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NOISE STUDY
US-60
Springfield, MO

Prepared for:

MoDOT PROJECT NO. J8P3102

March 2017

Prepared by:

GBA

TABLE OF CONTENTS

LIST OF REPORT EXHIBITS

LIST OF REPORT TABLES

APPENDIX

1.0 EXECUTIVE SUMMARY

This project is located on US-60 (James River Freeway) and MO-360 (James River Freeway). The limits of the project are from Route MM to Glenstone Ave. Because of the addition of auxiliary lanes, this project qualifies as a Type I Project and therefore requires a noise analysis for potential abatement measures. All areas of the project that included areas considered "Noise Sensitive" by the FHWA Noise Abatement Criteria Table were considered for noise abatement. The project area was divided into four separate Noise Sensitive Areas (NSAs).

NSAs 1 and 2 had receptors impacted by noise and were considered for noise abatement measures. After analyzing potential abatement measures, noise barriers in both NSA 1 and 2 were found to be feasible and reasonable per FHWA and MoDOT policies, pending a vote of benefitted owners and residents.

Table 1-1
Executive Summary Table

NSA	Impacted Receptors by Activity Category			Consideration of Noise Abatement Warranted?	Barrier Option	Abatement Feasible?	Benefited Receptors	Square Feet	Square Feet/ Benefited Receptor	Abatement Reasonable?
	B	C	Total							
1	68	-	68	Yes	1	✓	40	25,440	636	✓
2	28	8	36	Yes	2	✓	12	13,000	1,083	✓
3	-	-	0	No	-	-	-	-	-	-
4	-	-	0	No	-	-	-	-	-	-

2.0 PROJECT BACKGROUND

The project extends along US-60 and MO-360 in Springfield, MO. The work will consist of extending westbound and eastbound acceleration lanes at Route MM/MO-360, extending the westbound and eastbound acceleration lanes at MO-413/MO-360/US-60, extending the dual-left turn lane and extending the eastbound acceleration lane at US-60/US-160/Route FF, adding a dual left-turn lane and extending lanes on the eastbound on-ramp at US-60/MO-13 (Kansas Expressway), and adding auxiliary lanes for westbound and eastbound on US-60 between Glenstone Ave. and National Ave.

The addition of auxiliary lanes qualifies this project as a Type I project and therefore requires a noise analysis in accordance with 23 CFR 772, MoDOT Noise Policy EPG 127.13, and all Federal Highway Administration (FHWA) noise standards. Per FHWA and MoDOT regulations, if any part of a project is considered a Type I project, the entire project is considered a Type I project; therefore, all ramp extensions are also considered a Type I project. However, only the auxiliary lane addition and the eastbound on-ramp extension at the Route FF/US 160 interchange had noise sensitive receivers (shown below in boxes on Figure 2-1). Areas that did not include a noise sensitive receiver were not included in the noise analysis.

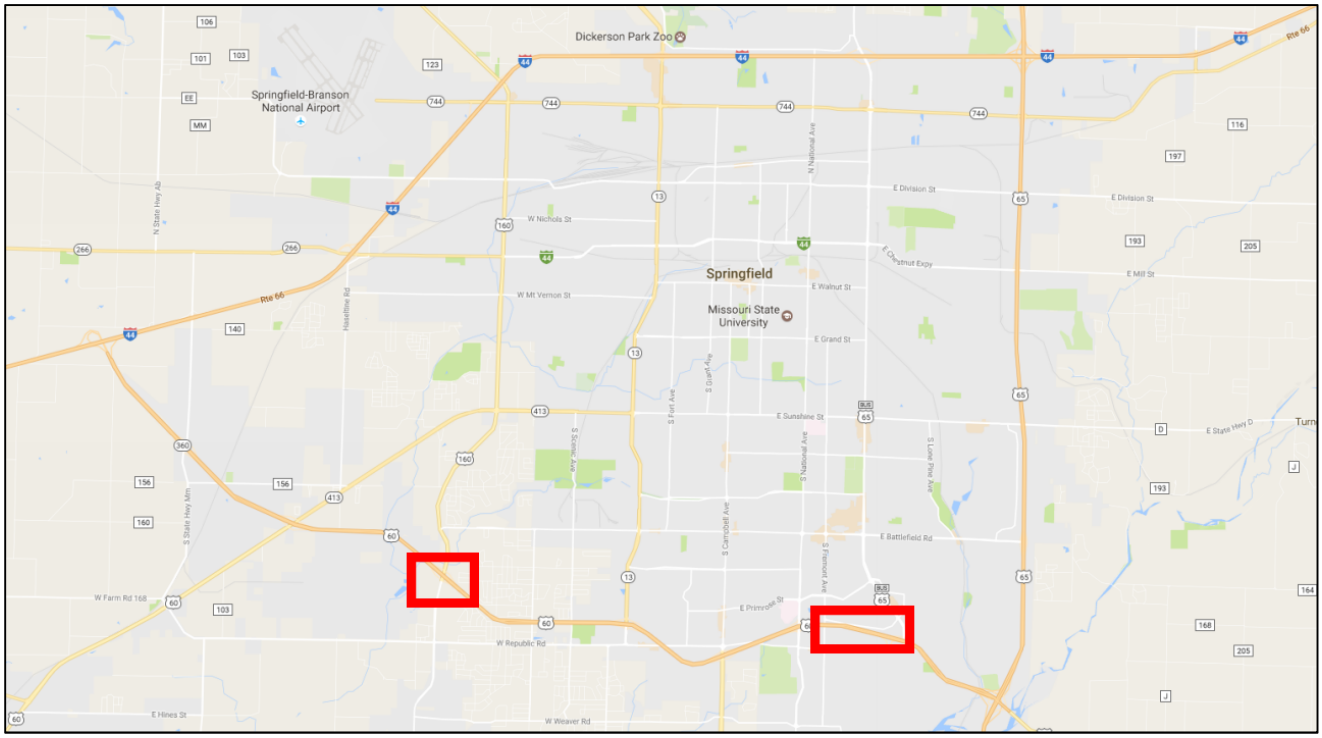


Figure 2-1 Location Map

3.0 NOISE ENVIRONMENT

The corridor consists mostly of residential areas south of US-60 and commercial zones north of US-60. To be considered for noise abatement, a receiver must be categorized under FHWA Noise Abatement Criteria (NAC) activity categories A-E, shown in Table 3-1. Building reduction factors are used when evaluating interior noise impacts for category D, shown in Table 3-2.

Table 3-1
FHWA Noise Abatement Criteria (Hourly A-Weighted Sound Level - Decibels)

Activity Category	Activity Criteria $L_{eq}(h)$*	Evaluation Location	Activity Descriptions
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67	Exterior	Residential.
C	67	Exterior	Active sports areas, amphitheaters, auditoriums, campgrounds, cemeteries, day care centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreational areas, Section 4(f) sites, schools, television studios, trails and trail crossings.
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools and television studios.
E	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F.
F	----		Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical) and warehousing.
G	----		Undeveloped lands that are not permitted.

*Approaching NAC is defined by MoDOT as being 1 dBA less than the NAC for Activity Categories A-E

The project area was divided into four separate NSAs to be analyzed, as seen on Exhibit 1 (NSA 4 not pictured). Only receivers within 500 feet of the modified roadways were included, as sufficient

Table 3-2
Building Noise Reduction Factors

Building Type	Window Condition	Noise Reduction Due to the Exterior of the Structure
All	Open	10 dB
Light Frame	Ordinary Sash	20 dB
	Storm Windows	25 dB
Masonry	Single Glazed	25 dB
	Double Glazed	35 dB

evidence indicates the Traffic Noise Model (TNM) software is not reliable beyond this distance. The number of equivalent residential receptors for non-residential land uses was determined by the frontage length compared to the average frontage of nearby residential properties. Fifty feet was used as the average frontage for calculations based on a selected sample of single-family homes in the study area. See Table 3-3 for all Equivalent Receptors Assumptions.

NSA 1 is the area south of US-60 between the Fremont Ave bridge and Kentwood Ave. One hundred five receptors are in the area, including 42 receptors at the Fremont Landing apartments, 36 receptors at multi-family homes, 22 single family homes, and 5 equivalent receptors at the playground of the Disney Elementary School. Receptors at the Fremont Landing Apartments were modeled on multiple stories at individual balconies.

Directly to the east of NSA 1 is NSA 2. Sixty-three total receptors are in the area, including 7 equivalent receptors at the baseball field of the Campbell United Methodist Church, 48 at the Hawthorn Suites apartments, and 8 total equivalent receptors at the YMCA baseball fields. Receptors at the Hawthorn Suites Apartments were modeled on multiple stories at individual balconies.

Across US-60 on the north side is NSA 3. The majority of the buildings in this area are not considered noise sensitive. There is a Panda Express and a Neighbor's Mill Bakery & Café in the project area that have outdoor seating for patrons. These restaurants were both analyzed under Category C.

NSA 4 is the area near the eastbound on-ramp extension at the US-60 and US-160 interchange. The James River Church West Campus was analyzed for interior noise impacts.

Table 3-3
Equivalent Receptor Assumptions

NSA 1	**Receiver**	**# of Receptors**	**Description**
	Disney Elementary	5	250 feet of frontage / 50 feet of average frontage
NSA 2	**Receiver**	**# of Receptors**	**Description**
	Campbell United Methodist Church	7	330 feet of frontage / 50 feet of average frontage
	YMCA Baseball Field 1	4	200 feet of frontage / 50 feet of average frontage
	YMCA Baseball Field 2	4	200 feet of frontage / 50 feet of average frontage
NSA 3	**Receiver**	**# of Receptors**	**Description**
	Panda Express	4	180 feet of frontage / 50 feet of average frontage
	Neighbor's Mill Bakery & Café	6	300 feet of frontage / 50 feet of average frontage
NSA 4	**Receiver**	**# of Receptors**	**Description**
	James River Church West Campus	13	650 feet of frontage / 50 feet of average frontage

4.0 ANALYSIS METHODOLOGY

Extech HD600 Datalogging Sound Level Meters were used and calibrated before each noise measurement, completed on December 1st and 2nd of 2016. Readings were taken at five different locations in the study area (see Exhibit 2) in 15-minute intervals while traffic along US-60 was counted by lane and categorized by cars, medium trucks, heavy trucks and motorcycles (see Table 4-1).

Table 4-1
Validation Measurement Traffic Counts

Field Measurement Locations	Date	Time Period	Hourly Traffic Based on Concurrent Traffic Counts (1)							
			Westbound US-60 (2)				Eastbound US-60 (2)			
			Autos	MT	HT	MC	Autos	MT	HT	MC
1/2	12/1/2016	3:45-4:00 PM	2720	72	52	0	2812	100	56	0
3/4	12/1/2016	4:25-4:40 PM	3068	40	48	0	2908	48	76	0
5	12/1/2016	5:15-5:30 PM	812	138	28	0	848	12	20	0
Field Measurement Locations	Date	Time Period	Hourly Traffic Based on Concurrent Traffic Counts (1)							
			Westbound US-60 (2)				Eastbound US-60 (2)			
			Autos	MT	HT	MC	Autos	MT	HT	MC
1/2	12/2/2016	11:25-11:40 AM	1816	36	40	0	1916	52	96	12
3/4	12/2/2016	10:45-11:00 AM	2060	60	64	4	1540	52	116	0
5	12/2/2016	9:55-10:10 AM	424	4	52	0	476	20	48	0

NOTES:

MT = Medium Trucks | HT = Heavy Trucks | MC = Motorcycles

FHWA TNM = Federal Highway Administration Traffic Noise Model

(1) Hourly volumes derived by extrapolation of counts taken during 15-minute period to a one-hour value

(2) Sum of volume from both lanes, including ramps where applicable. Individual lanes counted in field and modeled as such in TNM.

The FHWA Traffic Noise Model, TNM 2.5, was used to model all relevant roadways, receivers, terrain lines, barriers, building rows, and ground zones in the project area for the existing condition. The field measurements and their corresponding traffic counts validated the model by ensuring less than a 3 dBA difference between the measured noise levels and the modeled noise levels at each location, as shown in Table 4-2.

Table 4-2					
Measurement and Validation Data					
Field Measurement Locations	Short-Term Measurements			FHWA TNM L_{eq} (h) Noise Levels dBA	Measured Minus Modeled Noise Levels dB
	Date	Time Period	Measured Noise Levels (dBA) L_{eq}		
1	12/1/2016	3:45-4:00 PM	73.4	73.7	-0.3
2	12/1/2016	3:45-4:00 PM	78.9	76.6	2.3
3	12/1/2016	4:25-4:40 PM	79.6	76.7	2.9
4	12/1/2016	4:25-4:40 PM	76.6	75.3	1.3
5	12/1/2016	5:15-5:30 PM	71.2	69.9	1.3
1	12/2/2016	11:25-11:40 AM	72.6	72.6	0.0
2	12/2/2016	11:25-11:40 AM	77.7	75.4	2.3
3	12/2/2016	10:45-11:00 AM	77.9	75.2	2.7
4	12/2/2016	10:45-11:00 AM	74.7	73.8	0.9
5	12/2/2016	9:55-10:00 AM	66.2	68.7	-2.5
L_{eq} = Equivalent Noise Level			dB = Decibel	dBA = A-weighted Sound Level	
L_{eq} (h) = Hourly L_{eq}					

After validating the model, existing noise levels at each receiver were obtained. Receptors at single-family homes were modeled on the side of the house closest to US-60. At multi-family buildings with balconies, receptors were modeled at each individual balcony. However, per MoDOT policy, only first-story receptors were considered when attempting to benefit impacted residents. For receivers such as churches/restaurants/daycares/etc., an equivalent number of residential receptors were placed at an area of frequent human use. Traffic volumes based on the 2018 construction year were used. The distribution of traffic between lanes was determined from an existing PM peak hour count.

Next, using the TNM 2.5 software, the future auxiliary lane between National Ave and Glenstone Ave and the eastbound on-ramp extension at Highway FF was input into the future model. In addition, widening towards the median in both directions planned for the future was included. The previously modeled receivers, terrain lines, barriers, building rows, and ground zones were included along with any necessary adjustments for the future roadway. Future volumes were adjusted to the 2038 projections.

When traffic noise impacts were identified, noise abatement was then evaluated for feasibility and reasonableness. To be considered impacted, a receptor must have an L_{eq} at the loudest traffic noise hour approaching (within 1 dBA) or exceeding the NAC for the corresponding land use category, or exceeding existing noise levels by 15 dBA.

For noise abatement to be feasible, MoDOT requires at least a 5 dBA insertion loss for a minimum of 67 percent of first-row, impacted receptors. Feasibility also refers to the engineering limitations, including the physical constraints and other constructability constraint limits such as maintenance, drainage, safety, etc.

If a noise barrier is considered feasible, it is then checked for three mandatory reasonableness factors, all of which must be met. First, noise abatement measures cannot exceed 1300 ft^2 of noise wall or $36,000 of alternative noise abatement measures, per benefitted receptor. A benefitted receptor is defined as a receptor that receives at least a 7 dBA reduction in noise level after the addition of noise abatement measures. Secondly, noise abatement must provide a 7 dBA reduction for a minimum of 67 percent of first-row benefitted receptors. Finally, viewpoints of first-row, benefitted owners and residents will be acquired. The viewpoints of non-owner residents will be evaluated as a portion of an aggregate of 25 percent of the total. The viewpoints of owners will be evaluated as a portion of an aggregate of 75 percent of that total. Over 50 percent of the aggregate response must be in favor of abatement.

5.0 NOISE IMPACTS/ABATEMENT CONSIDERATIONS

One hundred ninety-one receptors were evaluated for noise impacts along the corridor. By NAC criteria, 104 were found to be impacted. No receptors were found to have an increase of 15 dBA over existing noise levels. For each NSA, impacted receptors and noise barrier options are detailed below and displayed on Exhibit 2. See Table 1 for individual receptor data.

NSA 1:

Sixty-eight receptors are impacted in the area. This includes all 42 receptors at the Fremont Landing Apartments, 20 receptors at the multi-family units along Redrex St, and 6 single family homes.

Noise barriers were analyzed 5' off the right-of-way to allow for access and maintenance. A noise barrier along the shoulder of eastbound US-60 was analyzed near the Fremont Landing Apartments. Barrier 1 is a 2,550' long barrier with an average height of 10'. See Table 2 for full barrier details. Forty receptors receive a 7 dBA or greater insertion loss, including all 26 impacted receptors at single and multi-family homes and all 14 impacted receptors on the first floor of the Fremont Landing Apartments. With an average of 636 ft^2 per benefitted receptor, Barrier 1 is both feasible and reasonable, pending a vote of first-row benefitted owners and residents.

NSA 2:

Thirty-six receptors are impacted, including 28 units at the Hawthorn Suites, and all 8 equivalent receptors at the YMCA baseball fields. Among the 28 units at the Hawthorn Suites are all 16 north-facing units in Building 7. Twelve of the east-facing units in Building 6 are impacted receptors, but none of these are on the first-story.

Barrier 2 is a continuation of Barrier 1 and was also analyzed 5' off the right-of-way. The barrier is 1000' long with an average height of 13'. See Table 3 for full barrier details. The barrier height was limited to a maximum of 10' near a transmission line crossing just west of the Hawthorne Suites. Twelve receptors are benefitted with an average of 1,083 ft^2 per benefitted

receptor. Therefore, Barrier 2 is also both feasible and reasonable, pending a vote of first-row benefitted owners and residents.

NSA 3:

No receptors were found to be impacted.

NSA 4:

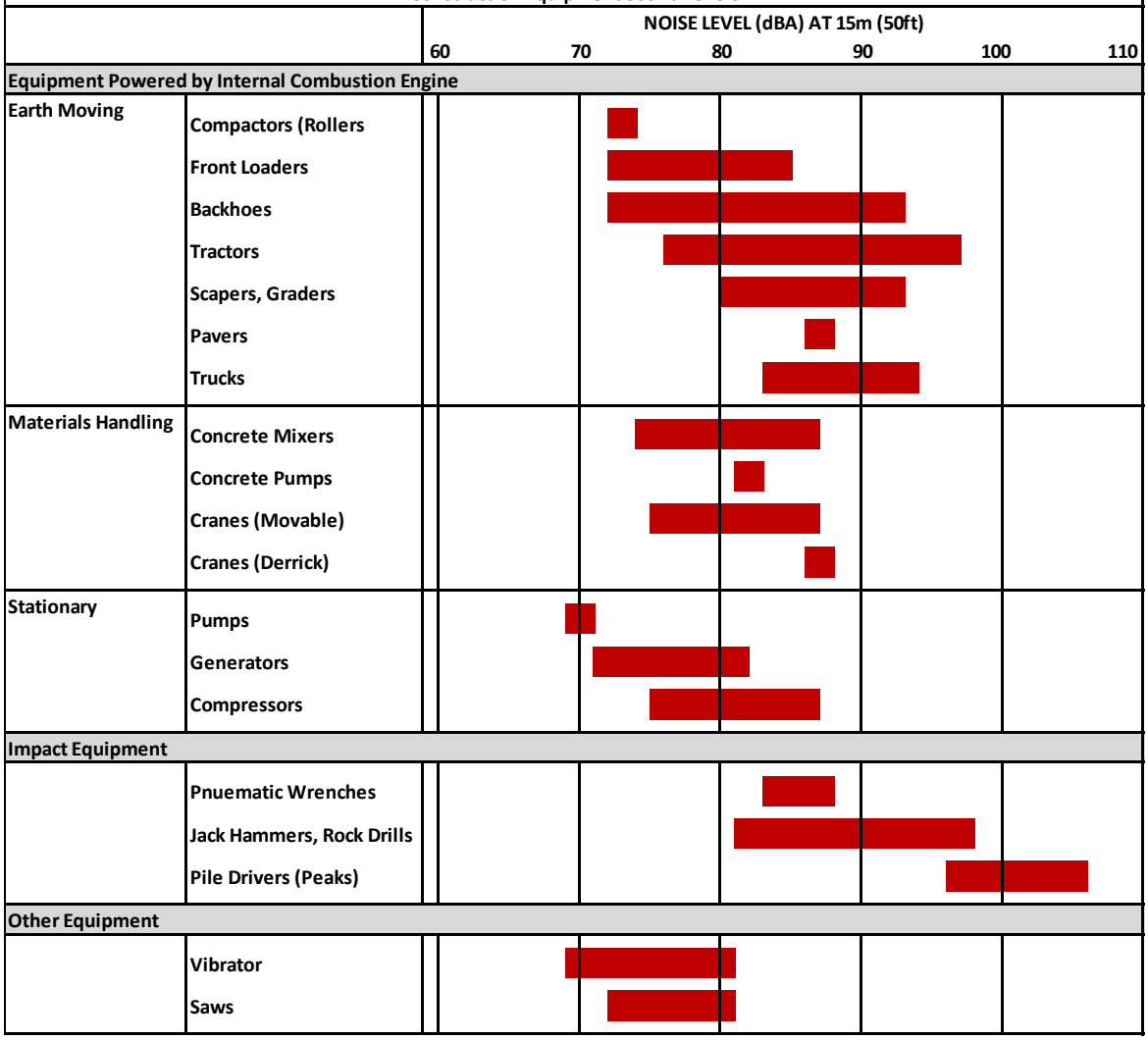
No receptors were found to be impacted.

6.0 CONSTRUCTION NOISE

As is required by 23 CFR 772.19, the temporary increase in noise levels due to construction was considered. These noise impacts will take place in the immediate vicinity of the construction activities and generally be limited to working hours. The figure below shows some typical operating noise levels at a distance of 50 feet. MoDOT construction specifications require all construction equipment to be in good working order. Mufflers are required to help reduce and address construction noise impacts. Interference with speech communication for those passing by, working, or living near the construction sites is to be expected. Overall, however, because of the distance of the construction areas to each NSA and the hours of equipment use, noise impacts due to construction are expected to be minor and to occur infrequently.

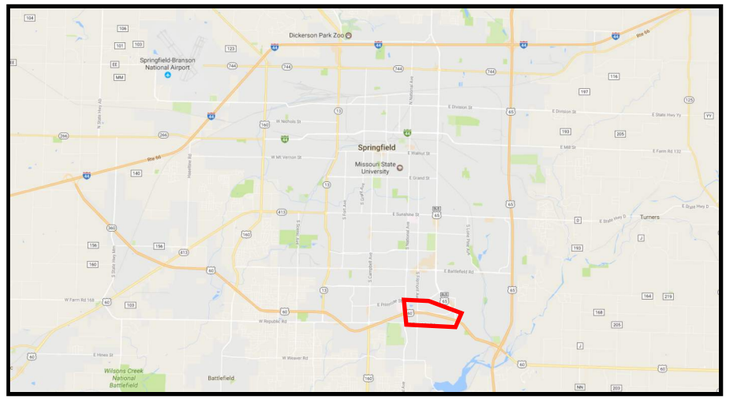
Figure 6-1

Construction Equipment Sound Levels

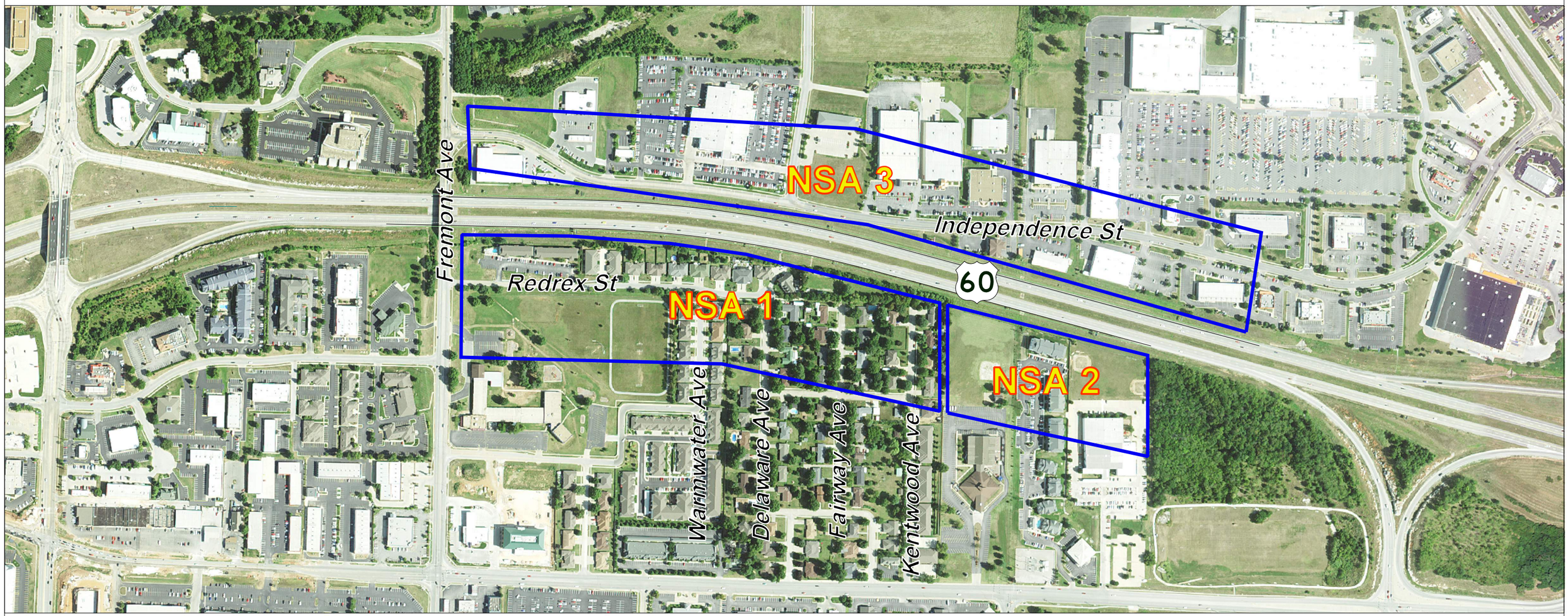


*SOURCE: U.S. Report to the President and Congress on Noise, February, 1972

Exhibit 1 - Noise Sensitive Area Map
US-60 Traffic Noise Study

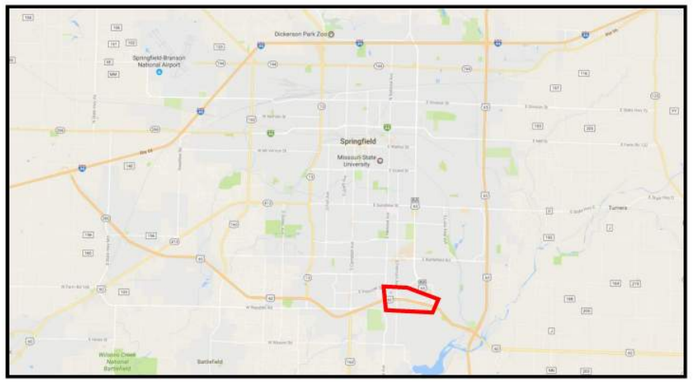


Not To Scale



*NSA 4 near US-60 and US-160 interchange not shown.

Exhibit 2 - Receiver Map
US-60 Traffic Noise Study



Not To Scale

NOTE: Noise Levels Based
On 2038 Traffic Projections

Legend

- Non-Impacted Receiver
- Impacted Receiver
- Non-Impacted Receiver (Multiple Receptors)
- Impacted Receiver (Multiple Receptors)
- Benefitted Receptor
- Sound Wall
- Field Measurement Location

Fremont Ave
Independence St
Redrex St
60
Neighbor's Mill Bakery & Cafe
Panda Express
Building B
Building A
Disney Elementary
Warmwater Ave
Delaware Ave
Fairway Ave
Kentwood Ave
West-facing Units
YMCA
Campbell United Methodist Church
North-facing units
East-facing units

*NSA 4 near US-60 and US-160 interchange not shown.

	Table 1 - Receiver Data								
	Receiver		Dwelling Units	Existing Level (dBA)	Future Level (dBA)	Increase (dBA)	Reduction (dBA)	Impact Crit.	Category
NSA 1	Disney Elementary		5	49.2	50.2	1.0	0.4	66	C
	Fremont Landing B11 & B12		2	75.4	76.2	0.8	7.0	66	B
	Fremont Landing B21 & B22		2	75.6	76.8	1.2	0.0	66	B
	Fremont Landing B31 & B32		2	75.5	76.6	1.1	0.0	66	B
	Fremont Landing B13 & B14		2	75.3	75.6	0.3	10.4	66	B
	Fremont Landing B23 & B24		2	75.6	76.8	1.2	0.0	66	B
	Fremont Landing B33 & B34		2	75.5	76.7	1.2	0.0	66	B
	Fremont Landing B15 & B16		2	75.3	75.6	0.3	11.6	66	B
	Fremont Landing B25 & B26		2	75.6	76.8	1.2	0.0	66	B
	Fremont Landing B35 & B36		2	75.5	76.7	1.2	0.0	66	B
	Fremont Landing A11 & A12		2	75.2	75.6	0.4	9.4	66	B
	Fremont Landing A21 & A22		2	75.5	76.7	1.2	0.0	66	B
	Fremont Landing A31 & A32		2	75.4	76.6	1.2	0.0	66	B
	Fremont Landing A13 & A14		2	75.2	75.6	0.4	9.7	66	B
	Fremont Landing A23 & A24		2	75.5	76.7	1.2	0.0	66	B
	Fremont Landing A33 & A34		2	75.4	76.6	1.2	0.0	66	B
	Fremont Landing A15 & A16		2	75.1	75.4	0.3	10.3	66	B
	Fremont Landing A25 & A26		2	75.4	76.6	1.2	0.0	66	B
	Fremont Landing A35 & A36		2	75.3	76.6	1.3	0.0	66	B
	Fremont Landing A17 & A18		2	74.7	75	0.3	11.3	66	B
	Fremont Landing A27 & A28		2	75.4	76.6	1.2	0.1	66	B
	Fremont Landing A37 & A38		2	75.4	76.6	1.2	0.0	66	B
	1573 Redrex St B1 & B2		2	59.5	61	1.5	6.9	66	B
	1573 Redrex St B3 & B4		2	67.4	68.5	1.1	9.2	66	B
	1573 Redrex St A1 & A2		2	63	63.5	0.5	6.3	66	B
	1573 Redrex St A3 & A4		2	70.1	71	0.9	8.8	66	B
	1575 & 1577 Redrex St		2	70.8	71.8	1.0	8.3	66	B
	1579 & 1581 Redrex St		2	71.8	72.6	0.8	8.2	66	B
	1583 & 1585 Redrex St		2	72.7	73.3	0.6	8.4	66	B
	1587 & 1589 Redrex St		2	73.4	73.7	0.3	8.4	66	B
	1591 & 1593 Redrex St		2	73.4	73.6	0.2	8.3	66	B
	1595 & 1597 Redrex St		2	74.1	74.3	0.2	8.6	66	B
	1599 & 1601 Redrex St		2	75.2	75.6	0.4	8.8	66	B
	1603 & 1605 Redrex St		2	73.6	73.9	0.3	9.5	66	B
	4007 & 4013 S Warmwater Ave		2	50.8	51.5	0.7	0.5	66	B
	4017 & 4023 S Warmwater Ave		2	48.2	49	0.8	0.0	66	B
	4027 & 4033 S Warmwater Ave		2	47.4	48.3	0.9	0.0	66	B
	4006 & 4012 S Warmwater Ave		2	53	53.9	0.9	0.6	66	B
	4016 & 4022 S Warmwater Ave		2	47.1	48.1	1.0	0.0	66	B
	4026 & 4032 S Warmwater Ave		2	47.8	48.6	0.8	0.0	66	B
	4005 S Delaware Ave		1	56.2	56.9	0.7	1.7	66	B
	4017 S Delaware Ave		1	55.5	56.6	1.1	3.4	66	B
	4027 S Delaware Ave		1	53.1	54	0.9	0.5	66	B
	4006 S Delaware Ave		1	66.8	67.2	0.4	7.1	66	B
	4018 S Delaware Ave		1	59	59.8	0.8	5.1	66	B
	4028 S Delaware Ave		1	56.4	57.3	0.9	4.2	66	B
	4040 S Delaware Ave		1	54.1	55	0.9	3.8	66	B
	4005 S Fairway Ave		1	69	69.5	0.5	7.9	66	B
	4017 S Fairway Ave		1	61.9	62.7	0.8	5.9	66	B
	4027 S Fairway Ave		1	57.9	59	1.1	4.7	66	B
	4039 S Fairway Ave		1	56.1	57.3	1.2	4.2	66	B
	4006 S Fairway Ave		1	71.3	71.6	0.3	9.2	66	B
	4018 S Fairway Ave		1	62.3	63.1	0.8	6.3	66	B
	4028 S Fairway Ave		1	58.8	59.8	1.0	4.9	66	B
	4040 S Fairway Ave		1	56.3	57.5	1.2	4.0	66	B
	4005 S Kentwood Ave		1	71.8	72.2	0.4	10.1	66	B
	4027 S Kentwood Ave		1	60	61.1	1.1	5.2	66	B
	4039 S Kentwood Ave		1	56.4	57.5	1.1	4.0	66	B
	4006 S Kentwood Ave		1	75.1	75.4	0.3	12.8	66	B
	4018 S Kentwood Ave		1	65.6	66.7	1.1	7.4	66	B
	4028 S Kentwood Ave		1	61.8	63.1	1.3	4.4	66	B
	4040 S Kentwood Ave		1	58.9	60.4	1.5	4.5	66	B

	Table 1 - Receiver Data (continued)								
	Receiver		Dwelling Units	Existing Level (dBA)	Future Level (dBA)	Increase (dBA)	Reduction (dBA)	Impact Crit.	Category
NSA 2	Campbell United Methodist Church		7	62.2	63	0.8	4.7	66	C
	Hawthorn Suites Building 7 Floor 1 A		1	74.1	74.3	0.2	7.7	66	B
	Hawthorn Suites Building 7 Floor 1 B		1	73.9	74	0.1	8.3	66	B
	Hawthorn Suites Building 7 Floor 1 C		1	73.8	73.8	0.0	8.4	66	B
	Hawthorn Suites Building 7 Floor 1 D		1	73.9	74	0.1	8.1	66	B
	Hawthorn Suites Building 7 Floor 2 A		1	74.9	76	1.1	0.1	66	B
	Hawthorn Suites Building 7 Floor 2 B		1	74.8	75.9	1.1	0.0	66	B
	Hawthorn Suites Building 7 Floor 2 C		1	74.8	75.9	1.1	0.1	66	B
	Hawthorn Suites Building 7 Floor 2 D		1	74.8	75.9	1.1	0.1	66	B
	Hawthorn Suites Building 7 Floor 3 A		1	75	76.2	1.2	0.0	66	B
	Hawthorn Suites Building 7 Floor 3 B		1	74.9	76.2	1.3	0.0	66	B
	Hawthorn Suites Building 7 Floor 3 C		1	74.9	76.2	1.3	0.0	66	B
	Hawthorn Suites Building 7 Floor 3 D		1	74.9	76.2	1.3	0.0	66	B
	Hawthorn Suites Building 7 Floor 4 A		1	74.9	76.1	1.2	0.0	66	B
	Hawthorn Suites Building 7 Floor 4 B		1	74.8	76.1	1.3	0.0	66	B
	Hawthorn Suites Building 7 Floor 4 C		1	74.8	76	1.2	0.0	66	B
	Hawthorn Suites Building 7 Floor 4 D		1	74.8	76	1.2	0.0	66	B
	Hawthorn Suites Building 6 Floor 1 A		1	57.2	56.8	0.0	2.7	66	B
	Hawthorn Suites Building 6 Floor 1 B		1	57.5	56.9	0.0	3.1	66	B
	Hawthorn Suites Building 6 Floor 1 C		1	56.5	56.7	0.2	2.6	66	B
	Hawthorn Suites Building 6 Floor 1 D		1	56	56.3	0.3	2.6	66	B
	Hawthorn Suites Building 6 Floor 2 A		1	61.6	61.3	0.0	6.3	66	B
	Hawthorn Suites Building 6 Floor 2 B		1	61.2	60.9	0.0	6.4	66	B
	Hawthorn Suites Building 6 Floor 2 C		1	60.6	60.3	0.0	5.8	66	B
	Hawthorn Suites Building 6 Floor 2 D		1	59.9	59.6	0.0	5.6	66	B
	Hawthorn Suites Building 6 Floor 3 A		1	62.3	62.6	0.3	5.7	66	B
	Hawthorn Suites Building 6 Floor 3 B		1	62.3	62.5	0.2	5.8	66	B
	Hawthorn Suites Building 6 Floor 3 C		1	62	62.1	0.1	5.9	66	B
	Hawthorn Suites Building 6 Floor 3 D		1	61.7	61.8	0.1	6.0	66	B
	Hawthorn Suites Building 6 Floor 4 A		1	62.6	63.4	0.8	3.5	66	B
	Hawthorn Suites Building 6 Floor 4 B		1	62.5	63.2	0.7	4.0	66	B
	Hawthorn Suites Building 6 Floor 4 C		1	62.3	62.9	0.6	4.8	66	B
	Hawthorn Suites Building 6 Floor 4 D		1	62	62.5	0.5	4.9	66	B
	Hawthorn Suites Building 6 Floor 1 E		1	63.2	64.1	0.9	4.8	66	B
	Hawthorn Suites Building 6 Floor 1 F		1	62.1	63.1	1.0	4.6	66	B
	Hawthorn Suites Building 6 Floor 1 G		1	61	62.3	1.3	4.5	66	B
	Hawthorn Suites Building 6 Floor 1 H		1	60.3	61.8	1.5	4.0	66	B
	Hawthorn Suites Building 6 Floor 2 E		1	68.2	68.3	0.1	5.9	66	B
	Hawthorn Suites Building 6 Floor 2 F		1	67.4	67.6	0.2	6.0	66	B
	Hawthorn Suites Building 6 Floor 2 G		1	66.5	66.7	0.2	6.0	66	B
	Hawthorn Suites Building 6 Floor 2 H		1	65.7	66	0.3	5.6	66	B
	Hawthorn Suites Building 6 Floor 3 E		1	68.6	69.2	0.6	3.3	66	B
	Hawthorn Suites Building 6 Floor 3 F		1	68	68.5	0.5	3.8	66	B
	Hawthorn Suites Building 6 Floor 3 G		1	67.5	67.9	0.4	4.6	66	B
	Hawthorn Suites Building 6 Floor 3 H		1	67.1	67.3	0.2	4.9	66	B
	Hawthorn Suites Building 6 Floor 4 E		1	68.7	69.8	1.1	1.4	66	B
	Hawthorn Suites Building 6 Floor 4 F		1	68.2	69.1	0.9	2.1	66	B
	Hawthorn Suites Building 6 Floor 4 G		1	67.7	68.4	0.7	2.7	66	B
	Hawthorn Suites Building 6 Floor 4 H		1	67.2	67.9	0.7	3.2	66	B
	YMCA Baseball Field 1		4	72.5	72.5	0.0	8.5	66	C
	YMCA Baseball Field 2		4	67.7	68.5	0.8	7.0	66	C
NSA 3	Panda Express		4	60.4	61.6	1.2	N/A	71	E
	Neighbor's Mill Bakery & Café		6	57.1	58.5	1.4	N/A	71	E
NSA 4	James River Church West Campus		13	65.3	66.8	1.5	N/A	76	D

Table 2				
Barrier 1				
Segment Number	Station (US-60)	Segment Length	Wall Height (ft)	Square Footage
	199+25			
1		1450	8	11600
	213+96			
2		100	10	1000
	215+00			
3		300	12	3600
	218+05			
4		550	14	7700
	223+53			
5		85	12	1020
	224+38			
6		65	8	520
	225+03			

Benefited Receptors: 40
Area (ft^2): 25,440
636 ft^2 / receptor

Table 3				
Barrier 2				
Segment Number	Station (US-60)	Segment Length	Wall Height (ft)	Square Footage
	225+03			
1		250	8	2000
	227+53			
2		50	10	500
	228+03			
3		50	12	600
	228+53			
4		100	14	1400
	229+53			
5		150	16	2400
	231+03			
6		200	18	3600
	233+02			
7		100	14	1400
	234+02			
8		50	12	600
	234+52			
9		50	10	500
	235+02			

Benefited Receptors: 12
Area (ft^2): 13,000
1,083 ft^2 / receptor

APPENDIX

- Glossary
- Field Measurement Summaries
- Field Measurement Graphs

Glossary

Alternative Noise Abatement Measures: Any method of noise abatement other than a noise wall, such as an earth berm.

Benefitted Receptor: The recipient of an abatement measure that receives a noise reduction at or above the minimum threshold of 7 dB(A).

Feasibility: Consideration of engineering factors and other constraints as they related to construction of noise abatement.

First-row Receptor: Noise-sensitive receptors that face project roadways and abut the roadway right-of-way without substantial visual occlusion from traffic noise. In the case of multi-story buildings, only ground level receptors are considered to be first-row.

Impacted Receptor: Any receptor that has an average hourly noise level at the loudest traffic noise hour approaching (within 1 dB) or exceeding the Noise Abatement Criteria Table for the corresponding land use category, or exceeding existing noise levels by 15 dBA.

Reasonableness: The combination of social, economic, and environmental factors considered in the evaluation of a noise abatement measure. Viewpoints of owners and residents of the benefitted receptors will be obtained. Noise abatement measures shall not exceed 1,300 square feet per benefitted receptor, in the case of noise walls. Where noise walls are not options, other noise abatement techniques may be considered, but cannot exceed $36,000 per benefitted receptor.

Receiver: The modeling location of a receptor or a group of receptors.

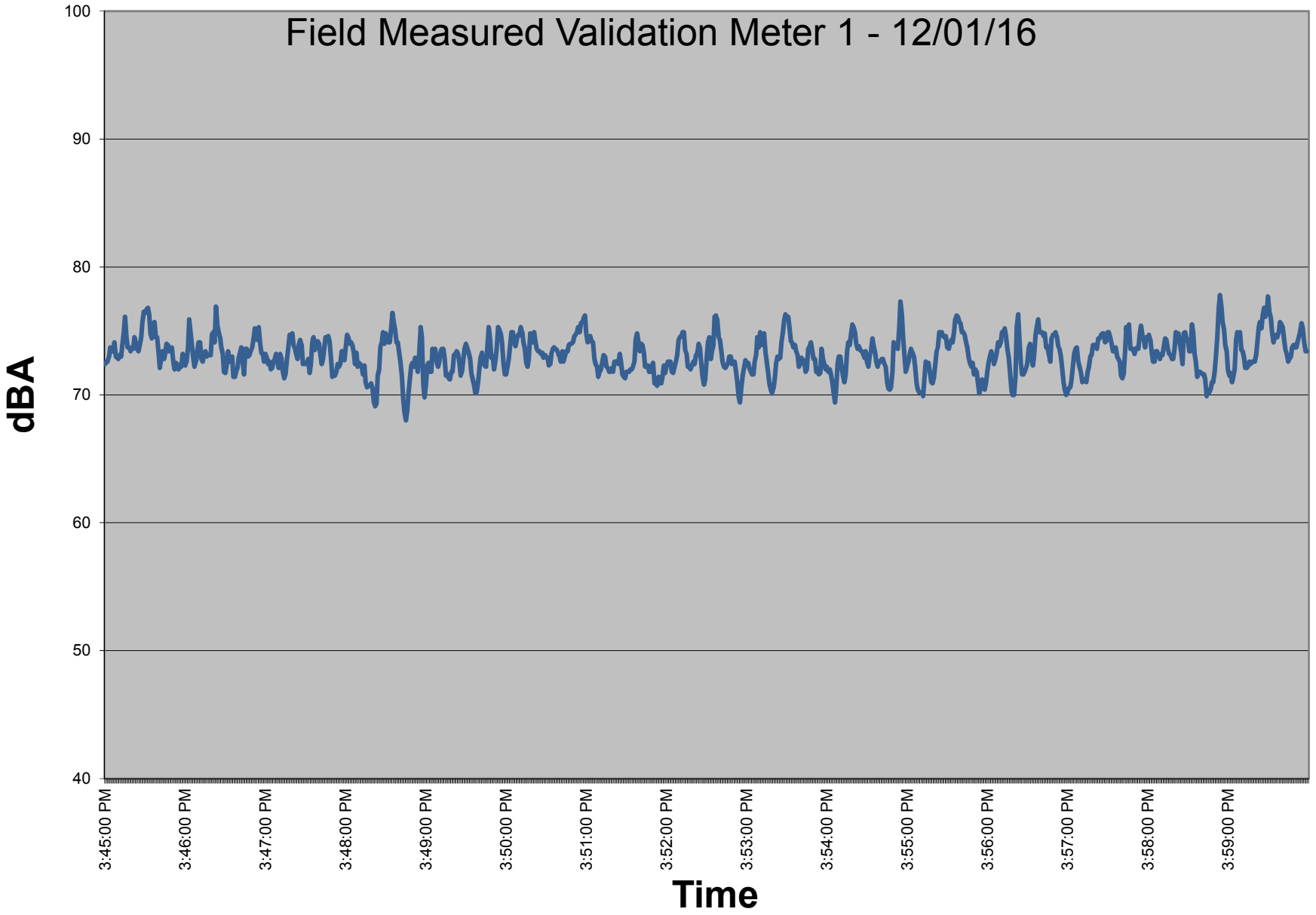
Receptor: A dwelling unit. Single family homes represent one receptor, and multi-family homes have a receptor for each individual unit. For non-residential land uses, an equivalent number of residential receptors is calculated based on average frontage length.

Field Measurement Summaries

Meter 1			Meter 2			Meter 3			Meter 4			Meter 5		
		1-Dec-16			1-Dec-16			1-Dec-16			1-Dec-16			1-Dec-16
Maximum Value =	77.8	dBA	Maximum Value =	83.6	dBA	Maximum Value =	87.6	dBA	Maximum Value =	84.7	dBA	Maximum Value =	83.3	dBA
Minimum Value =	68.0	dBA	Minimum Value =	71.6	dBA	Minimum Value =	71.6	dBA	Minimum Value =	67.5	dBA	Minimum Value =	62.4	dBA
Median Value =	73.1	dBA	Median Value =	78.7	dBA	Median Value =	79.5	dBA	Median Value =	76.1	dBA	Median Value =	69.4	dBA
L10 =	74.9	dBA	L10 =	80.7	dBA	L10 =	81.5	dBA	L10 =	78.8	dBA	L10 =	74.3	dBA
Average Value (L_{eq})=	73.4	dBA	Average Value (L_{eq})=	78.9	dBA	Average Value (L_{eq})=	79.6	dBA	Average Value (L_{eq})=	76.6	dBA	Average Value (L_{eq})=	71.2	dBA
TNM Modeled (L_{eq}) =	**73.7**	dBA	TNM Modeled (L_{eq}) =	**76.6**	dBA	TNM Modeled (L_{eq}) =	**76.7**	dBA	TNM Modeled (L_{eq}) =	**75.3**	dBA	TNM Modeled (L_{eq}) =	**69.9**	dBA
Difference =	-0.3	dBA	Difference =	2.3	dBA	Difference =	2.9	dBA	Difference =	1.3	dBA	Difference =	1.3	dBA

Meter 1			Meter 2			Meter 3			Meter 4			Meter 5		
		2-Dec-16			2-Dec-16			2-Dec-16			2-Dec-16			2-Dec-16
Maximum Value =	78.4	dBA	Maximum Value =	90.9	dBA	Maximum Value =	87.3	dBA	Maximum Value =	86.5	dBA	Maximum Value =	78.0	dBA
Minimum Value =	64.0	dBA	Minimum Value =	63.5	dBA	Minimum Value =	67.8	dBA	Minimum Value =	66.3	dBA	Minimum Value =	52.6	dBA
Median Value =	72.1	dBA	Median Value =	77.0	dBA	Median Value =	77.5	dBA	Median Value =	73.7	dBA	Median Value =	63.7	dBA
L10 =	74.8	dBA	L10 =	80.0	dBA	L10 =	80.3	dBA	L10 =	77.1	dBA	L10 =	70.0	dBA
Average Value (L_{eq})=	72.6	dBA	Average Value (L_{eq})=	77.7	dBA	Average Value (L_{eq})=	77.9	dBA	Average Value (L_{eq})=	74.7	dBA	Average Value (L_{eq})=	66.2	dBA
TNM Modeled (L_{eq}) =	**72.6**	dBA	TNM Modeled (L_{eq}) =	**75.4**	dBA	TNM Modeled (L_{eq}) =	**75.2**	dBA	TNM Modeled (L_{eq}) =	**73.8**	dBA	TNM Modeled (L_{eq}) =	**68.7**	dBA
Difference =	0.0	dBA	Difference =	2.3	dBA	Difference =	2.7	dBA	Difference =	0.9	dBA	Difference =	-2.5	dBA

GBA
architects
engineers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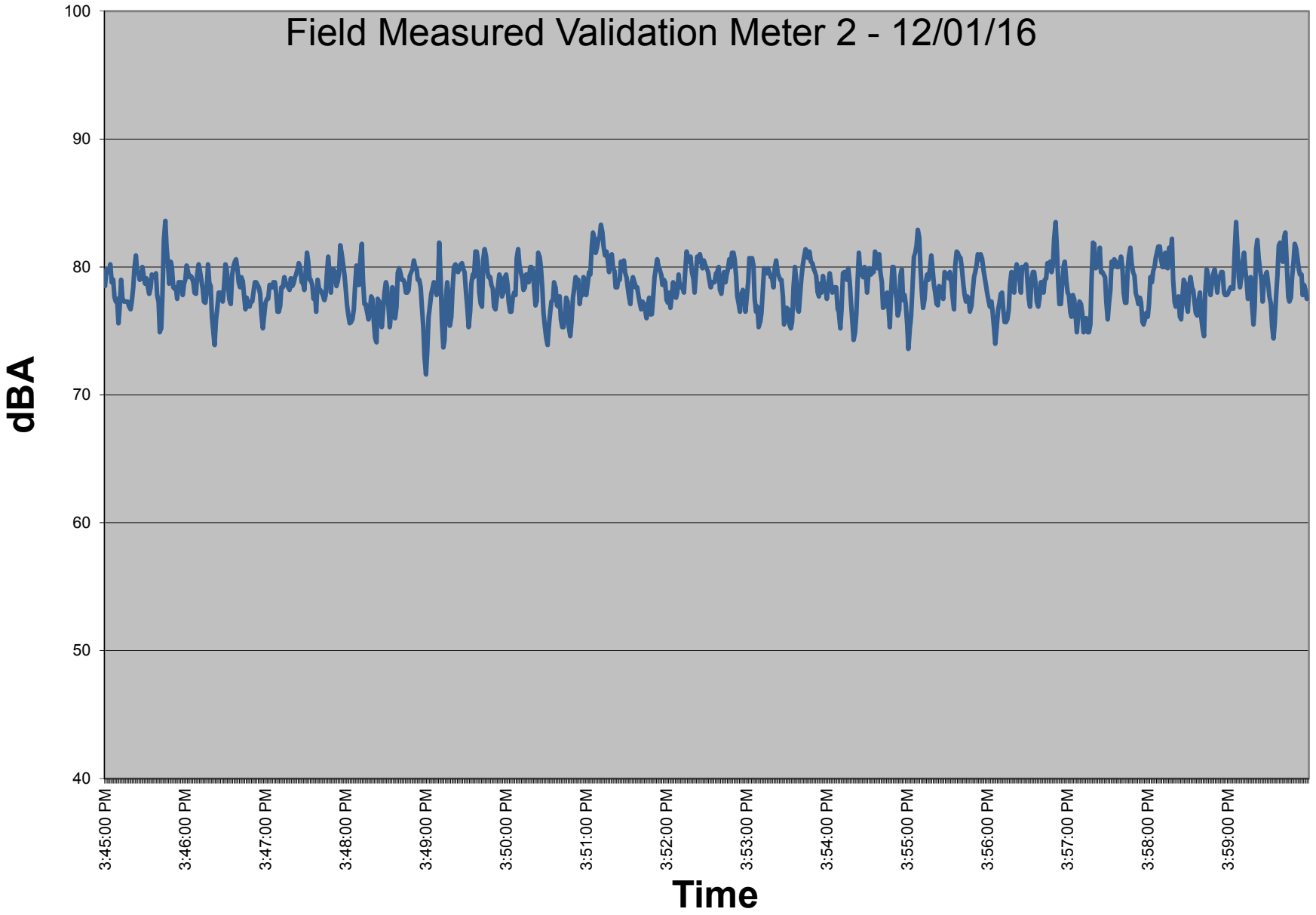
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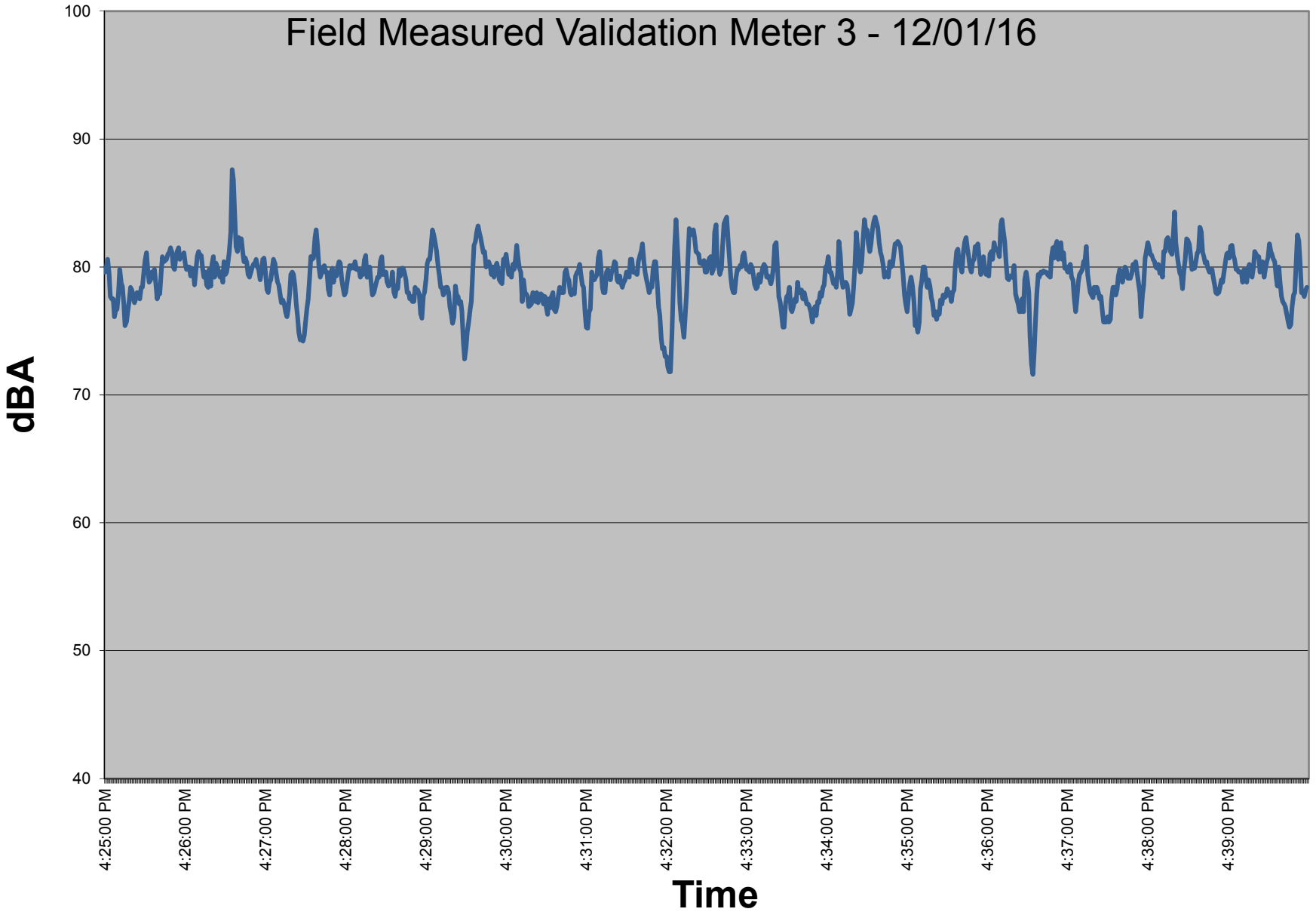
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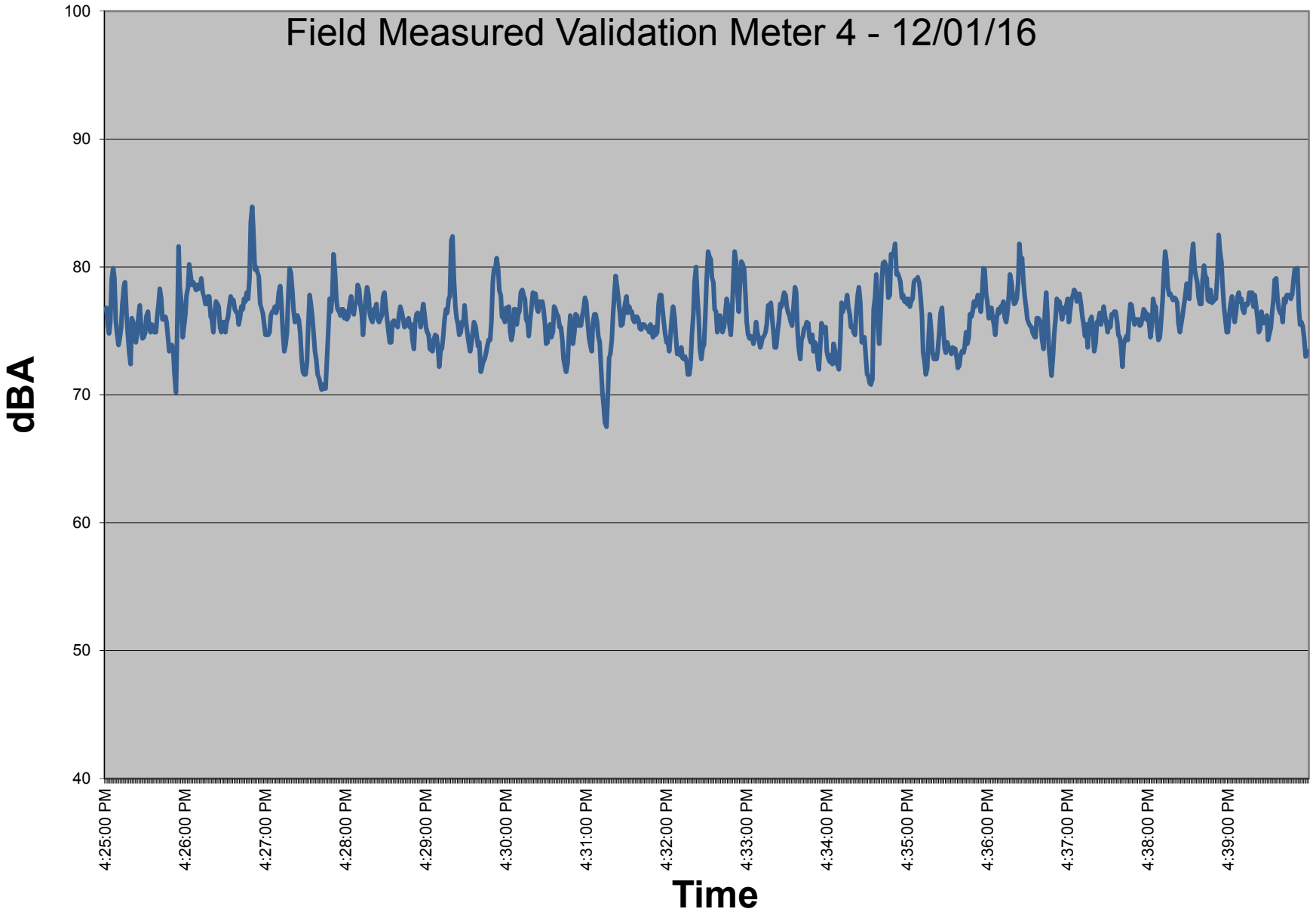
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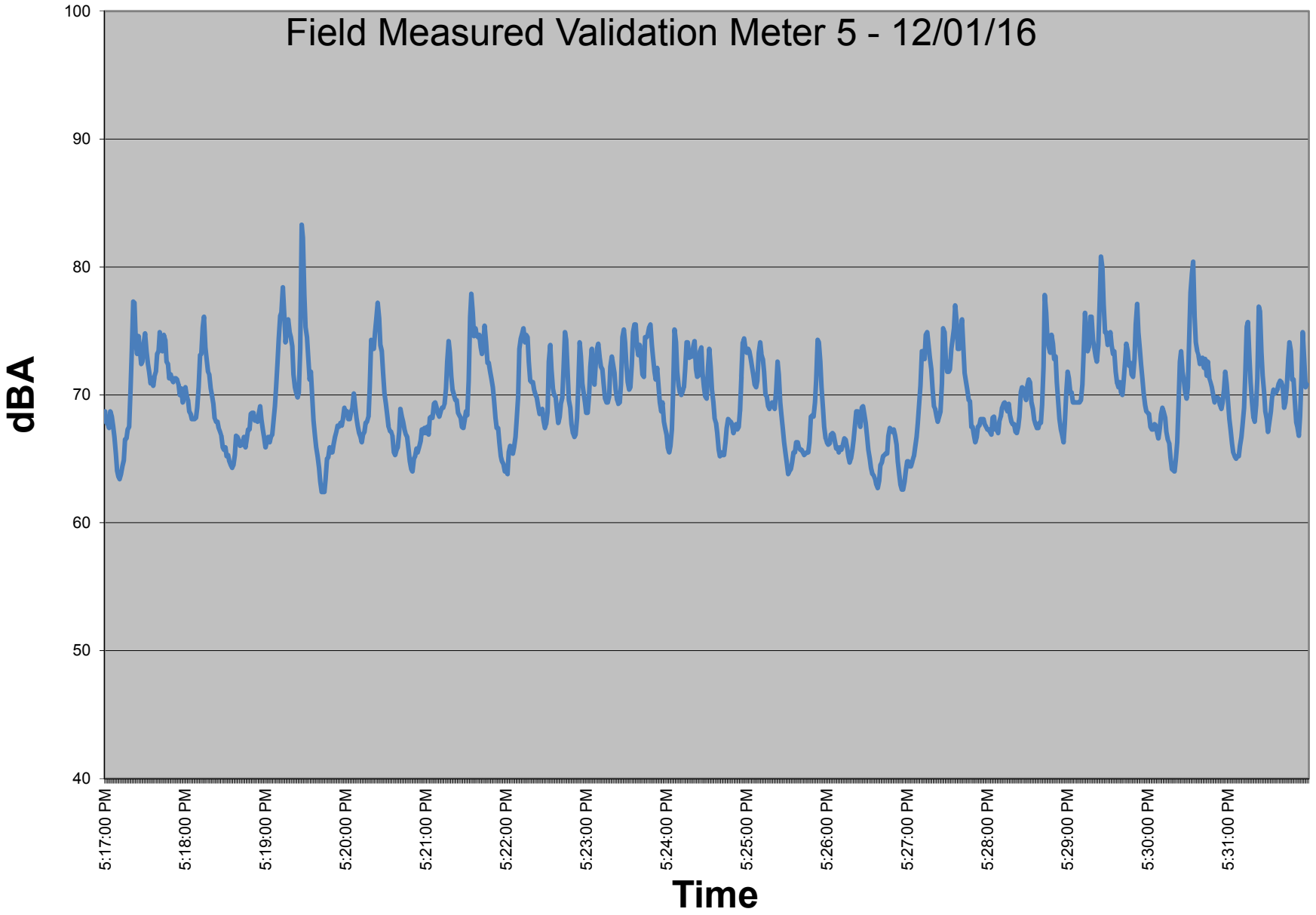
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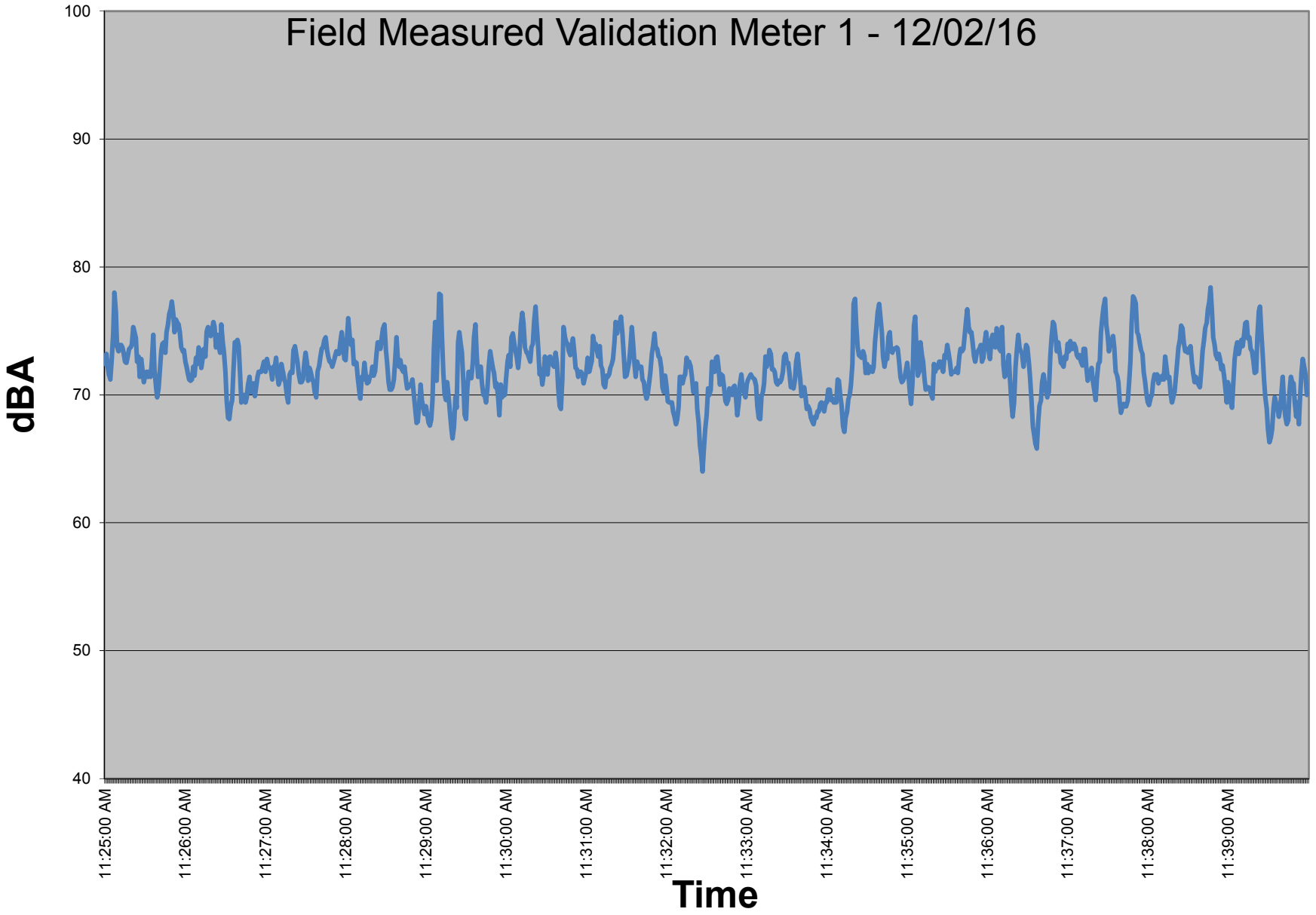
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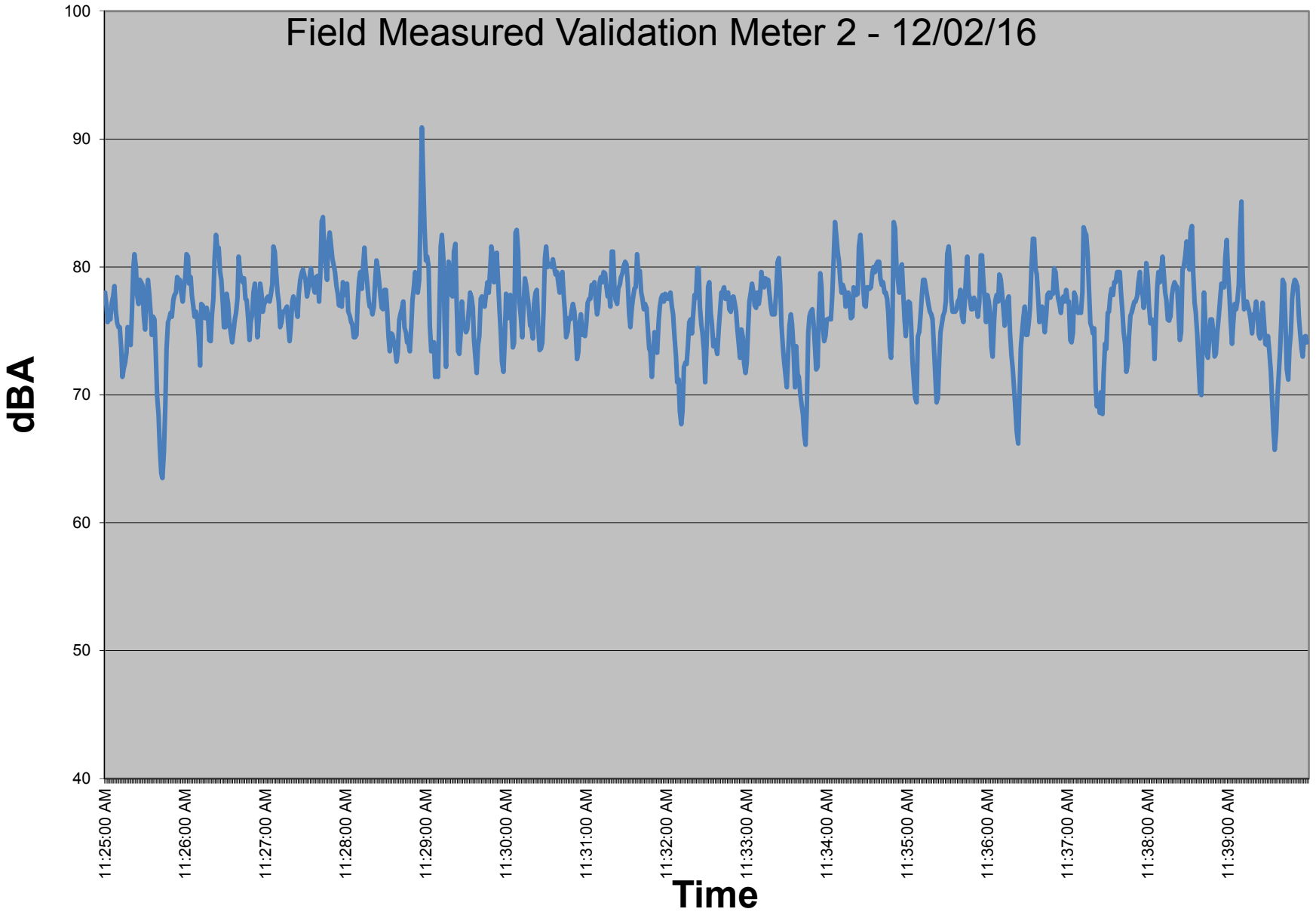
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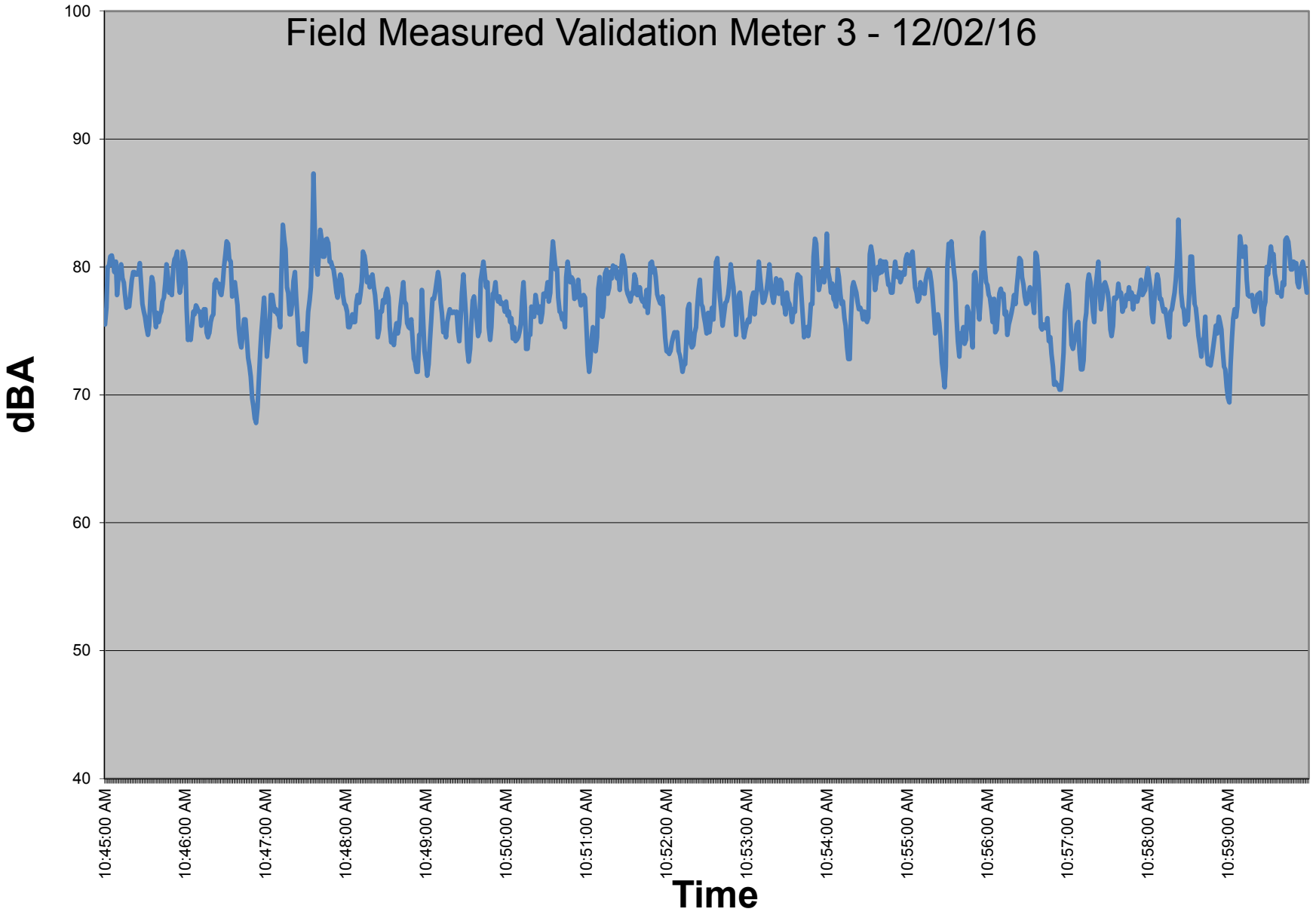
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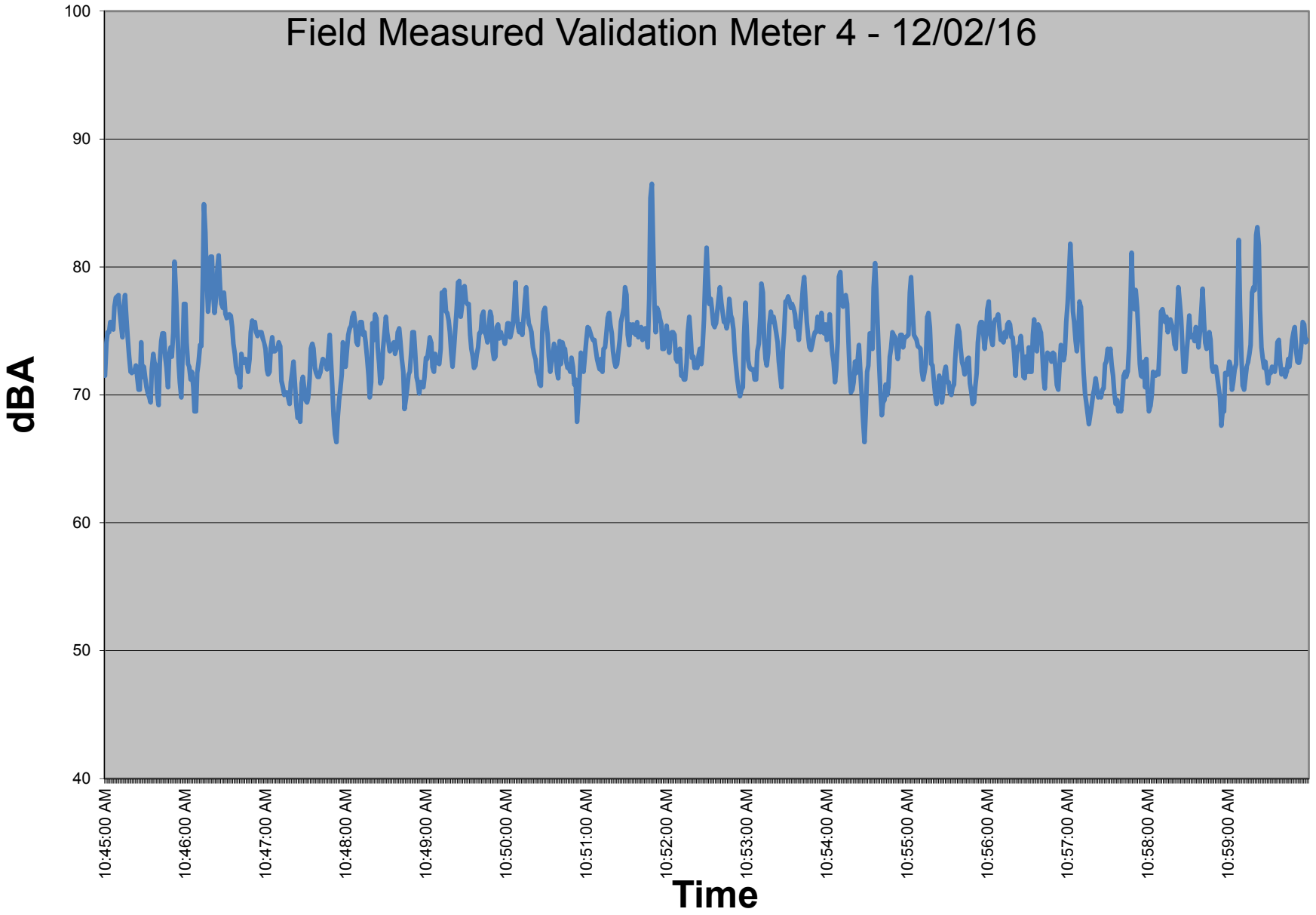
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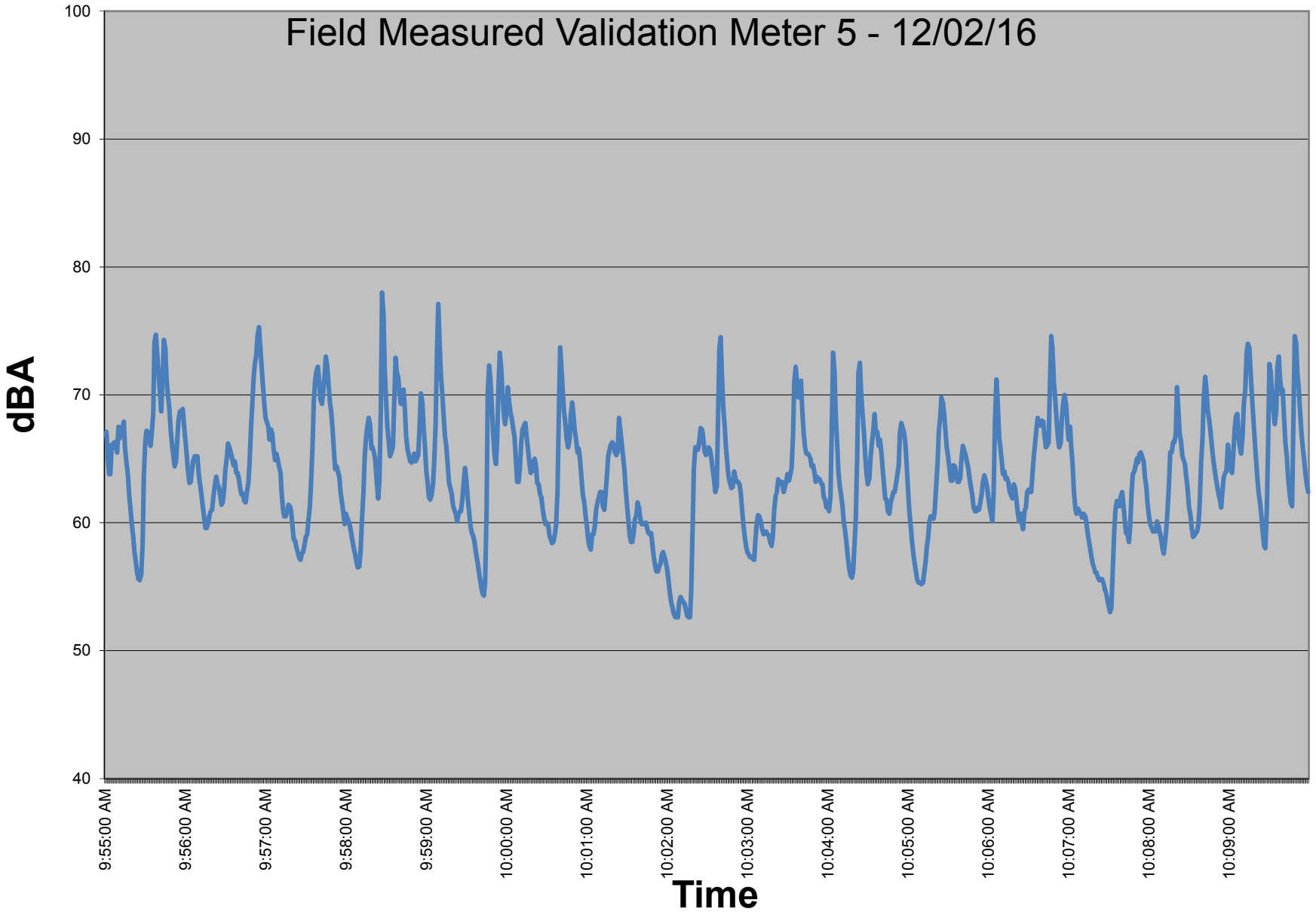
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