

Wind Turbine Sound

An Independent Investigation

Siting to Prevent Adverse Noise Impacts

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Institute of Noise Control Engineering
INCE Canon of Ethics

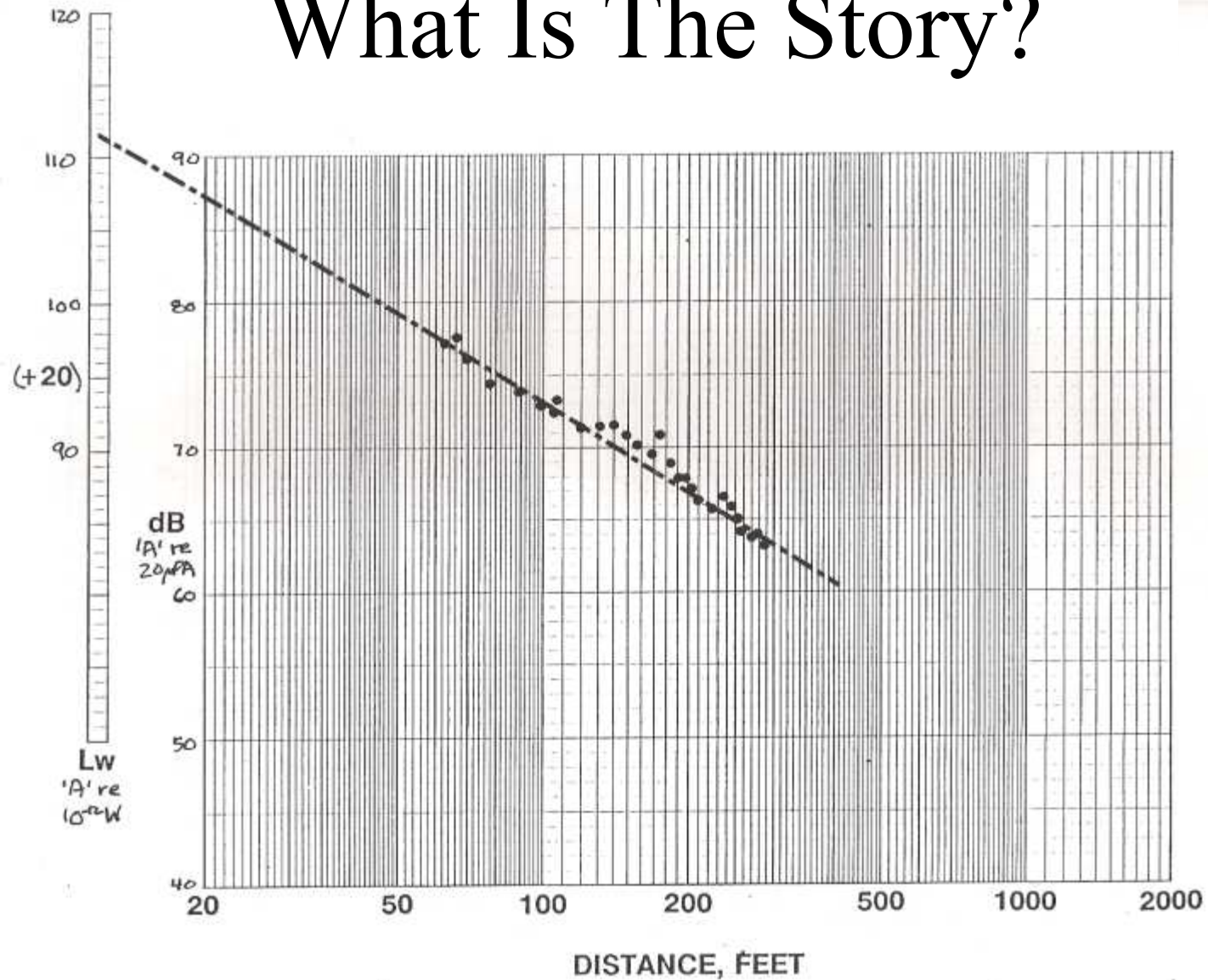
*Hold paramount the safety, health
and welfare of the public.*

“Be a good neighbor.”

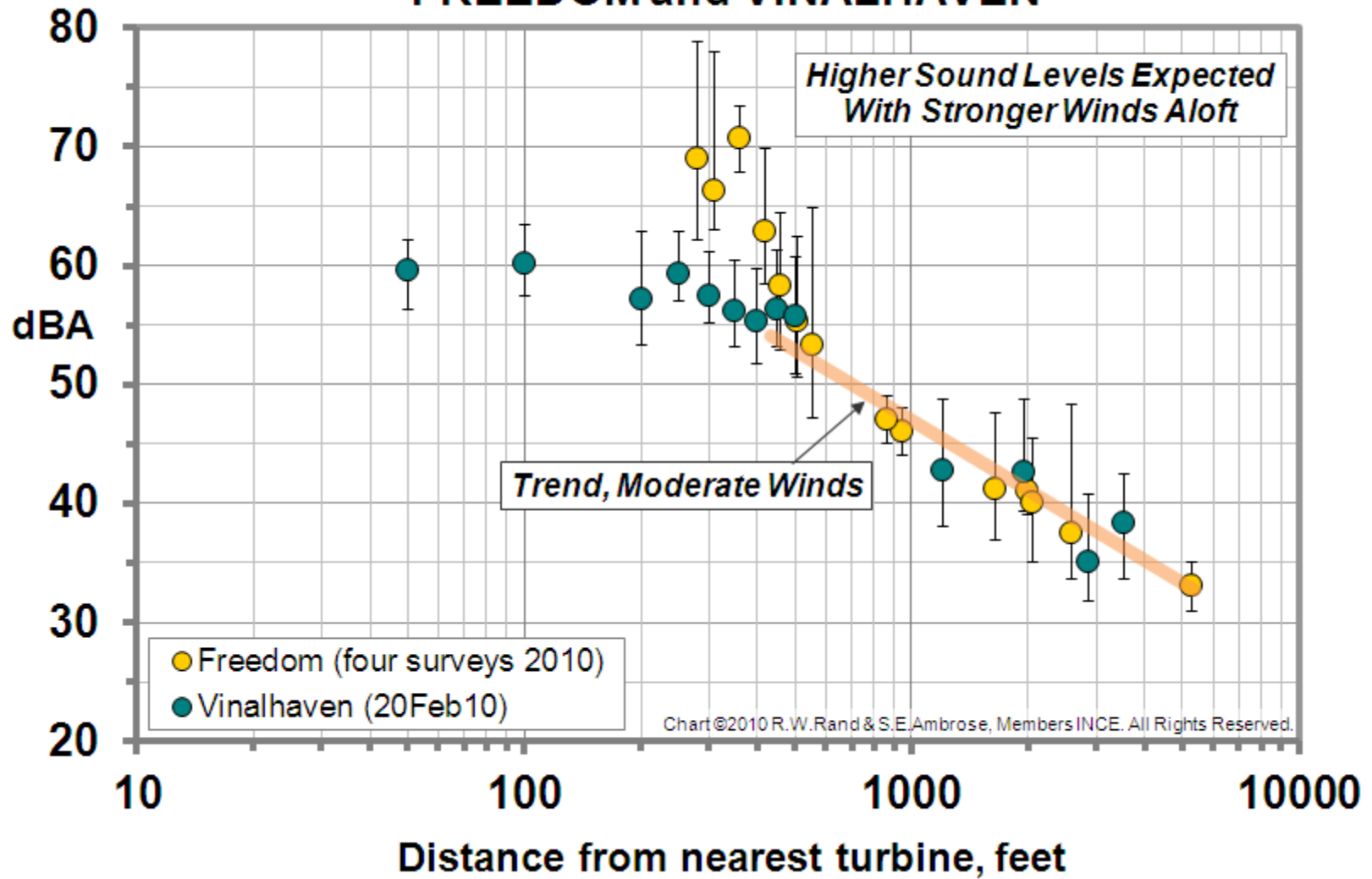
Power Generation Noise Control



What Is The Story?



FREEDOM and VINALHAVEN



KIBBY (Vestas V90s)

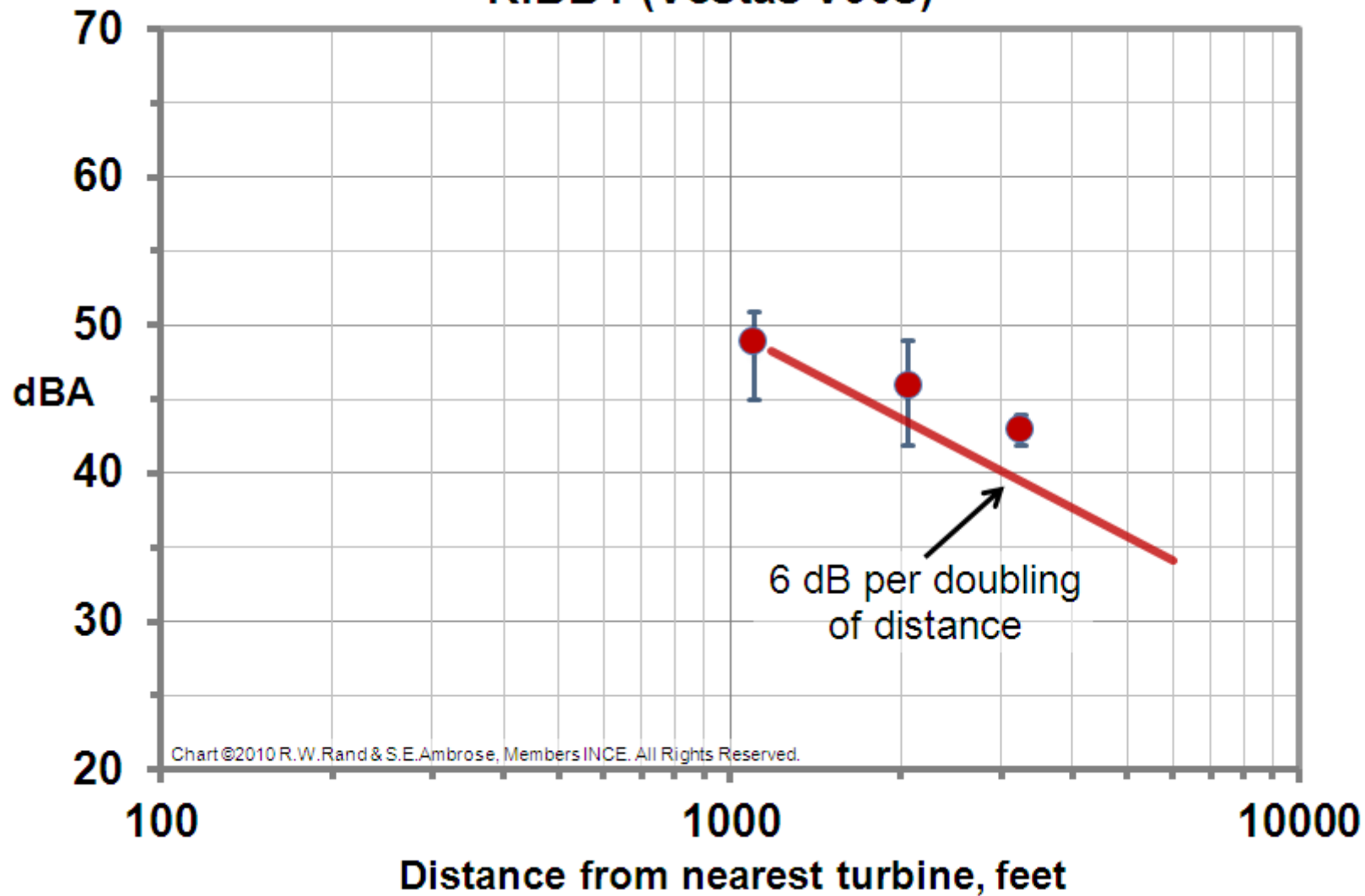
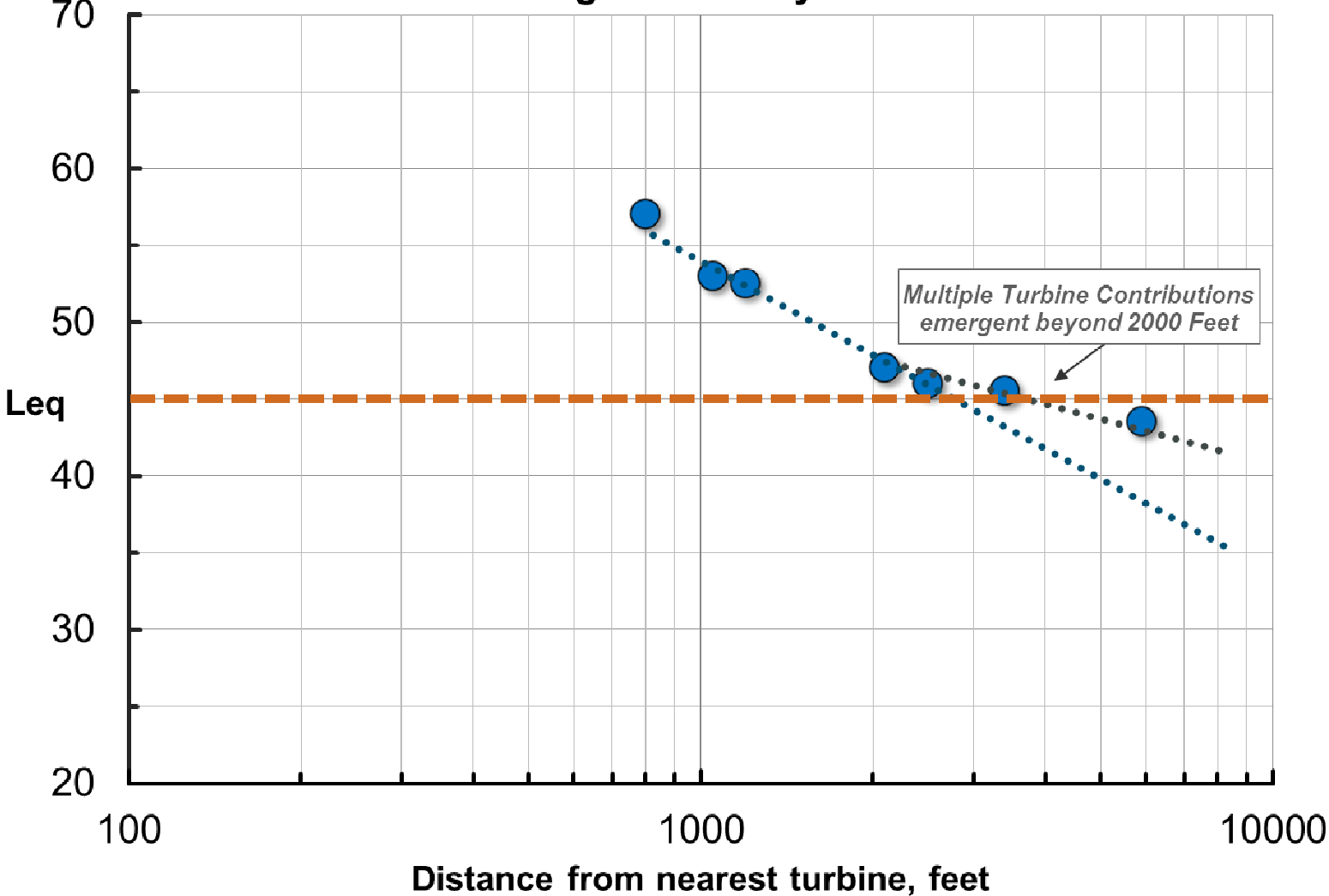
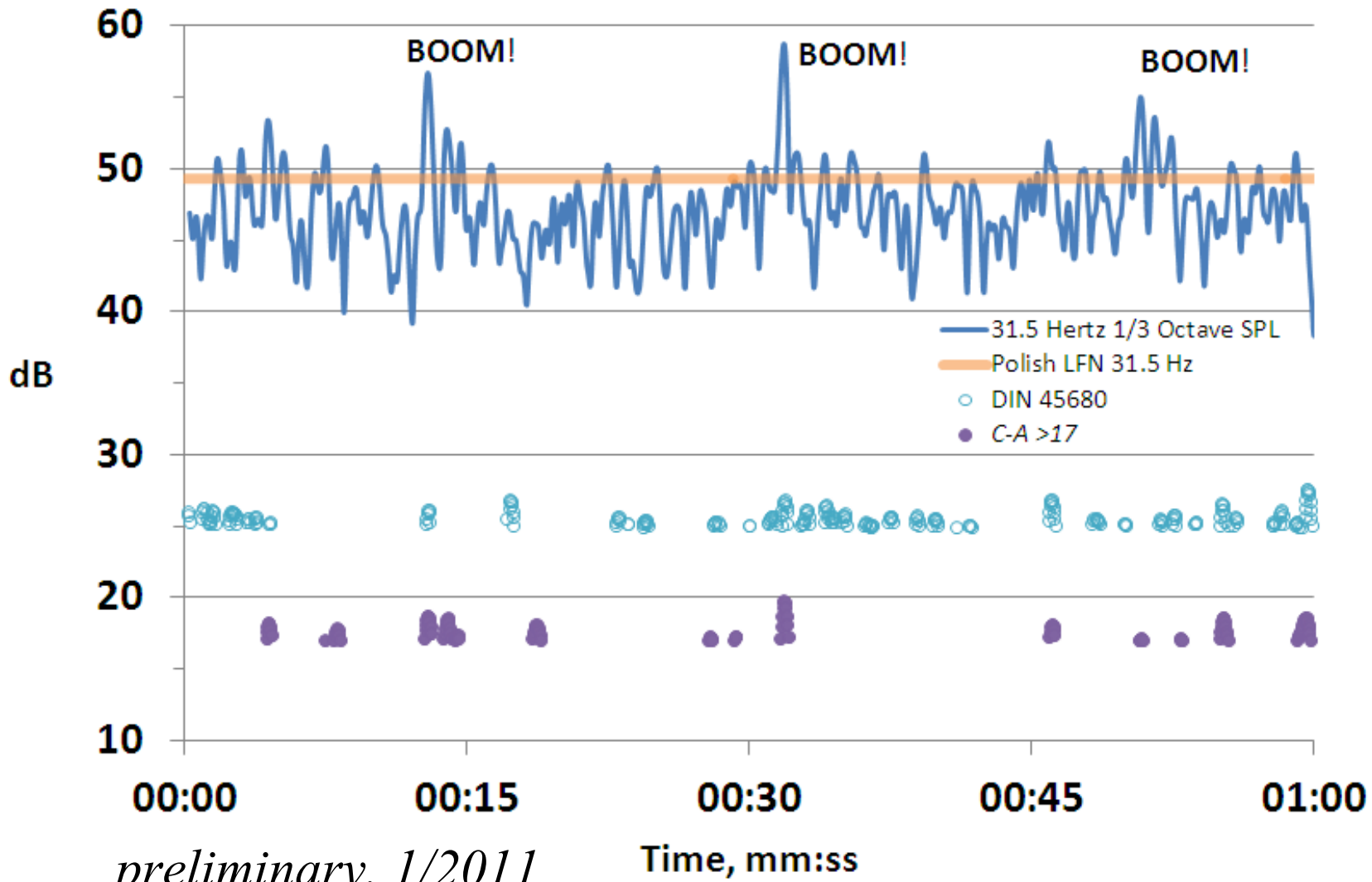


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Mars Hill Highest Hourly Sound Levels



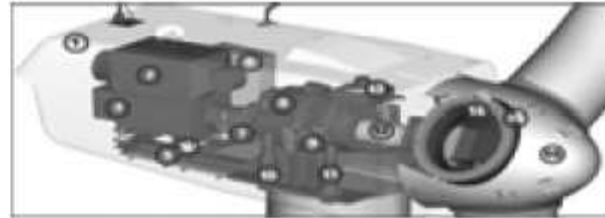
MARS HILL - BOOMING, October 2010



Types of Turbine Noise

● Mechanical

- Sources: gearbox, generator, and bearings
- Predominant with small wind turbines (rotor diameter less than 20 m)

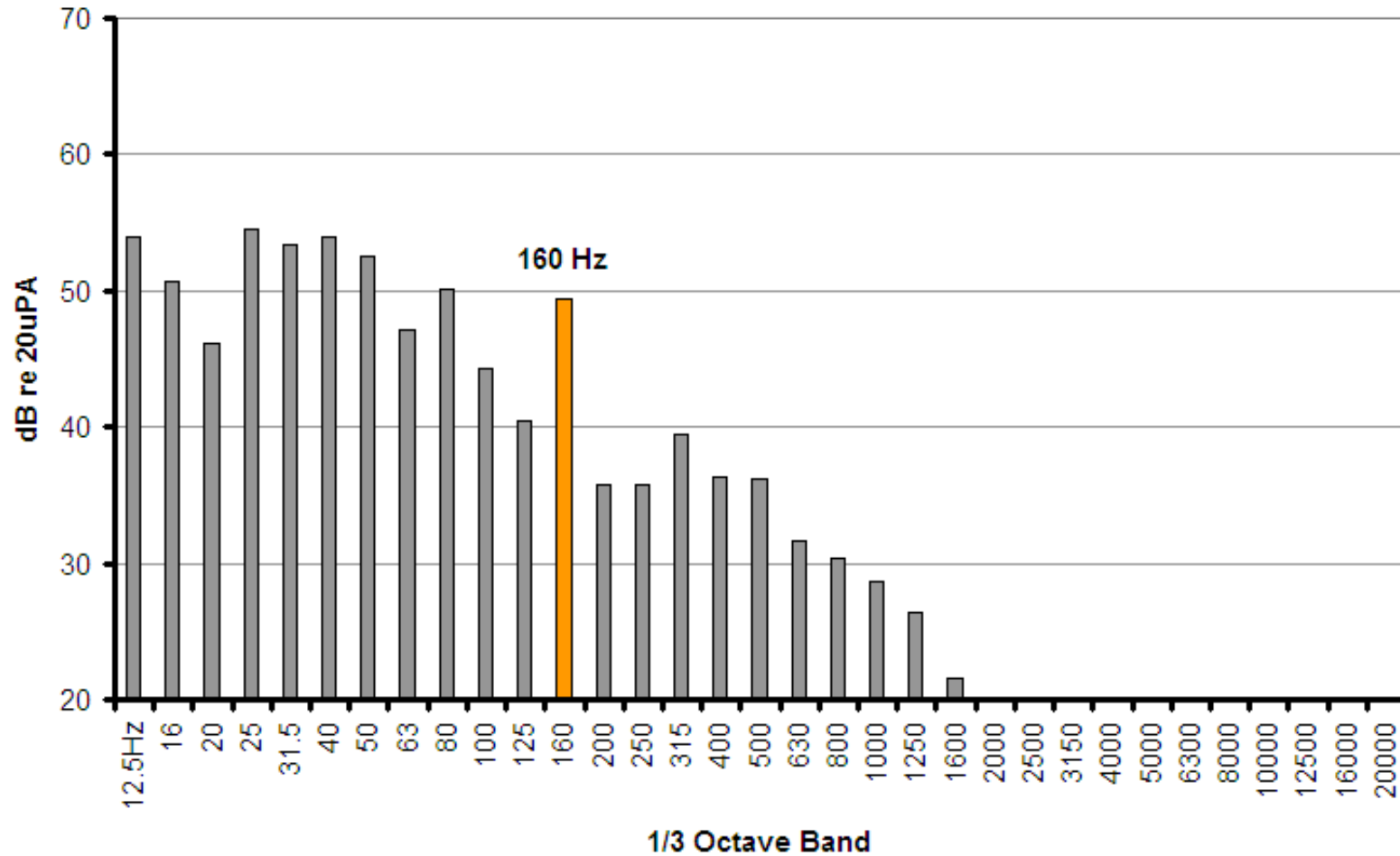


● Aerodynamic

- Source: rotor blades sweeping through the air
- Predominant with larger turbines



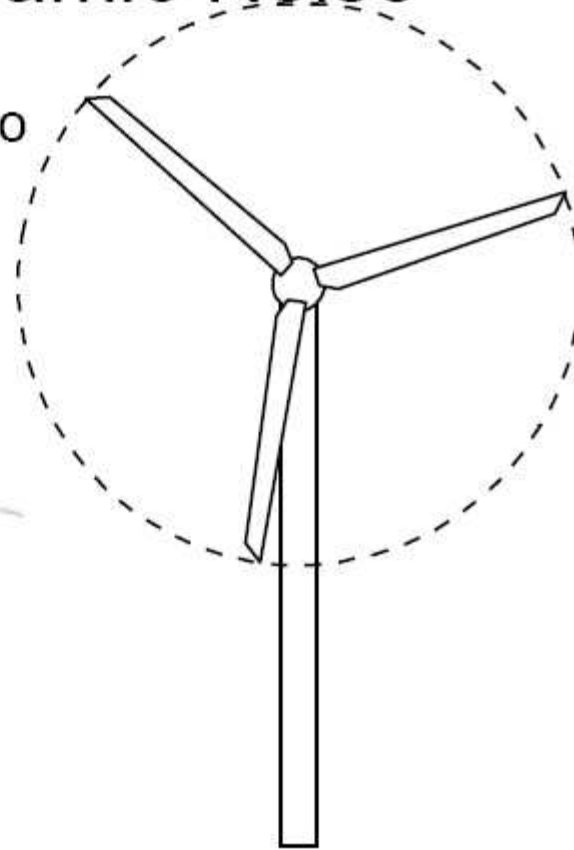
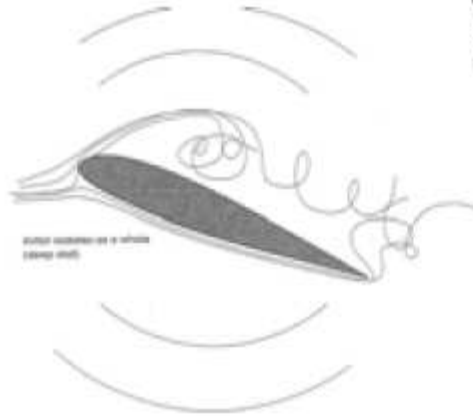
1/3 Octave Band Spectrum at 2050' from nearest turbine Small Wind Facility: GE 1.5sle Wind Turbines



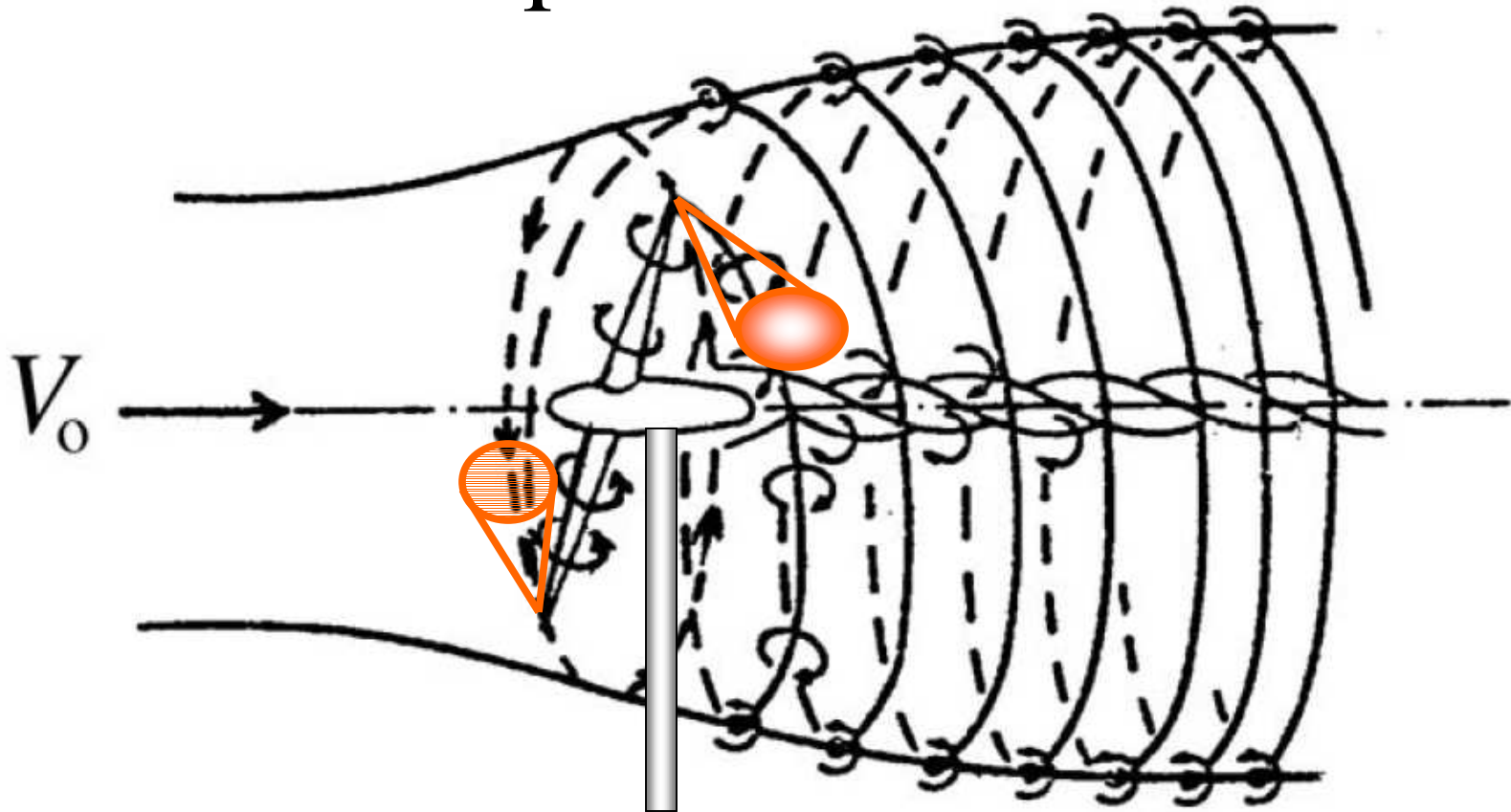
Aerodynamic Noise

● Tips Speed Ratio

● Blade Pitch

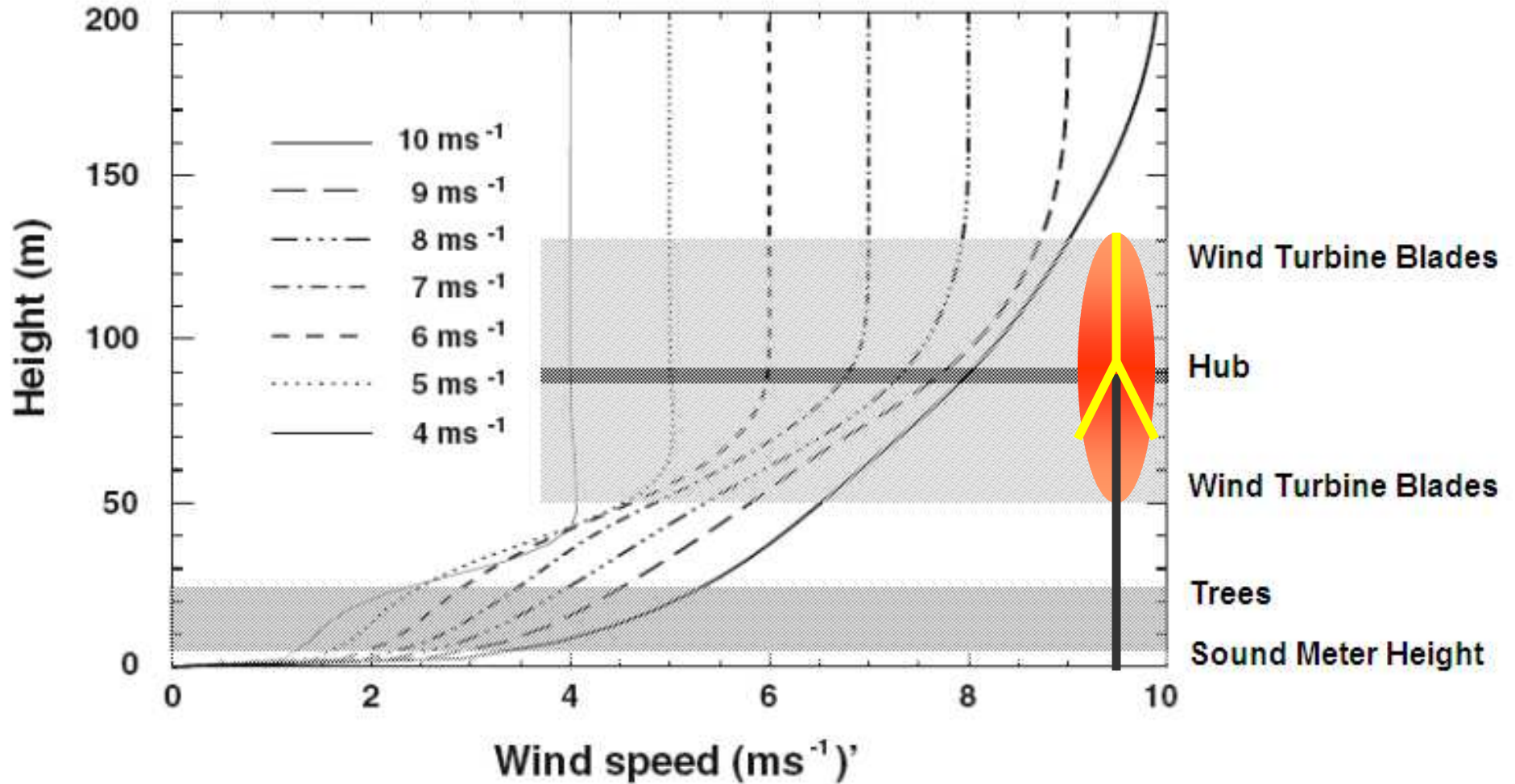


Tip Vortices

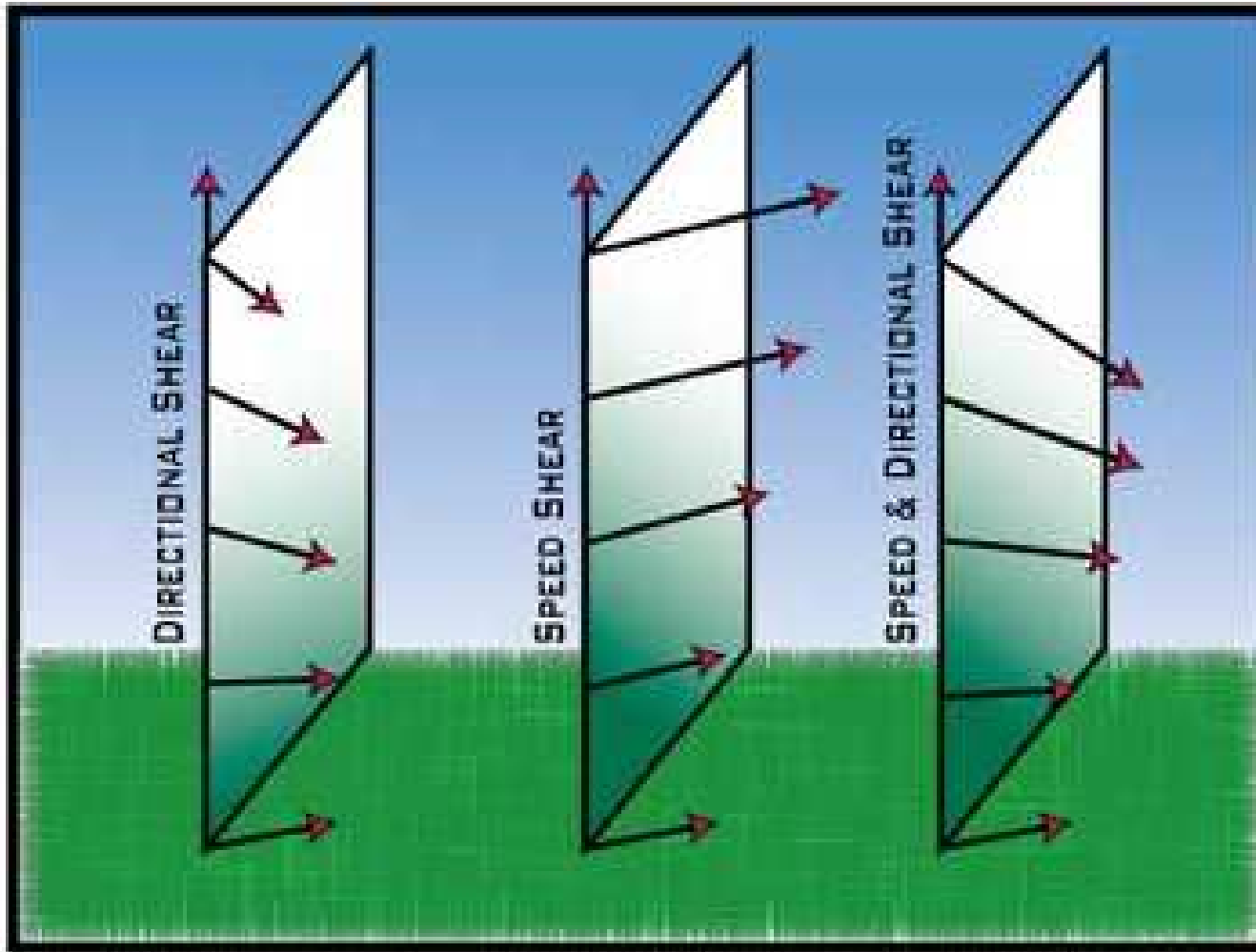


Source: Wilson and Lissaman (1974), reproduced with permission

Wind Gradient/Shear

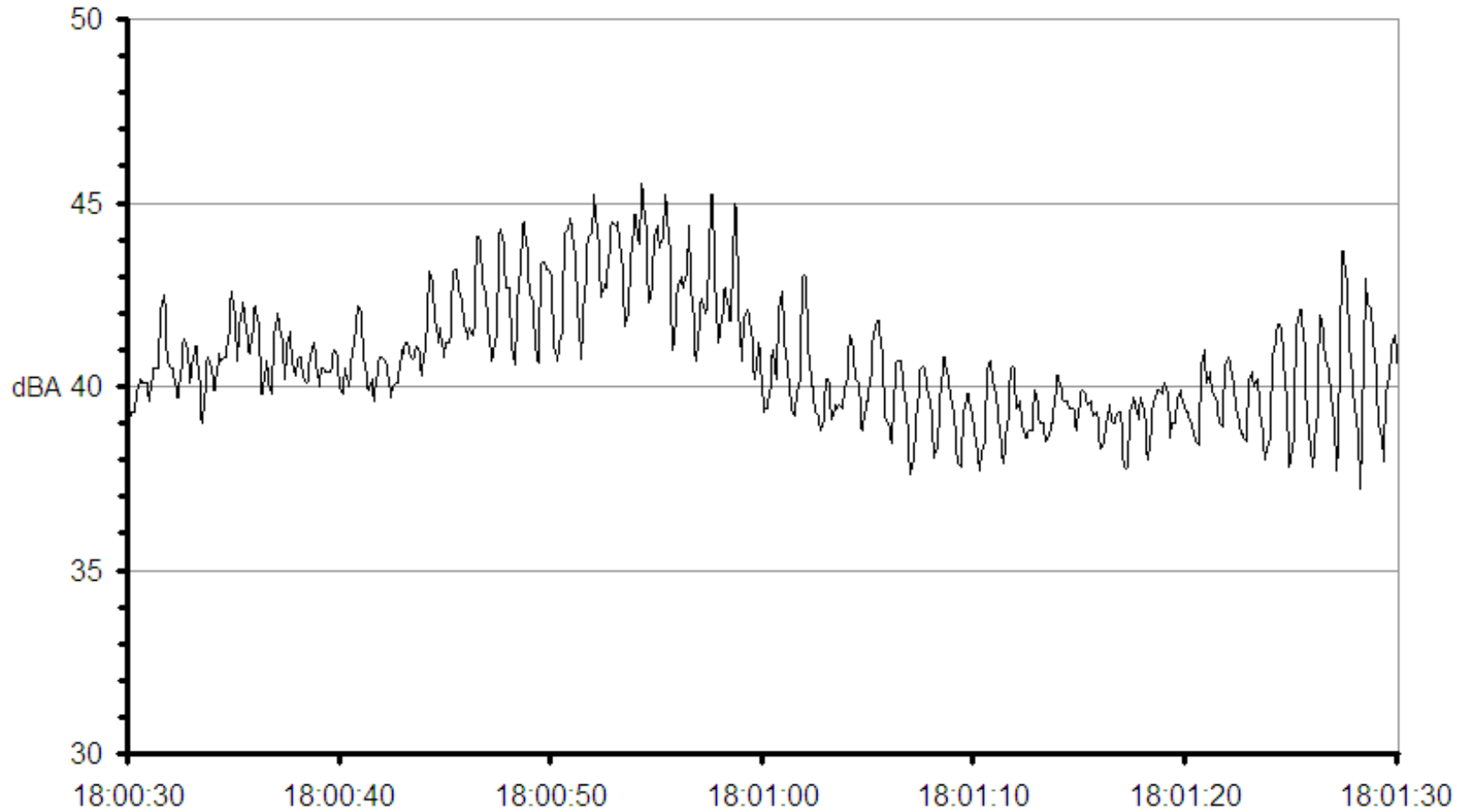


Wind Shear



Types of Wind Shear

**A-weighted Sound Level at 2050' from nearest turbine
Small Wind Facility: GE 1.5sle Wind Turbines**







Community Reaction to Noise

Community Response

Increase in Noise	Estimated Community Response
5 dB	Sporadic Complaints
10 dB	Widespread Complaints
15 dB	Threats of Community Action
20 dB	Vigorous Community Action

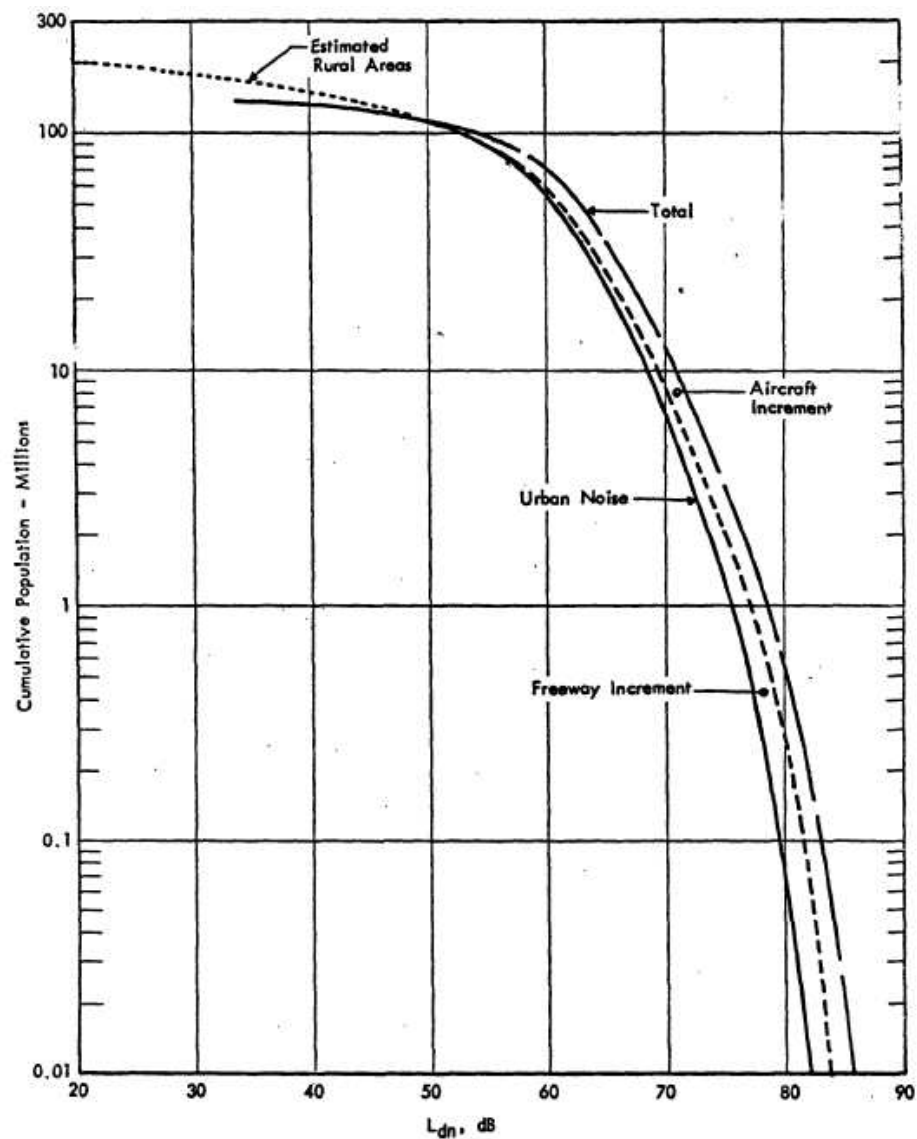
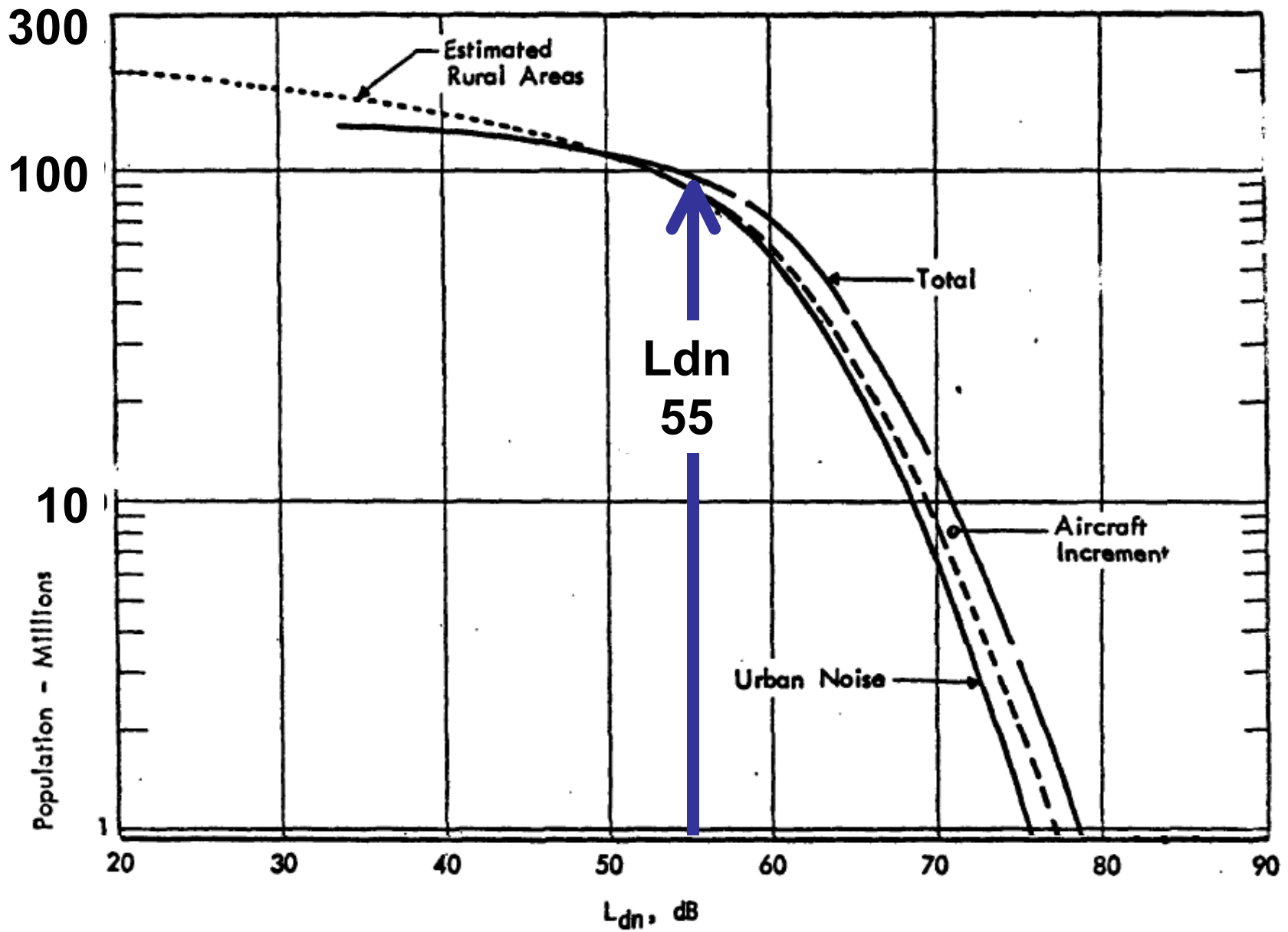


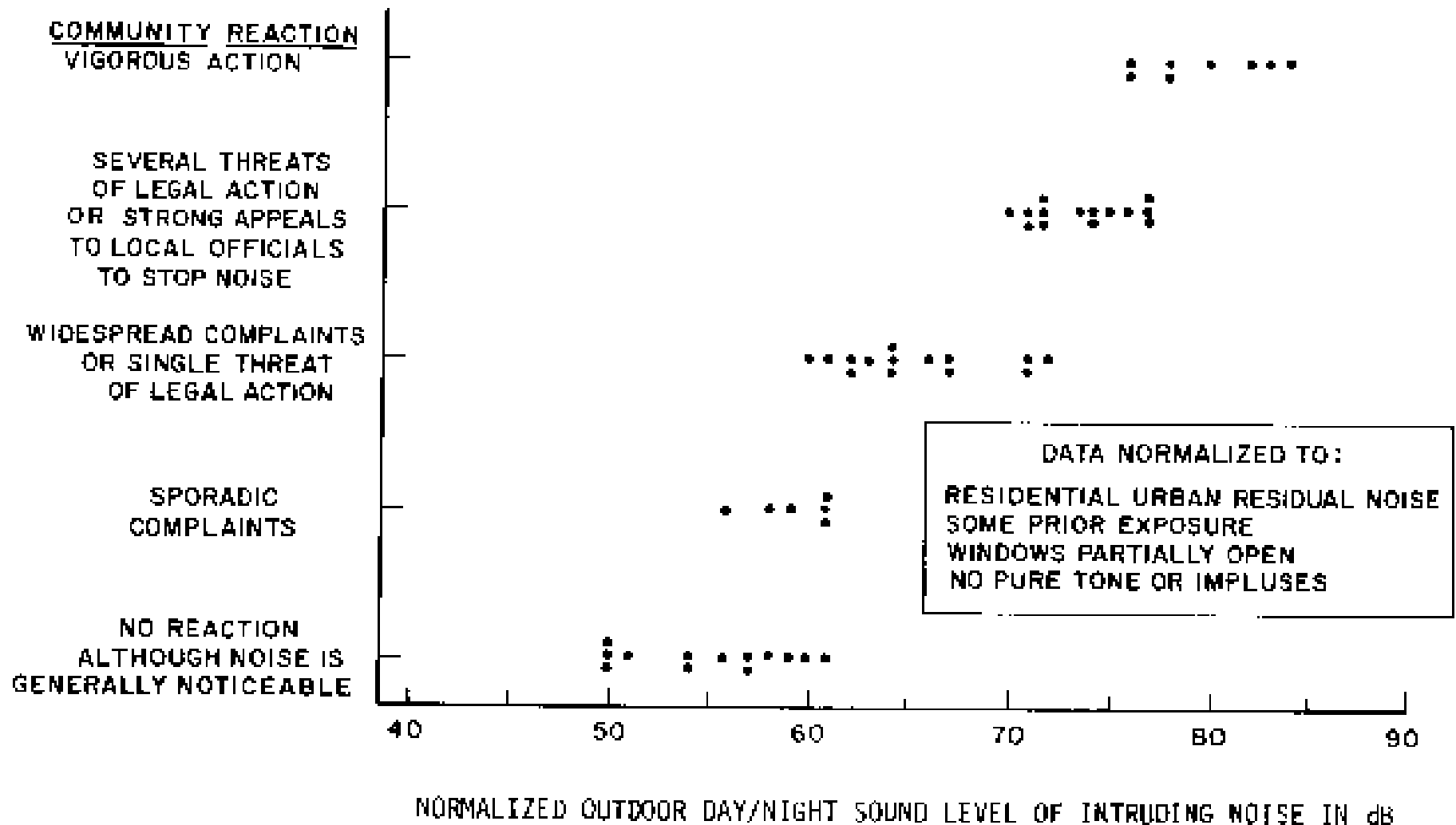
Figure 2 Residential Noise Environment of the National Population As A Function of Exterior Day-Night Average Sound Level (Ref B.5)



Towards a National Strategy (1977)

Encourage and assist Federal, State and local agencies in the adoption and implementation of a long-range noise control policy designed to prevent significant degradation of existing noise levels or exposure in designated areas. Such a "non-degradation" policy could be incorporated into land-use and development planning processes in an effort to reduce potential increases of noise levels or exposure in areas where quiet is at a premium, e.g., hospital zones, quiet residential areas, and wilderness areas.

EPA Normalized Ldn Method



Community Reaction - Rural

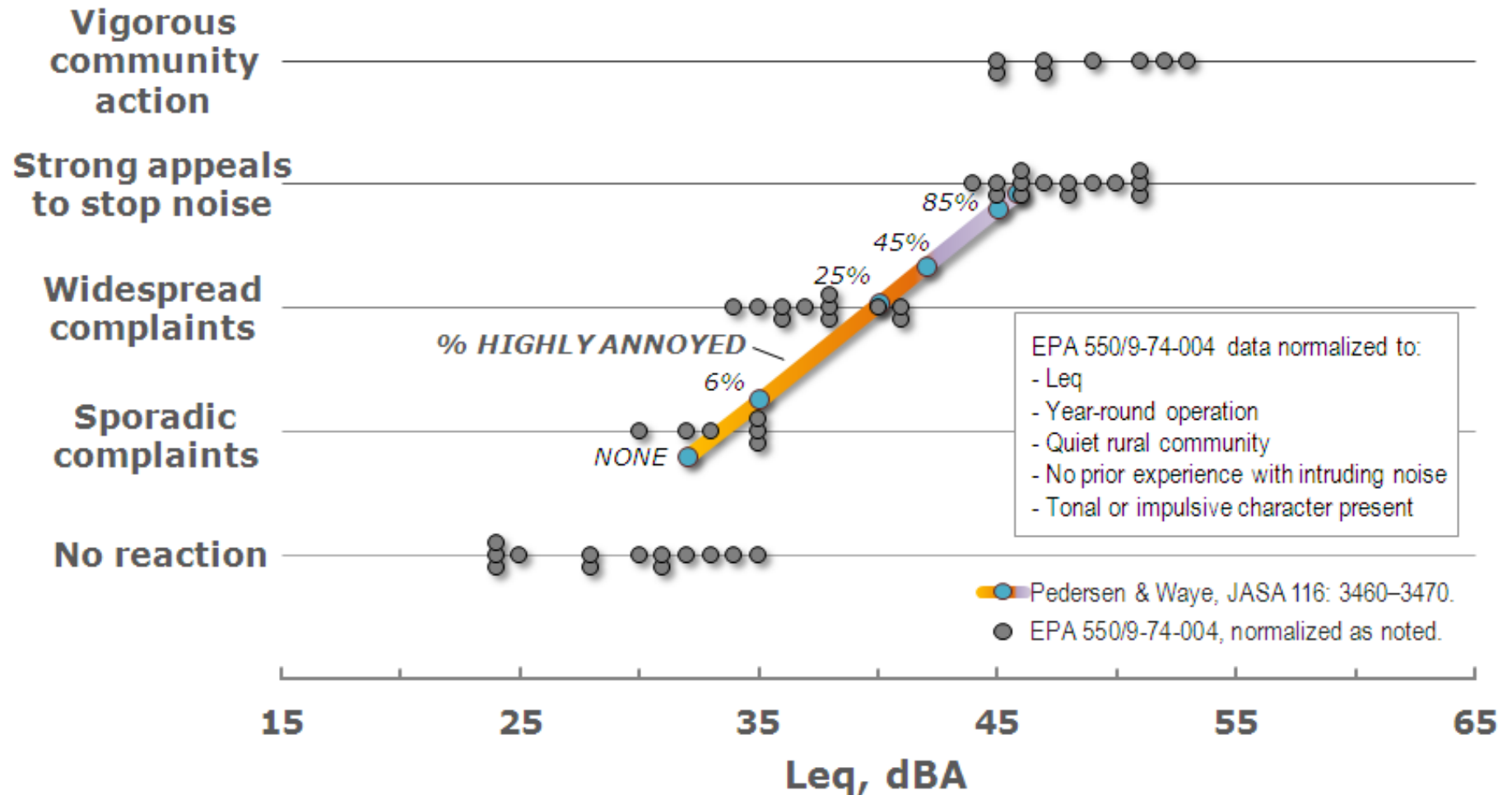
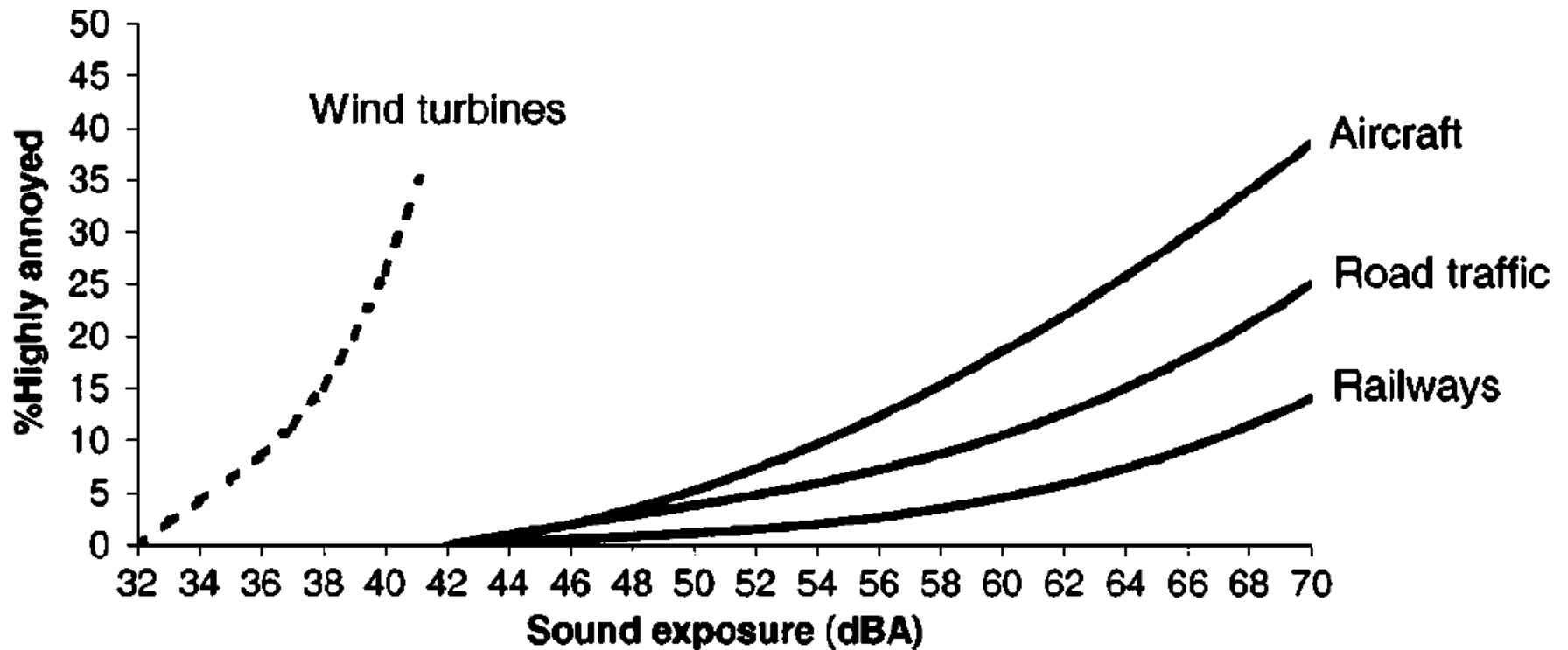


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Pedersen & Waye - Percent Highly Annoyed



**16 turbines 150–650 kW
150-160 ft in height**

E. Pedersen and K. P. Waye, Perception and annoyance due to wind turbine noise—a dose–response relationship. *J. Acoustical. Soc. Am.* 116 (6), December 2004, pp. 3460–3470.

Community Reaction – Maine

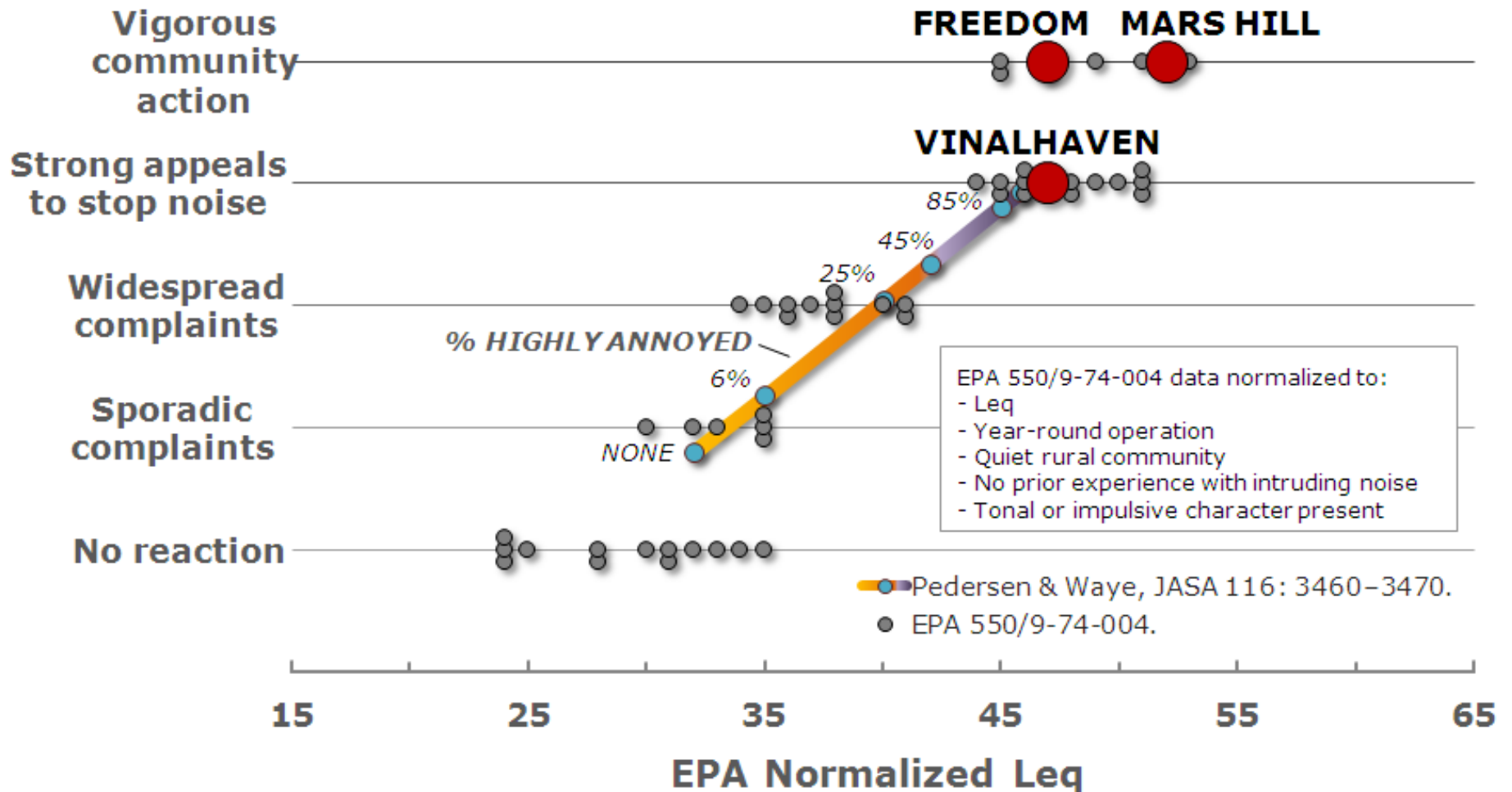
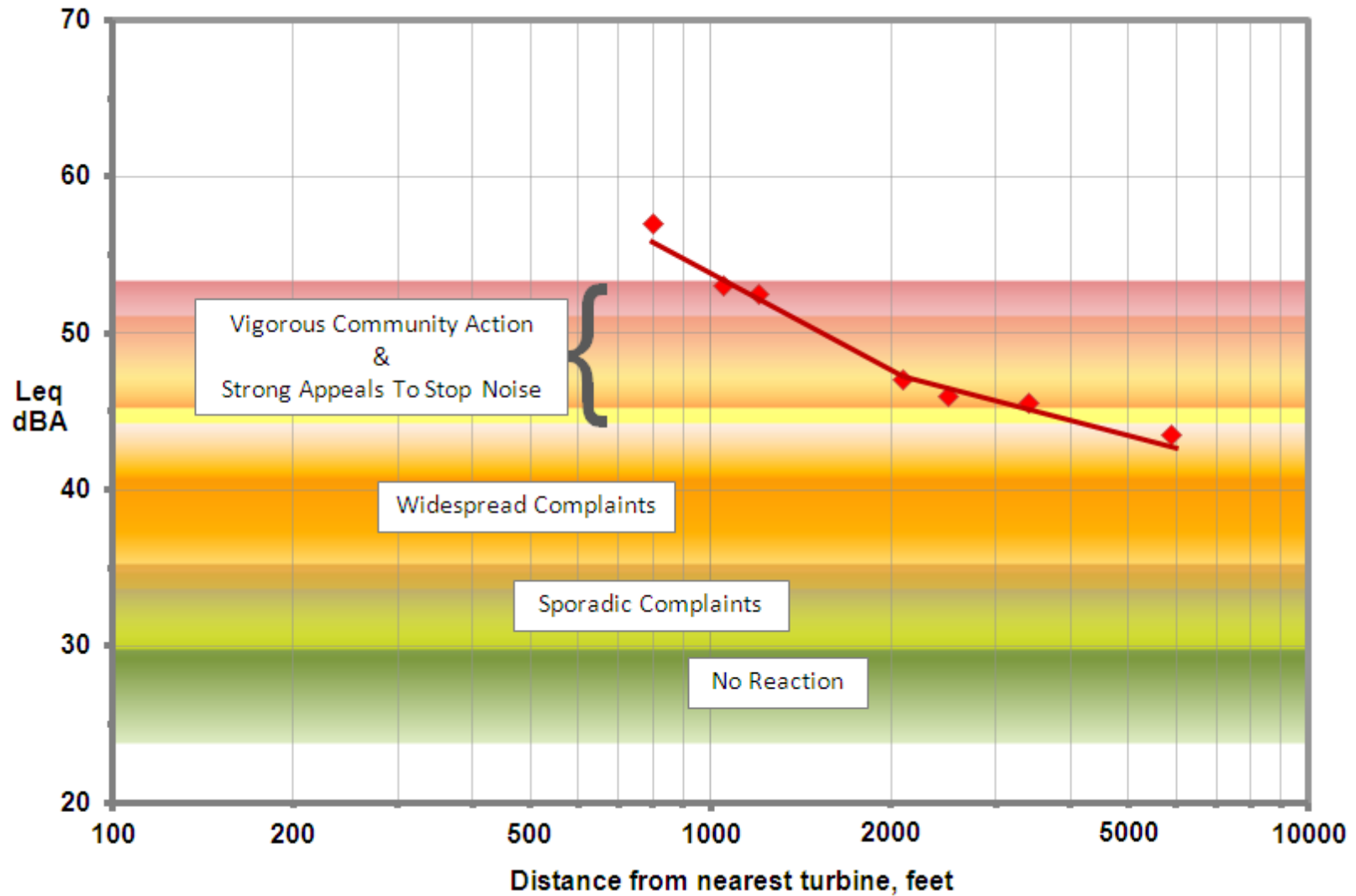
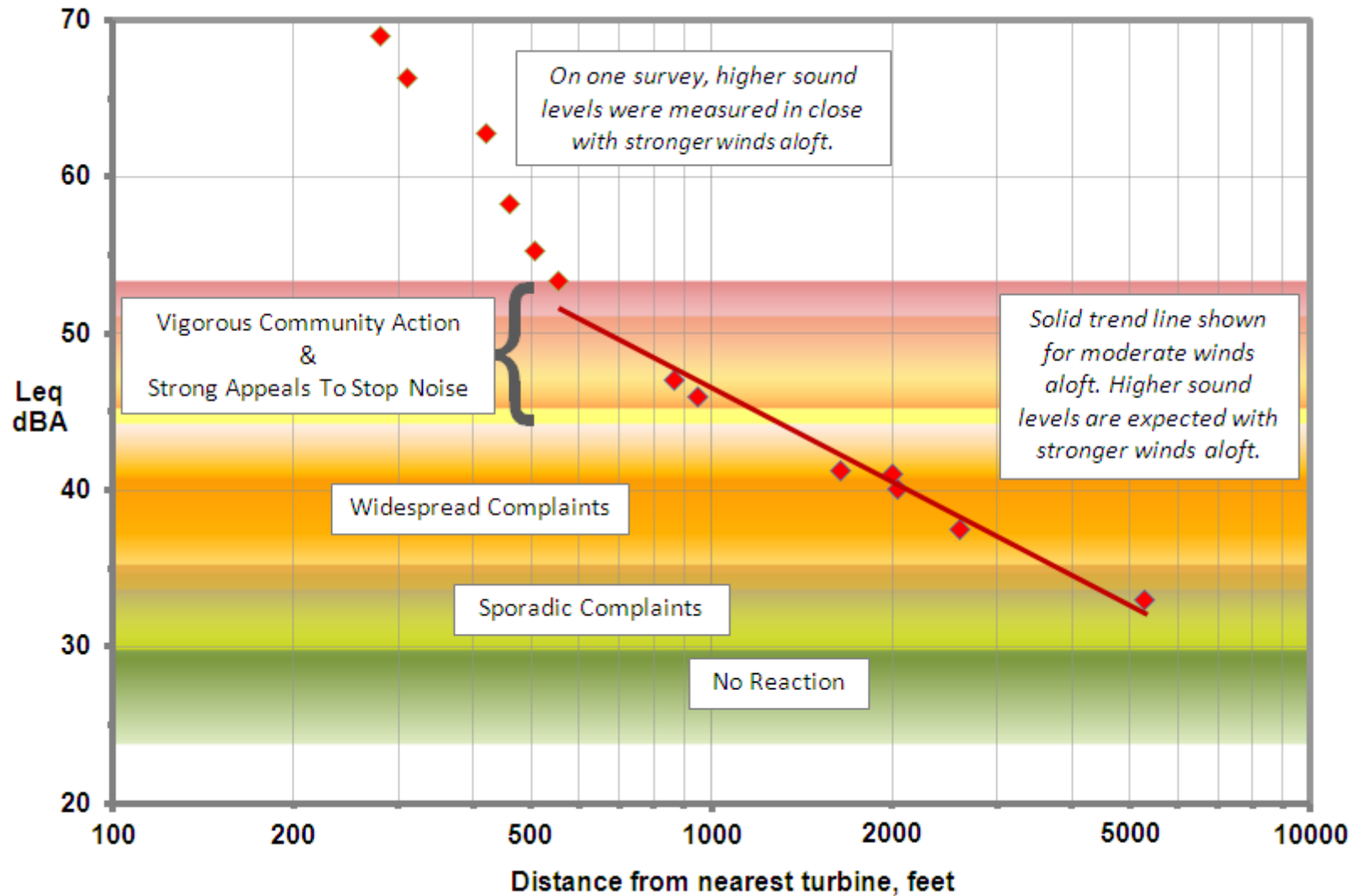


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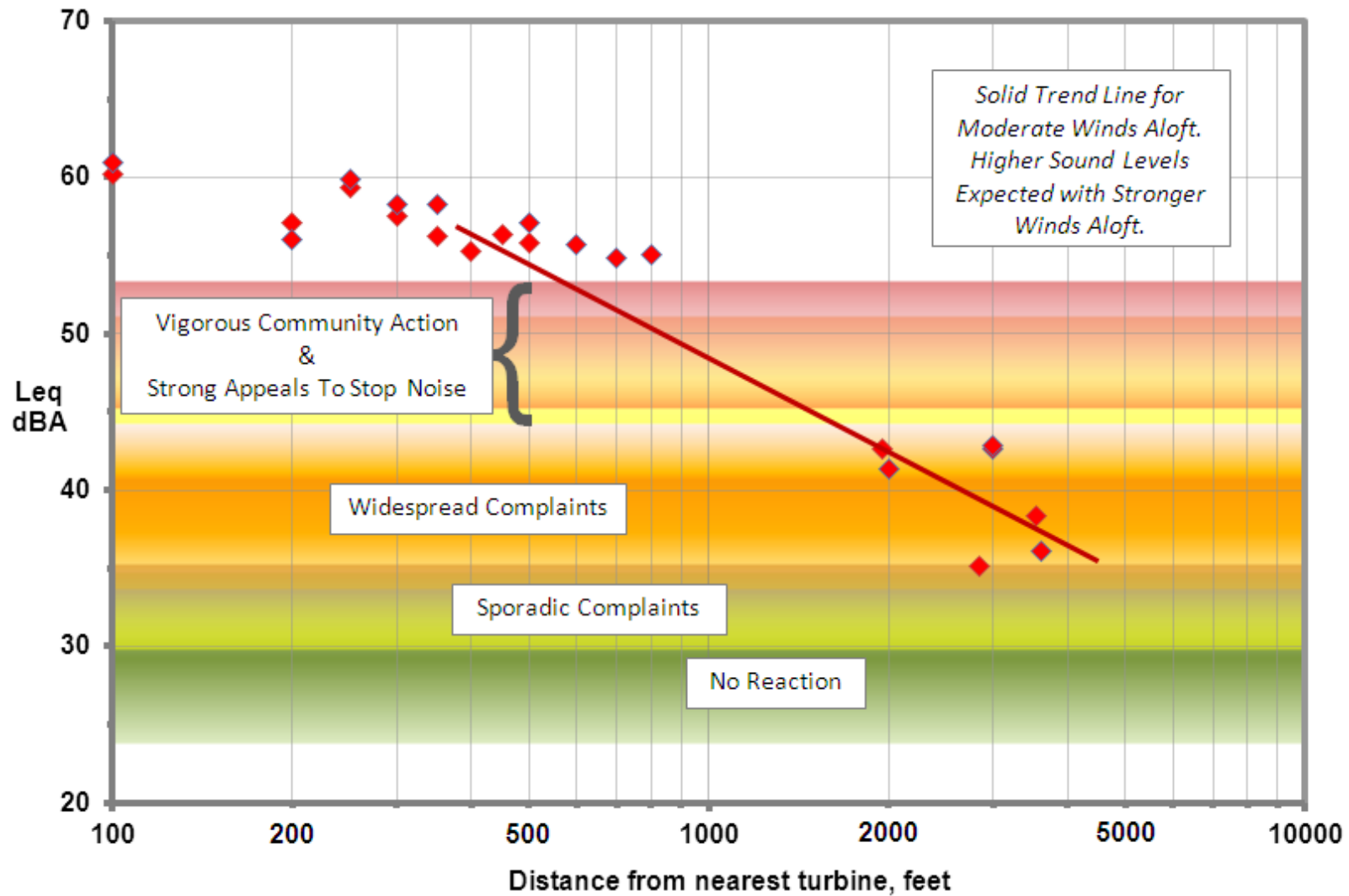
Community Reaction – Mars Hill



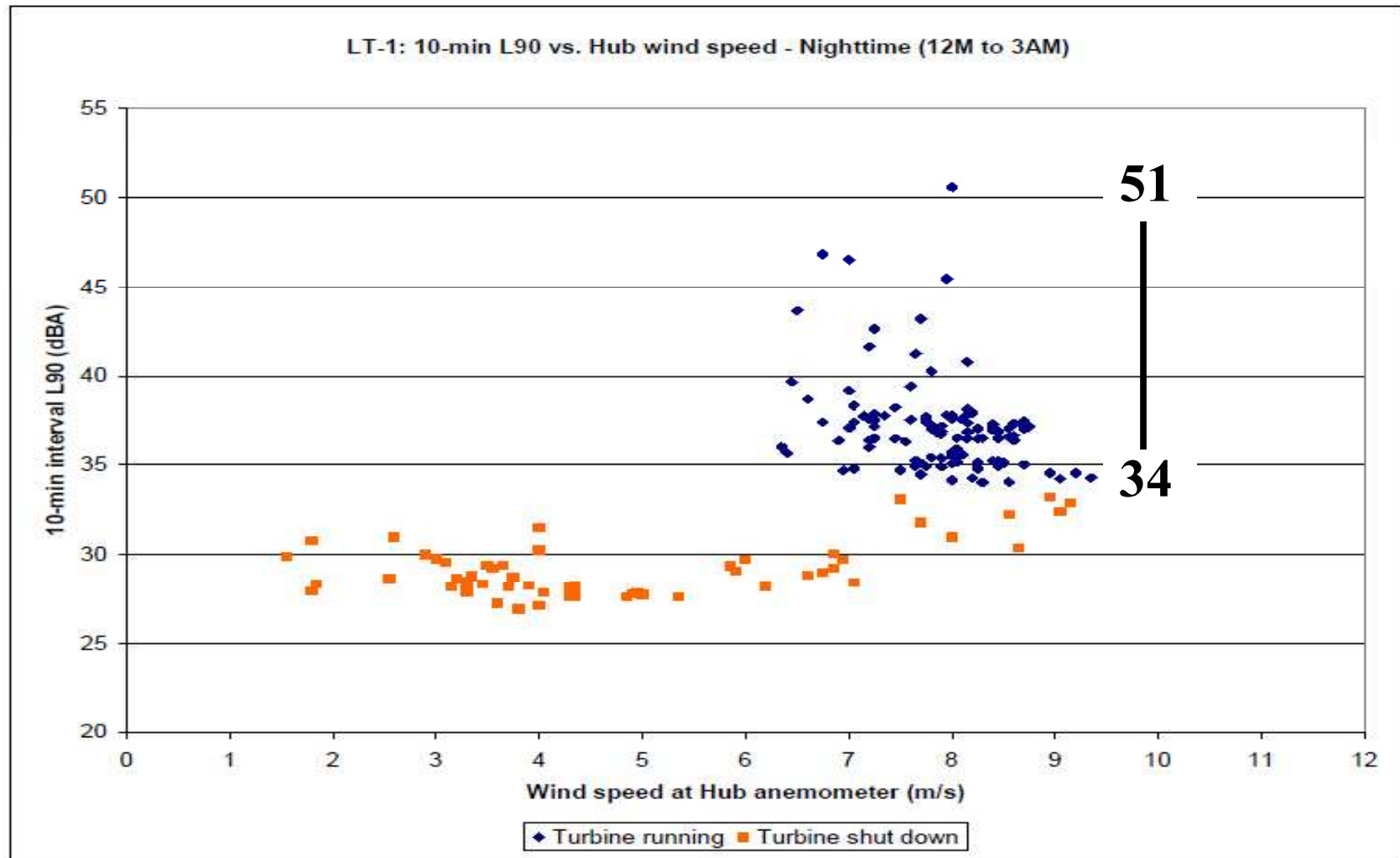
Community Reaction – Freedom



Community Reaction – Vinalhaven

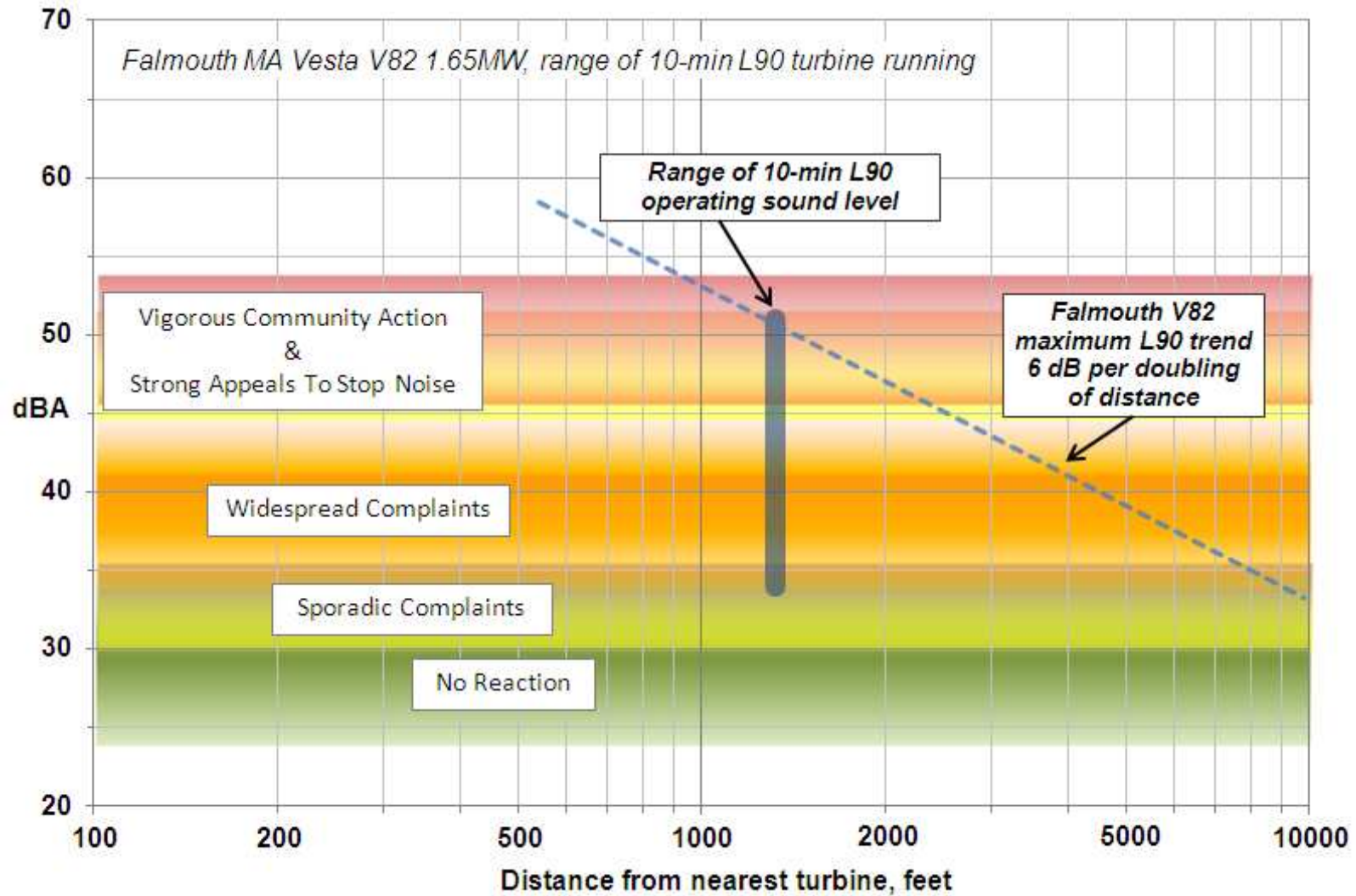


1 week in June, 1300ft – Falmouth, MA



from the Falmouth Wind Turbine Noise Study, HMMH Report No. 304390, 9/2010

Community Reaction – Falmouth, MA



Dr. Nissenbaum Mars Hill Findings 2010

1. Sleep disturbances/sleep deprivation *and the multiple illnesses that cascade from chronic sleep disturbance:* cardiovascular diseases, metabolic disturbances up to diabetes

2. Psychological stresses which can result in additional effects including cardiovascular disease, chronic depression, anger, and other psychiatric symptoms.

3. Increased headaches.

4. Unintentional adverse changes in weight.

5. Auditory and vestibular system disturbances.

6. Increased requirement for and use of prescription medication.

Dr. Nissenbaum Mars Hill Findings 2010

- **high probability of significant adverse health effects for those whose residence is located within 1100 meters (3600 ft)**
- **significant risk of adverse health effects are likely to occur in a significant subset of people out to at least 2000 m (>6500 ft)**
- **recommends 2200 meters separation**

No-Reaction Locations

Kibby – Residences are > 1 mile

Vinalhaven – Neighbors > 1 mile

Hull, MA – Under Logan Flight Path
daily exposure to aerodynamic noise
and urban noise levels, shorter
distances for no reaction

Wind Turbine Noise Control

*To date, the only
Reliable Noise Control Options
found so far are:*

SUFFICIENT SEPARATION DISTANCE
set during permitting

or

SHUTDOWN
if complaints result from operation.

Wind Turbine Sound An Independent Investigation

Thank you for listening

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