Reflections from Highway Noise Barriers and the Use of Absorptive Materials in the U.S.

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Presentation Overview

- A little history
- The Caltrans experience
- Other DOTs' perspectives
- What's going on?
- Some consequences and considerations
- How can TNM help?

A Little History

- **NCHRP 117 – Highway Noise Design Guide (1971)**
  - Community Reaction: Highway noise level L(Hwy) vs. Ambient level L(Amb)
    Modified from 1969 Boeing Field study by Sawley and Gordon:

L(Hwy) relative to L(Amb)	Community Reaction
L(Hwy) less than L(Amb)	No reaction
L(Hwy) 0 to 9 dB higher	No reaction to sporadic complaints
L(Hwy) 9 to 16 dB higher	Sporadic complaints to widespread complaints

A Little History

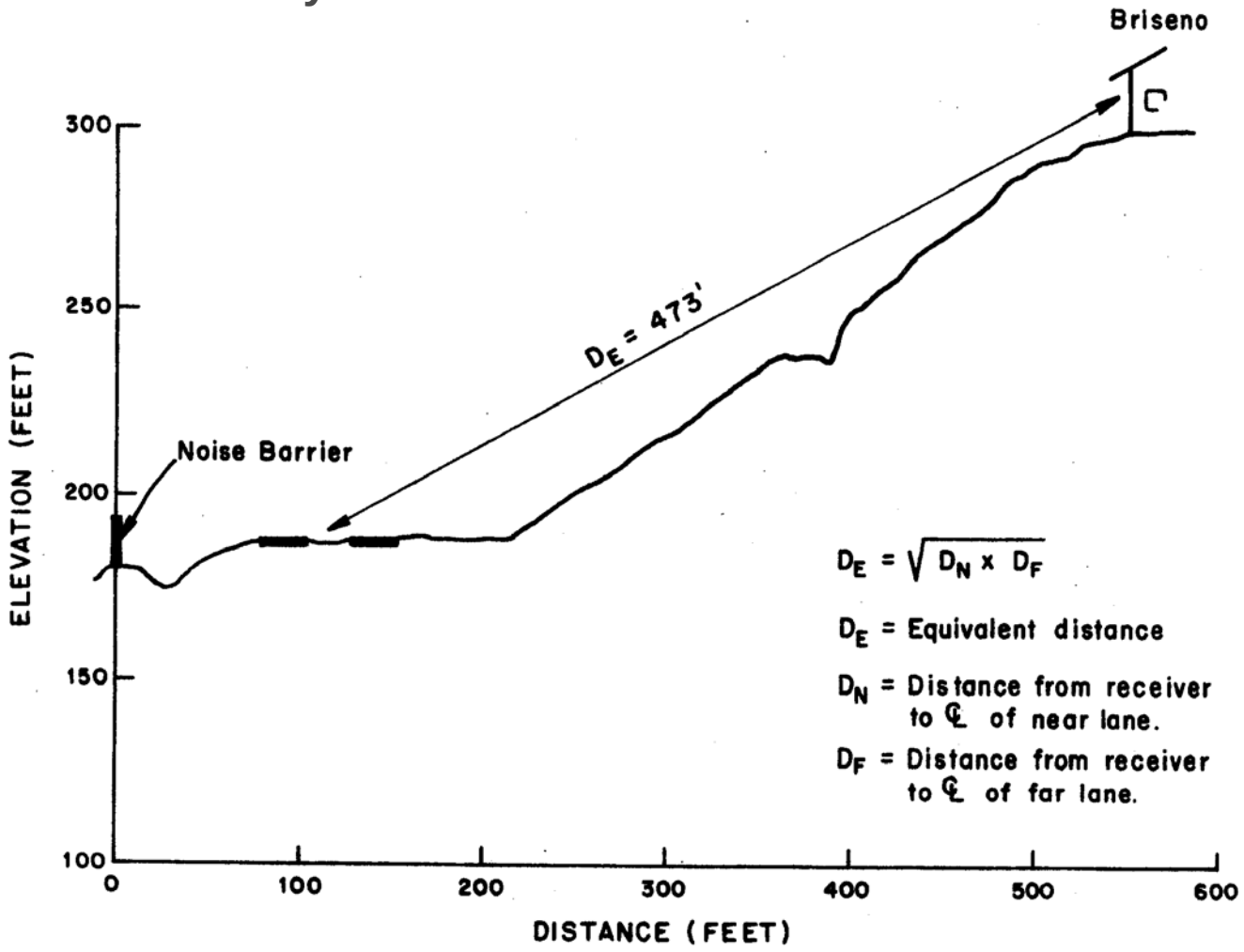
- **Guidance from 1973 BBN-developed FHWA "Fundamentals and Abatement" training course:**
  - Human response to sound level differences:
    - 0.5 dB – just barely detectable in laboratory environment
    - 2-3 dB – just detectable for "real-life sounds or noises"
    - 5 dB – readily noticeable
  - Receivers opposite the barrier (direct noise not blocked):
    - "Reflected noise increase usually not significant"
    - "Little benefit would be derived from making the barrier absorptive"
  - Similar language is repeated in 1980 FHWA Training Course

A Little History

- **1970s – Multiple reflections recognized as potential problem, where barrier IL degradations may be large**
- **Single reflections assumed okay – increase <3 dB**
- **Studies of multiple reflections from parallel barriers**
  - 1975 FHWA-sponsored BBN study – multiple reflections
  - 1980 Menge scale model study of sloped (tilted) barriers
  - 1982 Hayek parallel barrier study – analytical & empirical
  - 1987 Slutsky & Bertoni prediction procedure
  - Late 1980s – Anderson RAYverb model (later into TNM)
  - Early 1990s – Volpe Center parallel barrier studies, including the Dulles test barriers
  - Volpe report resulted in FHWA guidance on width-to-height ratio – greater than 10:1 means <3 dB increase, so “acceptable”

The Caltrans Experience
1978 – Mas Hatano "Evaluation of Noise Barrier Reflection"

- Thanks to Bruce Rymer for much historical material!



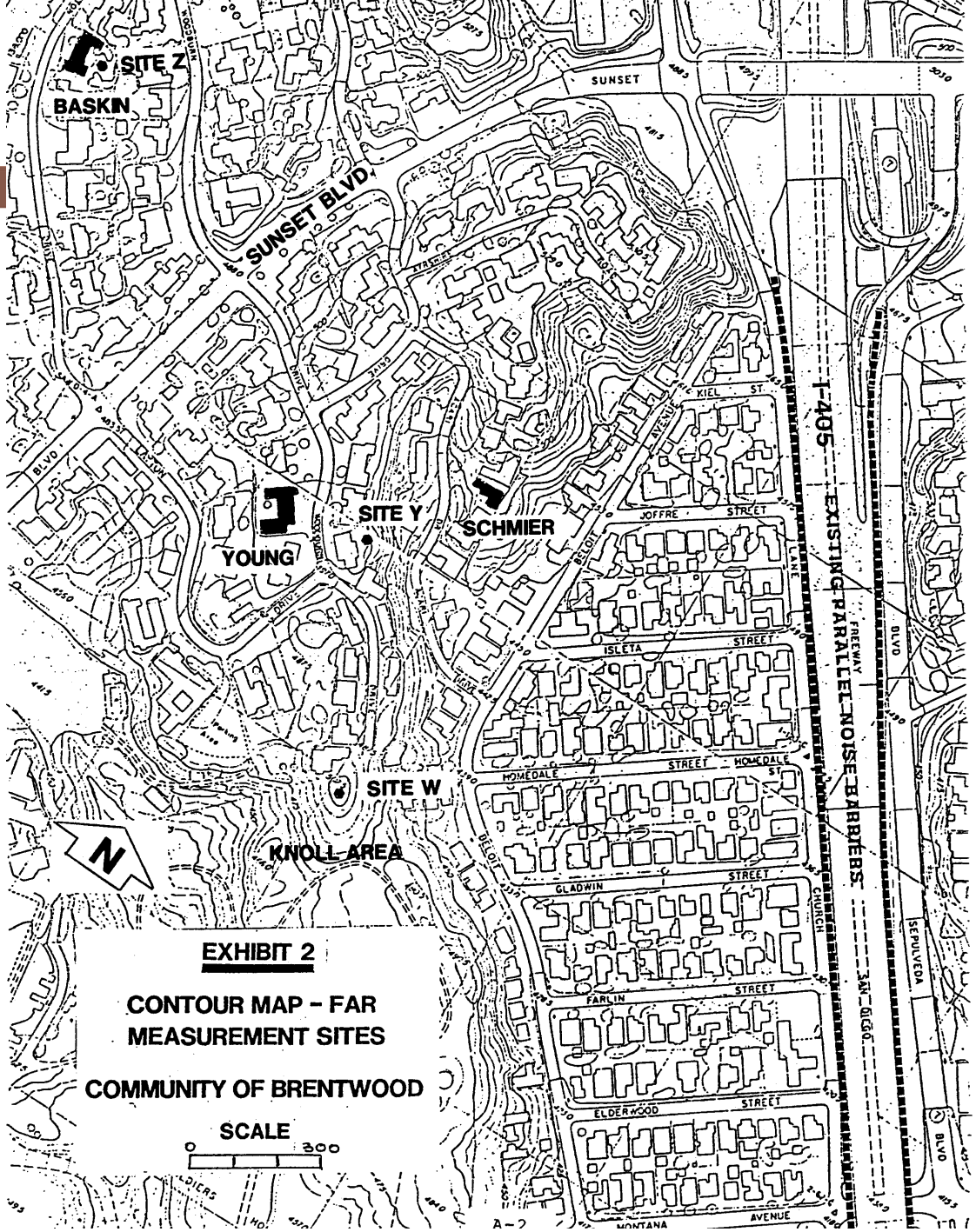
The Caltrans Experience
1978 – Mas Hatano “Evaluation of Noise Barrier Reflection”

- Measured along same roadway opposite wall & no wall
- Covered walls with absorptive blankets
- Could not reliably measure any noise-level increases
- Increases must be <3 dBA, so “can’t be normally perceived from one day to the next”

The Caltrans Experience

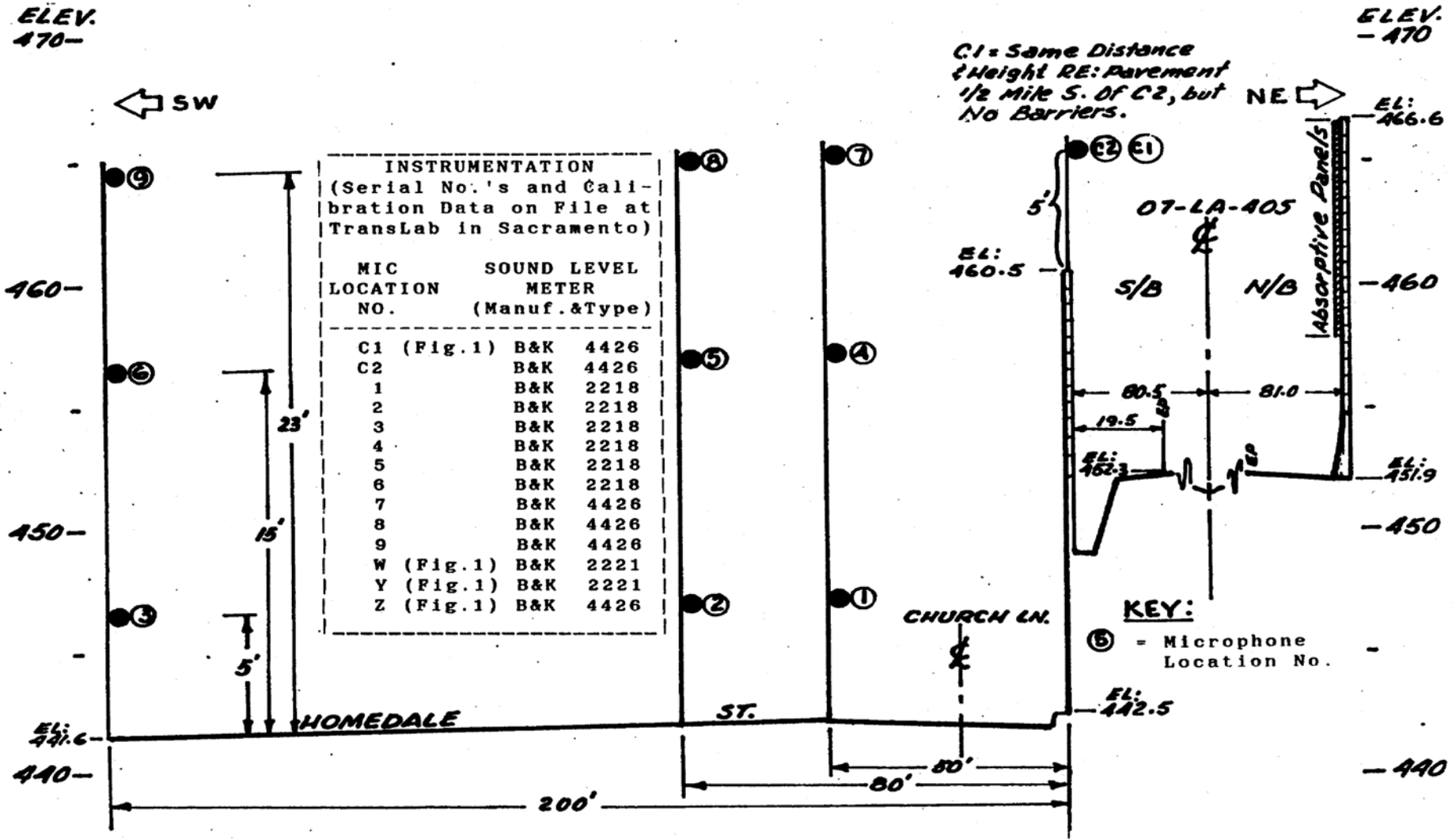
1989 –
Rudy Hendriks & Joe Hecker – Parallel Barrier Absorptive Demonstration Project

- Noise complaints after parallel reflective barriers built



The Caltrans Experience
1989 Parallel Barrier Absorptive Demonstration Project

Figure 2
07-LA-405 Brentwood - Parallel Noise Barrier Study
INSTRUMENTATION AT HOMEDALE STREET



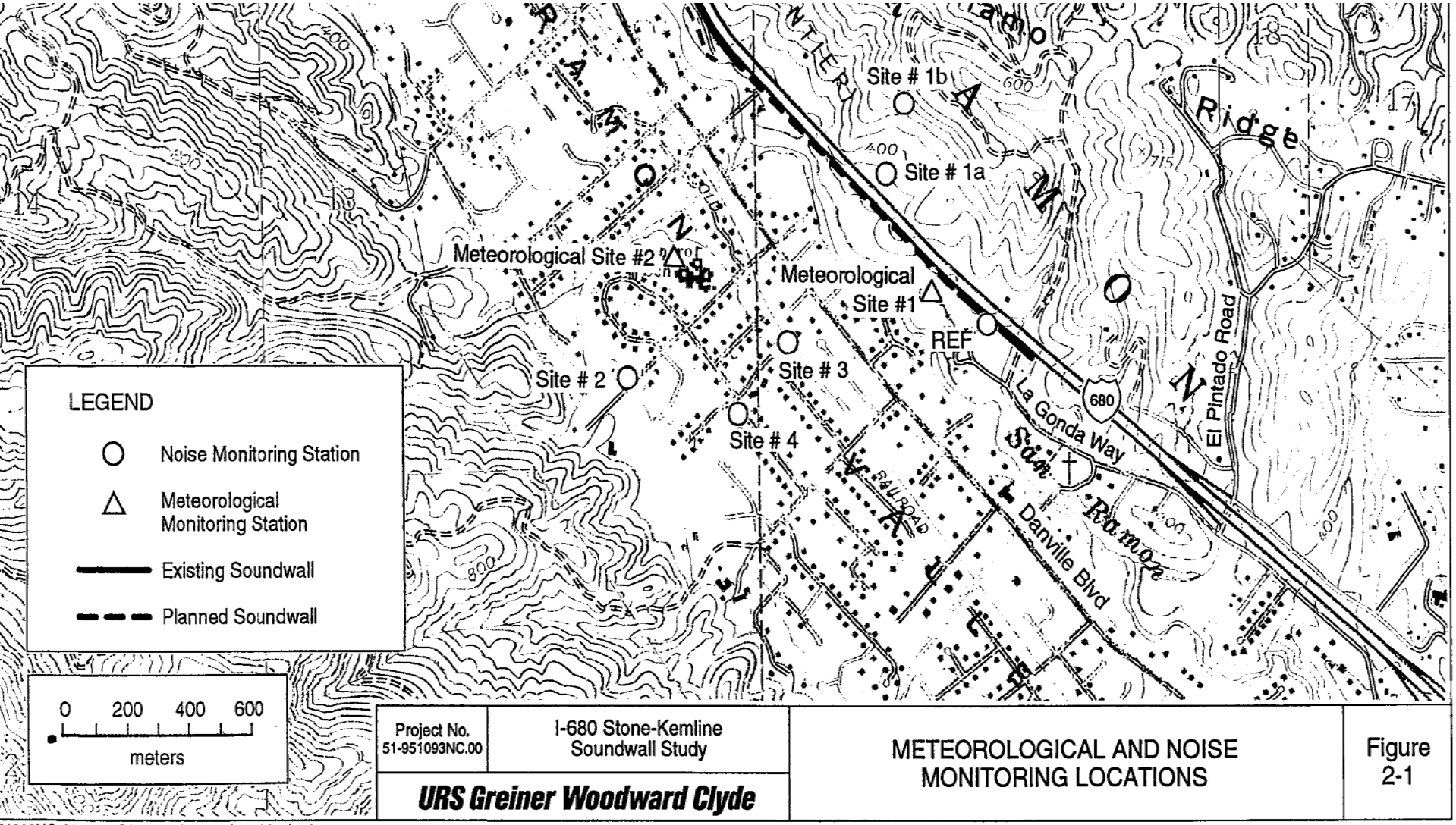
The Caltrans Experience
1989 Parallel Barrier Absorptive Demonstration Project

- Sound-absorptive material added to opposite-side barrier in carefully-conducted demonstration project of parallel barriers
- Sound-level decreases measured 0 to 3 dB
- Conclusion: differences inaudible, so ineffective treatment

The Caltrans Experience

- **1998 – Rudy Hendriks – Technical advisory: Guidelines for studying the effects of noise barriers on distant receivers**
  - Before and after noise barrier studies – detailed measurement methodology and documentation requirements
  - “A change of 3 dBA or less will be considered no change”

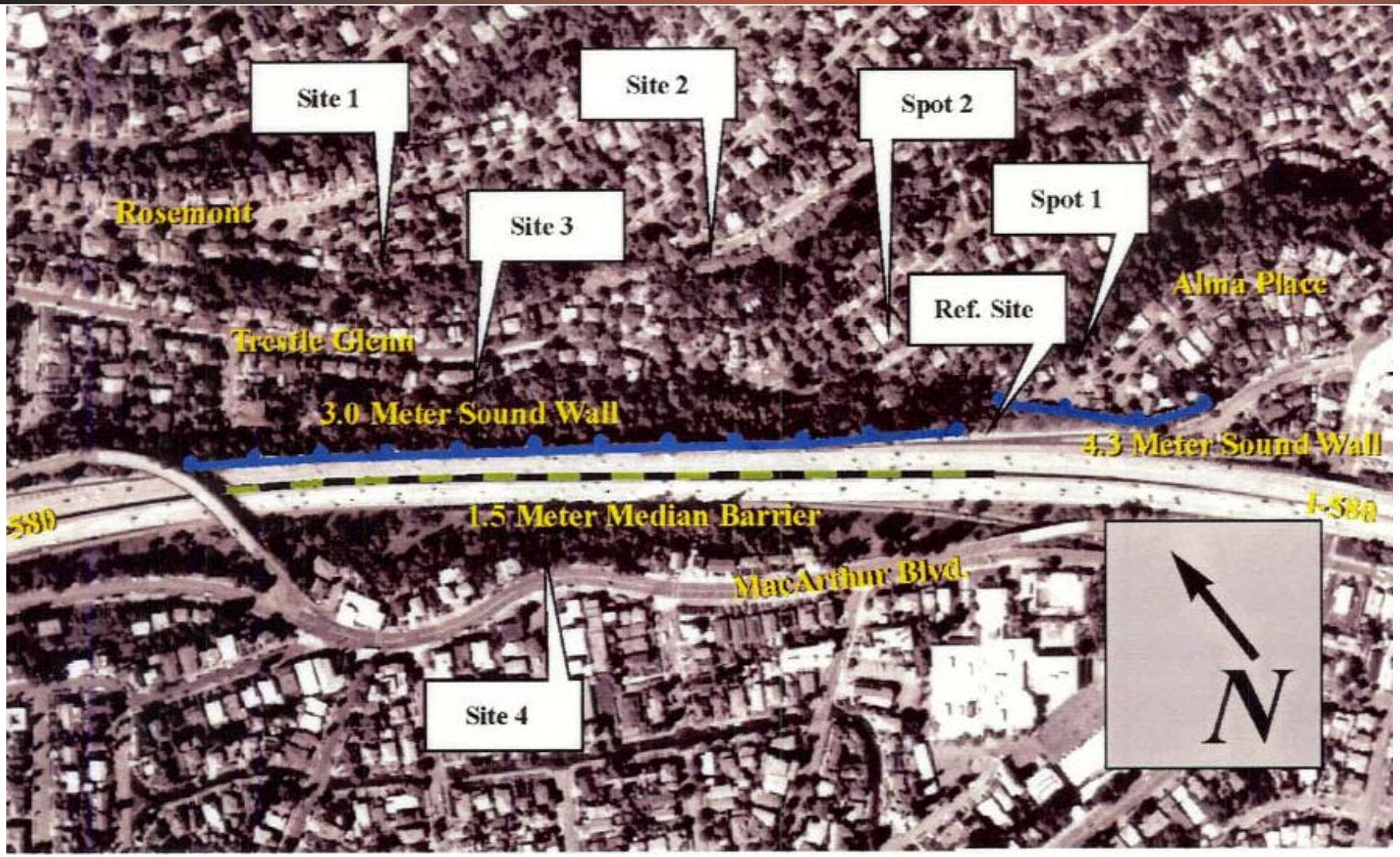
The Caltrans Experience
1999 URS/I&R/Caltrans – I-680 Before and After Barrier Study



The Caltrans Experience
1999 URS/I&R/Caltrans – I-680 Before and After Barrier Study

- Detailed noise and meteorological measurements:
  - Several sites at different distances: 300 to 3000 ft
  - Behind and opposite the barrier
  - Under morning and nighttime conditions
- Measured 1 to 2 dB increases opposite the barrier, higher increase was farther away
- Increases not considered significant

The Caltrans Experience
1999 Woodward-Clyde/I&R/Caltrans – I-580 Abatement Study



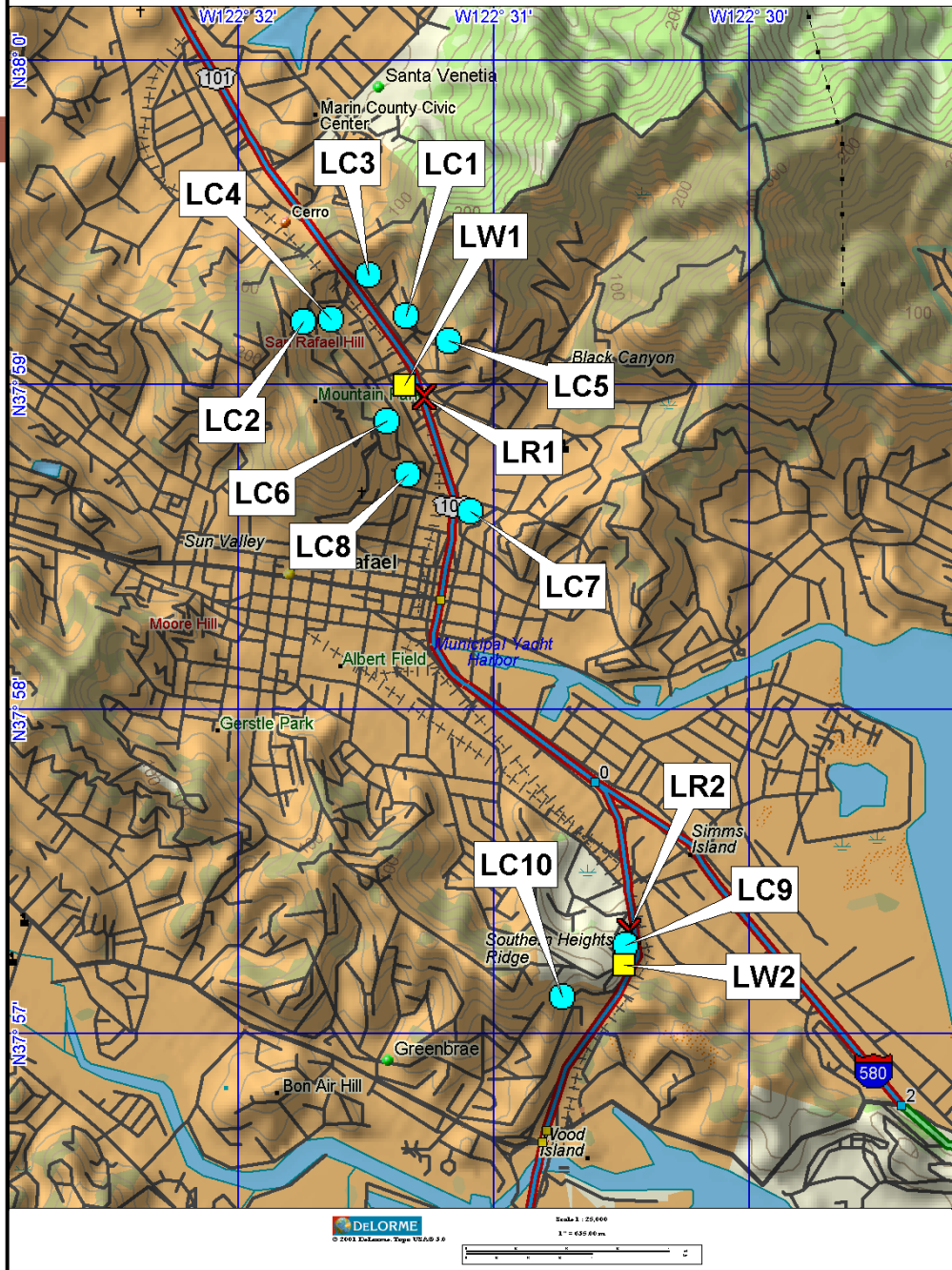
Source: Woodward-Clyde, 1999

The Caltrans Experience
1999 Woodward-Clyde/I&R/Caltrans – I-580 Abatement Study

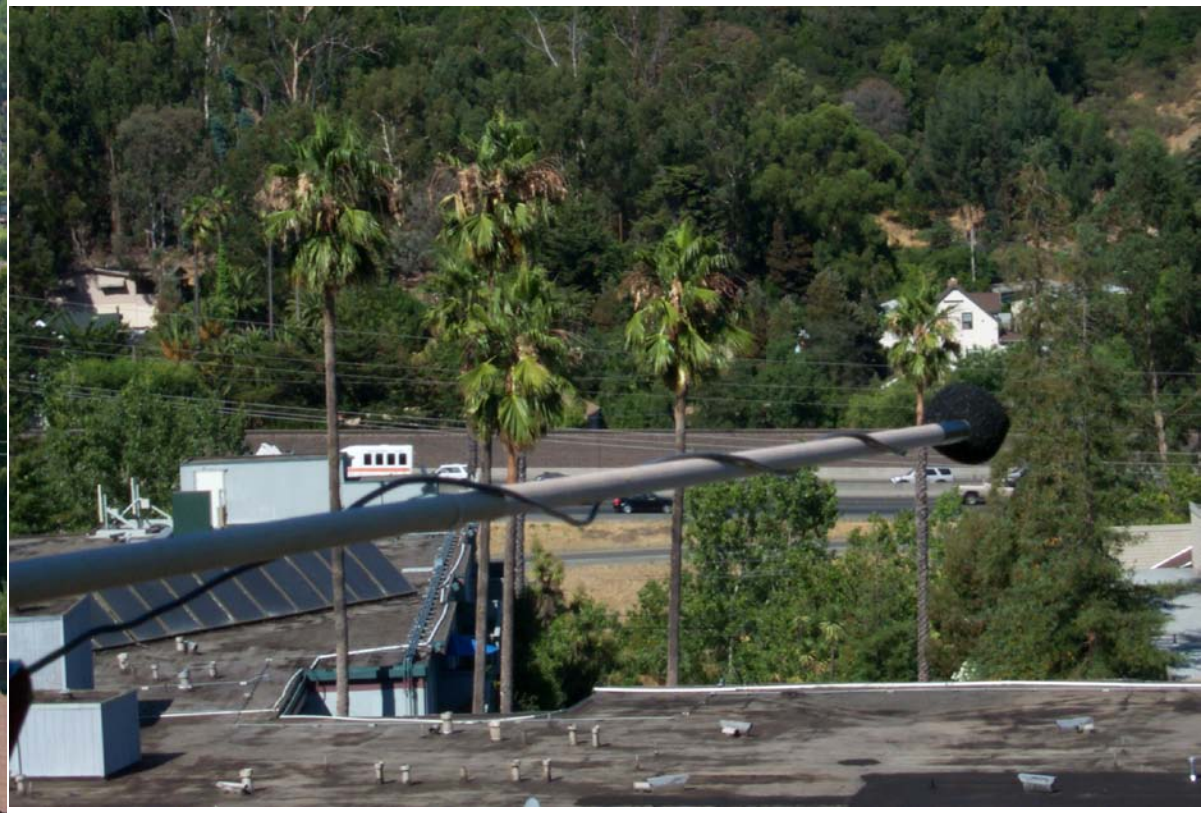
- Progressive noise abatement treatments, including walls and absorbing panels
- Detailed noise and meteorological measurements:
  - Several sites behind the barrier
  - Closest residence opposite the barrier
  - Under morning and nighttime conditions
- Measured 2 dB increase opposite the barrier
- Absorption on retaining wall increased barrier IL from 3-4 dB to 5 dB

The Caltrans Experience

- **2001 – JSA/HMMH U.S. 101, San Rafael**
  - New noise barrier generated complaints on opposite side of highway, on a rising hillside.
  - Long-term noise monitoring at 8 community sites
  - Simultaneous monitoring of atmospherics
  - Investigation of candidate absorptive materials for retrofit
  - Investigation of potential quiet asphalt overlays



The Caltrans Experience
2001 JSA/HMMH – U.S. 101 Noise Study



The Caltrans Experience
2001 JSA/HMMH – U.S. 101 Noise Study

The Caltrans Experience
2010 – U.S. 101 Noise Abatement Application

- Installed absorptive panels
- Added open-graded asphalt overlay

Photo: Marin Independent Journal

The Caltrans Experience
2010 – U.S. 101 Noise Abatement Application

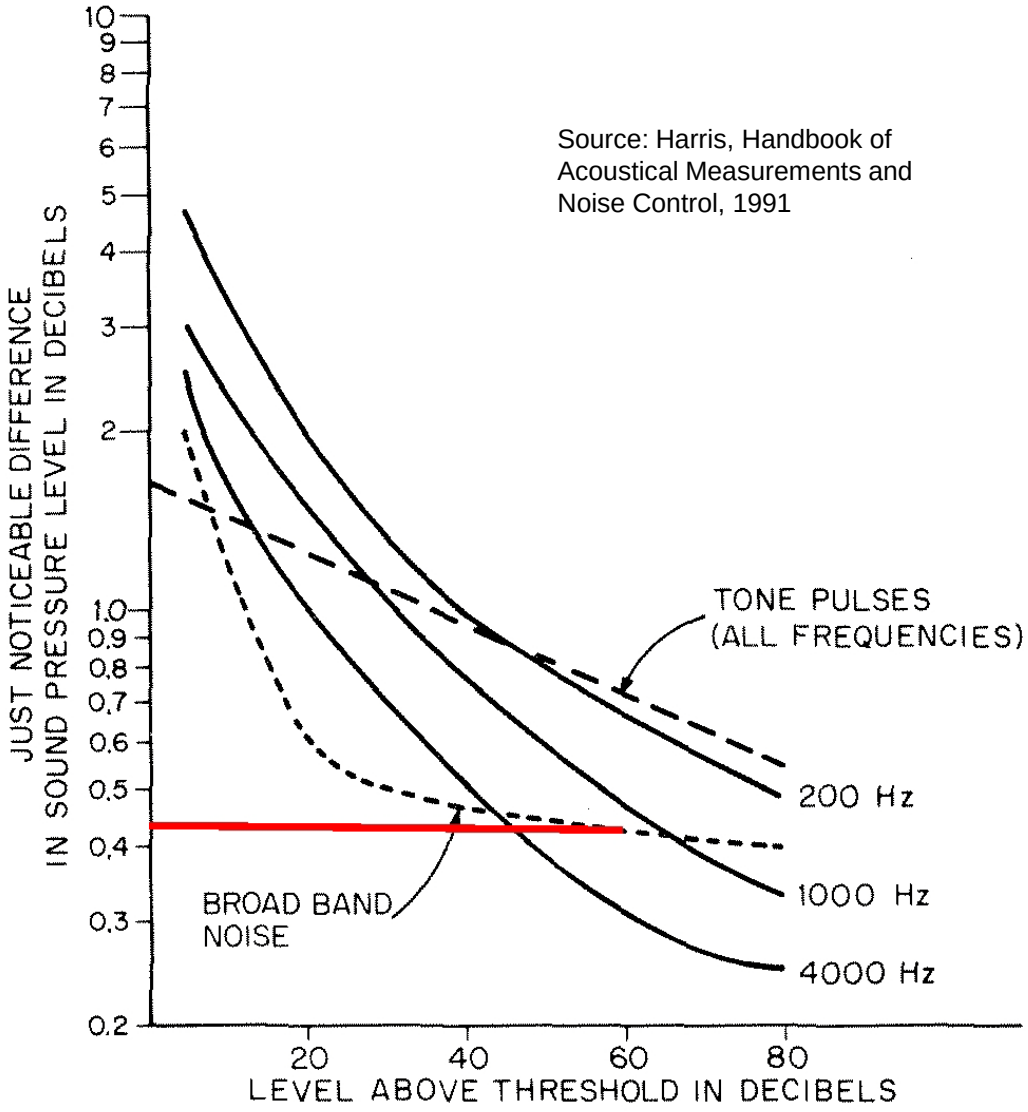
- **News report in Marin Independent Journal, Jan 2010**
  - “Patrick Murphy of San Rafael likes what he doesn't hear. Crews are finishing the installation of thousands of sound-absorbing panels as part of a $3 million retrofit of the existing Highway 101 soundwall to give area neighbors relief from freeway noise.”
  - "It's a significant change," said Murphy, who lives on Lincoln Hill in San Rafael and has lobbied Caltrans for more than a dozen years to improve the soundwalls. "The white noise that you hear is gone. What's missing is the 'shhhhh.'"

Other DOTs' Perspectives

- **Some DOTs started to specify sound-absorbing barriers opposite residential areas in the 1980s and 1990s.**
  - Complaints from opposite-side residents
  - Caltrans' experience
  - Recommendations from consultants
  - Post and panel construction made it affordable
- **DOTs with current policy of specifying absorption opposite noise-sensitive areas:**
  - Virginia DOT
  - New York State DOT
  - Massachusetts DOT
- **Caltrans' history with concrete block as primary barrier material – difficult to specify affordable absorption**

What's Going On?

- **Human sensitivity to changes in noise levels and sound**
  - 1947 JASA article by George Miller shows sensitivity to changes at less than 0.5 dB for broadband noise



Source: Harris, Handbook of Acoustical Measurements and Noise Control, 1991

What's Going On?

- **Whatever changes people hear are attributed to reflections from the new barrier built for the neighbors**
  - Long-term familiarity with a noise environment may enable residents to perceive small changes in level of 1 dB or less
  - Audio listening tests: people can hear frequency shifts of as little as 0.1 dB – heard as a change in sound character
  - New propagation paths may change temporal character of vehicle pass-bys – truck pass-bys sound different

Some Consequences and Considerations

- **People are hearing changes with new reflective barriers**
  - Fairness in state policies – who "deserves" a barrier
  - "Barrier envy" may influence attitudes
- **Accurate TNM has little safety factor in IL computation**
- **Loss of "insignificant" 1 or 2 dB in IL due to reflections can make barriers not attain minimum required 5 dB IL**
- **Which costs more: absorptive material or PR headaches, additional noise studies and lawsuits?**
- **Absorption can be cost effective depending on geometry**

How Can TNM Help?

- **TNM allows barriers to be specified as absorptive**
  - Absorptive barriers in TNM provide up to 1 dB more IL than reflective barriers (at locations in shadow zone of treated barrier), **but . . .**
  - Single reflections currently not implemented in TNM
  - Must use “image roads” or other methods to correctly account for single reflections
- **Parallel barrier module**
  - Estimates degradation from multiple reflections
  - Helps predict benefits of absorptive barriers or different geometries

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