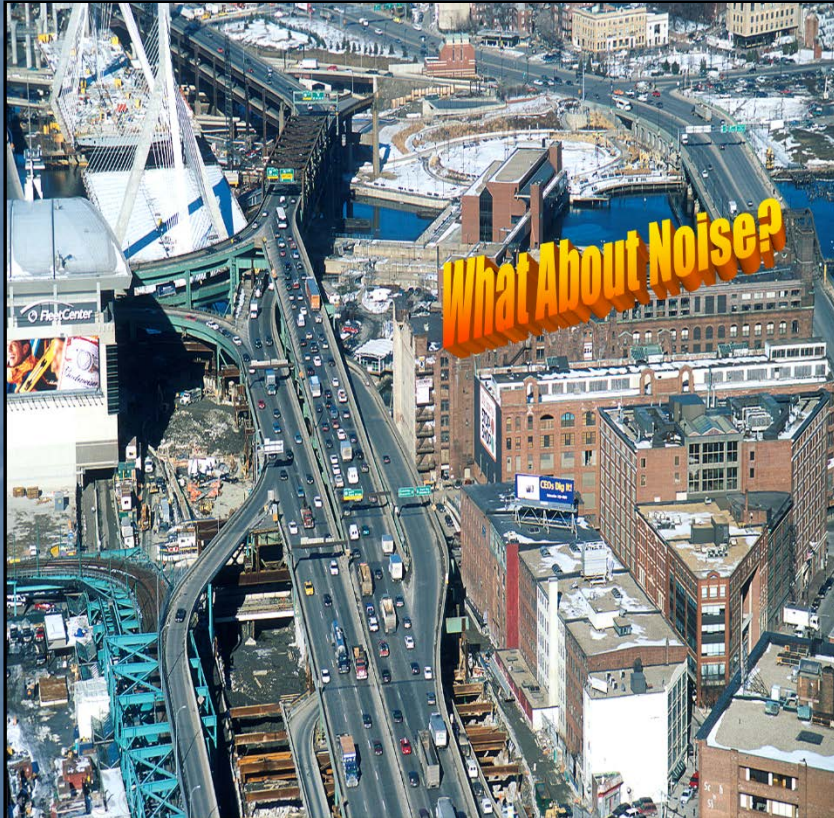
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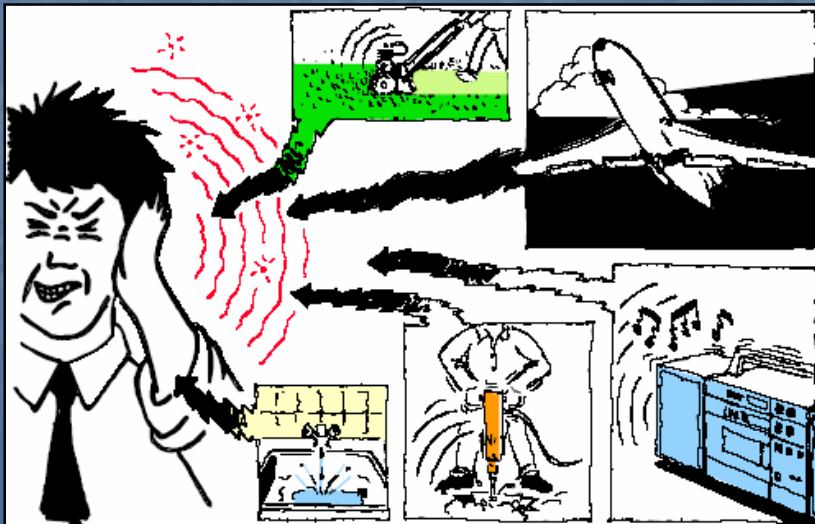
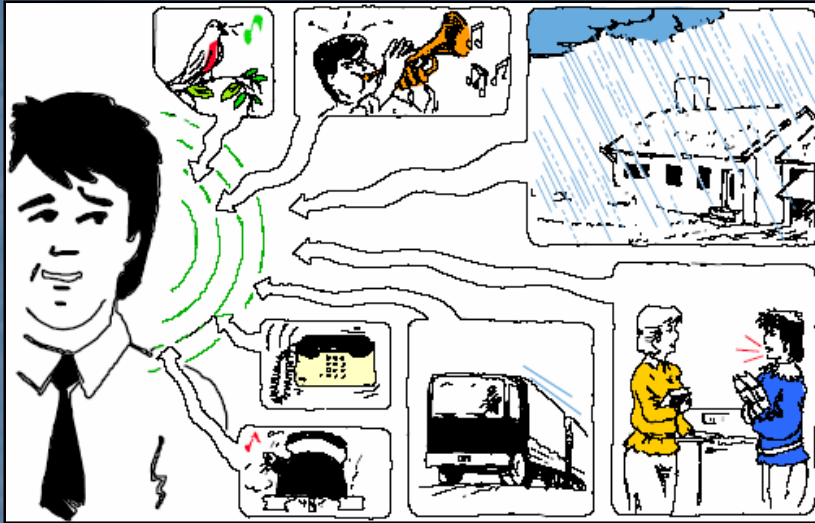


# Introduction



- Everybody loves new infrastructure & transportation projects - when they're done!
- But what about the dreaded construction phase?
- How can people cope with the disruption, traffic jams, dust, and most importantly, noise during construction?
- You'd never believe some of the curious noise control challenges that can present themselves.

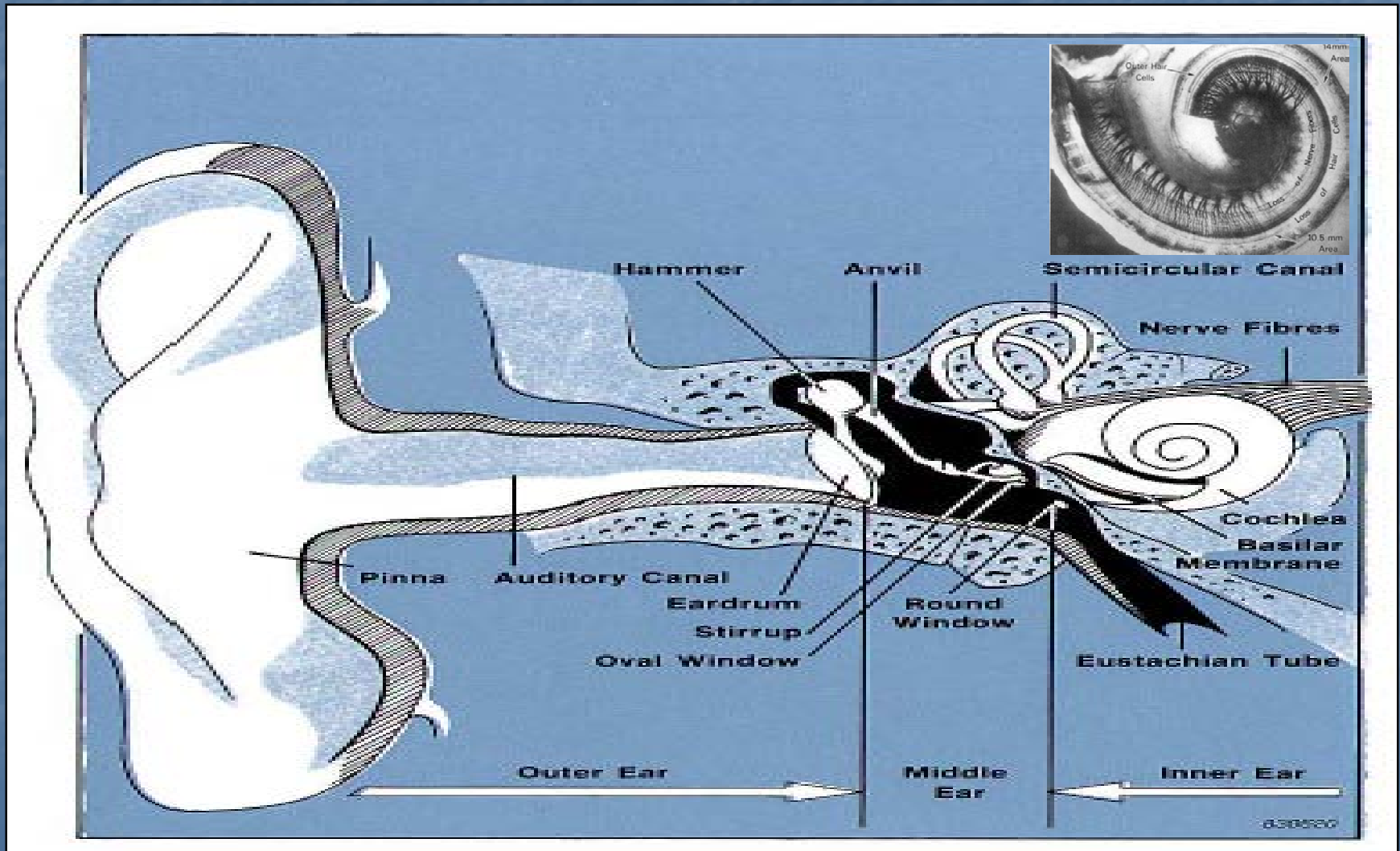
# Noise vs. Sound



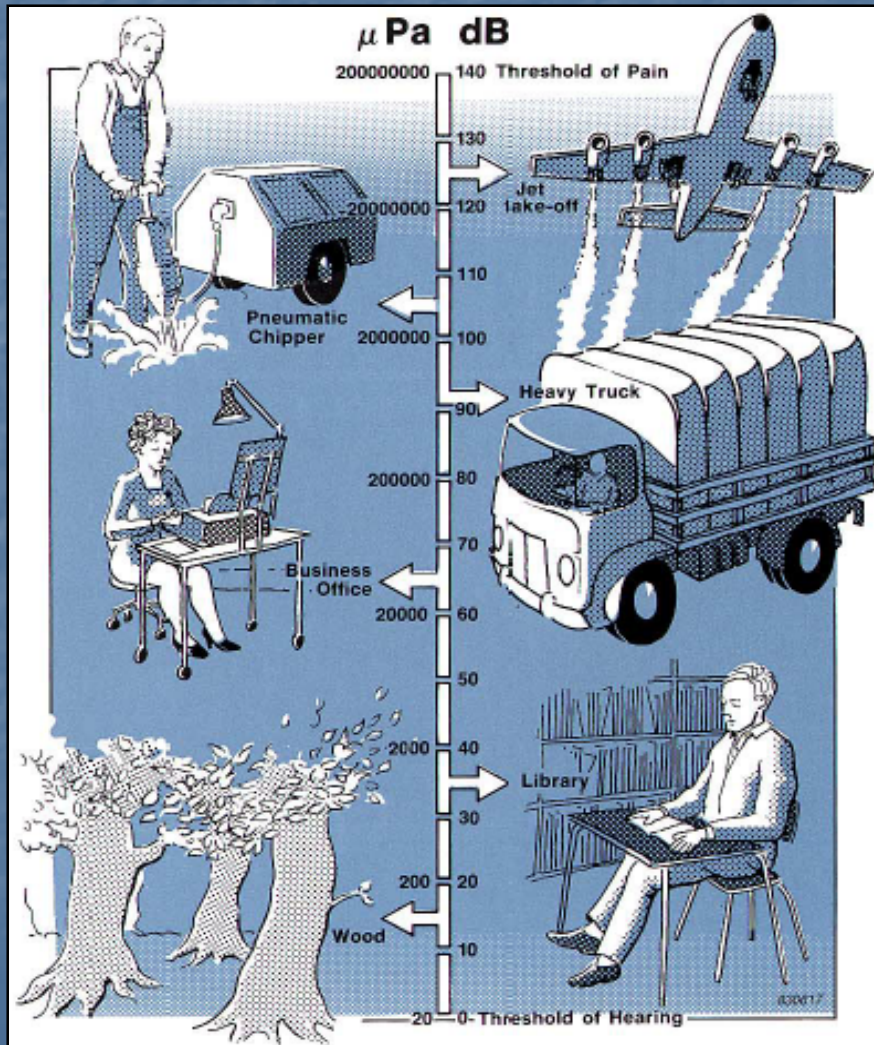
- Sound
  - Pleasant, controllable, desirable, pleasing, understandable
- Noise
  - Too loud, annoying, uncontrollable, interfering, undesirable
- But not all people react the same way to noise
- *"Noise is in the ear of the beholder."*



# Human Auditory System



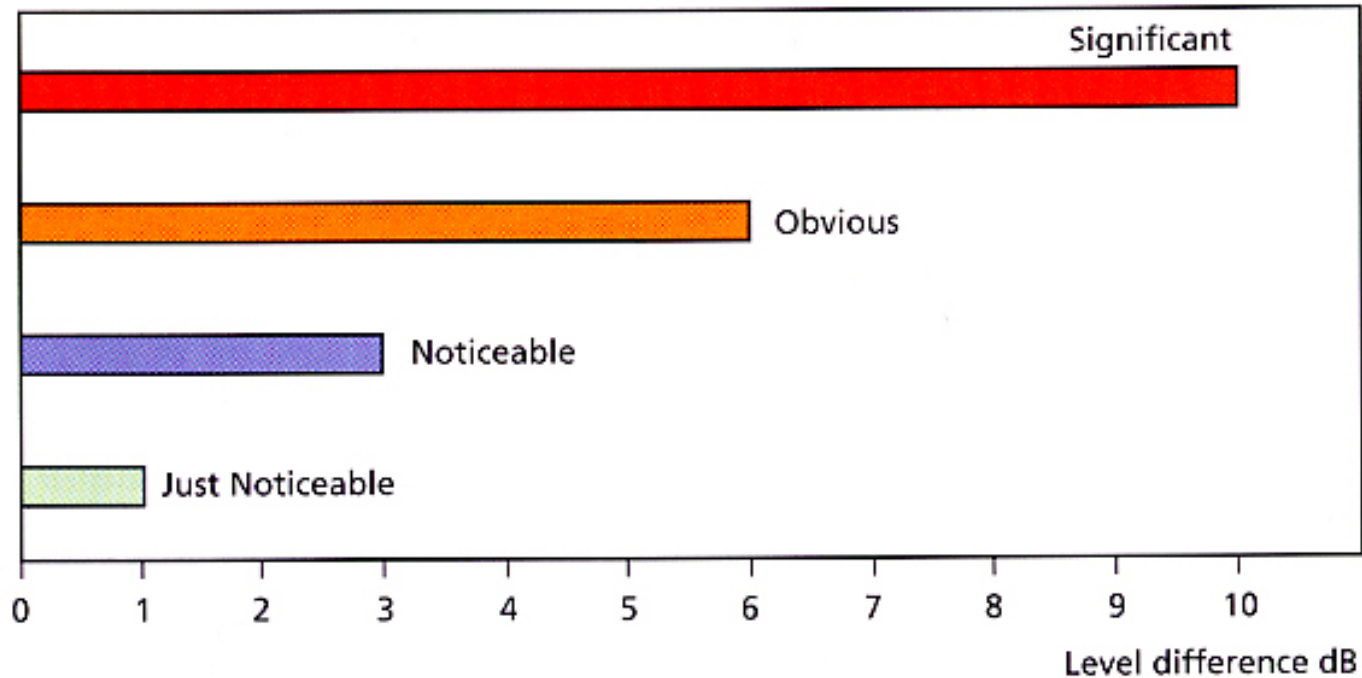
# What's a Decibel Anyway?



- Humans can hear fluctuations in air pressure over seven orders of magnitude
- More convenient scale needed: *Decibels*
  - Alexander Graham Bell
- $\text{dB} = 10 \text{ Log } (P/P_0)^2$   
Where  $P_0 = 20\mu\text{Pa}$
- *Does 0 dB mean no sound?*

# Subjective Response

Humans respond to sound logarithmically  
Better resolution at lower sound levels



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# Big Dig Noise Control

- Major urban construction for 15 years
- Must control both "physical" and "political" noise
- Most politically-charged environmental issue
- Noise accounted for half of all complaints
- Challenges can threaten project schedule/costs
- Must satisfy affected public, Fed/State/City officials, news media, and project managers
- Must be responsive, equitable, and successful!

# Noise Control Strategy



- High level of "command support"
- Implement consistent and equitable noise control policies
- Proactive avoidance of excessive noise
  - *Velvet glove approach*
- Ability to react with needed solutions
  - *Iron fist approach*
- Open and honest dialog with community – builds trust & tolerance
- Construction Noise Control Spec. 721.560





# CA/T Project Lot-Line Construction Noise Criteria Limits

Noise Receptor Locations and Land-Uses	Lot-Line Construction Noise Criteria Limits in dBA, RMS slow					
	Daytime (7 AM - 6 PM)		Evening (6 PM - 10 PM)		Nighttime (10 PM - 7 AM)	
	L10	Lmax	L10	Lmax	L10	Lmax
Noise-Sensitive Locations: (Residences, Institutions, Hotels, etc.)	75 or Baseline + 5 <i>(which ever is louder)</i>	85 90 (impact)	Baseline + 5	85	Baseline + 5 <i>(if Baseline &lt; 70)</i>  Baseline + 3 <i>(if Baseline &gt; 70)</i>	80  80
Commercial Areas: (Businesses, Offices, Stores, etc.)	80 or Baseline + 5	None	None	None	None	None
Industrial Areas: (Factories, Plants, etc.)	85 or Baseline + 5	None	None	None	None	None

Notes: L10 noise readings are averaged over 20 minute intervals. Lmax noise readings occur instantaneously.  
Baseline noise conditions must be measured and established prior to construction work commencing.

# CA/T Equipment Noise Limits (dBA Lmax 'slow' at 50 feet)

All Other Equipment	85 dBA	Impact Pile Driver	95 dBA
Auger Drill Rig	84 dBA	Jackhammer	85 dBA
Backhoe	78 dBA	Mounted Hoe Ram	90 dBA
Boring Jack Unit	80 dBA	Paver	77 dBA
Chain Saw	84 dBA	Pavement Scarifier	85 dBA
Clam Shovel	87 dBA	Pneumatic Tools	85 dBA
Compactor	80 dBA	Pumps	77 dBA
Compressor (air)	78 dBA	Rivet Buster Chipper	79 dBA
Concrete Plant	83 dBA	Rock Drill	81 dBA
Concrete Truck	79 dBA	Roller	80 dBA
Concrete Pump	81 dBA	Scraper	84 dBA
Concrete Saw	90 dBA	Shears	90 dBA
Crane	81 dBA	Slurry Plant	78 dBA
Dozer	82 dBA	Slurry Trencher	80 dBA
Dump Truck	76 dBA	Soil Mix Drill Rig	80 dBA
Excavator	81 dBA	Tractor	84 dBA
Flat bed Truck	74 dBA	Vacuum Excavator	85 dBA
Front End Loader	79 dBA	Vac. Street Sweeper	80 dBA
Generator	81 dBA	Ventilation Fan	79 dBA
Gradall	83 dBA	Vibratory Mixer	80 dBA
Grader	85 dBA	Vibratory Pile Driver	95 dBA
Grapple	85 dBA	Welder	73 dBA



# Source Noise Controls



- Source controls are most effective
- Prevents noise from being created
- Quieter equipment or alternative methods
- Time restrictions, prohibitions
- Backup Alarms!

# Pathway Noise Controls



- Noise barrier walls, mufflers, silencers and enclosures, increased distance
- Barriers must be tall enough to block the line-of-sight
- Must ensure no gaps through barriers
  - 1% hole lets 90% of the noise through



# Receiver Noise Controls



- Noise control directly affecting the listener
- Relocation out of noisy environment
- Building soundproofing
  - Windows, doors, roof, AC
- Personal hearing protection
- Compensation (Hush \$\$)
  - *Not with public money!*
- Public outreach, information, dialog, involvement

# Odd Noise Challenge No. 1



- Vacuum Excavators
  - Incredible low frequency rumble
  - Can penetrate buildings within several city blocks
  - Makes people feel sick
- In-depth noise study done for a typical vac-truck
  - Roots blower found to be the cause of the problem
- Noise Control
  - Extra enclosures, better silencers, operate at lower-power levels

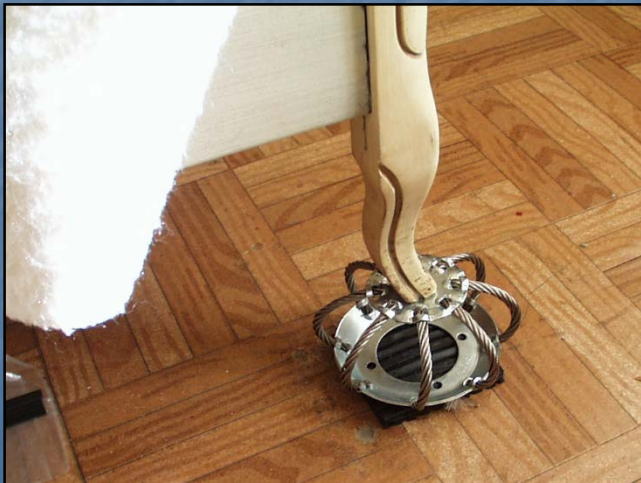


# Odd Noise Challenge No. 2



- Residential Soundproofing
  - Proactive noise mitigation
- Install additional window sash
  - Installed inside the residence
  - Need a Right-of-Entry Agreement
- Avoids problems such as:
  - Historic properties restrictions
  - Exposing asbestos or lead paint
- Can provide additional 10 decibels of noise reduction
  - Perceived as half as loud!

# Odd Noise Challenge No. 3



- Annoying building vibrations
  - Unexpected problem
  - Caused by shifting elevated I-93 Artery onto temporary columns
- Significant community outrage
  - People could not sleep
  - Complained of a variety of maladies
  - Politicians and media got involved
- Extensive vibration study done
  - Confirmed disturbing vibration levels
- Vibration control measures
  - Scarify/smooth Artery surface
  - Install vibration isolation bed springs



# Odd Noise Challenge No. 4



- Noise-related lawsuits!
- Harbor Towers
  - Nighttime disturbances
- Spaulding Rehabilitation Hospital
  - Wanted building to be taken
- Construction contractor claims
  - Lost time and inefficiencies
- Mounted full defenses in all cases
  - Special noise study for Spaulding Hosp.
    - Judge ruled in Project's favor
  - Offered Harbor Towers window sashes
  - Won every contractor claim suit



# Odd Noise Challenge No. 5

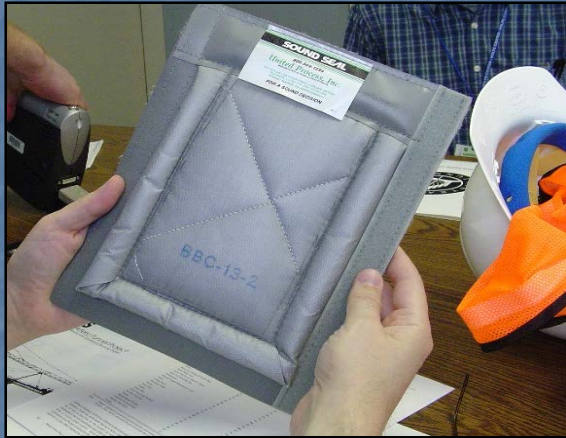


- Make a hoe ram disappear!
- Needed to work all night long near residential area
- Built the "Flynn Memorial Garage"
- Three-sided, roofed enclosure
- Double-layer plywood walls
- Insulated wall air gap
- Successfully reduced hoe ram noise to allow work all night





# Odd Noise Challenge No. 6



- Be careful joking in public!
- Community meeting to present noise control plans
- Asked how effective noise curtains would be?
- Did a spur of the moment live "demonstration"
- Wrong thing to do!
- Elderly woman explained the err of my ways
  - *And she was right*

# Odd Noise Challenge No. 7

- Surviving a Federal audit!
- Feds paying 80% of costs with FHWA responsible for oversight
- Summarized noise control program's policies, strategies, methods and costs for in-depth FHWA "Process Review"
- Estimated costs to be about **\$16 million** over life of project
- Survived audit, Feds pleased!
  - FHWA Roadway Construction Noise Model (RCNM, 2007)

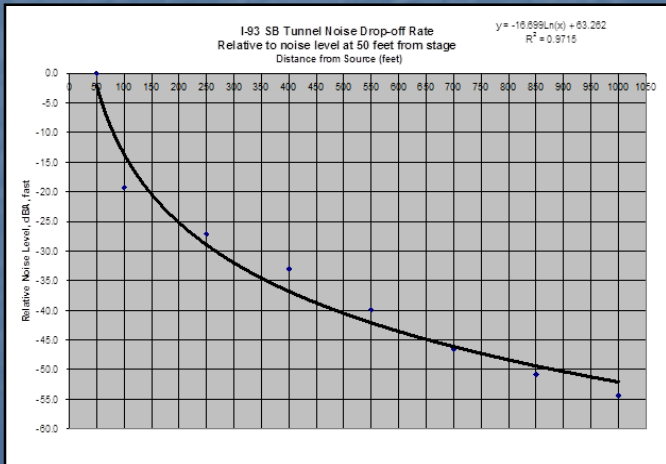
FHWA Process Review - CA/T Project Noise Control Program				
Estimates as of November 1997				
Cost Category	Past Costs	Future Costs	Total Costs	
	1996 - 1997	1998 - 2004	Entire Project	
Direct Expenses (staff, HO, subs)	\$2,522,520	\$2,803,840	\$5,326,360	
Indirect Expenses (equipment)	\$44,500	\$57,500	\$102,000	
Mitigation Costs (barriers, windows)	\$2,189,650	\$2,539,950	\$4,729,600	
Contractor Costs (Spec 721.560)	\$1,503,179	\$3,917,481	\$5,420,660	
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Sub Totals =	\$6,259,849	\$9,318,771	\$15,578,620	
		Total Cost =	<b>\$15,578,620</b>	
Project duration in years =	18	Annual Cost =	<b>\$865,479</b>	
Relative to total Project cost =	\$10,400,000,000	Percentage =	<b>0.15%</b>	



# Odd Noise Challenge No. 8



- Boston Pops concert in tunnel
  - To celebrate I-93 NB tunnel opening
- Needed suitable acoustics
  - Reverberation, propagation drop-off
- Tested acoustics in empty tunnel
  - Worked with Pops' sound engineers
  - 10 gauge yachting cannon
- Sounded good acoustically!
- But event scratched due to concern for public perception of costs



# Questions?

