

WILSON IHRIG  
ACOUSTICS, NOISE & VIBRATION

# Derek Watry

Principal & President,  
**Wilson Ihrig**



RAIL TRANSIT SEMINAR



August 26-28,  
2025

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SEATTLE, WA



# Results to Date of Continuous Rail Vibration Monitoring at University of Washington



RAIL TRANSIT SEMINAR



Katie Krainc & Derek Watry  
Wilson Ihrig



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# Master Implementation Agreement (MIA)



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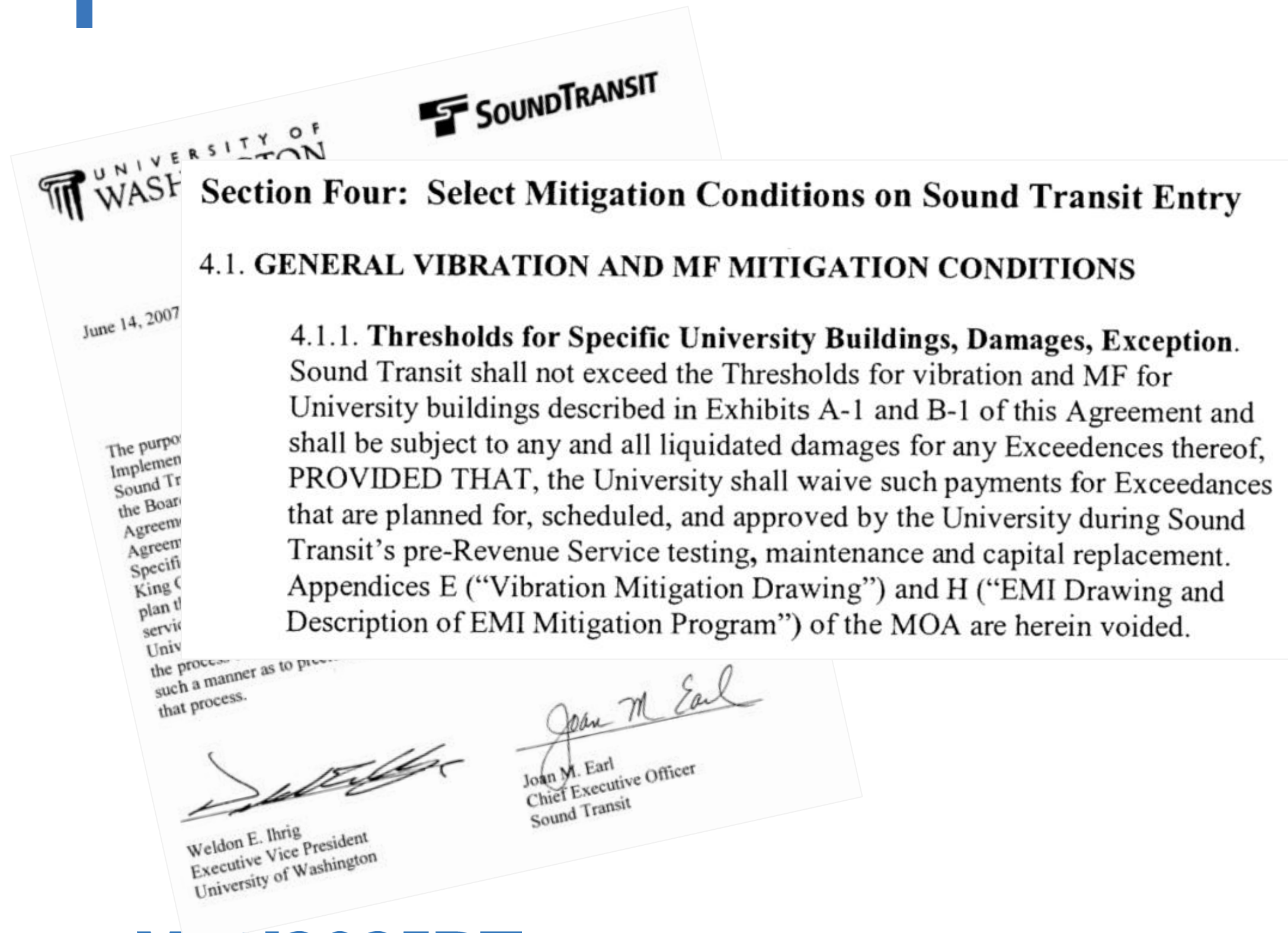
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# Master Implementation Agreement (MIA)



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# Master Implementation Agreement (MIA)

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**SOUNDTRANSIT**

**UNIVERSITY OF WASHINGTON**

**Section Four: Select Mitigation Conditions**

**4.1. GENERAL VIBRATION AND MF MITIGATION**

June 14, 2007

The purpose of this Master Implementation Agreement is to provide the Board of the University of Washington with the information necessary to plan the service of the University of Washington Sound Transit.

4.1.1. **Thresholds for Specific University Buildings**

Sound Transit shall not exceed the Thresholds for Specific University buildings described in Exhibit C. The University shall be subject to any and all liquidated damages as provided in the Agreement. PROVIDED THAT, the University shall not be liable for damages for any vibration that are planned for, scheduled, and approved by Sound Transit's pre-Revenue Service test results. Appendixes E ("Vibration Mitigation Measures") and F ("Description of EMI Mitigation Program") shall apply.

Weldon E. Ihrig  
Executive Vice President  
University of Washington

Joan M. Earl  
Chief Executive Officer  
Sound Transit

**Exhibit C  
Preferred Alternative  
Alignment Map**

**University of Washington Buildings**

- A. Bagley Hall
- B. Benson Hall
- C. Bioengineering/Genomics
- D. Burke Museum
- E. Center on Human Development and Disability (CHDD)
- F. Chemistry
- G. Health Sciences Imaging Center
- H. Electrical Engineering/Computer Science
- I. Fisheries Center (CMBL)
- J. Fisheries Sciences
- K. Fisheries Teaching and Research Center
- L. Fluke Hall
- M. Henderson Hall
- N. Johnson Hall
- O. Marine Sciences (MMBL)
- P. Marine Studies
- Q. Mechanical Engineering and Annex
- R. Moore Hall
- S. Oceanography Research Building
- T. Ocean Sciences
- U. Physics/Astronomy
- V. Roberts Hall
- W. Surgery Pavilion
- X. UW Medical Center-Cyclotron
- Y. Wilcox Hall
- Z. Winkenwerder Hall

**Stations**

**Crossover**

**Preferred Alternative**

**University of Washington Campus**

**NE 47th St**

**NE 45th St**

**Brooklyn Ave NE**

**University Way NE**

**15th Ave NE**

**NE 42nd St**

**University Bridge**

**NE Pacific St**

**NE Pacific Pl**

**Segment 2**

**Husky Stadium**

**Segment 1**

**University of Washington Station and Crossover**

**Modified Montlake Route**

**Montlake Blvd NE**

**I-5 Corridor**

**Roosevelt Way NE**

**Brooklyn Station**

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# Master Implementation Agreement (MIA)

**4.1.4. Monitoring Program.** Prior to construction of the Light Rail Transit System, the Parties shall jointly develop a detailed vibration and MF monitoring program to identify, measure and report on if and when a Threshold Exceedance occurs that is directly attributable to the Light Rail Transit System. The details of the monitoring program shall be memorialized in an Operating Agreement, PROVIDED THAT said Operating Agreement shall require that the monitoring program: be developed at Sound Transit expense; include early warning vibration detectors north and south of University Property; provide data that is auditable by the Parties in real time; is highly reliable; is acceptable to the University; is installed prior to Revenue Service for each segment of newly constructed Light Rail Transit System on University Properties; and is capable of identifying long term trends of increased average and peak vibration and MF levels over time attributable to the general degradation of the Light Rail Transit System.

Weldon E. Ihrig  
Executive Vice President  
University of Washington

Sound Transit



Health Sciences Imaging Center  
H. Electrical Engineering/Computer Science  
J. Fisheries Center (CMBL)  
K. Fisheries Sciences  
L. Fluke Hall  
M. Henderson Hall  
N. Mechanical Engineering and  
R. Annex  
S. Moore Hall  
T. Oceanography Research Building  
U. Physics/Astronomy  
V. Roberts Hall  
W. Surgery Pavilion  
X. UW Medical Center-Cyclotron  
Y. Wilcox Hall  
Z. Winkenwerder Hall

Preferred Alternative

Exhibit C  
Preferred Alternative  
Alignment Map

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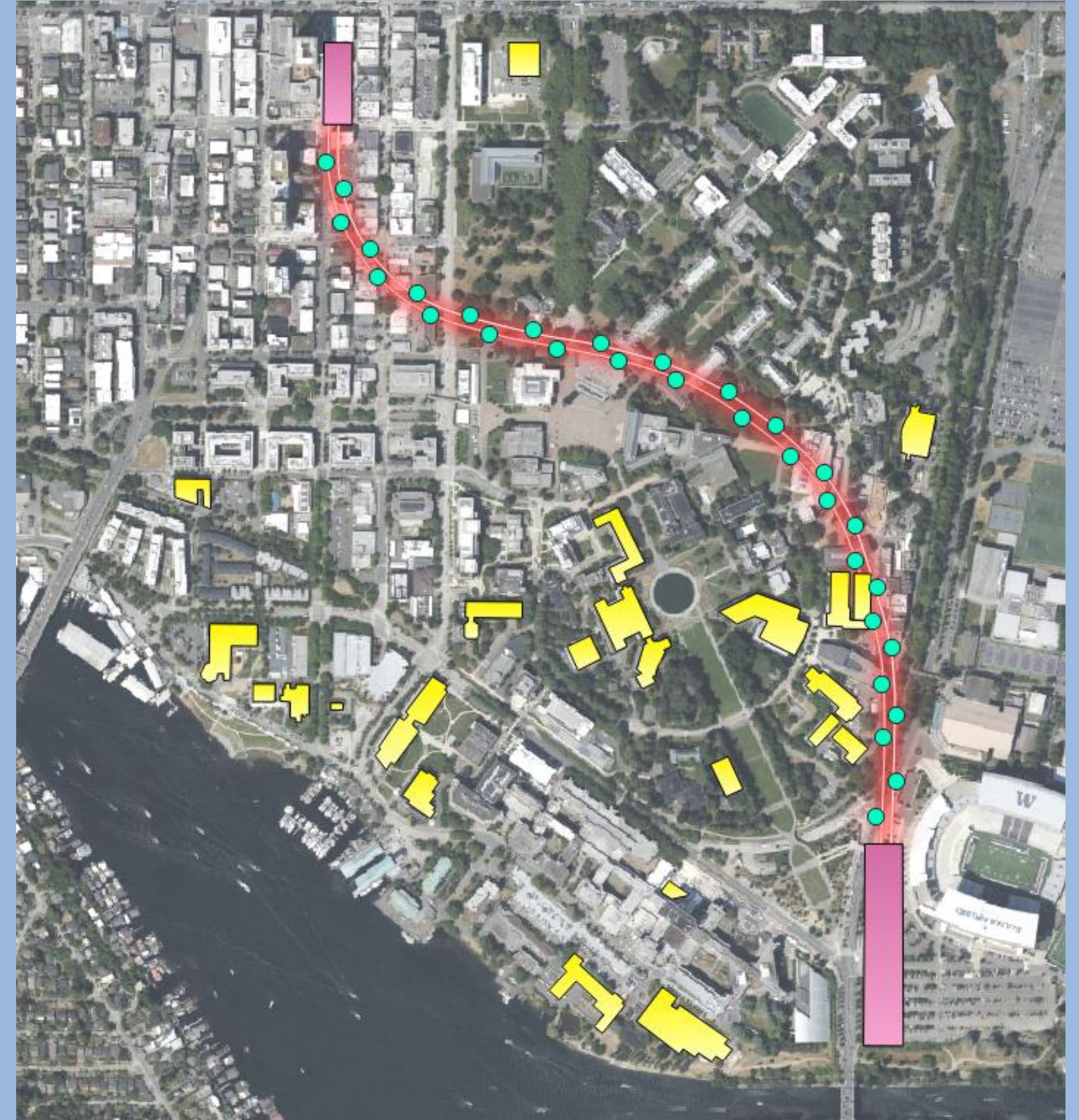


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## Sensitive University Buildings

- University of Washington Station to U District Station
- 24 sensitive buildings
- 31 monitors





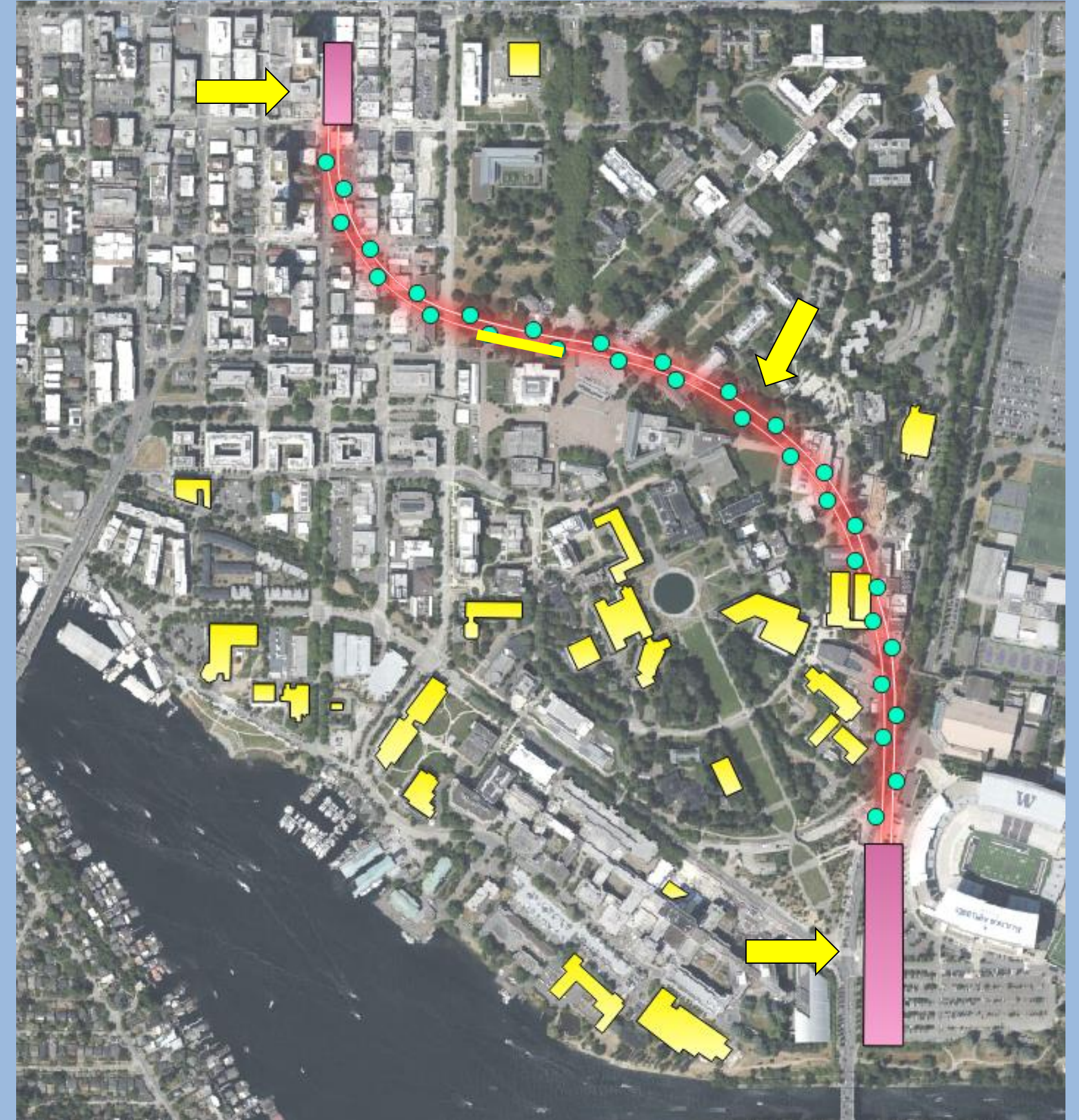


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## Sensitive University Buildings

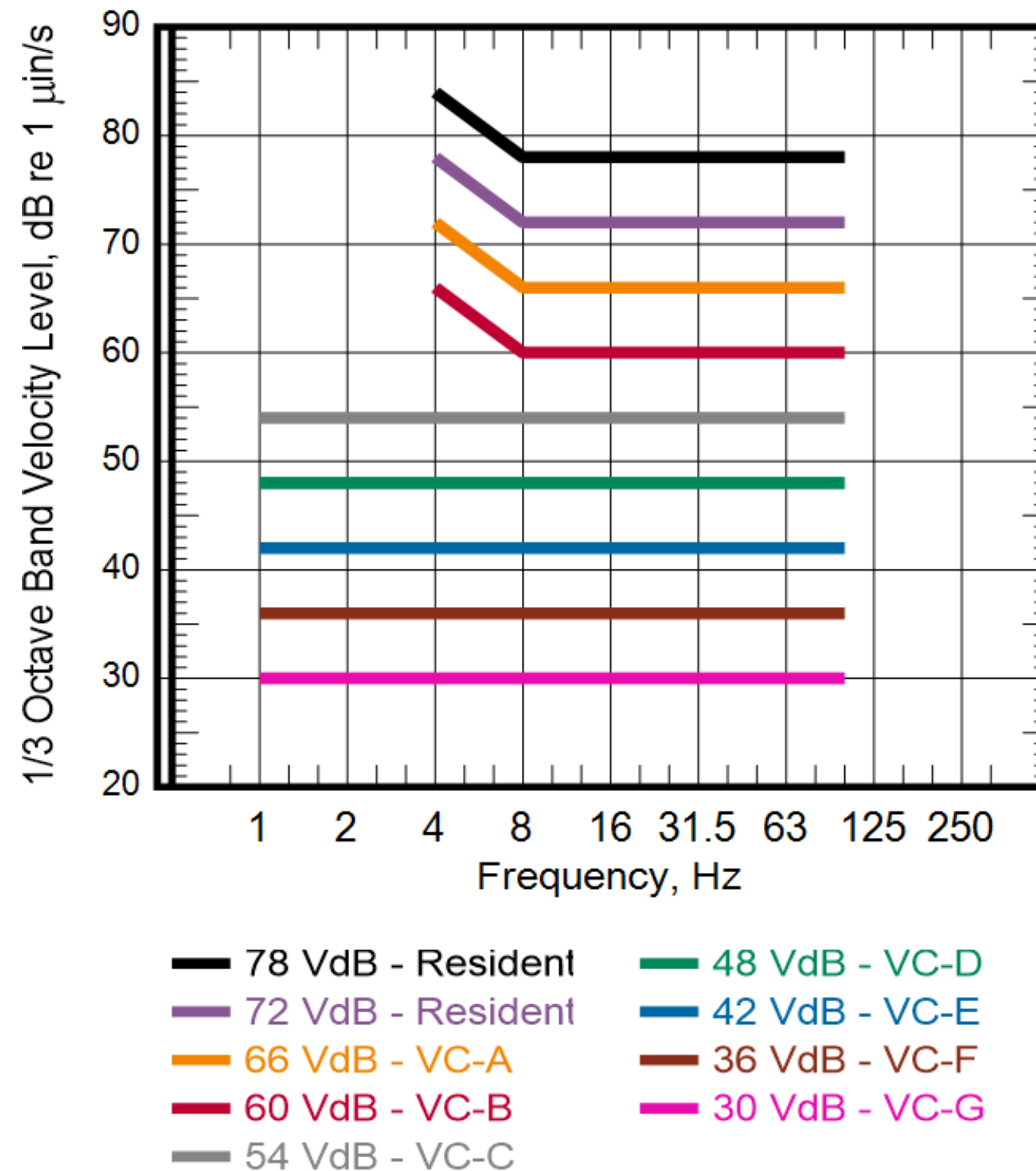
- University of Washington Station to U District Station
- 24 sensitive buildings
- 31 monitors







# Range of Vibration Criteria



## VC-F & VC-G

Extremely quiet research spaces; not recommended as a design criterion, only for evaluations

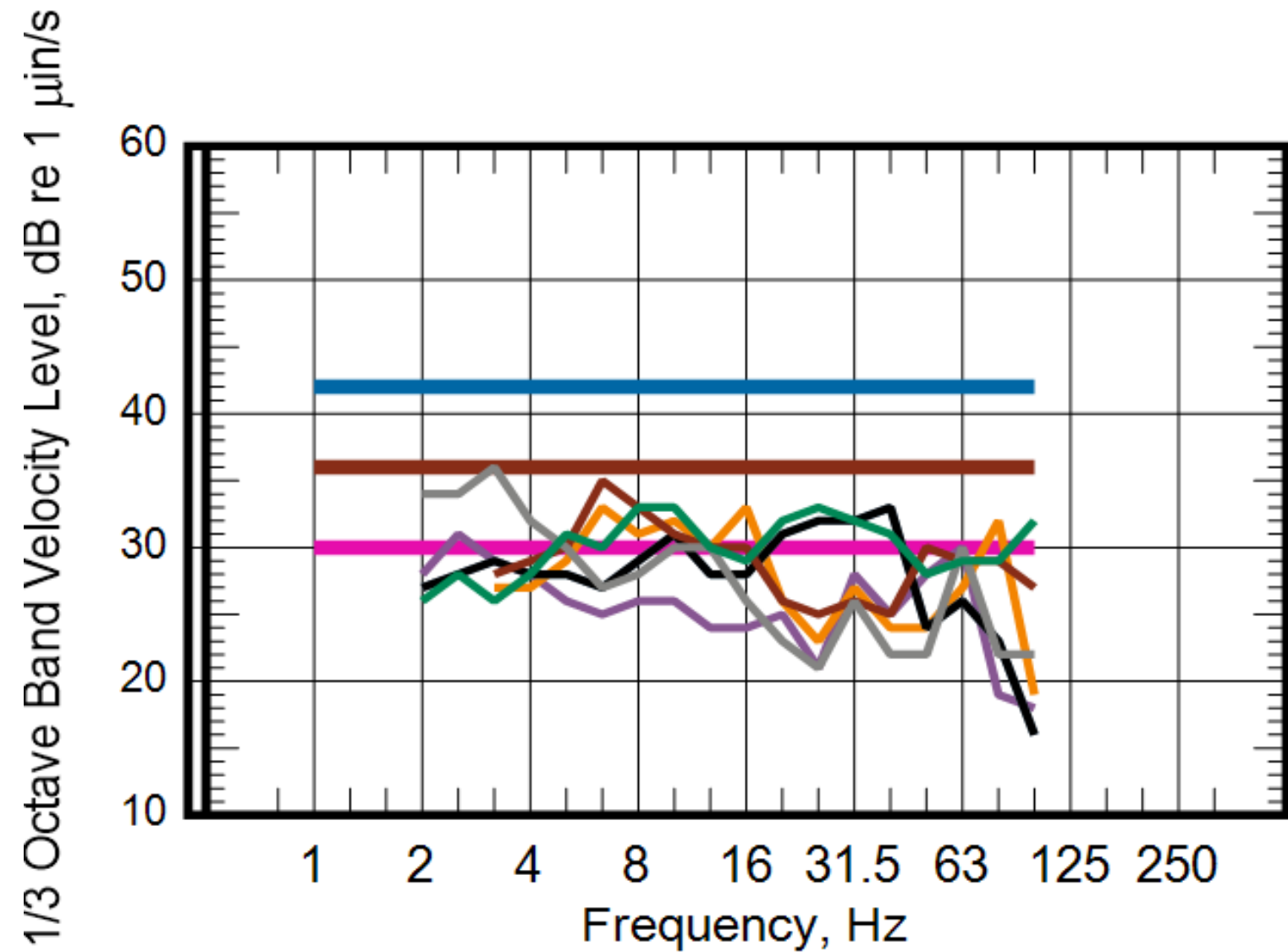






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# MIA Thresholds



- 42 VdB - VC-E
- 36 VdB - VC-F
- 30 VdB - VC-G
- New Chemistry
- EE/CS
- Bioengineering
- Ocean. Res. Bldg.
- Roberts Hall
- Physics/Astronomy
- Winkenwerder Hall

Most restrictive

Buildings with  
**lowest** thresholds

Lower than VC-G

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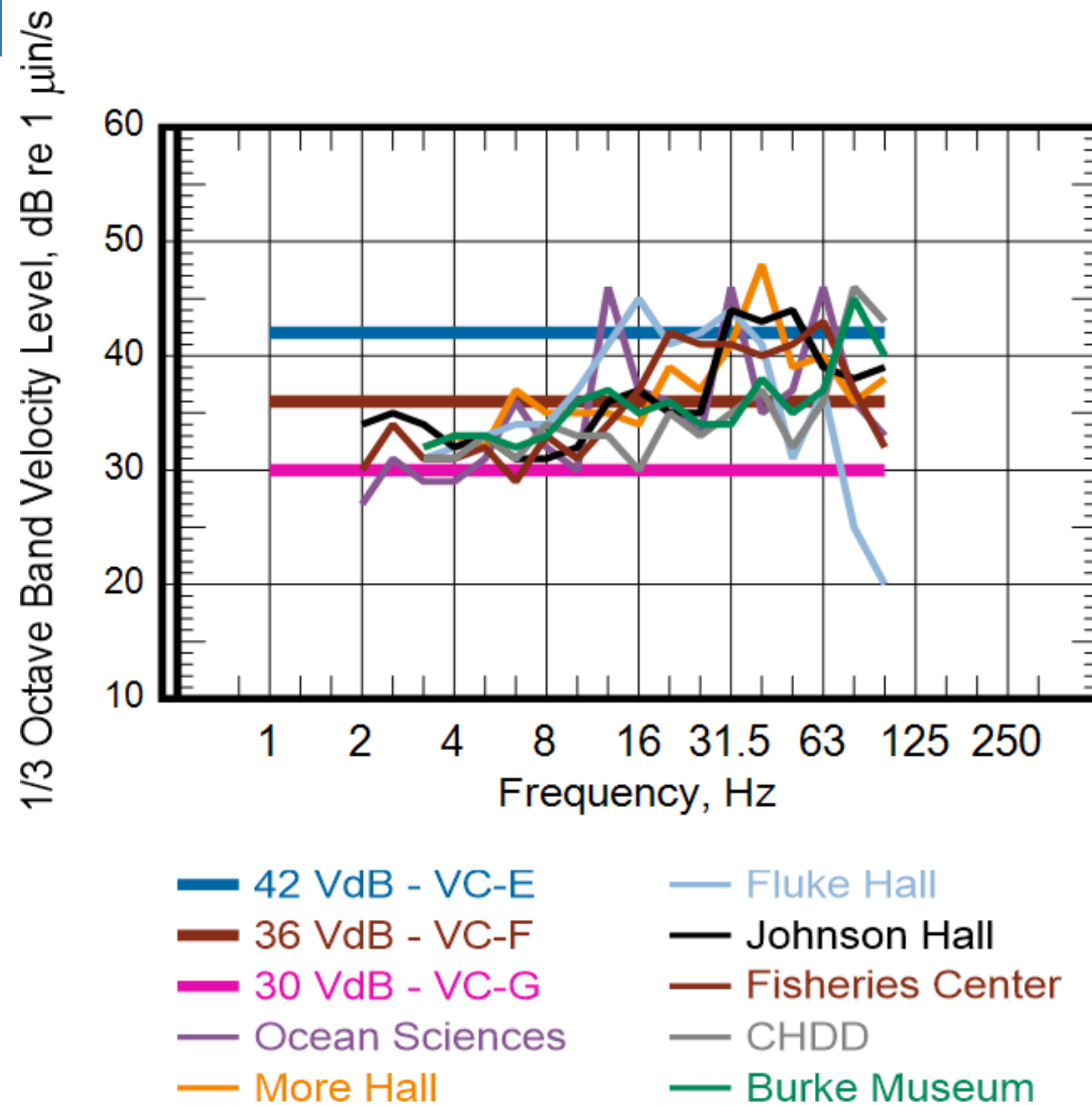






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# MIA Thresholds



Least restrictive

Buildings with  
**highest**  
thresholds

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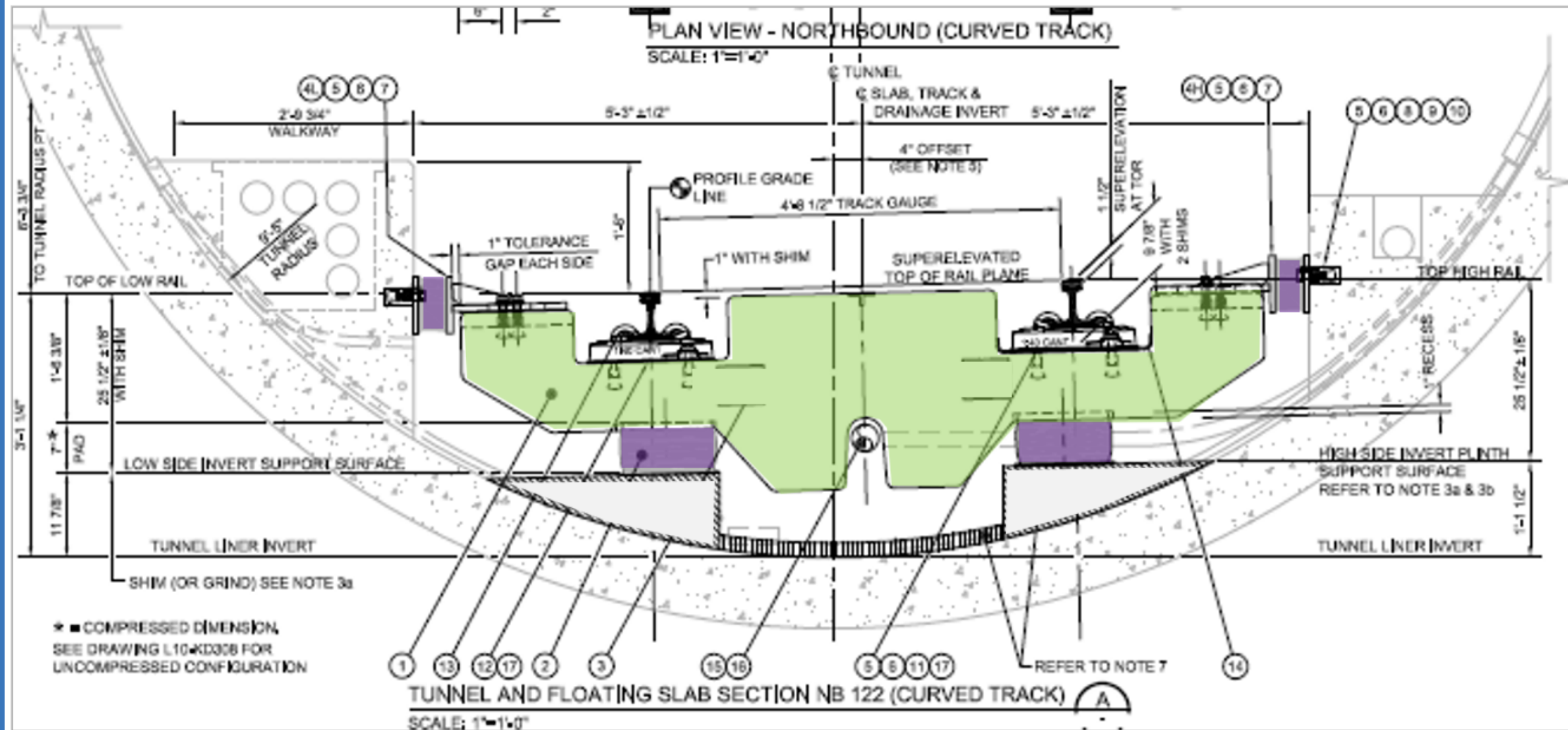






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# 5 Hz Floating Slab



## Additional factors

Ultra-straight rail  
Grinding program  
Vehicle FDL  
specifications



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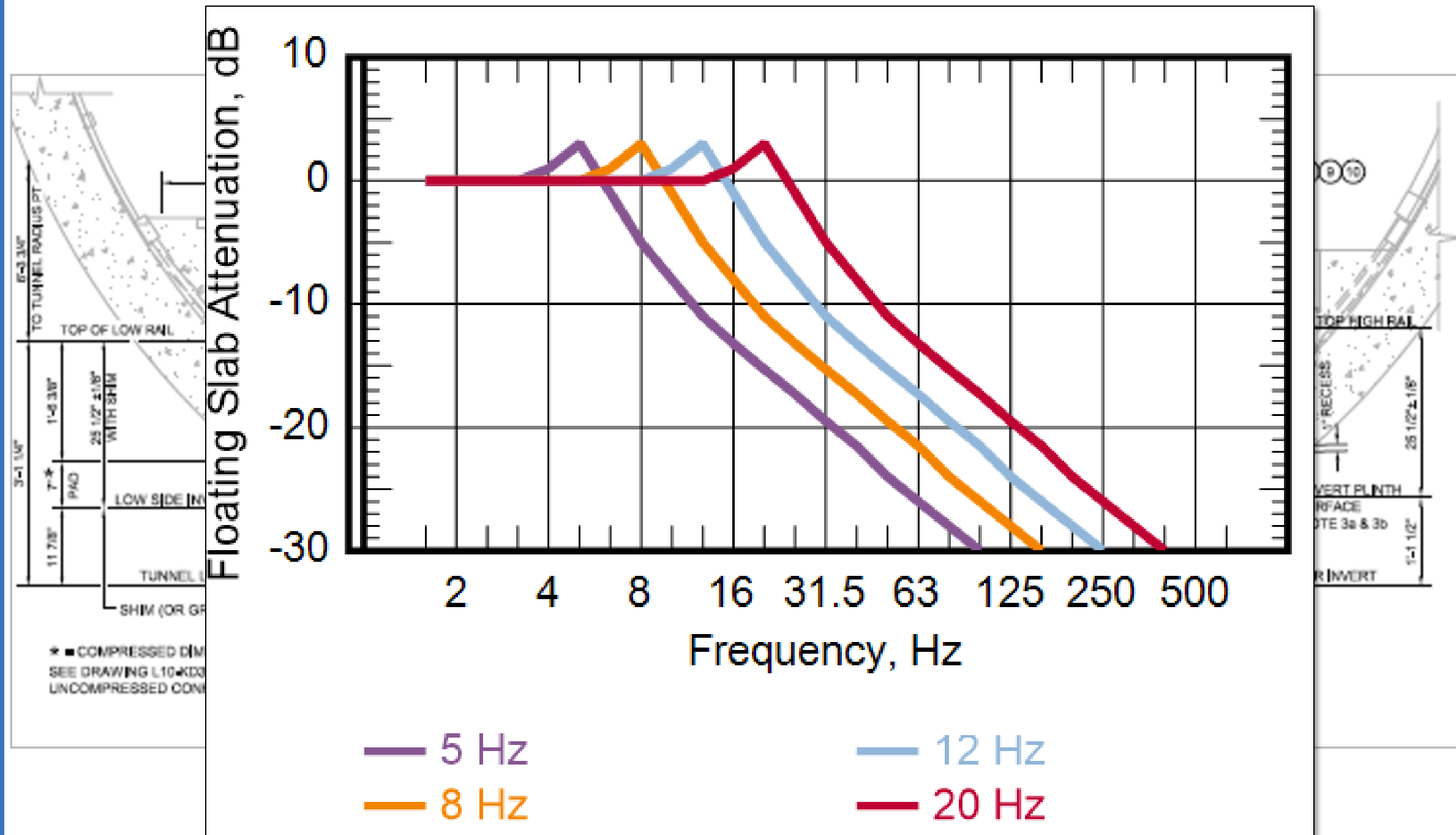
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# 5 Hz Floating Slab



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- Ultra-straight rail
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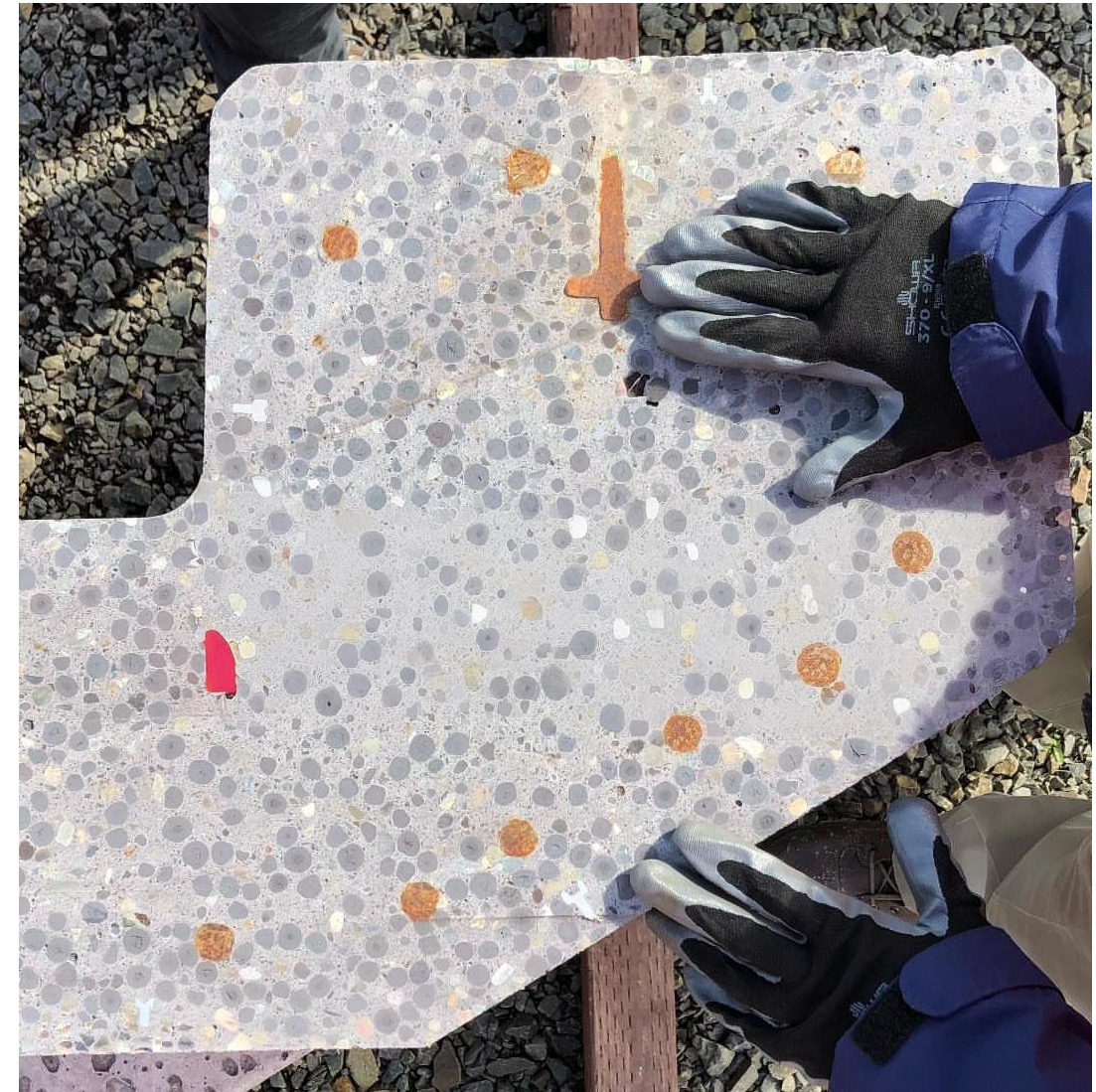
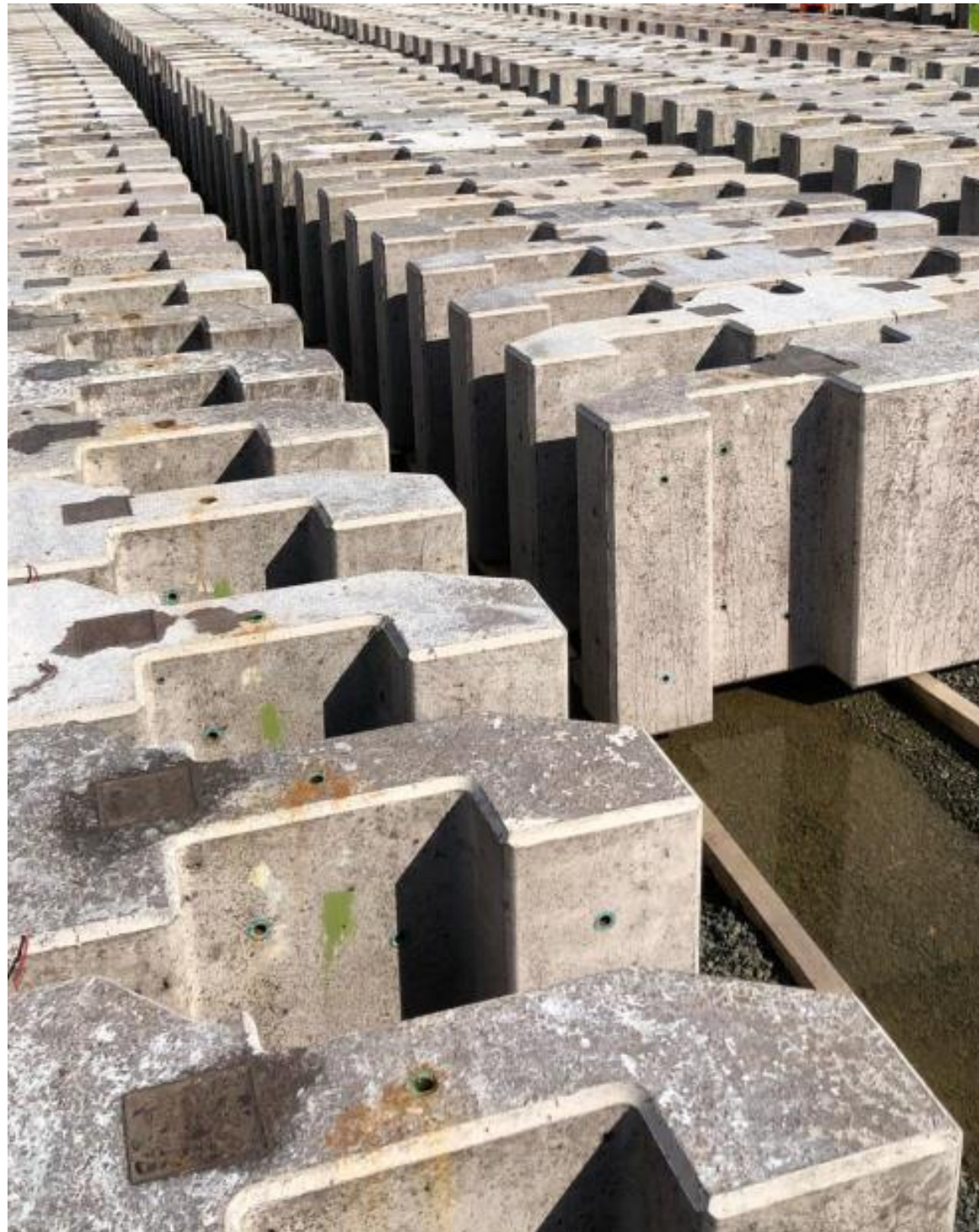
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# 5 Hz Floating Slab



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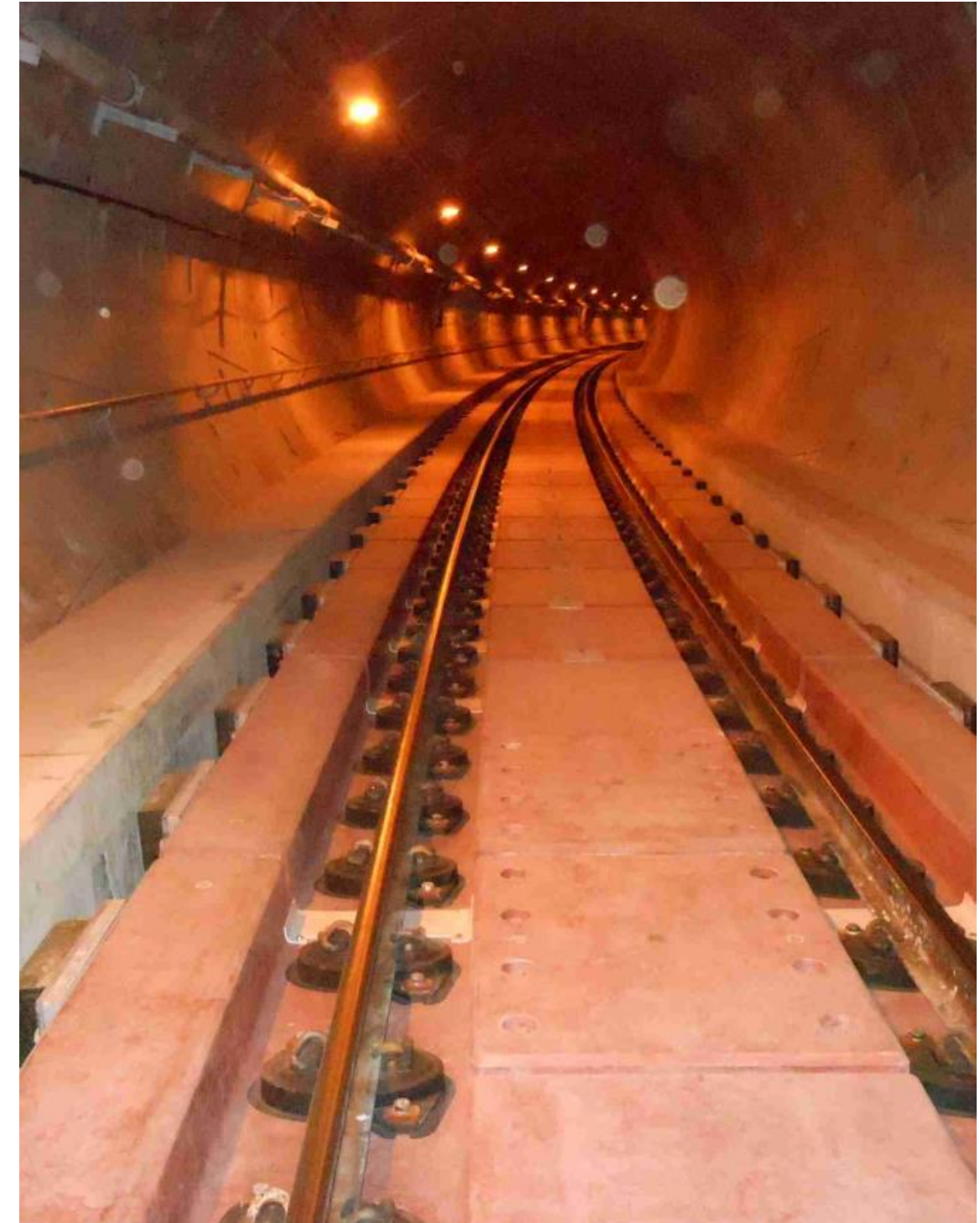
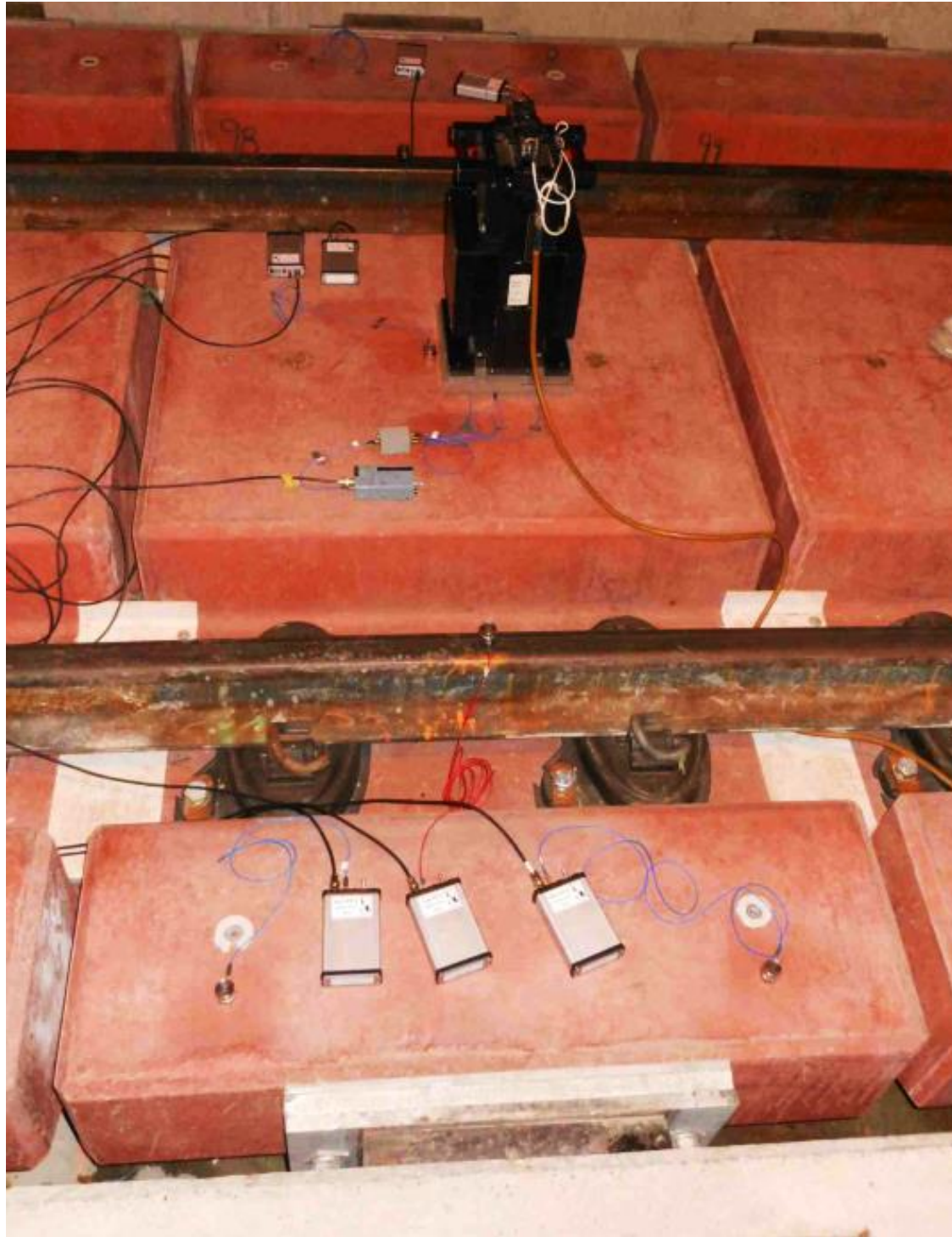






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# 5 Hz Floating Slab



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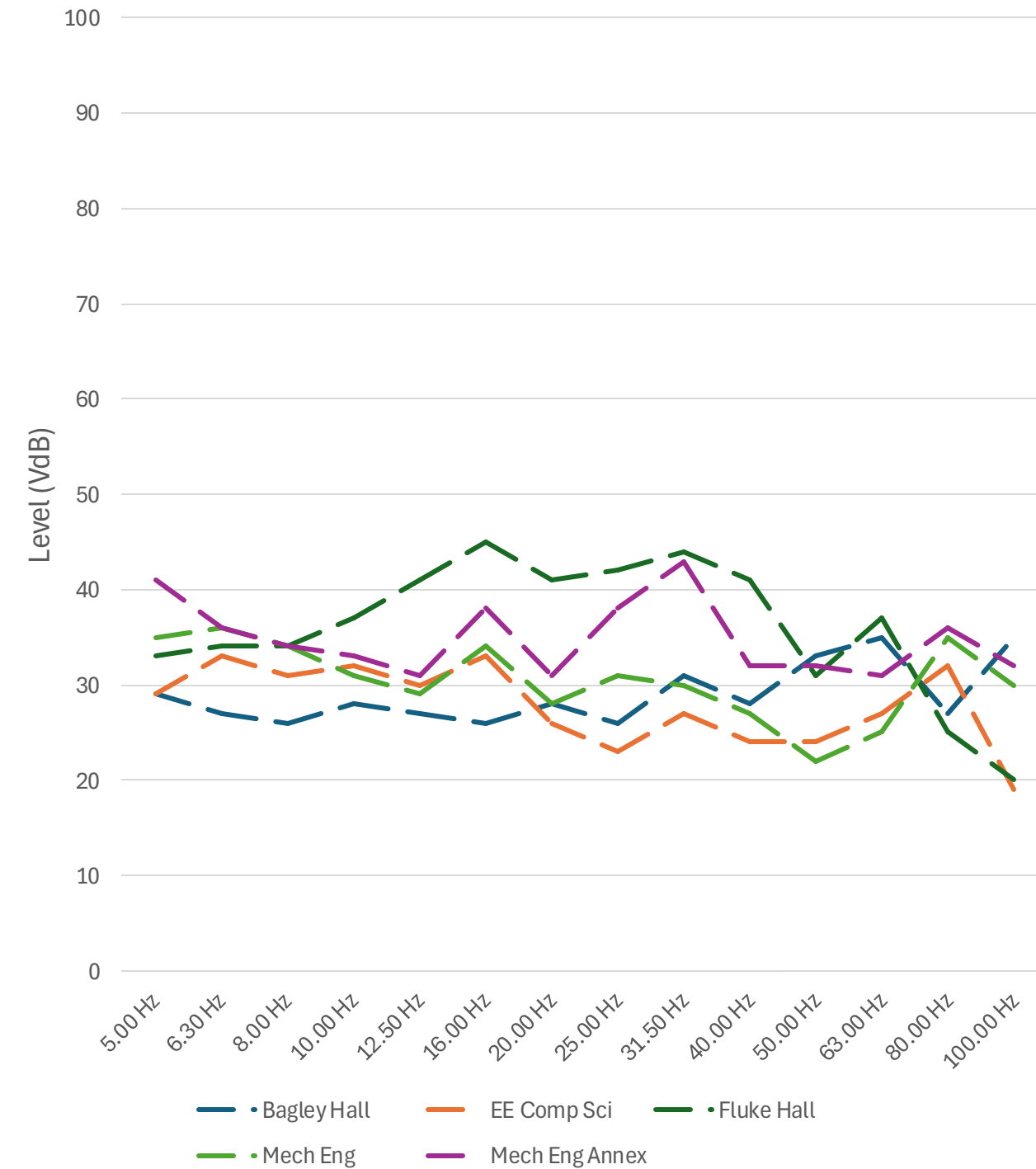




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# Vibration Adjustment Estimate (VAE)

- Criteria at buildings



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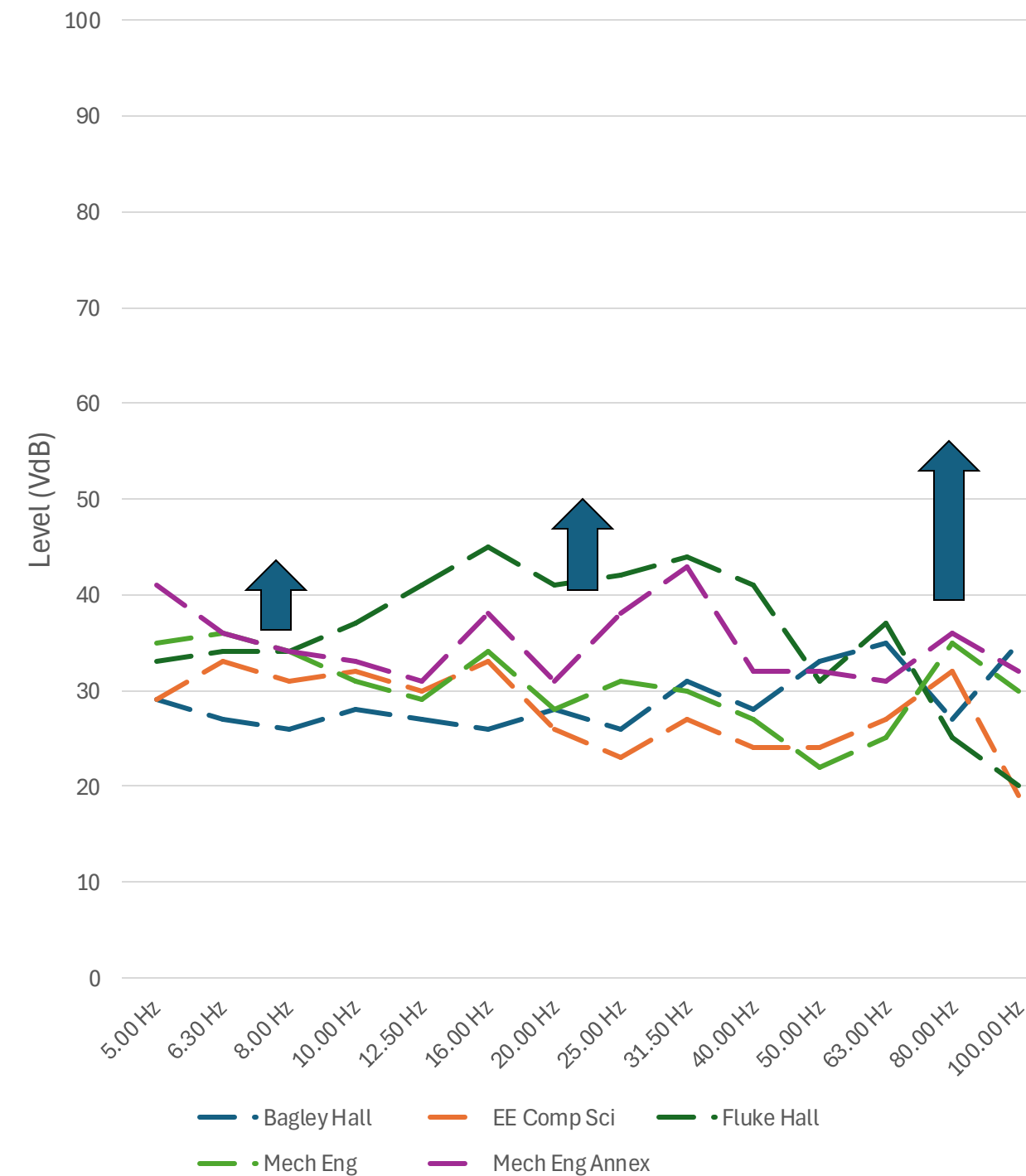




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# Vibration Adjustment Estimate (VAE)

- Criteria at buildings
- Apply VAE



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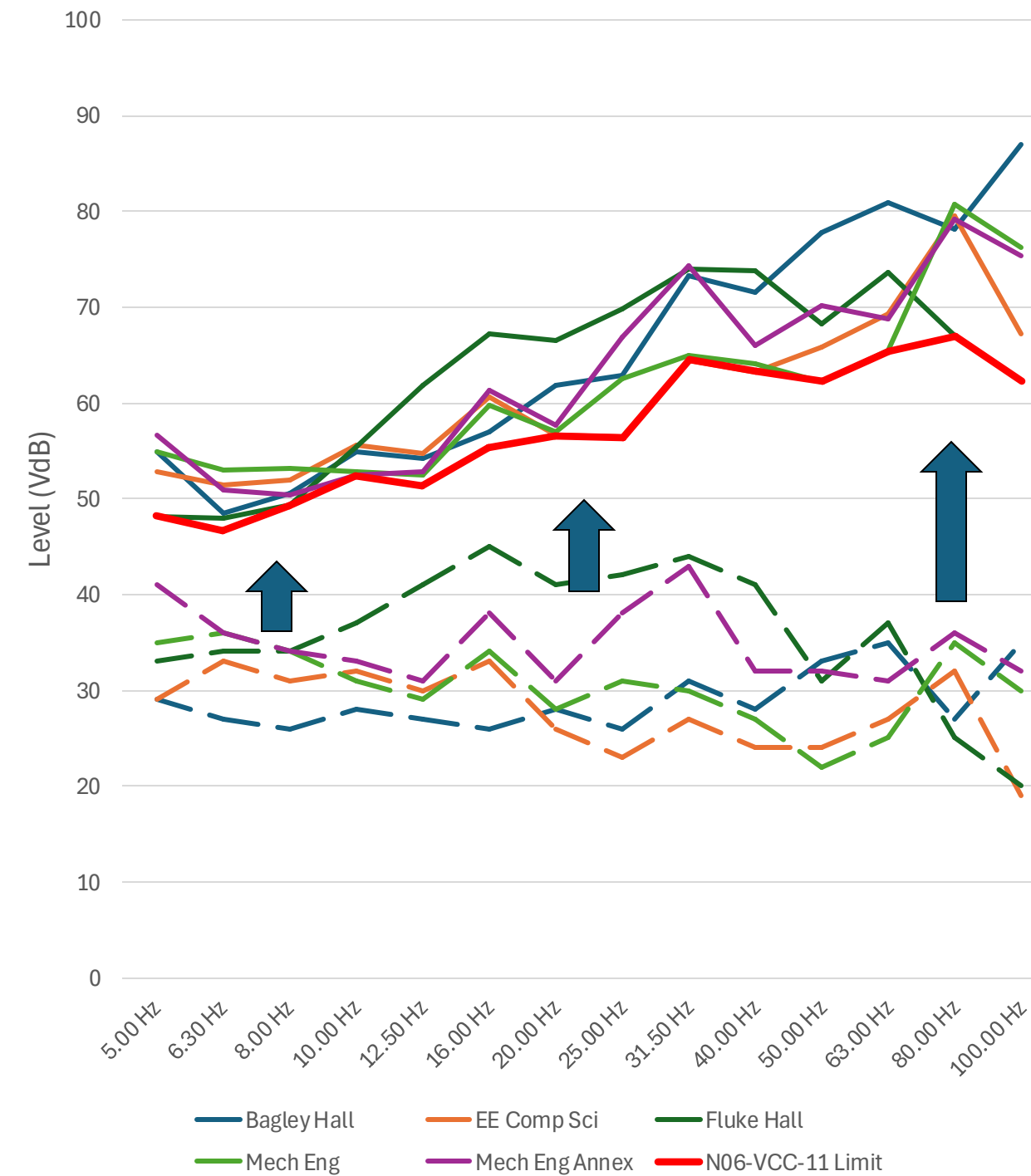
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# Vibration Adjustment Estimate (VAE)

- Criteria at buildings
- Apply VAE
- Criteria at monitor



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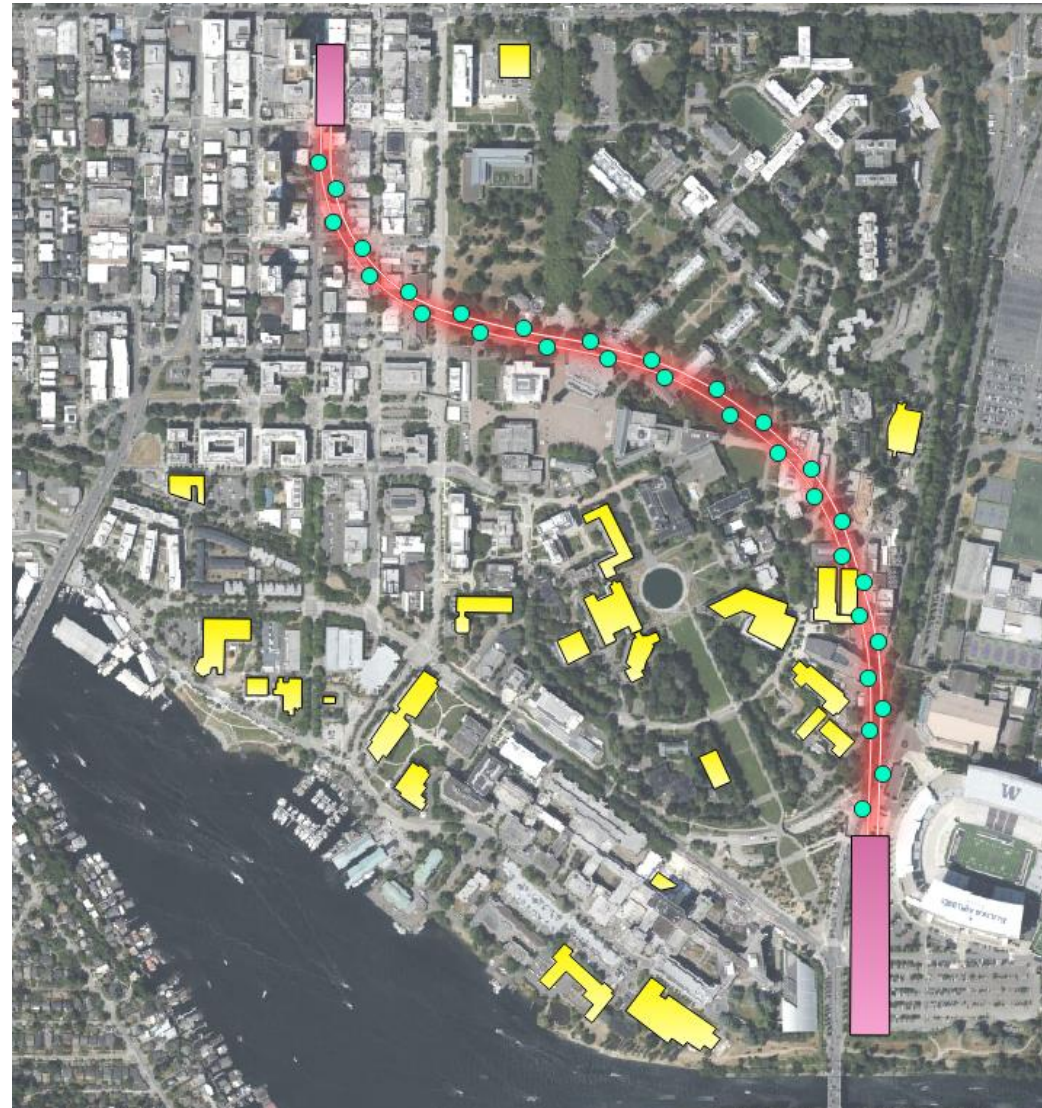
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## 31 monitor locations with redundant pairs







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# Monitoring system

- 31 monitor locations
- 2 Hz – 100 Hz in 1/3-octave bands
- VAE adjustment
- Continuous monitoring
- Warning & exceedance alarms
  
- Wheel flat detector



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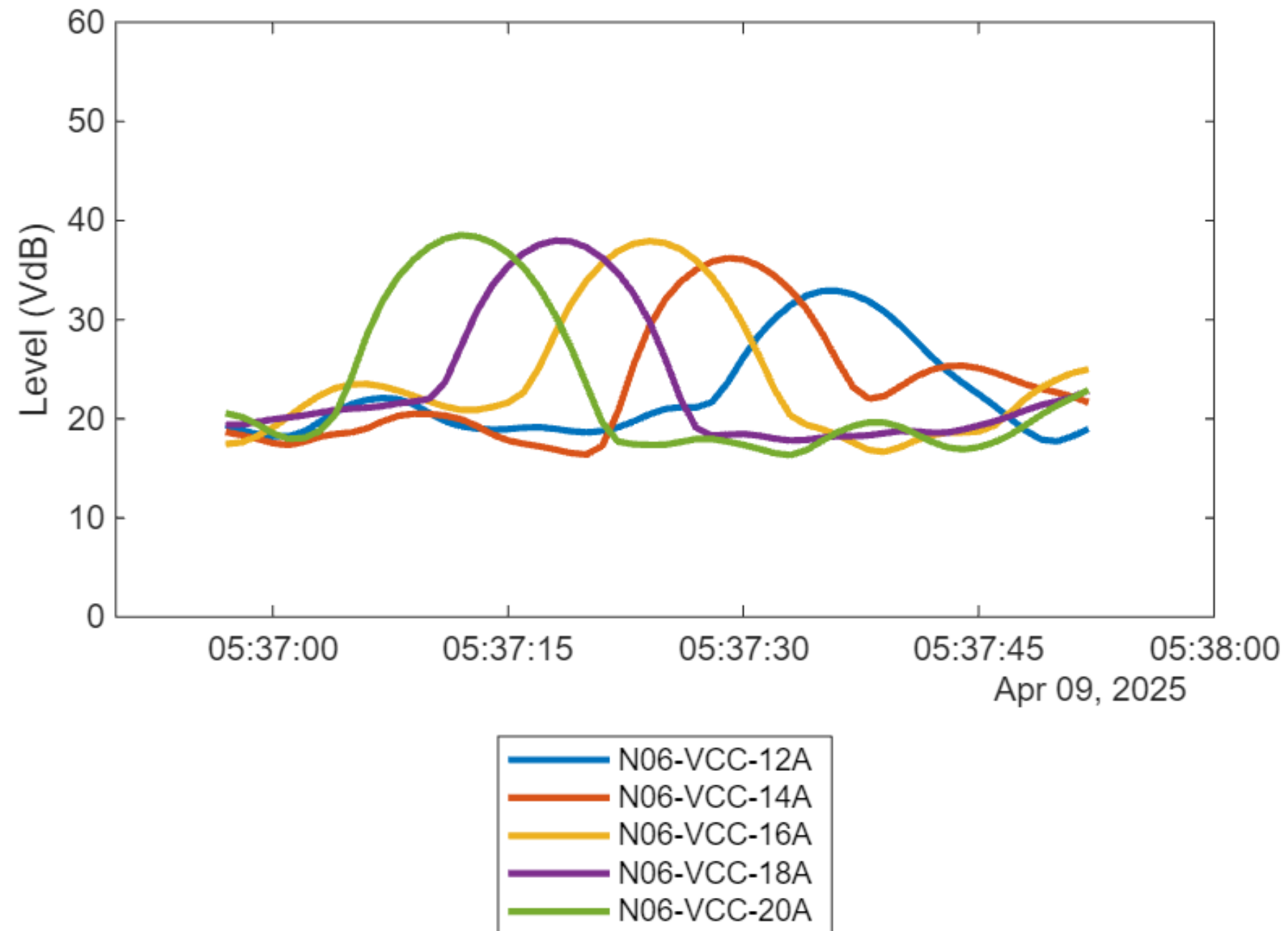
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# Single passby (5 Hz)



**Monitors 12-20**

Southbound,  
track on floating  
slab



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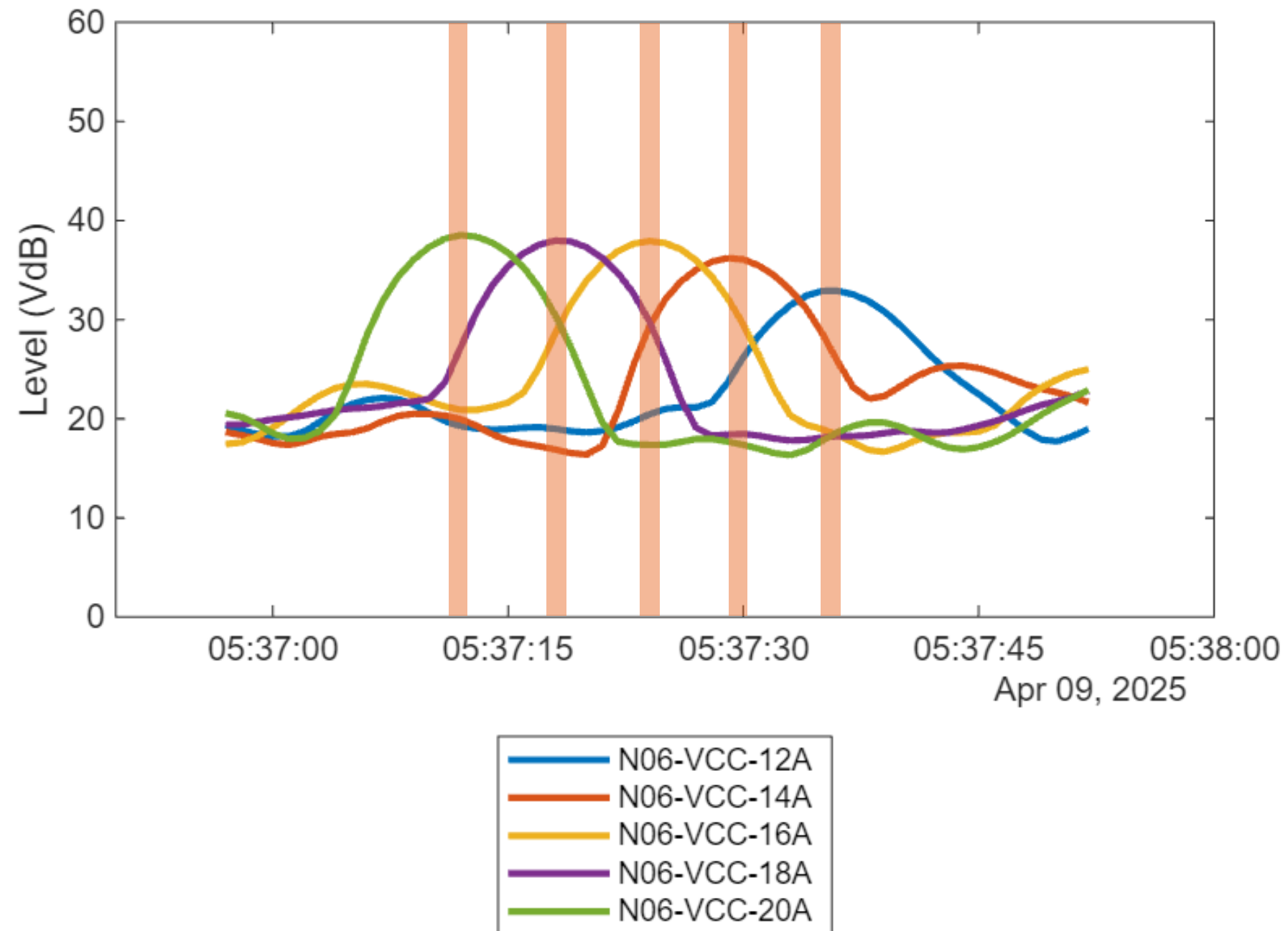
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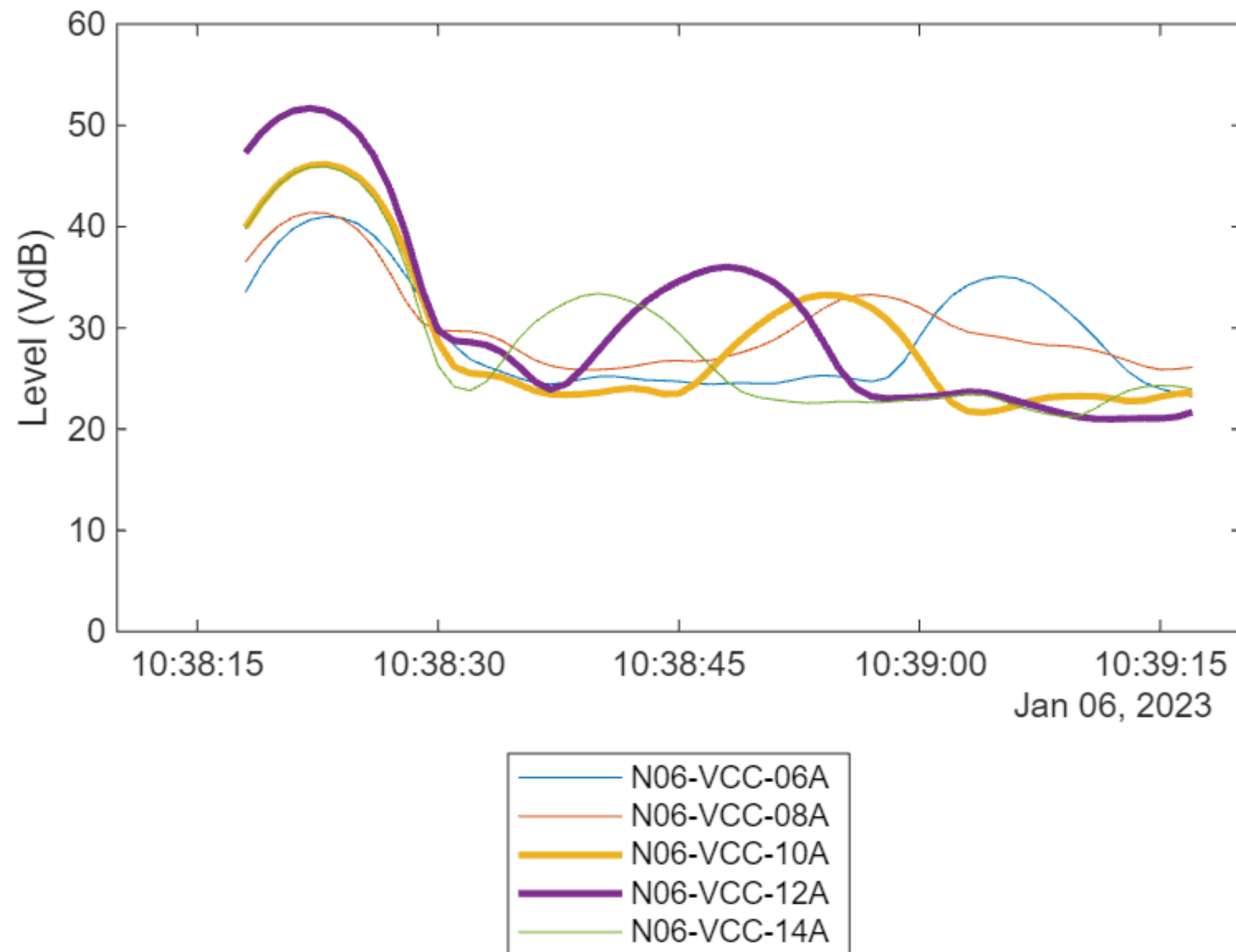






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# Non-train exceedances



Monitors 6-14, 6.3 Hz

Southbound,  
track on floating  
slab

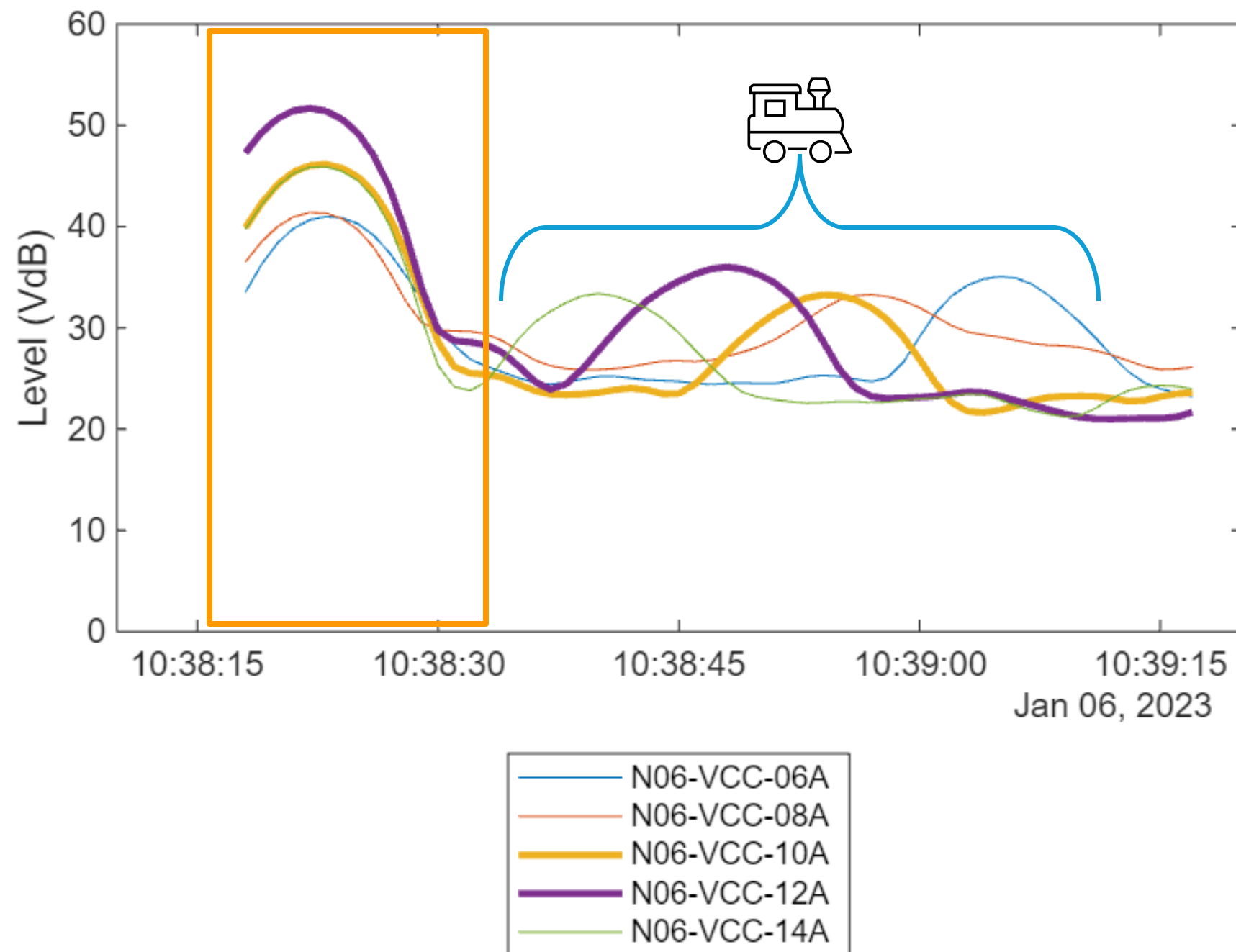
Exceedance  
triggered at  
Monitors 10 & 12





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# Non-train exceedances



Monitors 6-14, 6.3 Hz

Southbound,  
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slab

Exceedance  
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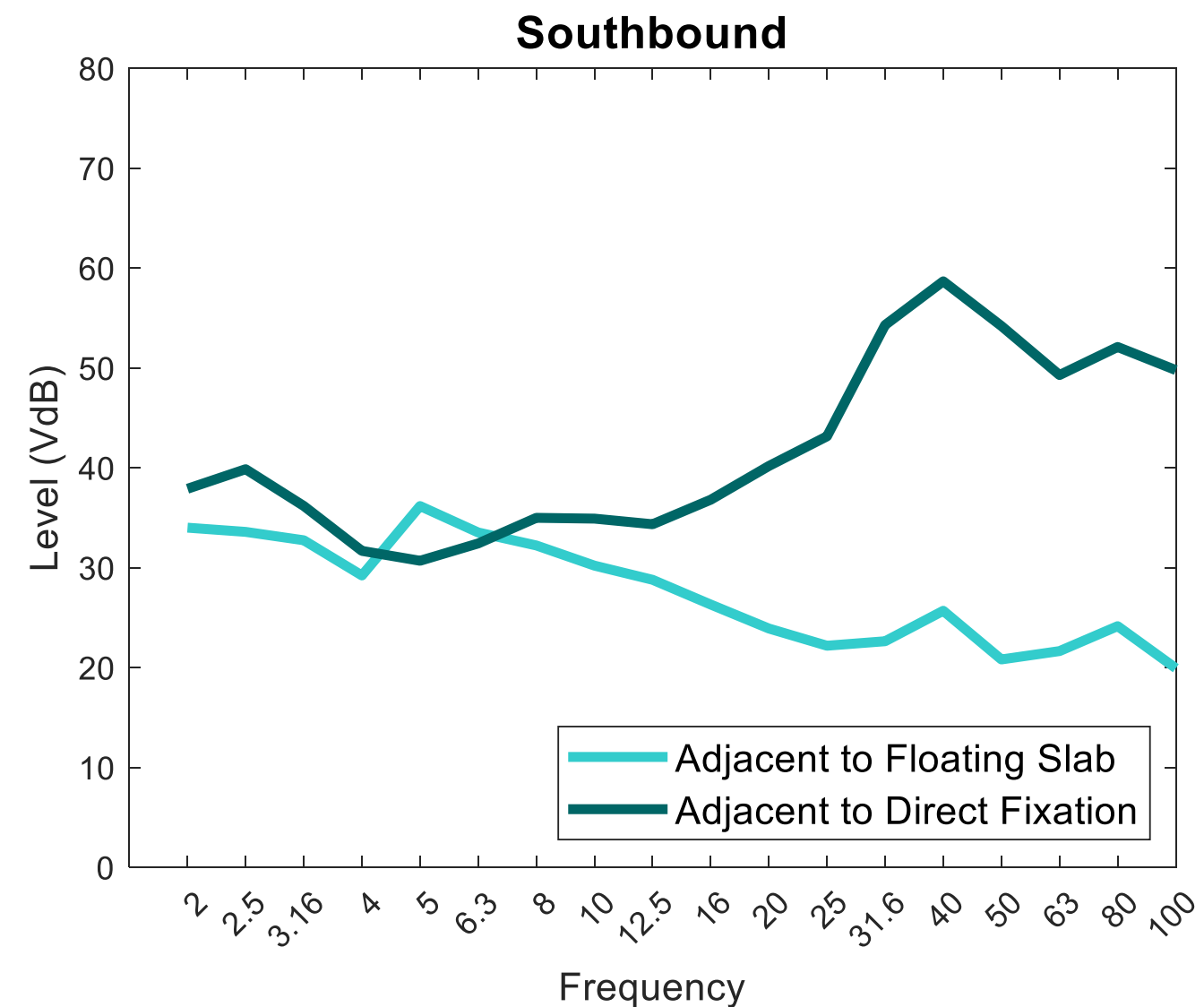
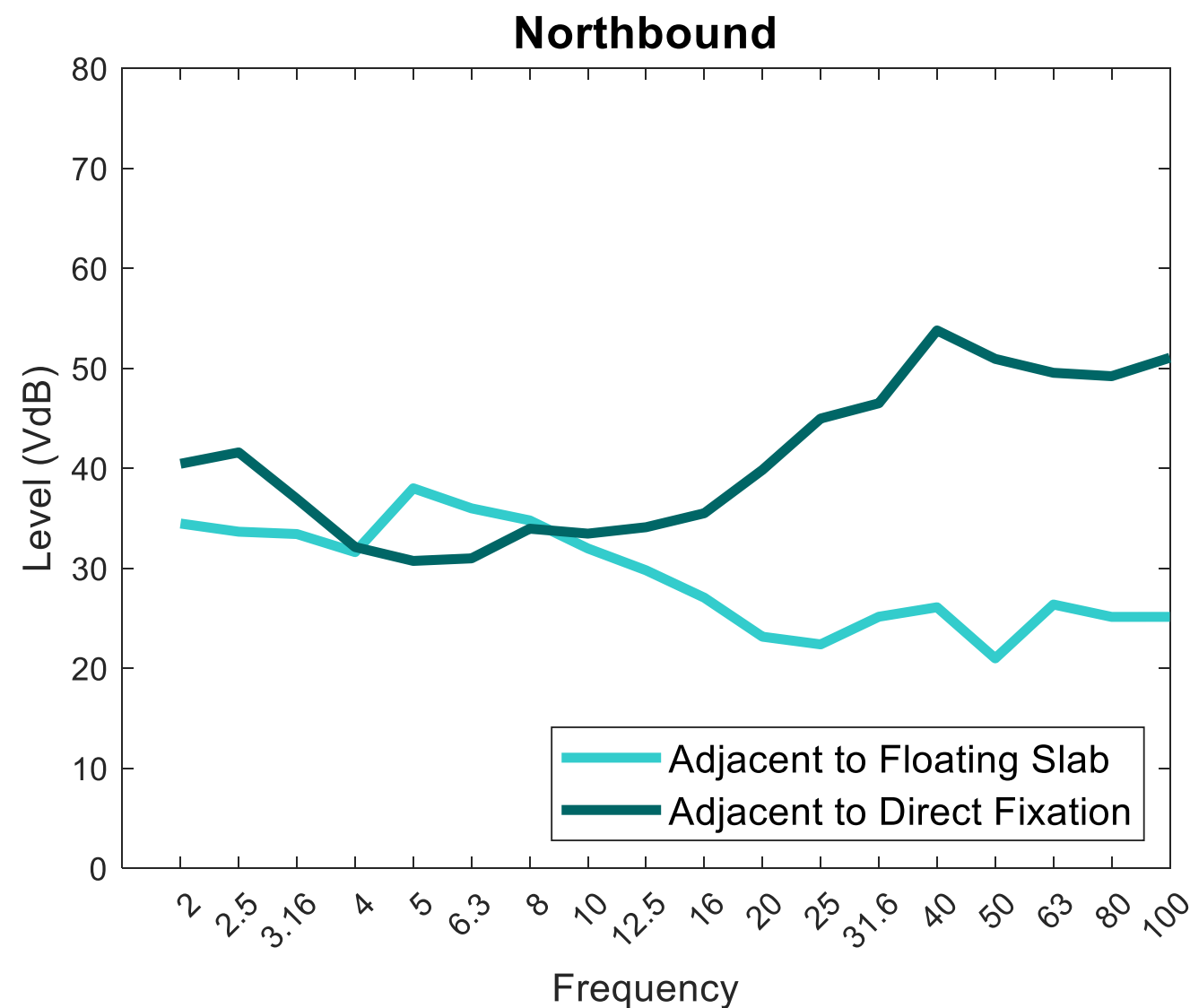






# Track on Floating Slab vs Direct Fixation

- Vibration is overall higher off of 5 Hz floating slab
- On 5 Hz floating slab there is a peak at the 5 Hz resonant frequency, but higher frequency vibration is attenuated





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# Trend Analysis

- Quarterly trend analysis
- Data from 2022 – present
- Pull 24h of data from the monitoring system each quarter
- Report & analyze data for each monitor at each frequency

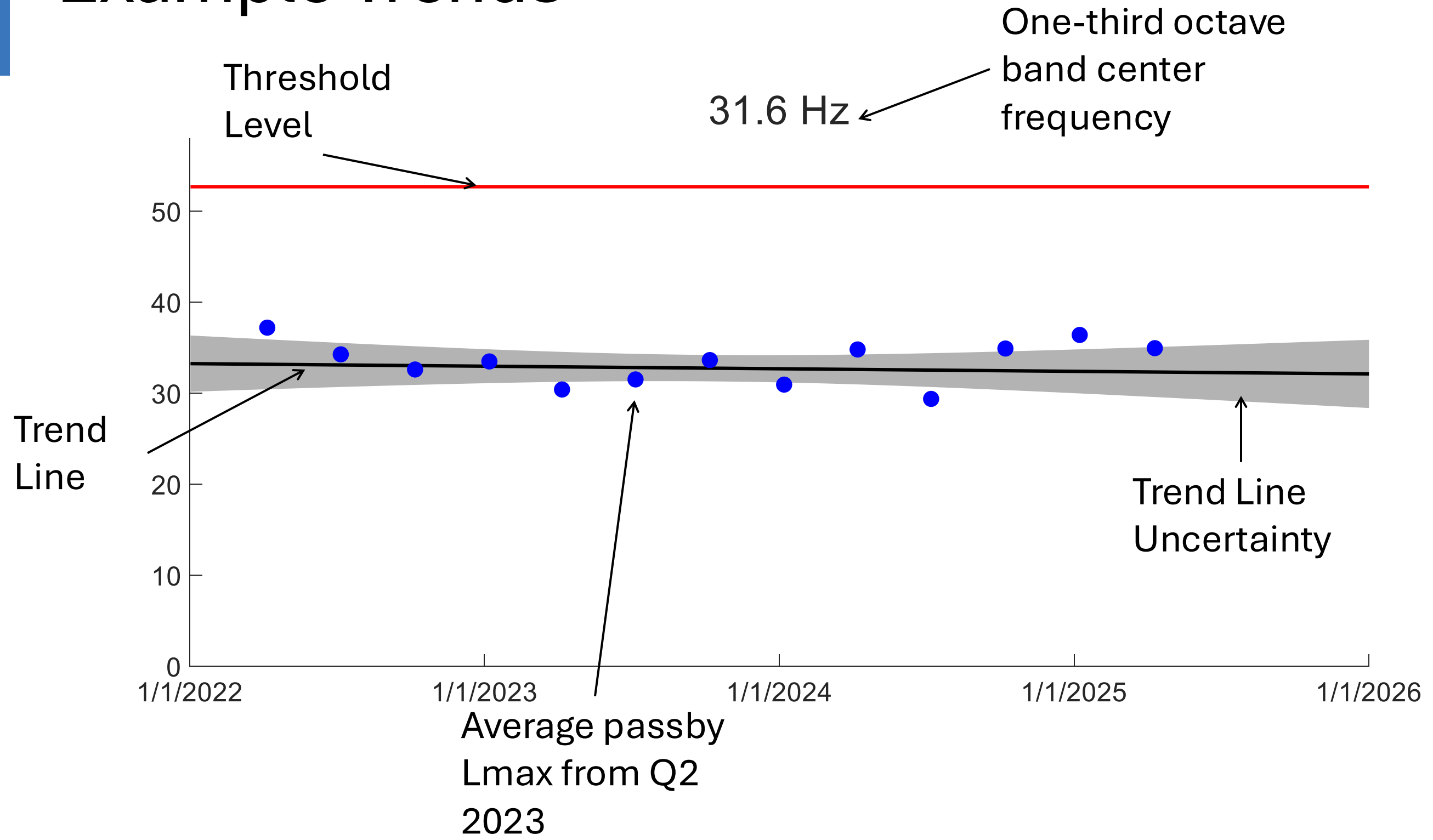






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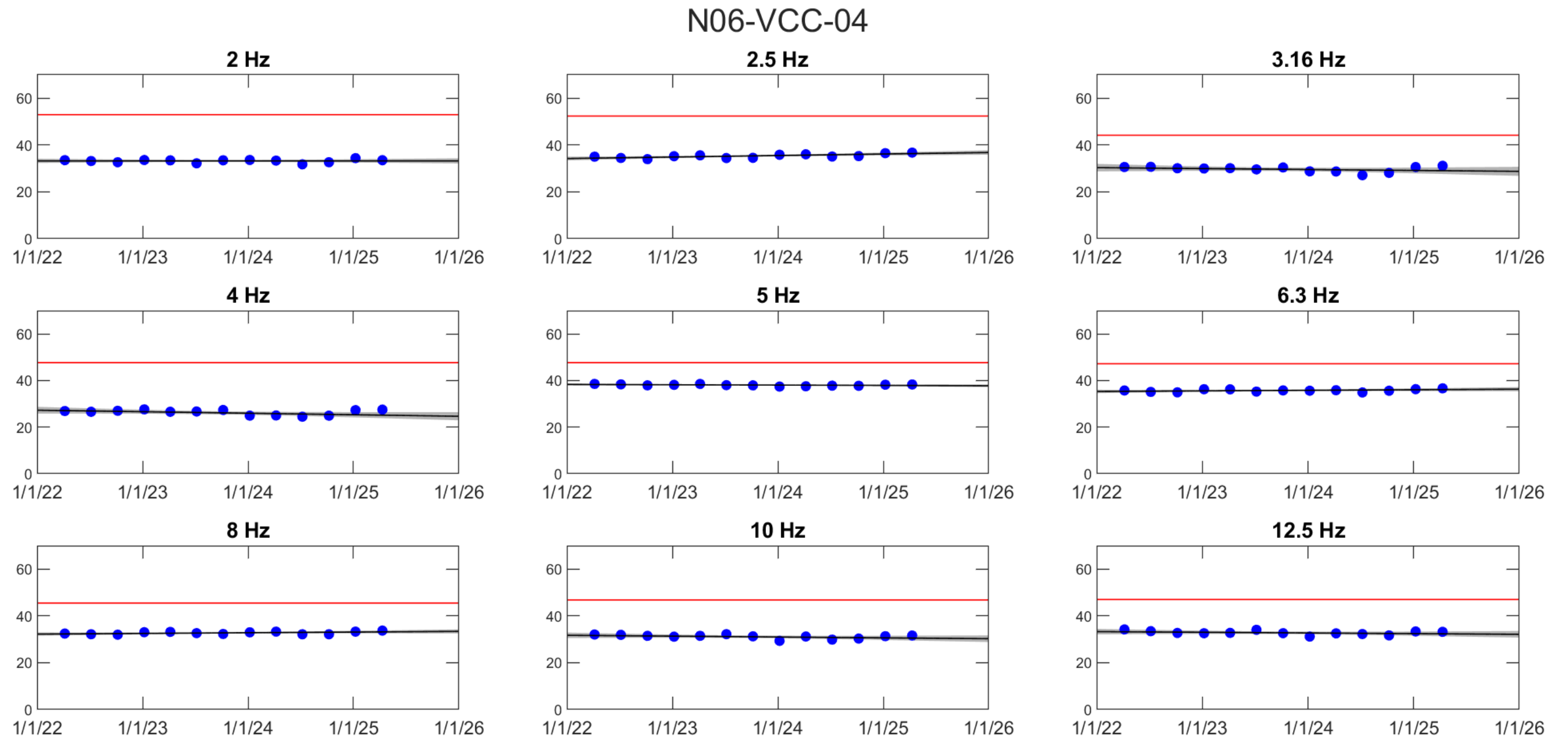
# Example Trends





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# Example Trends



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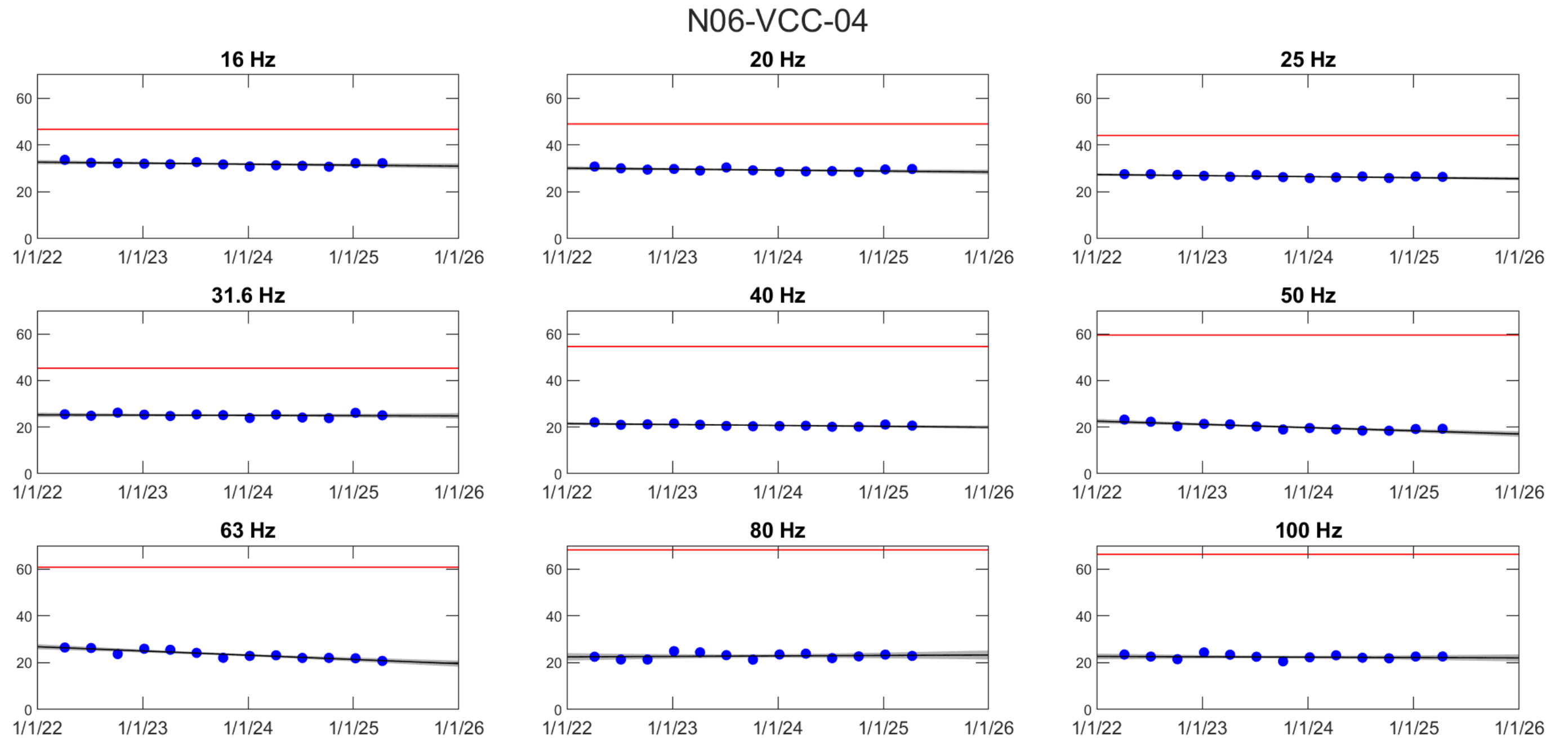






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# Example Trends



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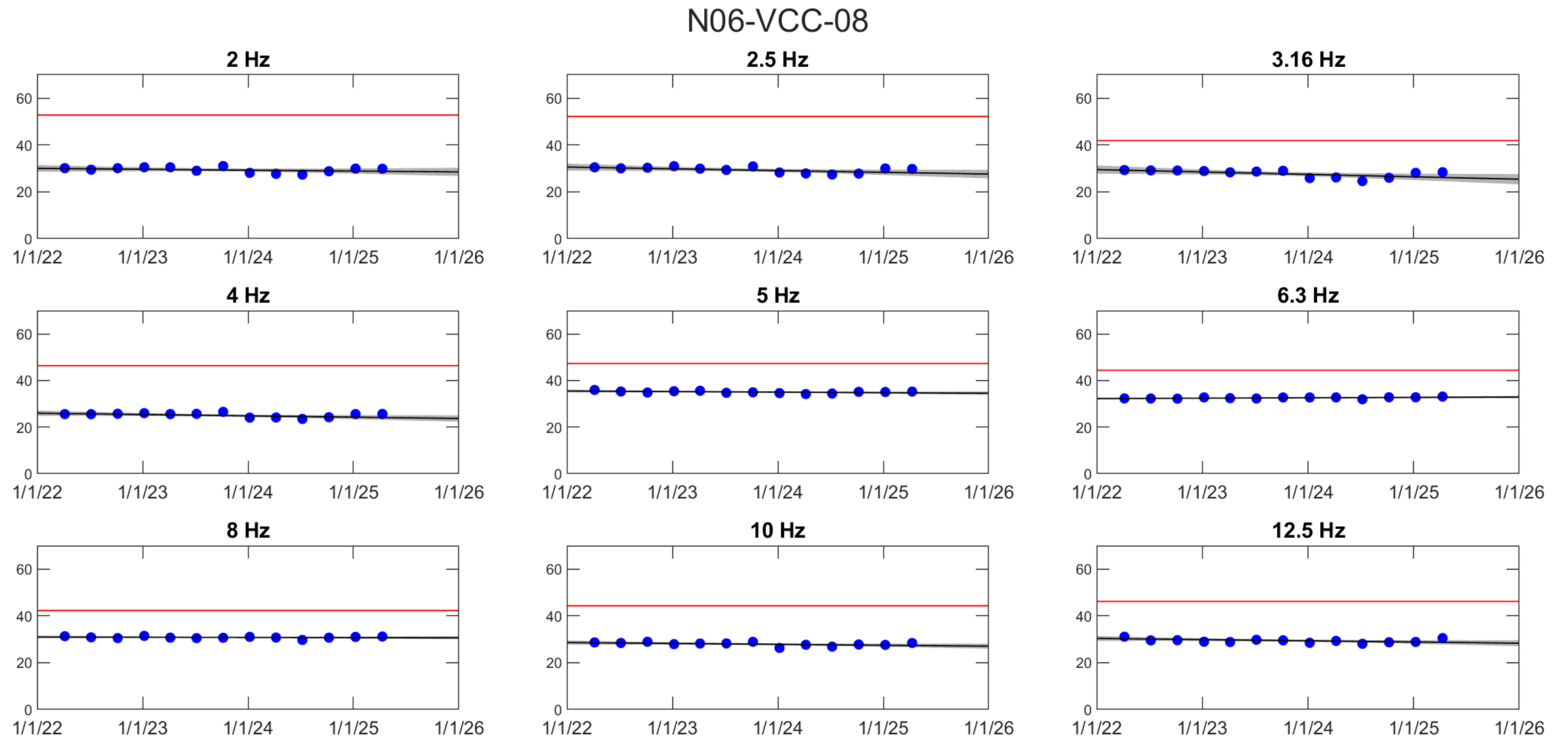
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# Example Trends



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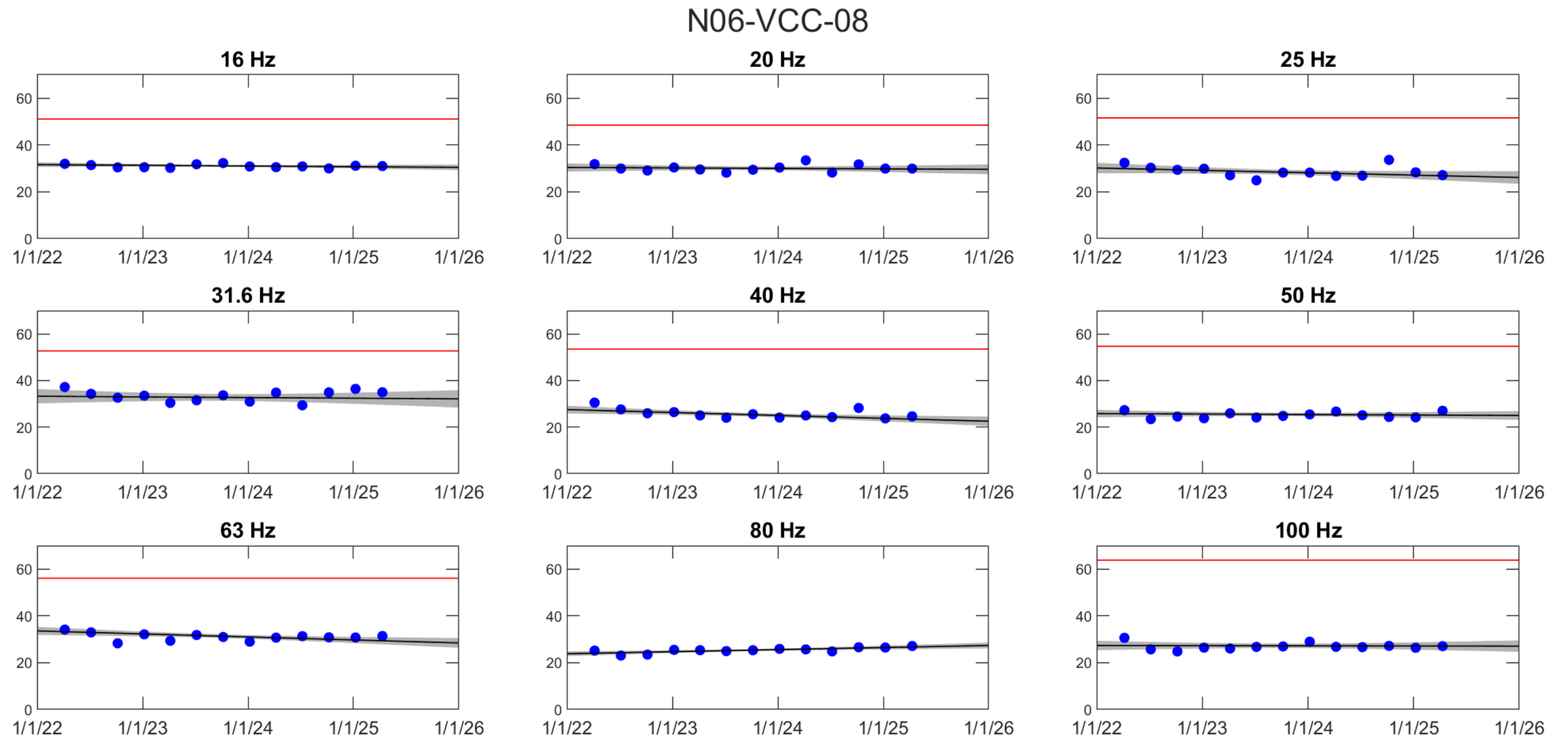






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# Example Trends



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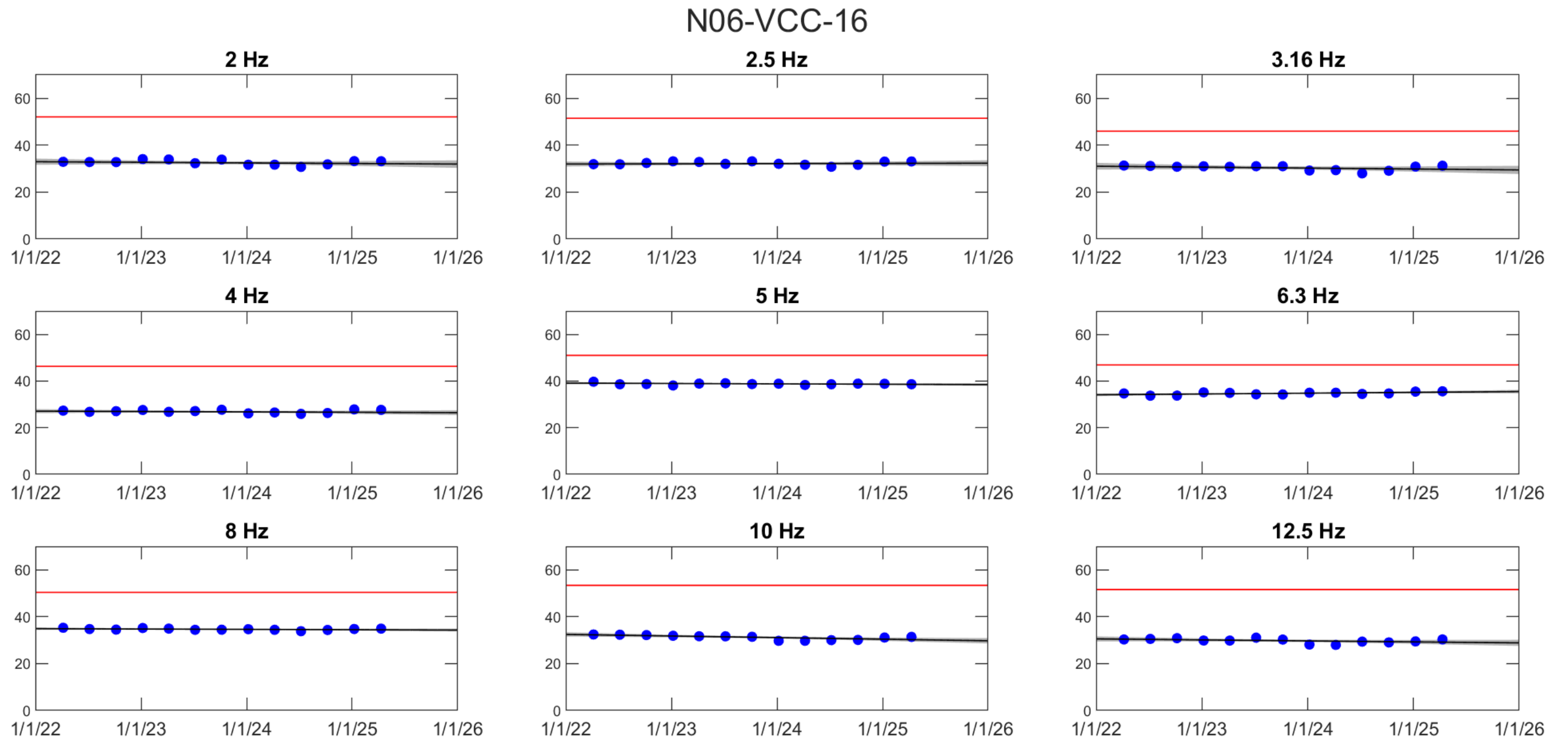
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# Example Trends



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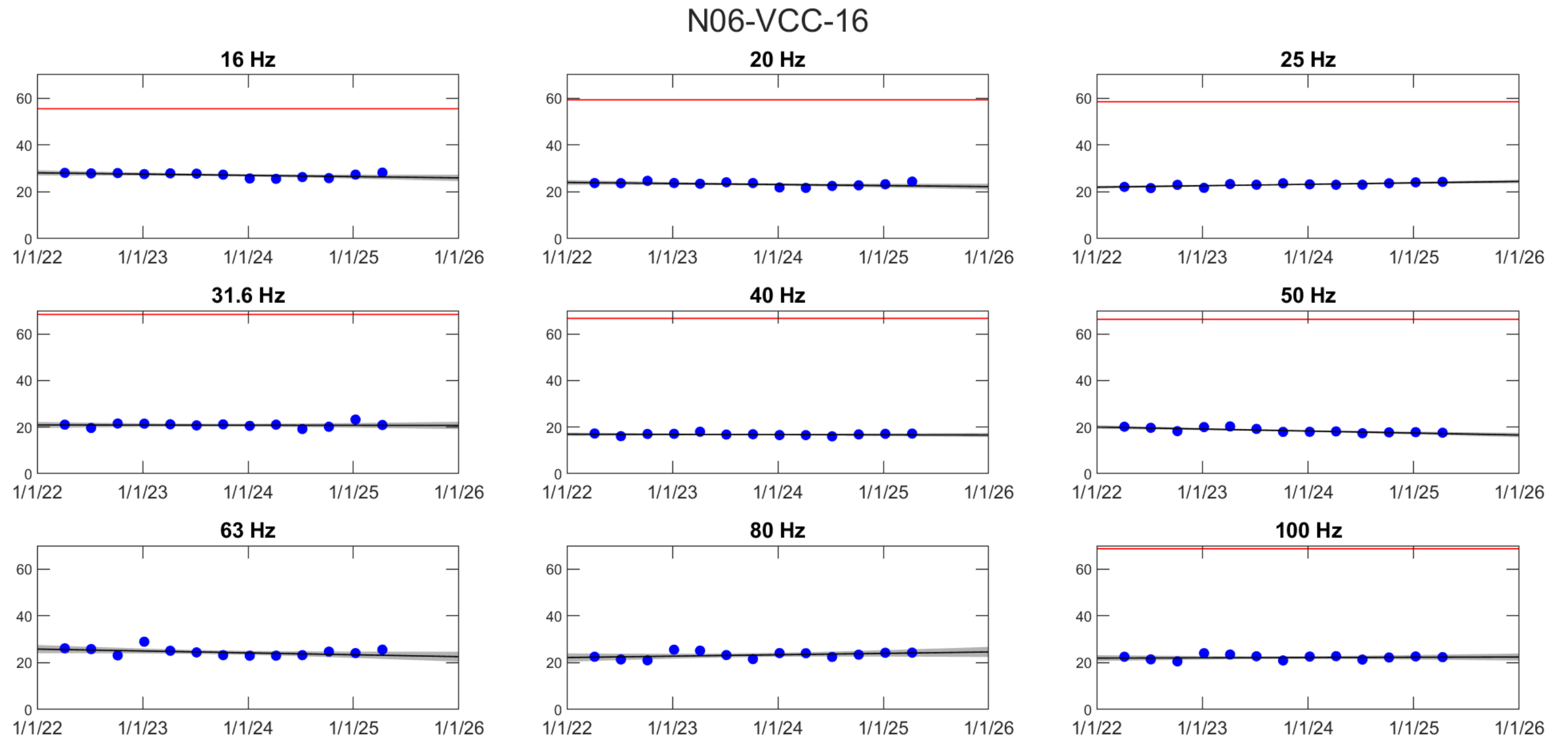






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# Example Trends



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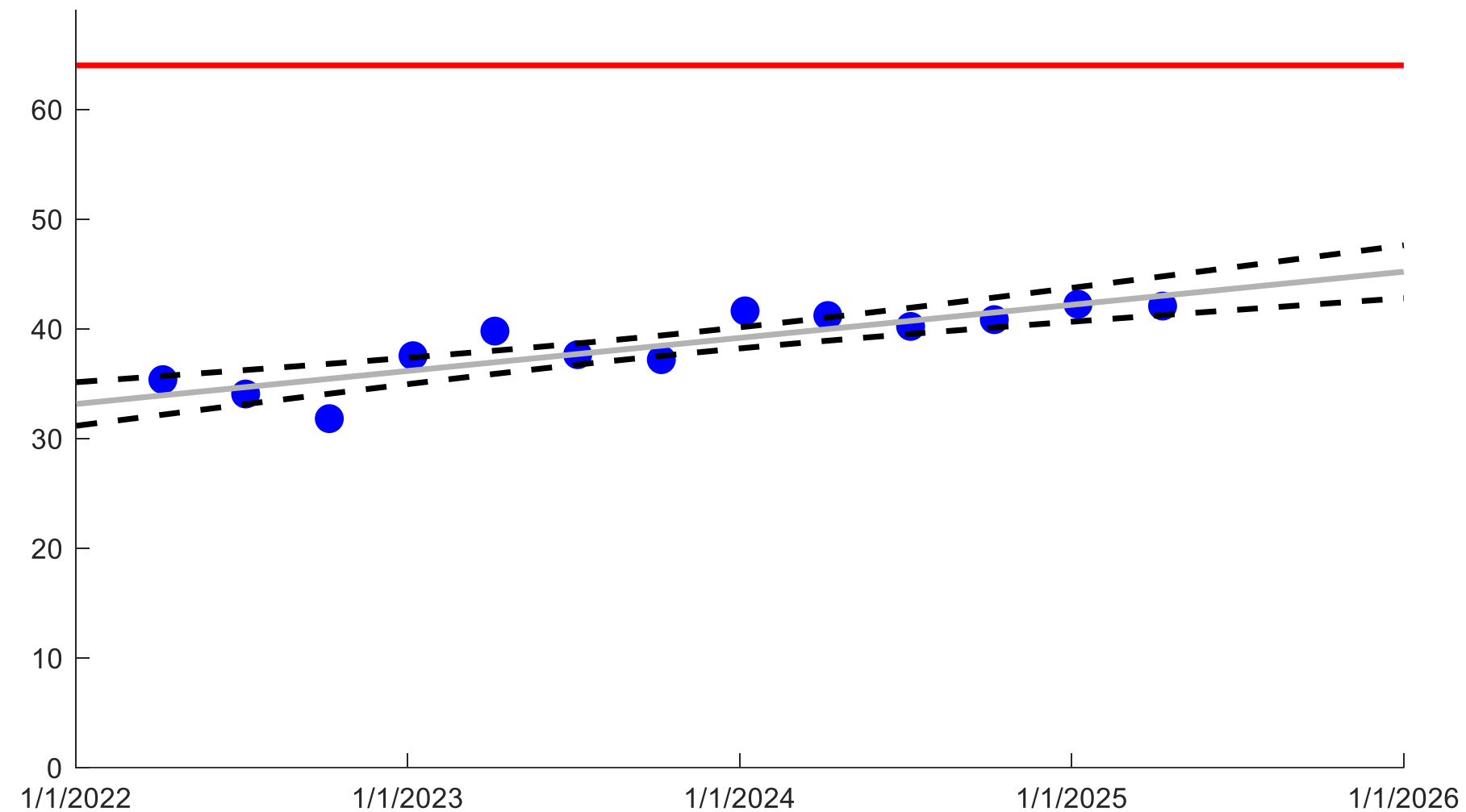


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# Example Trends – steepest trend

Monitor 29 (direct fixation, not on floating slab), 25 Hz

N06-VCC-29







# Maintenance and Operational Practices

- Grinding in 2023 did not noticeably alter vibration trends
- Wheel truing
- Operators slow down if WFD is triggered
- Turned off alerts for 2 Hz, 3.15 Hz, and 4 Hz 1/3-octave bands



# Expected changes for various conditions

- Wheel flats
  - Increased vibration in 1/3-octave bands 40 Hz and above, especially for speeds below 30 mph
- Rail Corrugation
  - Increase in vibration in the band with speed/(corrugation wavelength)
- Lack of lubrication
  - Expect wheel squeal at frequencies well above 100 Hz. This system cuts off at 100 Hz and therefore would not detect squeal through vibration.





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# Future work

- Continue reporting trends to fulfill MIA requirements
- Data analysis beyond trending to identify broader patterns
- Opportunities for machine learning algorithms





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# Acknowledgements

- Sound Transit
- James T Nelson, PhD
- IEM (International Electronic Machines Corp)





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# Thank you!



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