

FINAL REPORT

Anchorage Port Modernization Program In-air Noise and Ground-borne Vibration Analysis Monitoring Report



Prepared for

Municipality of Anchorage/Port of Anchorage



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Executive Summary

Aging infrastructure at the Port of Anchorage (POA) has far exceeded its economic and design life. Some of the oldest parts of the current infrastructure date back to the early 1960s. The POA is planning to undertake a reconstruction project—the Anchorage Port Modernization Program (APMP)—to improve and update these facilities. The APMP is planned for construction between 2017 and 2022 or later, dependent on available funding.

In advance of the APMP, the POA conducted a smaller-scale effort during spring 2016, known as the Test Pile Program (TPP). The TPP consisted of installing 10, 48-inch steel pipe indicator test piles adjacent to existing POA facilities. The primary purpose was to evaluate the performance of the pile installation equipment and methods under conditions similar to what will be used for production pile installation during the APMP. The information obtained during the TPP will be used to help inform, design, and implement the APMP.

The TPP was multifaceted, and a number of investigations and data sets were collected as the piles were installed. One of the efforts entailed an in-air noise and ground-borne vibration technical analysis to assess the potential impacts from the future construction of the APMP. The goal of this analysis is to evaluate how construction noise and ground-borne vibration during the APMP might affect residences close to the POA as well as workers within the POA boundary. This report summarizes the in-air noise and ground-borne vibration analysis conducted during the TPP. In general, results of the in-air noise and ground-borne vibration monitoring are summarized as follows:

In-air noise monitoring synopsis (residential areas): Monitored noise levels from pile driving did not exceed the Municipality of Anchorage (MOA) code limit of 80 A-weighted decibels (dBA) L_{eq} (equivalent continuous noise level, hourly). According to the long-term monitoring effort, sound levels in the Government Hill neighborhood during pile-driving activities ranged from 56 to 73 dBA L_{eq} , while sound levels in the Cherry Hill neighborhood ranged from 54 to 78 dBA L_{eq} . The loudest monitored pile driver sound levels were generally associated with the hydraulic impact pile driver followed by the diesel impact pile driver. Vibratory pile driver sound levels were measurable, but were lower than impact pile driver sound levels.

In-air noise monitoring synopsis (POA tenant locations): Monitored pile-driving noise levels were below the Occupational Safety & Health Administration maximum allowable impact levels, but fall within ranges for adverse occupational exposures during the course of an 8-hour workday. All personnel required to work outside at the shoreline or within 150 feet of pile-driving operations are recommended to wear hearing protection. Common types of hearing protection include ear plugs (disposable or reusable), semi-insert ear plugs, and ear muffs. Noise levels collected inside facilities near the pile-driving test locations do not indicate any exposures of concern.

Ground-borne vibration monitoring synopsis: Monitored vibration levels attenuated quickly with distance from the piles driven. As a result, ground-borne vibration from pile-driving activity was not perceptible or of a level that could be readily identified over baseline ground-borne vibration levels in the neighborhoods. The phenomenon experienced by some residents in the Government Hill neighborhood is most likely a result of low-frequency noise associated with impact pile driving rather than ground-borne vibration.

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Appendices

Appendix A: Noise and Vibration Monitoring Equipment Laboratory Calibration Sheets

Acronyms and Abbreviations

| | |
|-----------|---|
| APMP | Anchorage Port Modernization Program |
| dB | decibel |
| Caltrans | California Department of Transportation |
| dBA | A-weighted decibel |
| dB(C) | C-weighted decibel |
| EPA | U.S. Environmental Protection Agency |
| °F | Degrees Fahrenheit |
| FTA | Federal Transit Administration |
| IP | indicator pile |
| JBER | Joint Base Elmendorf-Richardson |
| L_{eq} | Equivalent continuous noise level |
| L_{max} | Maximum noise level |
| L_{min} | Minimum noise level |
| L_n | Statistical sound levels, representing the sound level exceeded for “n” percent of time |
| MOA | Municipality of Anchorage |
| mph | miles per hour |
| OSHA | Occupational Safety & Health Administration |
| POA | Port of Anchorage |
| PPV | peak particle velocity |
| rms | root mean square |
| SLM | sound level meter |
| TPP | Test Pile Program |

1 Introduction

The Port of Anchorage (POA) is vital infrastructure for moving goods in and out of Alaska. However, some of the oldest components of the current infrastructure date back more than 50 years. Due to the deteriorating conditions of the pilings, the docks no longer meet seismic standards and are unlikely to survive a major earthquake.

The POA began initial work on the current Anchorage Port Modernization Program (APMP) in 2014. The project is needed to provide safe, reliable, and cost-effective cargo and fuel operations to Anchorage and the state long into the future. The APMP is currently planned for construction between 2017 and 2022 or later, depending upon funding availability.

1.1 Report Purpose and Overview

Pile driving is a commonly used method for coastal and offshore construction. However, pile driving produces high sound pressure levels in both the surrounding air and underwater environment. The POA elected to conduct this in-air noise and ground-borne vibration analysis to proactively assess and address potential impacts associated with installation of the indicator piles as part of the Test Pile Project (TPP).

The current phase—the TPP—began in April 2016, with the first test piles driven in May 2016. The POA initiated the TPP to collect data that will be used to inform the design of APMP improvements. In-air noise from pile driving had been identified as a potential concern to nearby residents, especially those in the Government Hill and Cherry Hill neighborhoods, along with tenants physically located at the POA.

Noise measurements were taken at key locations within and adjacent to POA property during the TPP's pile-driving activities to help determine the effects of pile-driving noise. Measurements included continuous noise readings at long-term locations, combined with short-term readings taken throughout the POA property and within the two nearby residential neighborhoods (Government Hill and Cherry Hill). Ground-borne vibration monitoring data were also collected in those neighborhoods.

This *In-air Noise and Ground-borne Vibration Analysis Monitoring Report* presents an assessment of the in-air noise and ground-borne vibration data collected during the pile-driving activities of the TPP that occurred between April and June 2016. The following multi-faceted monitoring approach was used:

- Conduct baseline acoustic monitoring
- Conduct short-term monitoring of pile-driving in-air noise and ground-borne vibration
- Conduct continuous long-term noise monitoring during the TPP

Public input early in the TPP identified the need to evaluate ground-borne vibration monitoring in addition to traditional noise monitoring. Public involvement was an important component and one of the key drivers of the in-air noise and ground-borne vibration analysis. To keep the public engaged, the project team hosted a neighborhood noise monitoring event at one of the Government Hill parks on May 2, 2016. Specialists were on hand to show how the noise monitors worked and what information was being collected. During other short-term in-air monitoring events, project team members spoke to members of the public who stopped by to inquire about the project or the monitoring effort. The project team also presented at a number of Government Hill and Cherry Hill community meetings during spring 2016.

1.2 Test Pile Program Details

The TPP consisted of installing 10, 48-inch steel pipe indicator test piles adjacent to the existing POA facilities. Installation of the indicator piles occurred with a combination of a vibratory hammer (used to drive the pile the first 50 feet) and an impact hammer (used to drive the pile to final tip elevation) to achieve the ultimate depth of approximately 150 feet below mudline.

Noise and ground-borne vibration are variable for a number of reasons, including the type of pile driver being used. Vibratory hammers cause the sediment surrounding the pile to liquefy, allowing the pile to penetrate the substrate. Generally, vibratory pile driving results in less intense in-air noise levels, but may be more impactful underwater. Impact hammers consist of a heavy piston that is lifted and dropped against the top of the pile. Impact pile driving generally results in higher in-air sound levels, but can be less impactful to the underwater environment. While not specifically identified as a goal of the in-air monitoring program initially, variability in sound levels for the various pile hammers was also achieved by the in-air noise monitoring effort.

Hammers: The construction contractor used the following types of hammers: APE 400 Vibratory Hammer, APE D180 Diesel Impact Hammer, and APE 15-4 Hydraulic Impact Hammer. Diesel hammers carry their own fuel and generate their own power internally. Hydraulic hammers use an external hydraulic source, which then is left to fall freely or is accelerated downward by pressurized gas above the piston. Each of these hammers has its own acoustic emission level, which was captured as part of this report.

Hydroacoustic abatement systems: The 10 piles were installed using a combination of different pile hammers and hydroacoustic noise abatement systems. These hydroacoustic noise abatement systems have little to no influence on monitored in-air sound levels; therefore, they are not applicable to the analysis provided in this document. The hydroacoustic data collection and analysis of the effectiveness of the hydroacoustic abatement systems are being addressed under a separate effort and are not part of this report.

1.3 Regulatory Environment

The following subsections provide information on the in-air noise and ground-borne vibration regulatory limits and guidelines.

1.3.1 In-air Community Noise Regulations

Noise and vibration regulations and guidelines provide the regulatory framework for the TPP and the APMP. The Municipality of Anchorage (MOA) provides construction noise limits via the Municipal Code, specifically Section 15.70. The following text from the MOA Municipal Code applies to construction noise from the project:

Construction: No person shall operate or cause the operation of any tools or equipment used in construction, drilling, repair, alteration or demolition work:

- a. So that the sound therefrom creates a noise disturbance across a residential real property boundary or within a noise-sensitive zone between the hours of 10:00 p.m. and 6:00 a.m. during the construction season, between the hours of 10:00 p.m. and 7:00 a.m. during other months, or at any time on Sundays or state holidays;*
- b. So that the sound level therefrom exceeds an L_{eq} of 80 dB(A) at or within a residential real property boundary or within a noise sensitive zone during any one hour of the daily period from 6:00 a.m. to 10:00 p.m. during the construction season or from 7:00 a.m. to 10:00 p.m. during other months; or*

- c. *So that the sound level therefrom exceeds an L_{eq} of 80 dB(A) at or within a commercial or industrial real property boundary during any one hour of the daily period from 6:00 a.m. to 10:00 p.m. during the construction season or from 7:00 a.m. to 10:00 p.m. during other months.*

1.3.2 In-air Port of Anchorage Worker and Tennant Noise Regulations

Noise exposures for workers and tenants were assessed against thresholds established by Occupational Safety & Health Administration (OSHA) and U.S. Environmental Protection Agency (EPA) guidelines. Note that there is no functional difference between construction and industrial noise standards.

1.3.2.1 Occupational Health & Safety Administration

OSHA has identified maximum instantaneous sound level limits for workers as well as total noise exposure limits for periods of work. The OSHA maximum regulatory limit for hazardous impact noise is 140 A-weighted decibels (dBA).

1.3.2.2 U.S. Environmental Protection Agency

Noise exposure for workers is assessed for an entire 8-hour work shift. Noise levels measured closest to the pile-driving activities do not reach the continuous 90 dBA threshold for an entire 8-hour work shift, which is necessary to classify the pile driving as hazardous noise.

The EPA has identified a 24-hour average exposure level of 70 dBA as the level of environmental noise that would prevent any measurable hearing loss over a lifetime. Likewise, levels of 55 dBA outdoors and 45 dBA indoors are identified as preventing activity interference and annoyance. These levels of noise are considered to be those that would permit spoken conversation and other activities such as sleeping, working, and recreation, which are part of the daily human condition. The levels are not single-event, or “peak” levels. Instead, they represent averages of acoustic energy over short periods (e.g., 8 or 24 hours) and over long periods (e.g., years). For example, occasional higher noise levels would be consistent with a 24-hour energy average of 70 dBA, so long as a sufficient amount of relative quiet is experienced for the remaining period (EPA 1974). This study did not collect a day/night average noise exposure reading. This 70 dBA average, however, is only a recommendation, and neither the EPA nor the Federal Transit Administration (FTA) has identified any adverse hearing impacts from industrial operations with noise levels similar to those identified here (FTA 2016).

1.3.3 Ground-Borne Vibration Guidelines

Locally, the MOA provides ground-borne vibration regulation that is applicable to the project. The MOA’s regulation is a nuisance-based ordinance that is provided in MOA Municipal Code. Specifically, the following consideration for vibration is stated in Section 15.70:

Vibration: No person shall operate or cause the operation of any device that produces low-frequency, inaudible sound that creates vibration above the vibration perception threshold of any individual within a residential real property boundary or within a noise-sensitive zone between the hours of 10:00 p.m. and 7:00 a.m. the following day.

Additional guidelines have been established by the FTA and the California Department of Transportation (Caltrans). The Caltrans *Transportation and Construction Induced Vibration Guidance Manual* (Caltrans 2005) guidelines are particularly useful to the TPP since they are specific to pile driving. Construction ground-borne vibration associated with pile-driving efforts is characterized as a “transient” ground-borne vibratory source because it is not a more steady ground-borne vibration source like that of traffic on a busy railroad corridor. For context, Caltrans guidelines indicate that for transient sources, a peak particle velocity (PPV) inches per second of 0.04 is barely perceptible, and PPV lower than that is generally not perceptible (Caltrans 2005). In the context of building damage, the minimum PPV level when damage may occur (i.e., at extremely fragile historic buildings, ancient monuments, and ruins) is

0.08 PPV. The structures on POA property are characterized as modern industrial/commercial buildings, which Caltrans indicates have a damage criterion of 0.5 PPV.

2 Methodology

TPP in-air noise and ground-borne vibration monitoring was conducted in the neighborhoods surrounding the POA, while tenant noise monitoring was completed outside tenant locations within the POA itself. Neighborhood noise monitoring consisted of a combination of (1) long-term unattended monitors set up as semi-permanent noise monitoring stations that monitored sound levels 24 hours per day, 7 days per week, for the duration of the TPP; and (2) short-term attended monitors with an operator present during some of the pile-driving efforts. Ground-borne vibration levels were monitored in the neighborhoods simultaneously with the short-term noise monitors while some of the piles were driven. Noise levels at tenant locations were measured outside tenant buildings on POA property.

All noise measurements were completed with Larson Davis 831 American National Standards Institute Type 1 sound level meters equipped with 1/2-inch microphones and windscreens. In addition, Vaisala Weather Transmitters (Model WXT520) were deployed to log weather conditions at the long-term monitoring locations. Prior to deployment, or the start of a measurement, the calibration of each sound level meter was verified in the field using a hand calibrator, specifically a Larson Davis CAL200. Calibration sheets are included in Appendix A. The portable meteorological stations measured wind speed, precipitation, temperature, and humidity. Microphones were protected by windscreens that are effective up to 10 miles per hour (mph). Data were downloaded and battery power swapped out approximately weekly, if not more often.

At both neighborhoods, pile-driving noise from a minimum of two pile installations was also collected during the short-term monitoring events. These measurements were conducted for slightly longer periods to capture the noise associated with one continuous pile-driving sequence. The pile-driving sequence generally consisted of the piles being set via vibratory hammer, followed by impact pile driving, to achieve the ultimate depth of approximately 150 feet below the mud line. Audio recordings of each pile-driving effort were collected during the short-term measurements so that the quality and content of pile-driving noise in the community can be conveyed to the public, as necessary. Additionally, during the short-term measurements, video recordings of each pile driven were attempted where views to a specific pile were possible; in some instances, video recording was not possible due to intervening buildings, topography, and/or vegetation blocking the sight line.

After installation of the first pile, the POA received comments from the public that identified concerns relating to suspected ground-borne vibration levels from pile driving. To address this concern, the POA elected to conduct ground-borne vibration monitoring. Ground-borne vibration levels were monitored with Instantel® Micromate portable vibration monitors. One vibration monitor was placed in relatively close proximity (i.e., within 100 feet) to the pile being driven, while a second vibration monitor was deployed in the neighborhoods, coincidental with a short-term noise monitor.

The tenant noise monitoring effort consisted of baseline noise measurements at the pile-driving location and occupied locations near the work site. Measurements collected during pile-driving operations were used to develop noise gradients that identify the distance from the source (pile driving) to areas of hazardous noise exceeding levels of the 90 dBA 8-hour hazardous noise for workers limit. If a POA tenant location was identified within a hazardous noise zone, interior noise levels during pile driving were analyzed.

2.1 In-air Noise Monitoring Locations (Residential Areas)

Two long-term monitoring sites were set up for the duration of the TPP construction activities. Additionally, several short-term monitoring events occurred in nearby residential areas during many of the pile-driving events. During the short-term monitoring events, more “mobile” neighborhood measurements were conducted at several locations within the Government Hill neighborhood. These

extra neighborhood measurements were done to characterize pile-driving noise within the neighborhood, farther away from the POA and parks than the other monitoring locations.

2.1.1 Long-term Monitoring

Noise levels at two long-term monitoring sites were measured between April 27 and June 3, 2016. These unattended noise monitors collected both baseline noise levels and noise levels during the pile-driving events.

LT-01 – Long-term monitoring site at the POA near Government Hill: A long-term noise monitoring station was located on the bluff near the southern boundary of the POA (see Figure 1 and Figure 2). This site was selected due to its secure location, open exposure to construction activities, and proximity to the Government Hill neighborhood. Observed non-pile-driving sound sources included POA-related sources such as heavy truck and construction noise, railroad traffic, roadway traffic, and military and non-military aircraft overhead. Natural sound sources included wind interacting with vegetation and birds.

LT-02 – Long-term monitor site at the Cherry Hill residential area: Based on a meeting held on April 5, 2016, with JL Properties/Aurora Housing representatives, a second long-term noise monitoring station was located within the Cherry Hill neighborhood on Joint Base Elmendorf-Richardson (JBER). This monitoring site was located between a residential building and an adjacent playground. The noise meter was affixed to a pole approximately 20 feet in the air to be representative of noise levels in living spaces located in the second story building apartment units (see Figure 3). Monitoring noise levels at this height is considered conservative since shielding from ground effects is less at this height.

Observed non-pile-driving sound sources included POA-related noises such as heavy truck and construction noise, railroad traffic, roadway traffic, and military and non-military aircraft overhead. Natural sound sources included wind interacting with vegetation and birds.

Equipment: Noise specialists set up Larson Davis 831 American National Standards Institute Type 1 sound level meters (SLMs) equipped with 1/2-inch microphones and windscreens at the two long-term locations. In addition, Vaisala Weather Transmitters (model WXT520) were deployed to log weather conditions at both long-term measurement sites.

Prior to the start of the long-term measurements, field calibration of the Larson Davis 831 was verified using a hand calibrator (Larson Davis CAL200). (All noise monitoring equipment used for the in-air noise monitoring was calibrated within the previous year in a laboratory; see Appendix A.) In the field, the SLM performed an internal self-calibration daily. Battery power for the SLM was manually replaced approximately every 5 to 10 days, at which time data for the previous monitoring period were downloaded.



Figure 1. Residential-related Noise Monitoring Locations

2016 Test Pile Program



Figure 2. LT-01 Site: Government Hill Long-term In-air Noise Monitoring Site on Bluff within the POA Boundary



Figure 3. LT-02 Site: Cherry Hill Long-term In-air Noise Monitoring Site within JBER

2.1.2 Short-term Monitoring

During the TPP, pile-driving noise was also collected via short-term monitors to capture the noise associated with the pile-driving sequence.

Short-term measurements were conducted at four measurement locations (two sites at Government Hill concurrently or two sites at Cherry Hill concurrently) to evaluate the existing acoustic environment at noise-sensitive areas outside the POA property (i.e., neighborhood residential areas). Based on which pile was being driven, the analysts chose the short-term site that was closest to the pile (e.g., either the Cherry Hill or the Government Hill location). Generally, the short-term monitoring was conducted at Cherry Hill for piles located farther north. For piles farther south, the short-term monitoring was conducted in the Government Hill location.

Government Hill: Within the Government Hill neighborhood, two park locations were selected for short-term noise monitoring due to their open exposure to the POA and proximity to residences. These parks are Brown's Point Park (ST-01 site) and Susan Nightingale McKay Memorial Park (ST-02 site; see Figure 4 and Figure 5).

Observed non-pile-driving sound sources at Brown's Point Park included POA-related truck traffic and construction, train horns, vehicles (trucks and motorcycles), birds, and military and non-military aircraft overhead. General observed sounds sources at Susan Nightingale McKay Memorial Park were dominated by POA-related truck traffic and construction as well as military and non-military aircraft overhead. The indicator pile (IP) tests observed from the Government Hill short-term location included IP5, IP7, IP9, and IP10.



Figure 4. ST-01 Site: Government Hill Short-term Noise Monitoring Site (Brown's Point Park)



Figure 5. ST-02 Site: Government Hill Short-term Noise Monitoring Site (Susan Nightingale McKay Memorial Park)

Cherry Hill: Within the Cherry Hill neighborhood, two locations were selected for short-term noise monitoring based on proximity to residences. These measurement locations were adjacent to the multi-family housing units situated atop the bluff closest to the POA. One was located on the southern end of the Cherry Hill residential housing area (ST-03 site) and the other on the northern end of the housing complexes (ST-04 site) closest to the POA property (see Figure 6 and Figure 7).

Observed non-pile-driving sound sources at the two short-term noise monitoring sites at Cherry Hill were the same as those sound sources observed at the long-term station located at Cherry Hill. The IP tests observed from the Government Hill short-term location included IP4 and IP2.



Figure 6. ST-03 Site: Cherry Hill Short-term Noise Monitoring Site (southern site)



Figure 7. ST-04 Site: Cherry Hill Short-term Noise Monitoring Site (northern site)

“Mobile” monitoring locations (“Neighborhood Measurements”): During the short-term measurements taken on Government Hill, noise specialists also collected brief “mobile” noise measurements in response to community concerns. This entailed taking the noise meter from one of the parks and setting it up to collect spot measurements from varying distances farther into the residential neighborhood from the short-term monitoring sites. This was done to determine how pile-driving noise attenuated with distance.

2.2 In-air Noise Monitoring Locations (Port of Anchorage Tenant Locations)

Within the POA boundary, 11 potential sites were initially identified for noise monitoring. A meeting with tenants was scheduled for April 14, 2016, that was intended to further define specific locations for monitoring. Generally, it was decided that locations in proximity to pile-driving activities would be monitored individually, and locations that were farther removed would have grouped or representative noise monitoring conducted.

Monitoring consisted of noise measurements near the pile-driving location and occupied locations near the work site (Figure 8). Measurements collected during the pile-driving operations are used to develop noise gradients that identify the distance from the source (pile driving) to the threshold of hazardous noise levels (90 dBA OSHA classified hazardous noise) and 80 dBA (MOA Noise Ordinance construction noise limit). Occupied or potentially occupied facilities identified within the hazardous noise zones were assessed for interior noise levels during the pile-driving process and during normal operations. For comparison purposes, baseline sound levels were also collected to identify the change in noise resulting from pile driving at tenant and worker locations. Due to the duration of TTP activities, and to minimize any daily noise variations, both ambient and TPP impacted noise measurements were collected on the same day.



Figure 8. POA Tenant Noise Monitoring Locations
2016 Test Pile Program

2.3 Ground-borne Vibration Monitoring Locations

During several of the short-term in-air noise monitoring events, vibration equipment (InstanTel® Micromate units) was deployed (see Figure 9, Figure 10, and Figure 11). This occurred at the following specific sites: ST-01, ST-02, ST-03, ST-04, NM01, and NM02 (see Figure 12). When deployed, one vibration monitor was located immediately adjacent to one of the short-term noise monitoring stations; the other vibration monitor was located in the landward vicinity of the pile being driven at the POA. PPV inches per second were collected at 1-minute intervals to document the potential for human perception and structural damage.



Figure 9. Vibration Equipment: Accelerometer and Geophone Cord





Figure 10. Vibration Monitoring Equipment Set Up Onshore near Pile-Driving Location

Figure 11. Setting Up Vibration Monitoring Equipment near Pile-Driving Location



Figure 12. Vibration Monitoring Locations

2.4 Data Collected

2.4.1 Noise Data

To analyze community noise impacts and to fully characterize the baseline acoustic environment and noise emissions from pile driving, the following sound metrics and data were collected:

- A-weighted decibel (dBA) minimum noise level (L_{min}), maximum noise level (L_{max}), statistical sound level (L_{10} , L_{50} , L_{90}), and equivalent continuous noise level (L_{eq}) values on an hourly basis;
- C-weighted decibel (dBC) L_{min} , L_{max} , L_{10} , L_{50} , L_{90} , and L_{eq} values on an hourly basis;
- One-third octave-band linear (i.e., unweighted decibels [dB]) sound levels ranging from 6.3 Hertz (Hz) to 20,000 Hz.

A-weighting and C-weighting refers to the human response to sound. The L_{eq} is the time logarithmically averaged sound level for a given period. For example, the MOA Noise Ordinance for construction is based on the hourly L_{eq} . One-third octave band data were also collected to address any tonal concerns that the POA would like to address in the future. One-third-octave band data could be used to describe phenomenon associated with specific frequencies. Because of the voluminous amount of data collected for this effort, sound levels presented in this report are A-weighted and confined to the following metrics, which are included to provide greater detail on the quality and content of monitored baseline and pile-driving sound levels:

- L_{eq} : The logarithmically averaged sound level for a given period, often based on an hourly period and, while not technically correct, is often referred to as the “average” sound level for a given period. The L_{eq} is the most frequently used noise metric in environmental noise and is used in many regulatory limits. For example, the MOA uses the L_{eq} metric in their noise ordinance.
- L_{min} : Minimum sound level monitored for a given period.
- L_{max} : Maximum sound level monitored for a given period.
- L_N : Statistical sound level, such as L_{10} , L_{50} , and L_{90} , provides the sound level exceeded for a specific percentage of time over a given monitoring period (i.e., hourly). Therefore, L_{10} is the sound level that was exceeded 10 percent of the time and L_{90} is the sound level that was exceeded 90 percent of the time. L_{50} can be described as the “median” sound level and represents the sound level exceeded 50 percent of the time. L_{90} is often referred to as the “residual sound level” because it excludes the vast majority of transitory sound sources, and what remain are the sustained sound sources at a given site.

The short- and long-term monitors were programmed to log exceedances of the MOA Noise Ordinance daytime (6:00 a.m. to 10:00 p.m.) construction noise limit of 80 dBA L_{eq} (hourly). Audio recordings were conducted during each short-term measurement. In addition to what is summarized in this report, all data collected have been provided to the POA electronically.

2.4.2 Vibration Data

According to the FTA Noise and Vibration Impact Assessment (FTA 2016), construction activities can be a source of ground-borne vibration. Activities such as pile driving and operation of heavy equipment may cause ground-borne vibration during construction. Vibration is an oscillatory motion that can be described in terms of displacement, velocity, or acceleration (FTA 2016). Velocity or acceleration is typically used to describe vibration. Two descriptors are frequently used during discussions of quantification of vibration: the PPV and the root mean square (rms).

- PPV: The PPV is defined as the maximum instantaneous positive or negative peak of the vibration signal.
- rms: The rms is typically calculated over a 1-second period and is the square root of the average of the squared amplitude of a signal.

PPV is used in this document because it can be used to assess both structural damage potential and human annoyance, while rms is typically used for assessing human annoyance only.

2.4.3 Meteorological Data

The portable meteorological stations at both long-term monitoring sites measured wind speed (mph), wind direction, precipitation (inches), temperature (degrees Fahrenheit [°F]), and percent relative humidity.

3 Results/Data

3.1 Results Synopsis

A total of 10 piles were installed between May 3 and June 7, 2016. A combination of short- and long-term monitoring resulted in the collection of data during 9 of the 10 pile-driving events. This section summarizes the data collected in the field during these select, representative pile-driving events.

3.2 Baseline Sound Levels

Sound levels in both the Government Hill and Cherry Hill neighborhoods are variable dependent upon anthropogenic sound sources such as aircraft at JBER and Merrill Field, non-pile-driving activity at POA, lawn mowers, rail traffic, and roadway traffic. Additional sound sources include natural sounds of wildlife such as birds and wind interacting with vegetation. Since pile driving at the POA would be restricted to daytime hours (i.e., 7:00 a.m. to 10:00 p.m.), baseline sound levels are provided for daytime periods only (Table 1). Baseline sound levels were identified via monitoring data obtained at the two long-term monitoring stations; however, these data exclude any periods when the TPP pile-driving operations were active. These baseline sound levels are representative of the Government Hills neighborhood (LT-1) and the Cherry Hill neighborhood (LT-2).

Baseline sound levels are somewhat high, with daytime levels in the Government Hill neighborhood of 60.2 dBA L_{eq} and 65.1 dBA L_{eq} in the Cherry Hill neighborhood. Statistical sound levels (e.g., L_{10} , L_{50} , and L_{90}) do not show great variability between one another, which demonstrates that the daytime sound levels were not influenced greatly by short duration events, such as an individual aircraft flyover.

Table 1. Baseline Daytime Sound Levels

| Monitoring Location | | L_{eq} | L_{min} | L_{max} | L_{10} | L_{50} | L_{90} |
|---------------------|---------|----------|-----------|-----------|----------|----------|----------|
| LT-01 | Minimum | 43.8 | 35.8 | 53.2 | 46.3 | 40.8 | 38.0 |
| | Average | 60.2 | 46.3 | 76.5 | 56.4 | 51.8 | 49.3 |
| | Maximum | 79.7 | 52.4 | 99.6 | 76.3 | 58.0 | 54.9 |
| LT-02 | Minimum | 43.2 | 35.7 | 56.5 | 45.2 | 41.2 | 38.8 |
| | Average | 65.1 | 46.2 | 78.5 | 56.4 | 51.4 | 49.0 |
| | Maximum | 81.3 | 56.3 | 107.3 | 74.0 | 60.9 | 58.4 |

3.3 Noise Monitoring by Pile Location

Pile-driving sound levels are reported here in the sequence in which they were driven.

3.3.1 Pile Location 8

Test pile location 8 was set in the pile template on May 2, 2016, and driven to depth via vibratory and hydraulic impact pile drivers on May 3, 2016. Figure 13 depicts the noise measurement locations for Pile 8. Meteorological conditions during the survey were obtained via a nearby meteorological station or

from field observations, since the meteorological equipment deployed at the long-term stations malfunctioned. The meteorological conditions during the survey were a temperature of 44° F, wind speeds of less than 10 mph, humidity of 60 percent, and no precipitation.

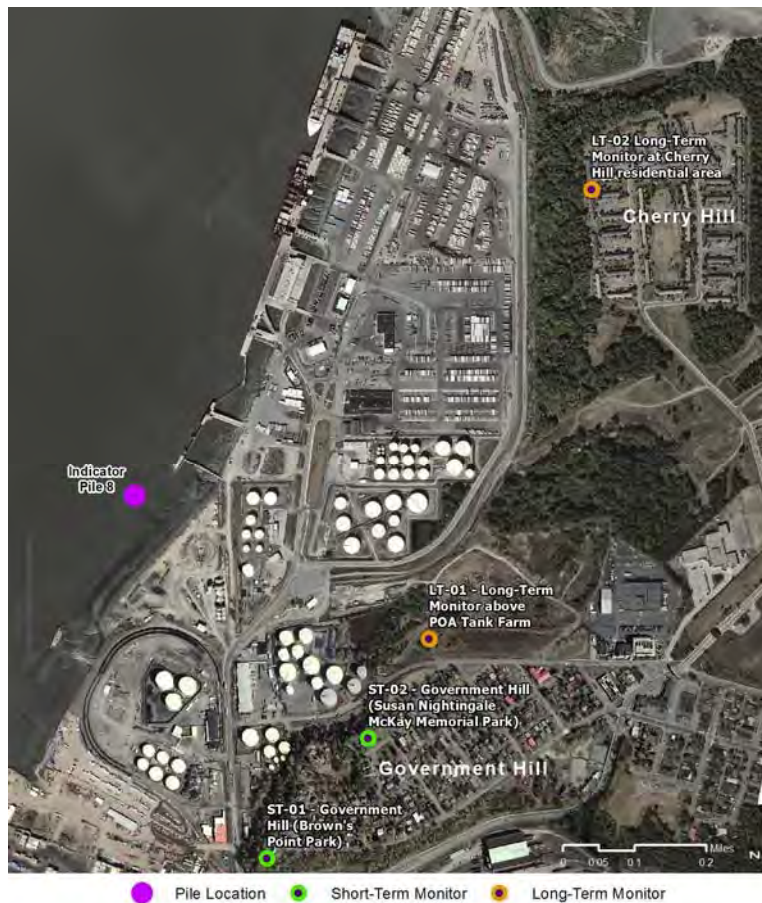


Figure 13. Pile 8 Measurement Locations

Table 2 provides a summary of measured sound levels from Pile 8 for both pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took 1 hour with small breaks in between to adjust the equipment. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 14 and Figure 15 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. At times, the 1-minute L_{eq} sound levels exceed 80 dBA; however, these are not considered exceedances of the MOA ordinance since they do not exceed 80 dBA L_{eq} (hourly) when logarithmically averaged over the entire pile-driving period. Data monitored at ST-01 during the impact pile-driving event became corrupted due to meter malfunction. The error with the SLM was rectified for piles driven after Pile 8.

Table 2. Pile 8 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L_{eq} | L_{min} | L_{max} | L_{10} | L_{50} | L_{90} |
|--------------------|---------------------|-------------------------|----------|-----------|-----------|----------|----------|----------|
| Vibratory | LT-01 | 2,411 | 55.9 | 47.1 | 80.3 | 57.7 | 54.0 | 51.7 |
| | LT-02 | 4,056 | 56.0 | 46.2 | 82.4 | 56.7 | 53.2 | 51.2 |
| | ST-01 | 2,844 | 58.6 | 52.2 | 80.9 | 59.3 | 57.0 | 55.3 |
| | ST-02 | 2,481 | 58.1 | 50.9 | 79.7 | 58.9 | 56.1 | 54.1 |
| Impact (hydraulic) | LT-01 | 2,411 | 57.7 | 46.6 | 76.2 | 61.5 | 53.1 | 50.5 |
| | LT-02 | 4,056 | 58.3 | 46.4 | 77.4 | 61.6 | 52.6 | 49.8 |
| | ST-02 | 2,481 | 56.8 | 42.2 | 76.2 | 59.2 | 52.2 | 48.5 |

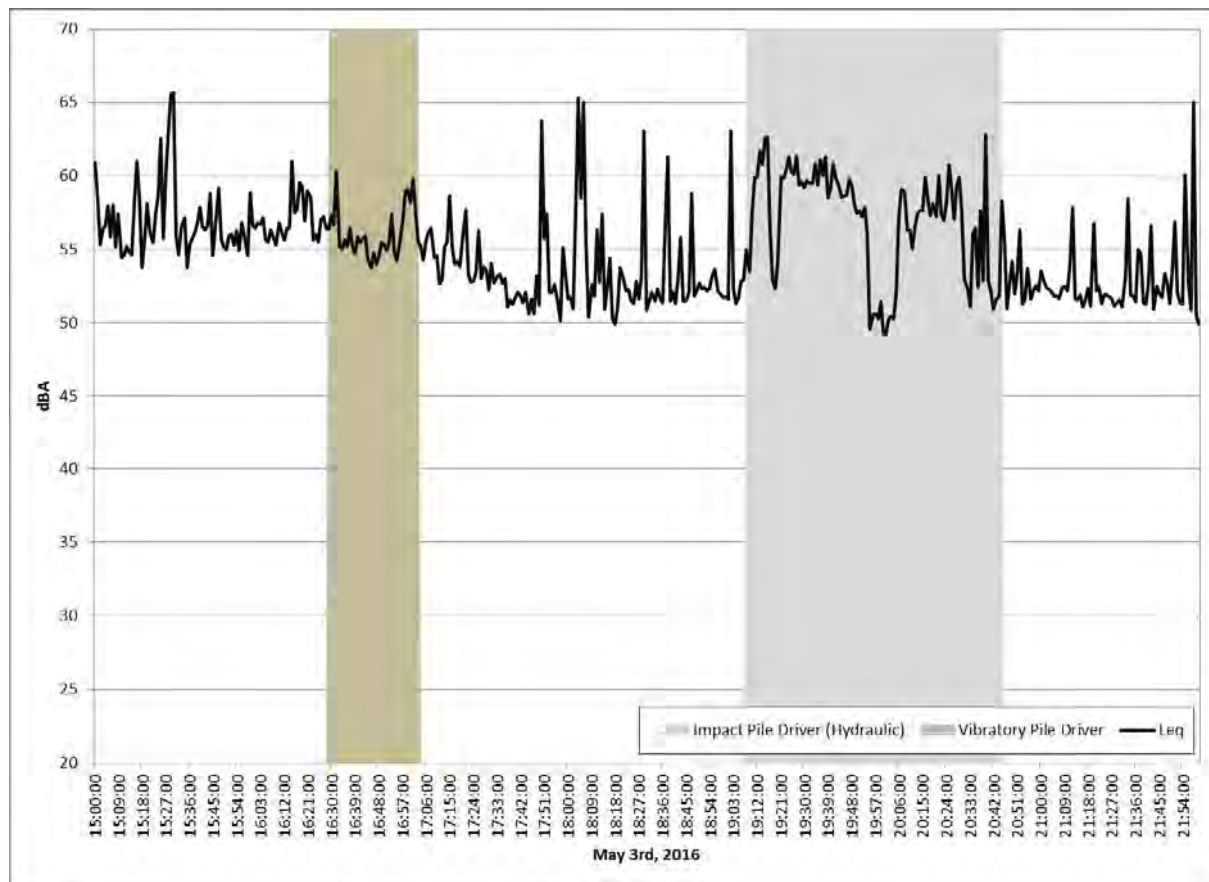


Figure 14. Pile 8 Time-history at the Government Hill Long-term Monitor (LT-01)

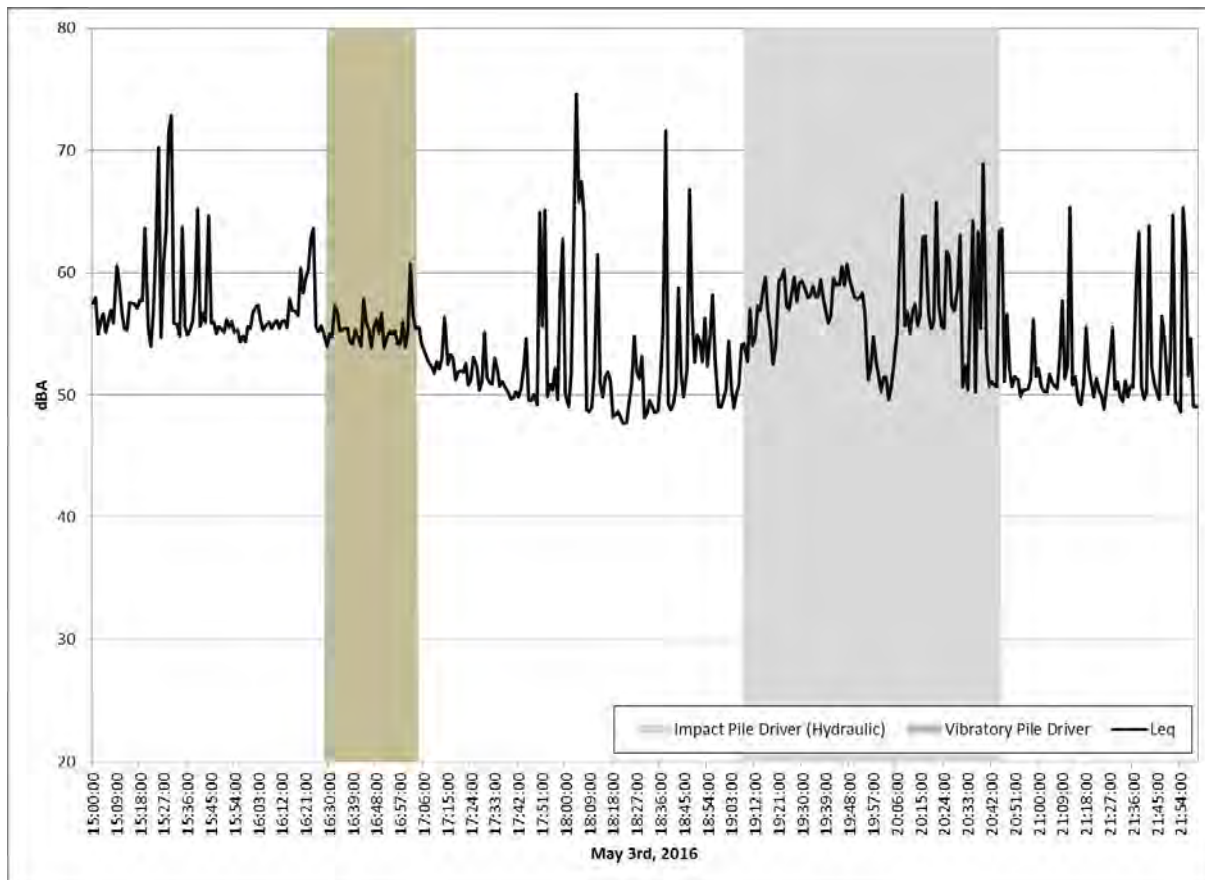


Figure 15. Pile 8 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.2 Pile Location 9

Test pile location 9 was set in the pile template and driven to depth via vibratory and diesel impact pile drivers on May 6 and 7, 2016. Figure 16 depicts the measurement locations for Pile 9. Meteorological conditions during the survey were obtained via the meteorological equipment deployed at the long-term station. The meteorological conditions during the survey were a temperature of 46°F, wind speeds of approximately 3 mph, humidity of 69 percent, and no precipitation.

Table 3 provides a summary of measured sound levels from Pile 9 for both pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour, with a large break between impact driving efforts that started on May 6 to fix the pile driver. Pile driving resumed the morning of May 7 and included another 2-hour-long pause when the pile driver was intermittently working. These breaks in pile driving were necessary for adjustment of the pile-driving equipment. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 17 and Figure 18 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. When logarithmically averaged over the entire pile-driving period, they do not exceed 80 dBA L_{eq} (hourly). A power failure occurred at LT-02 on May 6; therefore, no vibratory pile-driving noise was monitored at the station that day.

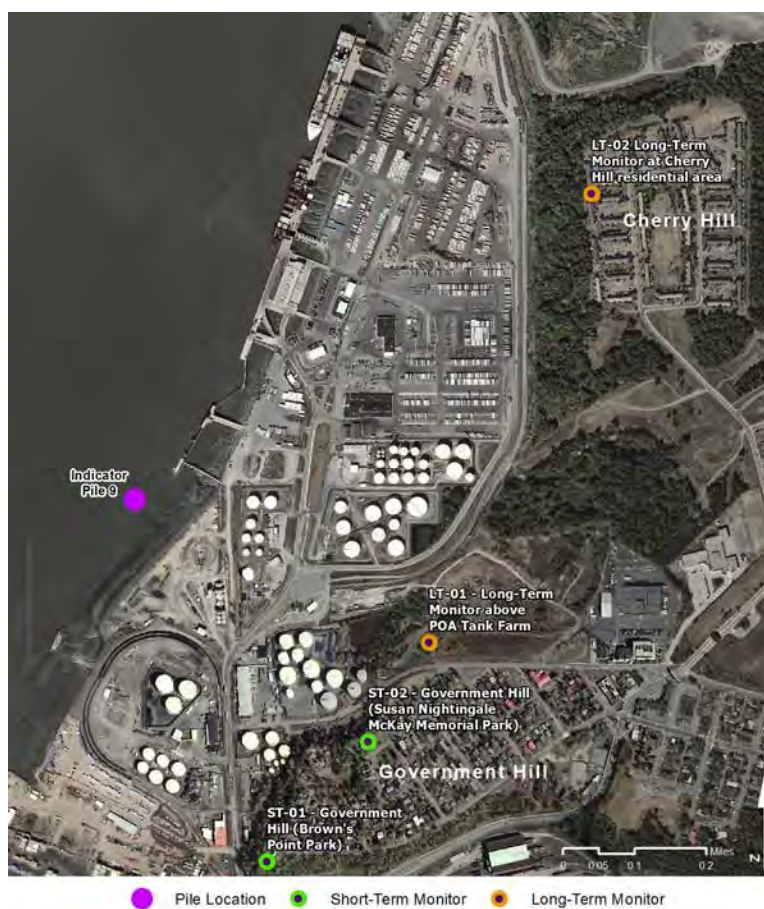


Figure 16. Pile 9 Measurement Locations

Table 3. Pile 9 Sound Levels

| Pile Driver Type | Monitoring Location (month/day) | Distance to Pile (feet) | L _{eq} | L _{min} | L _{max} | L ₁₀ | L ₅₀ | L ₉₀ |
|------------------|---------------------------------|-------------------------|-----------------|------------------|------------------|-----------------|-----------------|-----------------|
| Vibratory | LT-01 | 2,411 | 55.5 | 48.2 | 75.4 | 57.8 | 53.3 | 51.0 |
| | ST-01 | 2,844 | 55.9 | 50.0 | 68.8 | 57.4 | 54.9 | 53.1 |
| | ST-02 | 2,481 | 58.3 | 51.7 | 72.7 | 59.6 | 57.0 | 55.4 |
| Impact (diesel) | LT-01 (5/6) | 2,411 | 58.1 | 48.3 | 82.9 | 58.7 | 54.3 | 51.6 |
| | LT-01 (5/7) | 2,411 | 56.9 | 46.0 | 76.7 | 58.8 | 53.3 | 50.8 |
| | LT-02 (5/7) | 4,058 | 54.9 | 42.7 | 76.0 | 56.8 | 50.5 | 47.8 |
| | ST-01 | 2,844 | 61.2 | 51.3 | 83.6 | 62.7 | 58.5 | 55.9 |
| | ST-02 | 2,481 | 60.5 | 53.2 | 80.1 | 62.1 | 58.5 | 56.6 |

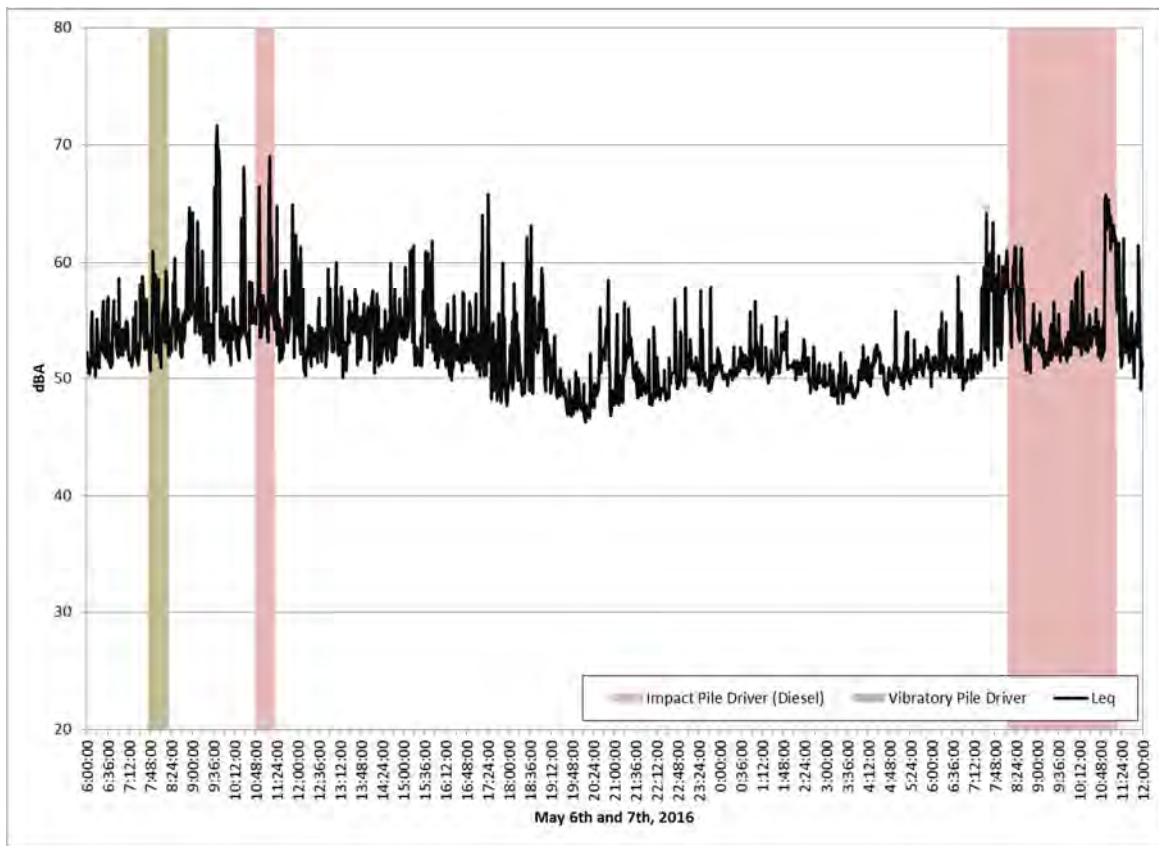


Figure 17. Pile 9 Time-history at the Government Hill Long-term Monitor (LT-01)

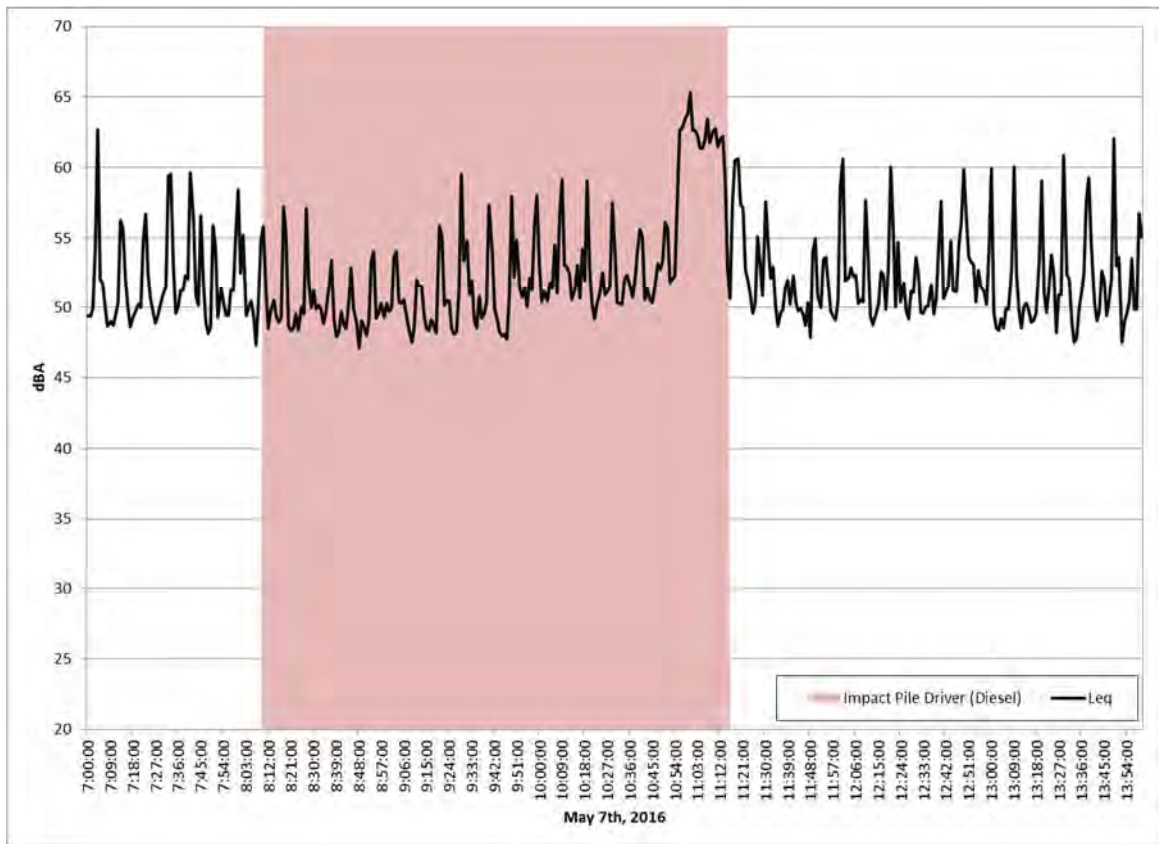


Figure 18. Pile 9 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.3 Pile Location 4

Test pile location 4 was set in the pile template on May 12, 2016, and driven to depth via vibratory, hydraulic, and diesel impact pile drivers on May 12 and 13, 2016. Figure 19 depicts the measurement locations for this pile. The meteorological conditions on May 12 were a temperature of 57° F, wind speeds of approximately 2–3 mph, humidity of 57 percent, and no precipitation. The meteorological conditions on May 13 were a temperature of 49°F, wind speeds of approximately 1 mph, humidity of 72 percent, and no precipitation.

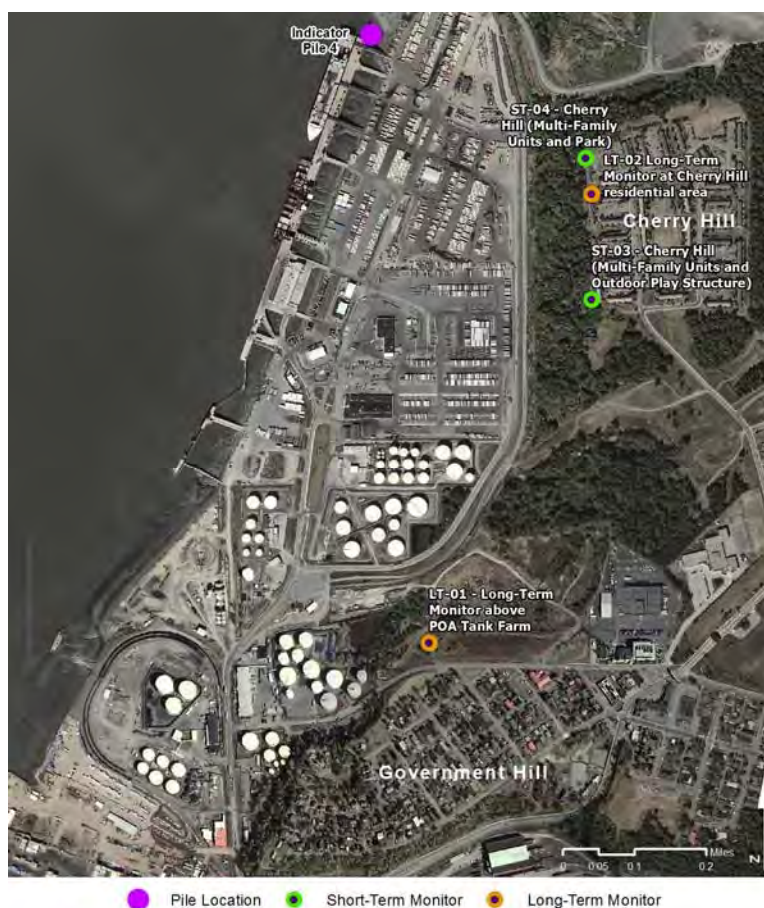


Figure 19. Pile 4 Measurement Locations

Table 4 provides a summary of measured sound levels from Pile 4 for the pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour, with a large break between impact driving efforts that started on May 12 to adjust the equipment. Specifically, the contractor had technical difficulties with the hydraulic pile driver that could not be rectified by May 13; therefore, the contractor elected to utilize the diesel impact pile driver to finish driving the pile on May 13. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 20 and Figure 21 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. At times, the 1-minute L_{eq} sound levels exceed 80 dBA; however, these are not considered exceedances of the

MOA ordinance since they do not exceed 80 dBA L_{eq} (hourly) when logarithmically averaged over the entire pile-driving period.

Table 4. Pile 4 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L_{eq} | L_{min} | L_{max} | L_{10} | L_{50} | L_{90} |
|--------------------|---------------------|-------------------------|----------|-----------|-----------|----------|----------|----------|
| Vibratory | LT-01 | 4,508 | 63.1 | 47.5 | 89.0 | 62.0 | 55.4 | 52.5 |
| | LT-02 | 2,004 | 66.4 | 48.1 | 94.6 | 64.1 | 54.1 | 51.1 |
| | ST-03 | 2,541 | 62.7 | 45.4 | 87.2 | 59.3 | 55.1 | 52.1 |
| | ST-04 | 1,828 | 67.9 | 48.0 | 94.4 | 62.3 | 57.3 | 54.3 |
| Impact (hydraulic) | LT-01 | 4,508 | 70.7 | 50.8 | 95.7 | 63.9 | 57.9 | 55.2 |
| | LT-02 | 2,004 | 76.3 | 48.4 | 105.5 | 64.6 | 56.6 | 53.1 |
| | ST-03 | 2,541 | 76.7 | 49.0 | 103.8 | 69.2 | 58.5 | 54.6 |
| | ST-04 | 1,828 | 78.6 | 50.0 | 102.7 | 71.1 | 60.5 | 55.8 |
| Impact (diesel) | LT-01 | 4,508 | 56.1 | 45.6 | 82.4 | 57.8 | 52.6 | 49.9 |
| | LT-02 | 2,004 | 59.7 | 48.8 | 90.0 | 62.8 | 53.3 | 51.4 |
| | ST-03 | 2,541 | 56.8 | 48.7 | 72.1 | 58.5 | 53.4 | 51.4 |
| | ST-04 | 1,828 | 62.3 | 47.9 | 79.2 | 62.5 | 56.1 | 51.7 |

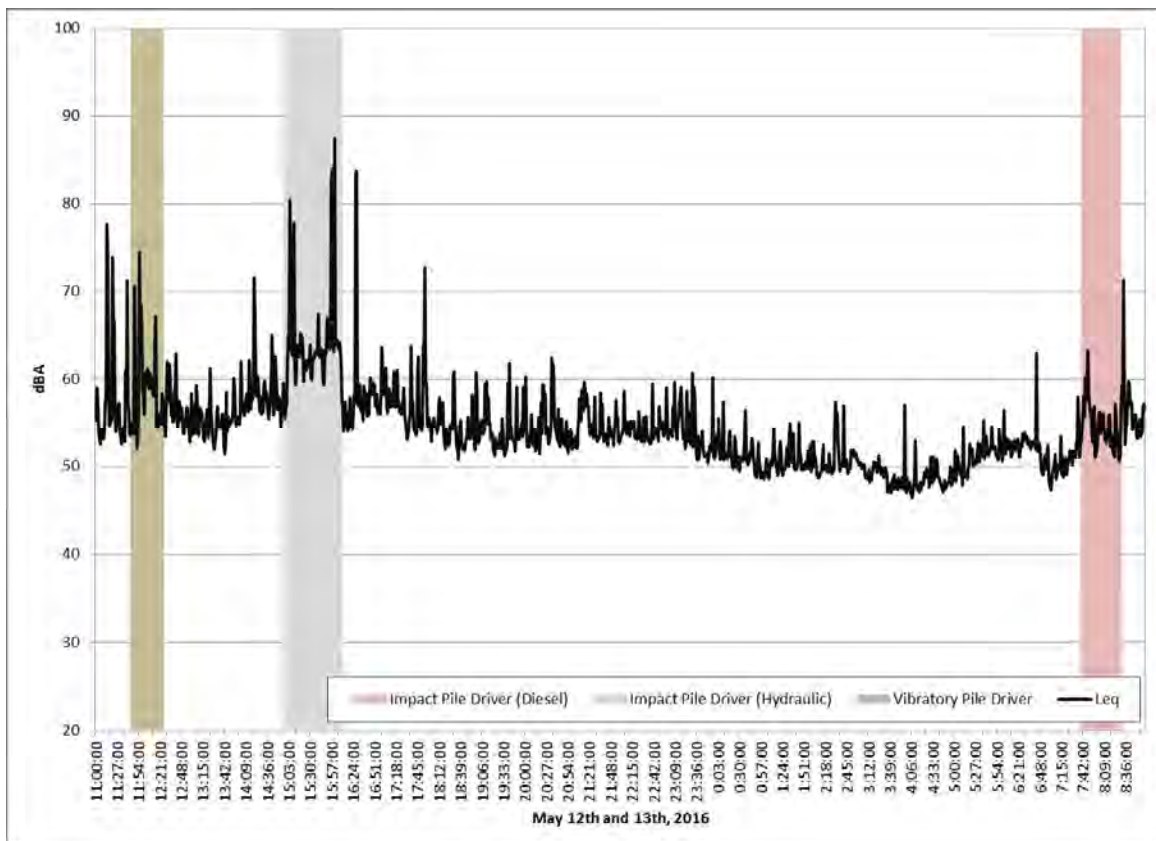


Figure 20. Pile 4 Time-history at the Government Hill Long-term Monitor (LT-01)

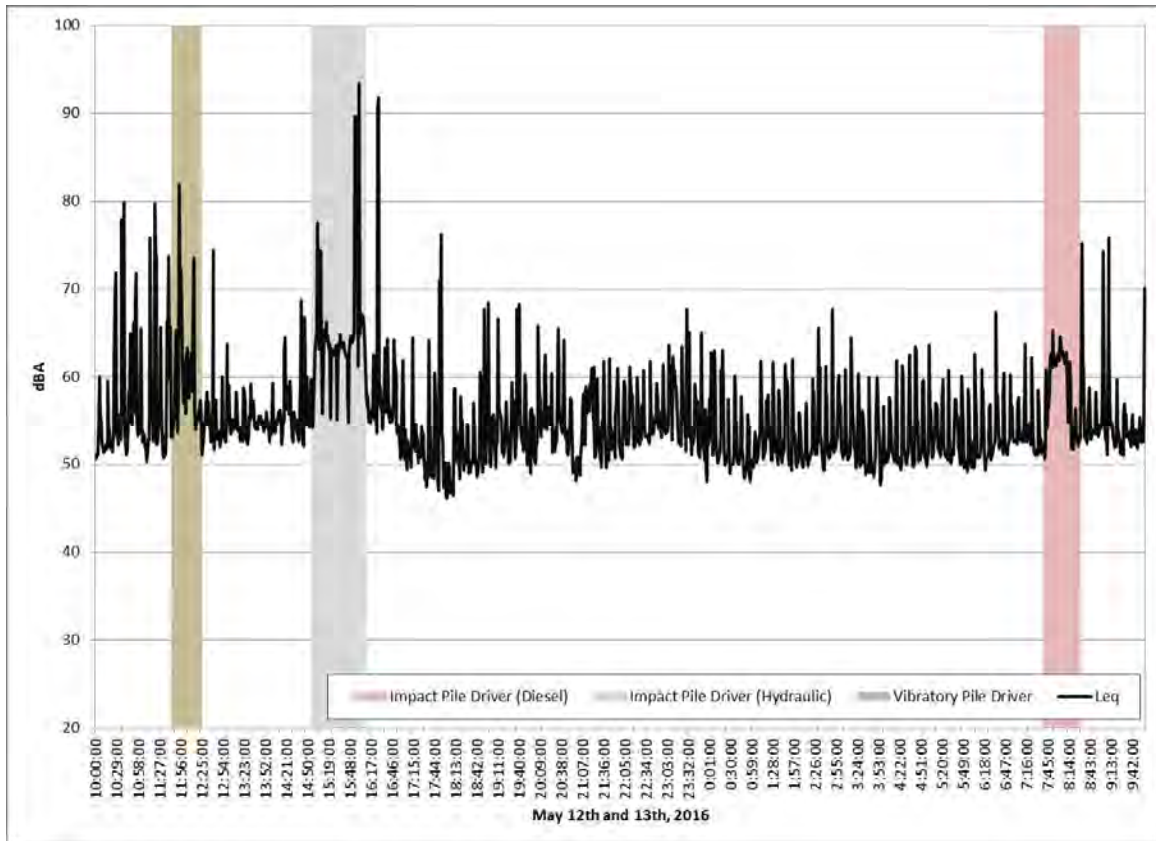


Figure 21. Pile 4 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.4 Pile Location 5

Test pile location 5 was set in the pile template and driven to depth via vibratory and diesel impact pile drivers on May 18, 2016. Figure 22 depicts the measurement locations for this pile. The meteorological conditions during the survey were a temperature of 52°F, wind speeds of 2 mph, humidity of 71 percent, and no precipitation.

Table 5 provides a summary of measured sound levels from Pile 5 for the pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 23 and Figure 24 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. At times, the 1-minute L_{eq} sound levels exceed 80 dBA; however, these are not considered exceedances of the MOA ordinance since they do not exceed 80 dBA L_{eq} (hourly) when logarithmically averaged over the entire pile-driving period.

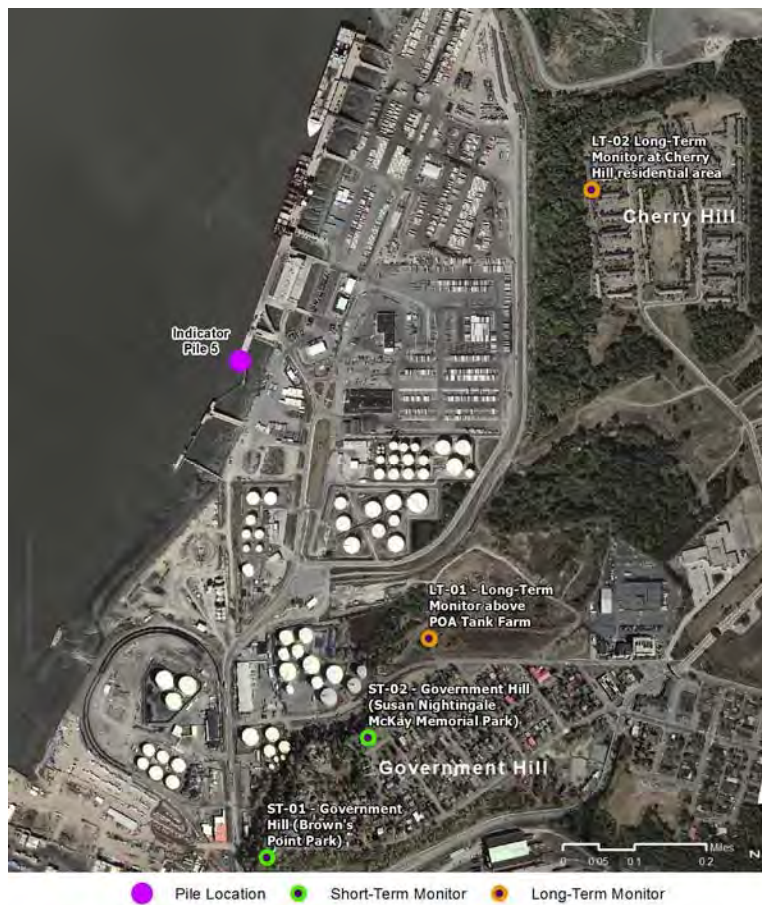


Figure 22. Pile 5 Measurement Locations

Table 5. Pile 5 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L _{eq} | L _{min} | L _{max} | L ₁₀ | L ₅₀ | L ₉₀ |
|------------------|---------------------|-------------------------|-----------------|------------------|------------------|-----------------|-----------------|-----------------|
| Vibratory | LT-01 | 2,481 | 58.7 | 45.5 | 88.0 | 58.5 | 53.8 | 50.6 |
| | LT-02 | 2,844 | 65.6 | 47.2 | 94.3 | 59.2 | 53.3 | 50.9 |
| | ST-01 | 3,674 | 61.1 | 52.4 | 81.0 | 63.2 | 59.0 | 56.2 |
| | ST-02 | 2,940 | 61.7 | 48.7 | 86.0 | 63.6 | 58.2 | 54.2 |
| Impact (diesel) | LT-01 | 2,481 | 61.6 | 45.5 | 89.3 | 63.5 | 53.3 | 49.6 |
| | LT-02 | 2,844 | 68.0 | 45.4 | 98.4 | 65.5 | 52.1 | 49.3 |
| | ST-01 | 3,674 | 60.1 | 51.0 | 80.3 | 62.5 | 58.2 | 55.4 |
| | ST-02 | 2,940 | 61.9 | 51.4 | 84.4 | 62.8 | 57.6 | 55.2 |

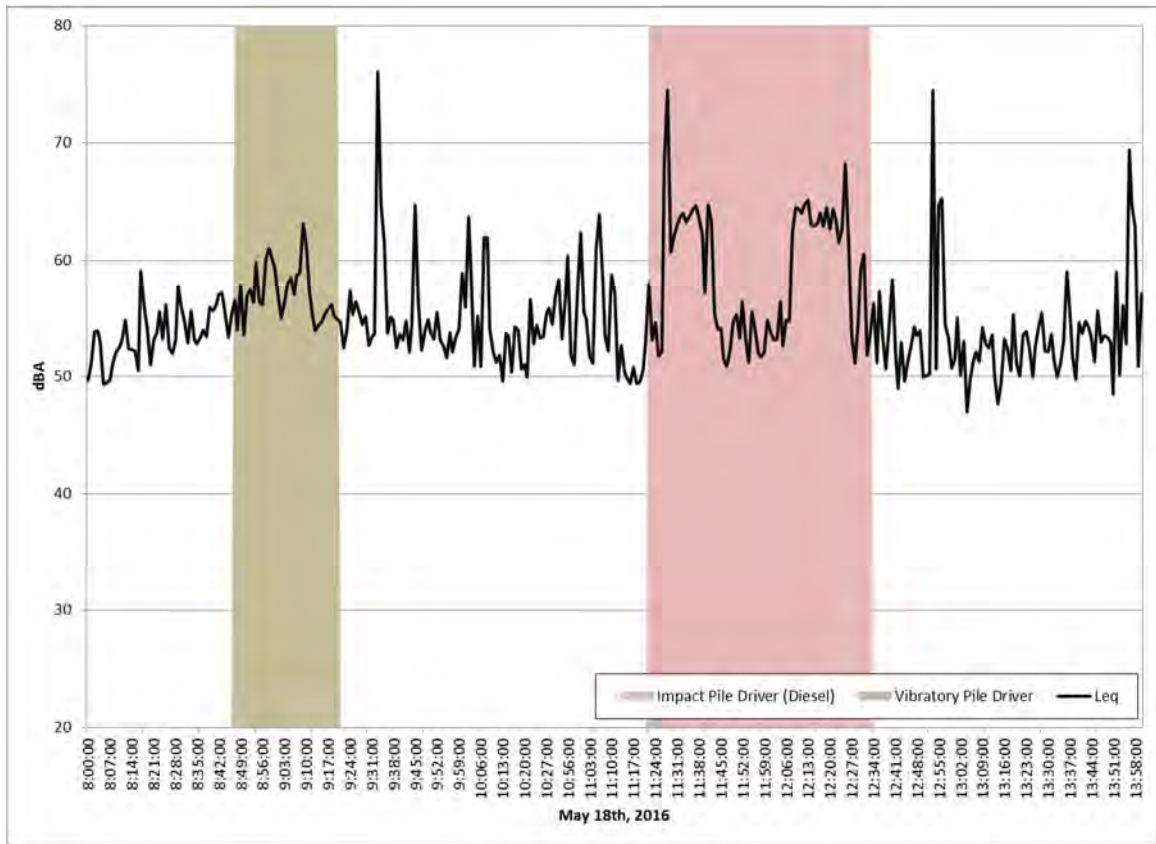


Figure 23. Pile 5 Time-history at the Government Hill Long-term Monitor (LT-01)

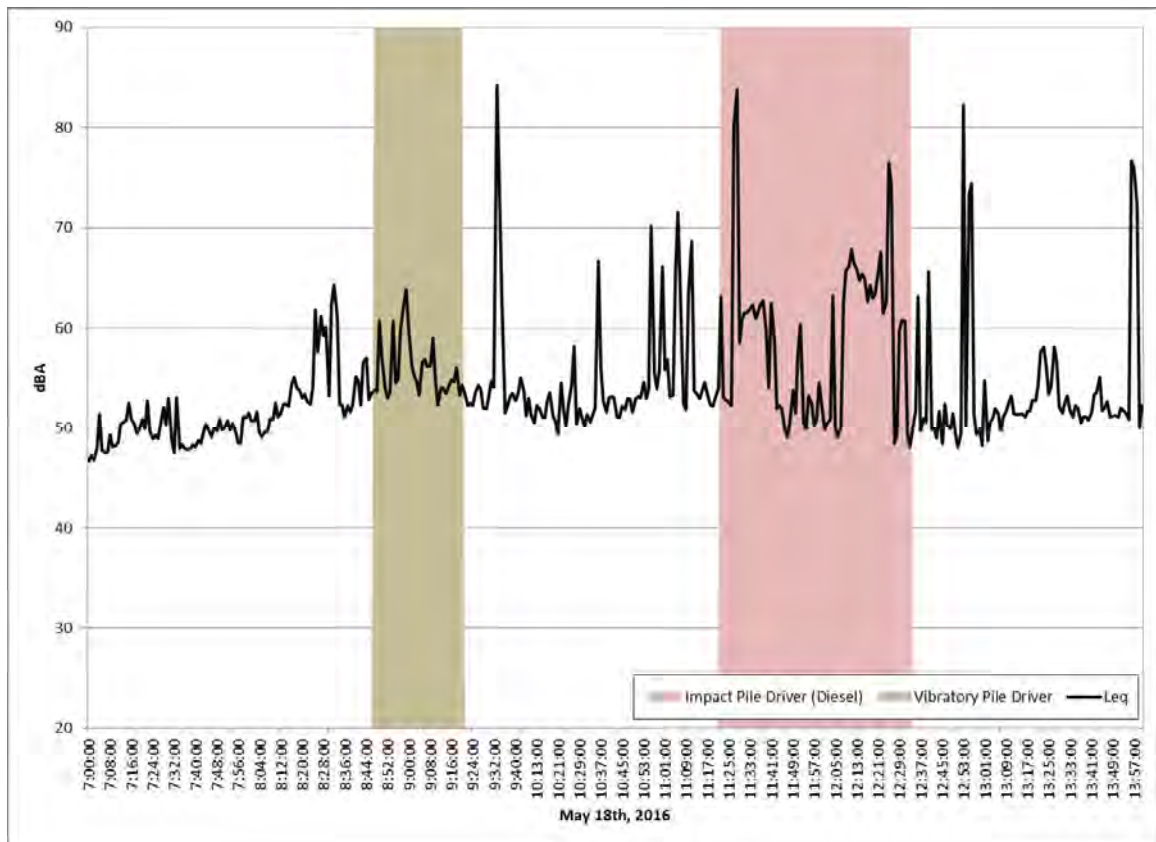


Figure 24. Pile 5 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.5 Pile Location 2

Test pile location 2 was set in the pile template and driven to depth via vibratory and diesel impact pile drivers on May 19, 2016. Figure 25 depicts the measurement locations for this pile. The meteorological conditions during the survey were a temperature of 51°F, wind speeds of 2 mph, humidity of 75 percent, and no precipitation.

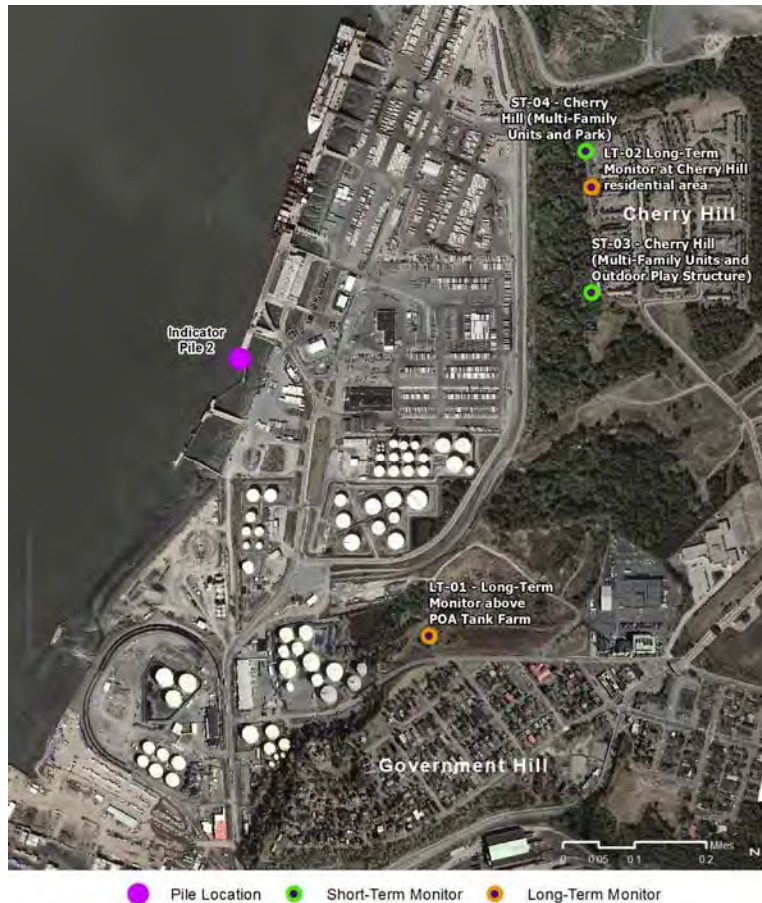


Figure 25. Pile 2 Measurement Locations

Table 6 provides a summary of measured sound levels from Pile 2 for the pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 26 and Figure 27 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. When logarithmically averaged over the entire pile-driving period, they do not exceed 80 dBA L_{eq} (hourly).

Table 6. Pile 2 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L_{eq} | L_{min} | L_{max} | L_{10} | L_{50} | L_{90} |
|------------------|---------------------|-------------------------|----------|-----------|-----------|----------|----------|----------|
| Vibratory | LT-01 | 2,481 | 56.4 | 46.5 | 73.9 | 59.5 | 54.0 | 49.8 |
| | LT-02 | 2,844 | 58.3 | 43.4 | 82.4 | 59.5 | 51.2 | 46.3 |
| | ST-03 | 2,642 | 57.8 | 43.0 | 82.0 | 55.9 | 52.5 | 49.7 |
| | ST-04 | 2,976 | 60.5 | 41.8 | 85.2 | 54.7 | 50.7 | 48.5 |
| Impact (diesel) | LT-01 | 2,481 | 61.5 | 46.7 | 89.7 | 64.4 | 54.4 | 50.9 |
| | LT-02 | 2,844 | 67.1 | 45.1 | 94.8 | 67.3 | 53.9 | 48.8 |
| | ST-03 | 2,642 | 63.3 | 43.5 | 88.2 | 60.5 | 54.2 | 49.3 |
| | ST-04 | 2,976 | 67.0 | 42.5 | 94.0 | 61.2 | 54.7 | 50.0 |

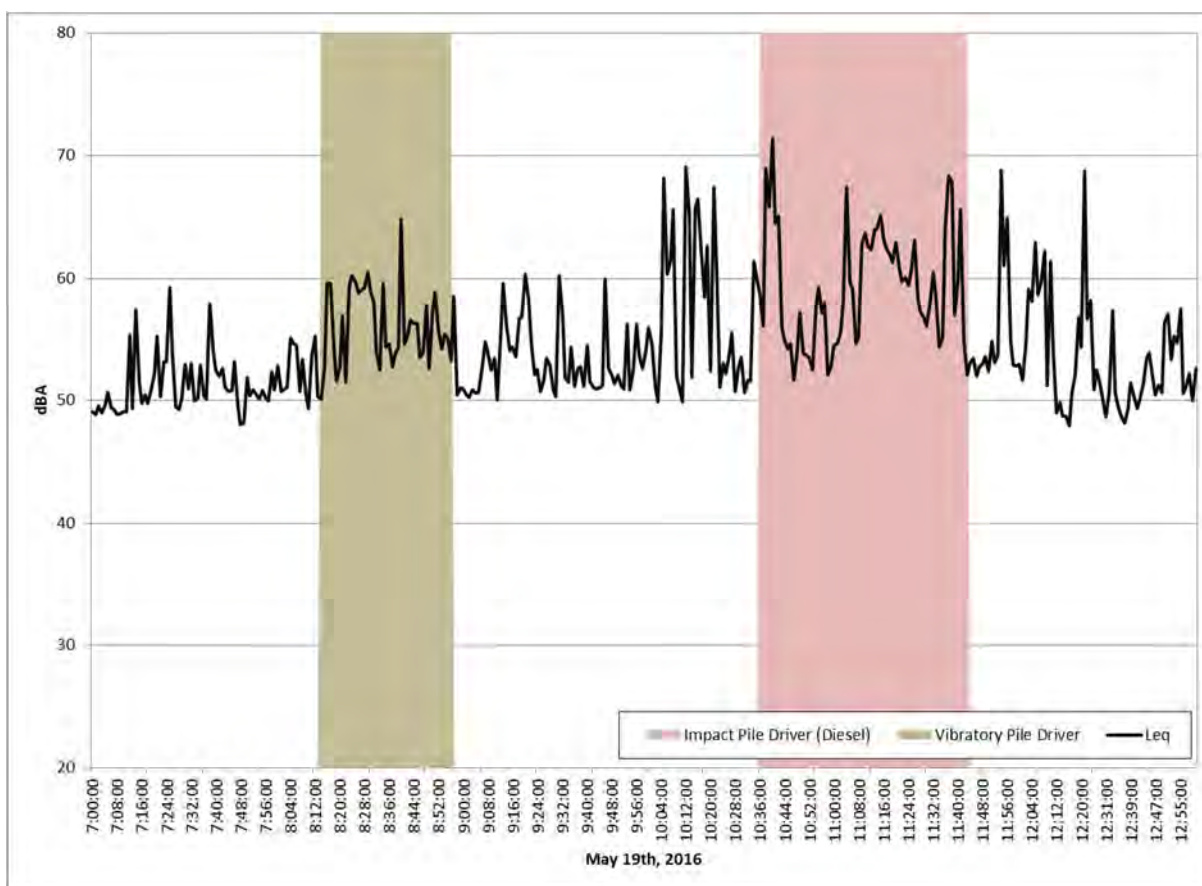


Figure 26. Pile 2 Time-history at the Government Hill Long-term Monitor (LT-01)

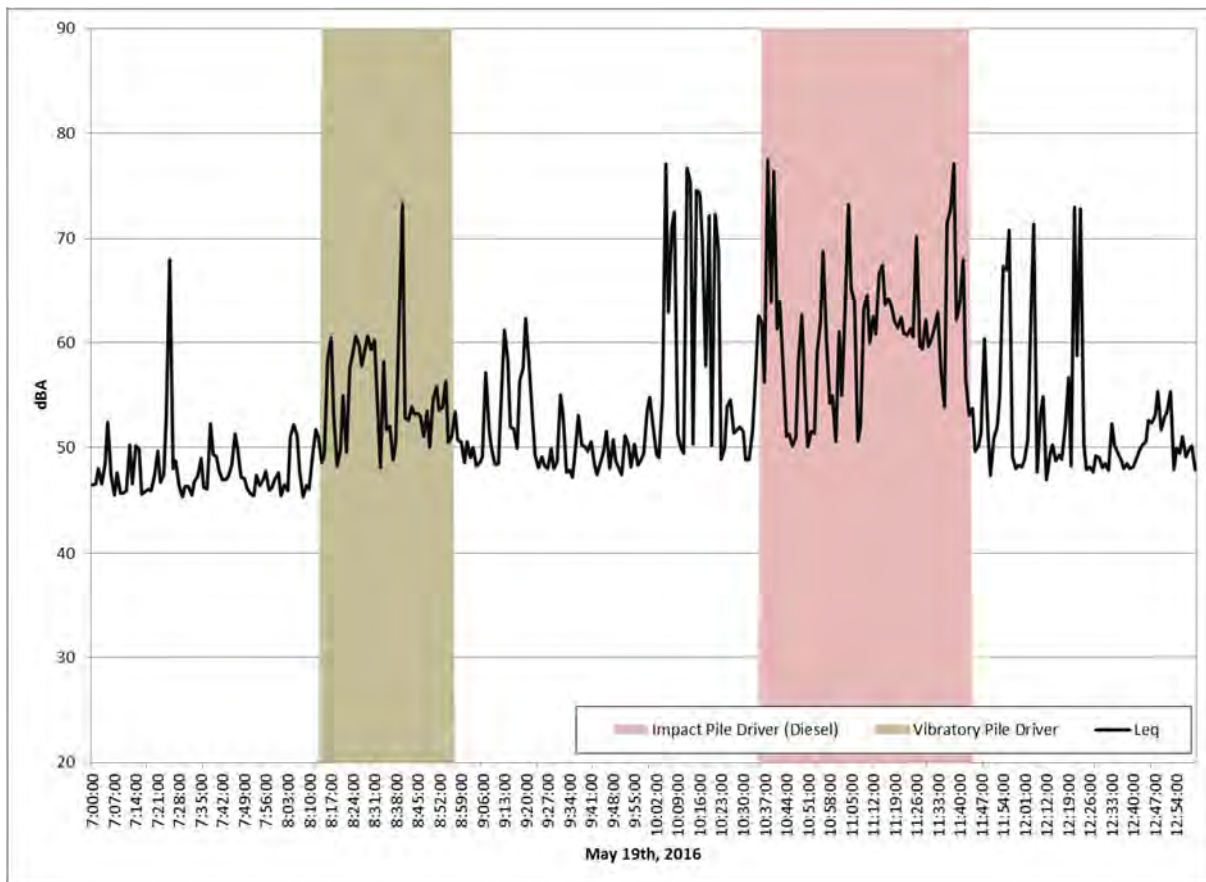


Figure 27. Pile 2 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.6 Pile Location 7

Test pile location 7 was set in the pile template and driven to depth via vibratory and diesel impact pile drivers on May 25, 2016. Figure 28 depicts the measurement locations for this pile. The meteorological conditions during the survey were a temperature of 57°F, wind speeds of 2 mph, humidity of 58 percent, and no precipitation.

Table 7 provides a summary of measured sound levels from Pile 7 for the pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 29 and Figure 30 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. At times, the 1-minute L_{eq} sound levels exceed 80 dBA; however, these are not considered exceedances of the MOA ordinance since they do not exceed 80 dBA L_{eq} (hourly) when logarithmically averaged over the entire pile-driving period.

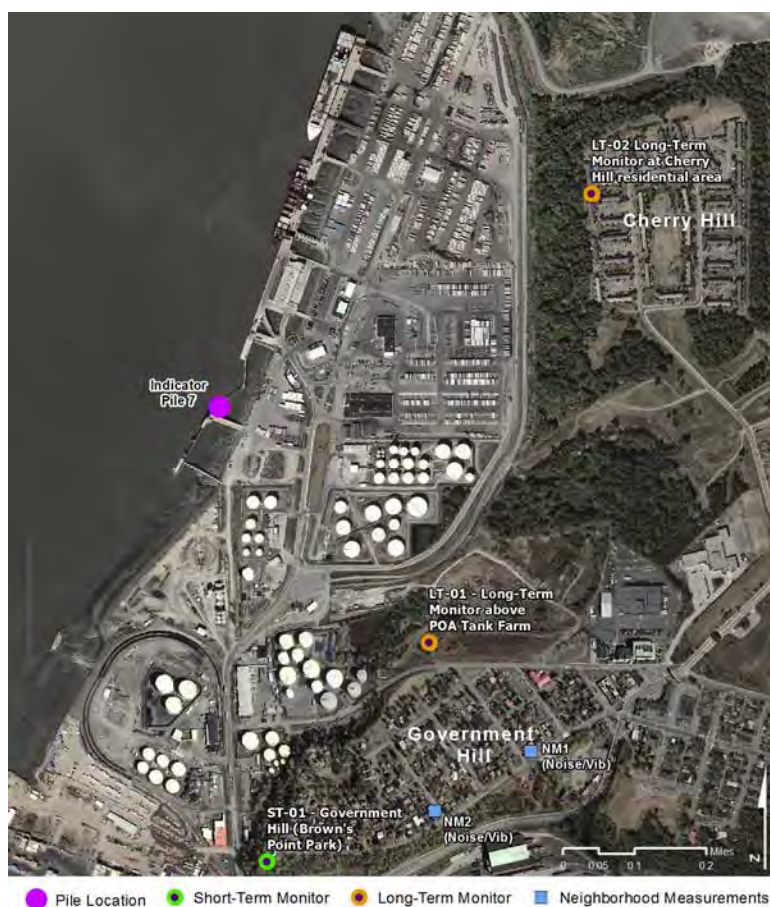


Figure 28. Pile 7 Measurement Locations

Table 7. Pile 7 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L _{eq} | L _{min} | L _{max} | L ₁₀ | L ₅₀ | L ₉₀ |
|------------------|---------------------|-------------------------|-----------------|------------------|------------------|-----------------|-----------------|-----------------|
| Vibratory | LT-01 | 2,327 | 58.1 | 46.1 | 78.8 | 60.5 | 54.3 | 50.2 |
| | LT-02 | 3,165 | 62.7 | 48.4 | 87.7 | 61.8 | 54.3 | 51.6 |
| Impact (diesel) | LT-01 | 2,327 | 65.5 | 44.3 | 94.5 | 63.3 | 53.4 | 48.7 |
| | LT-02 | 3,165 | 71.9 | 47.1 | 101.0 | 64.9 | 53.7 | 50.3 |
| | ST-01 | 3,374 | 63.3 | 49.0 | 90.8 | 61.6 | 57.5 | 54.3 |
| | NM01 | 3,425 | 68.1 | 40.5 | 92.4 | 63.9 | 47.6 | 43.6 |
| | NM02 | 3,376 | 50.8 | 41.6 | 67.1 | 52.7 | 46.9 | 44.3 |

Note: NM = Neighborhood Measurement

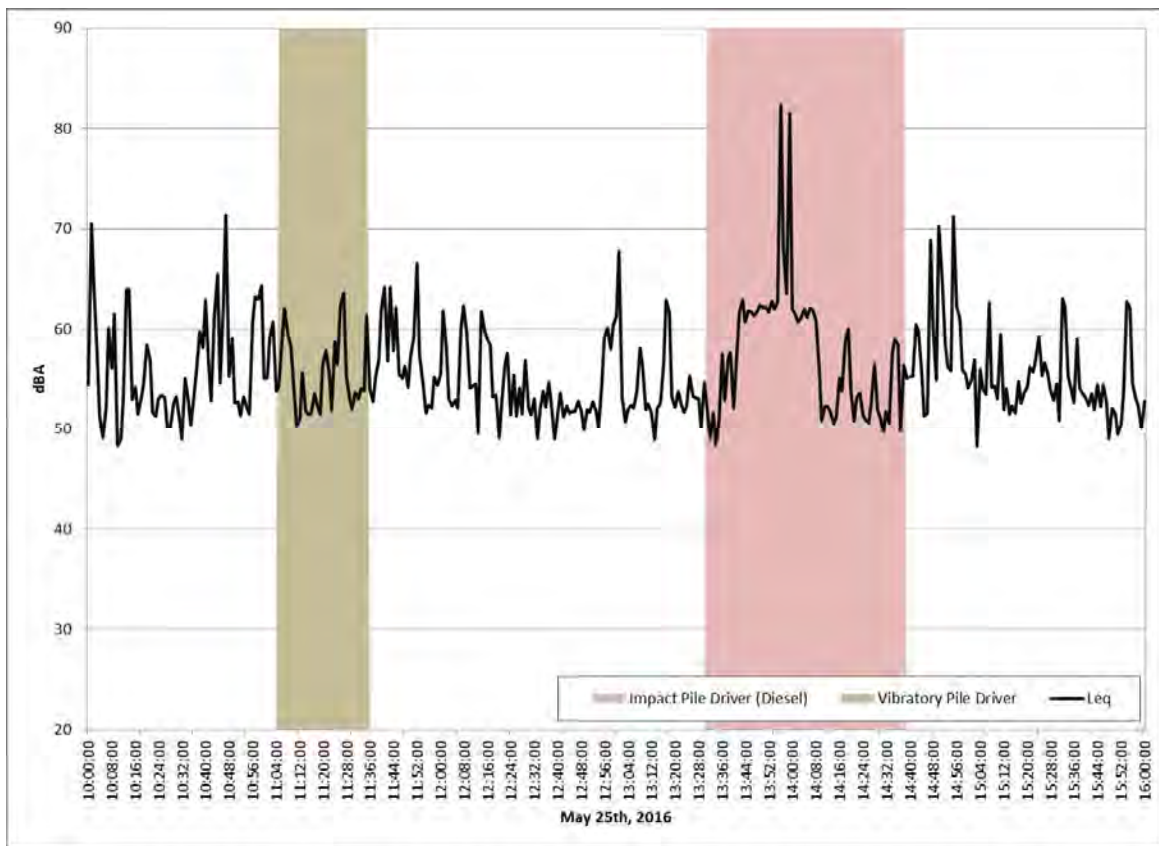


Figure 29. Pile 7 Time-history at the Government Hill Long-term Monitor (LT-01)

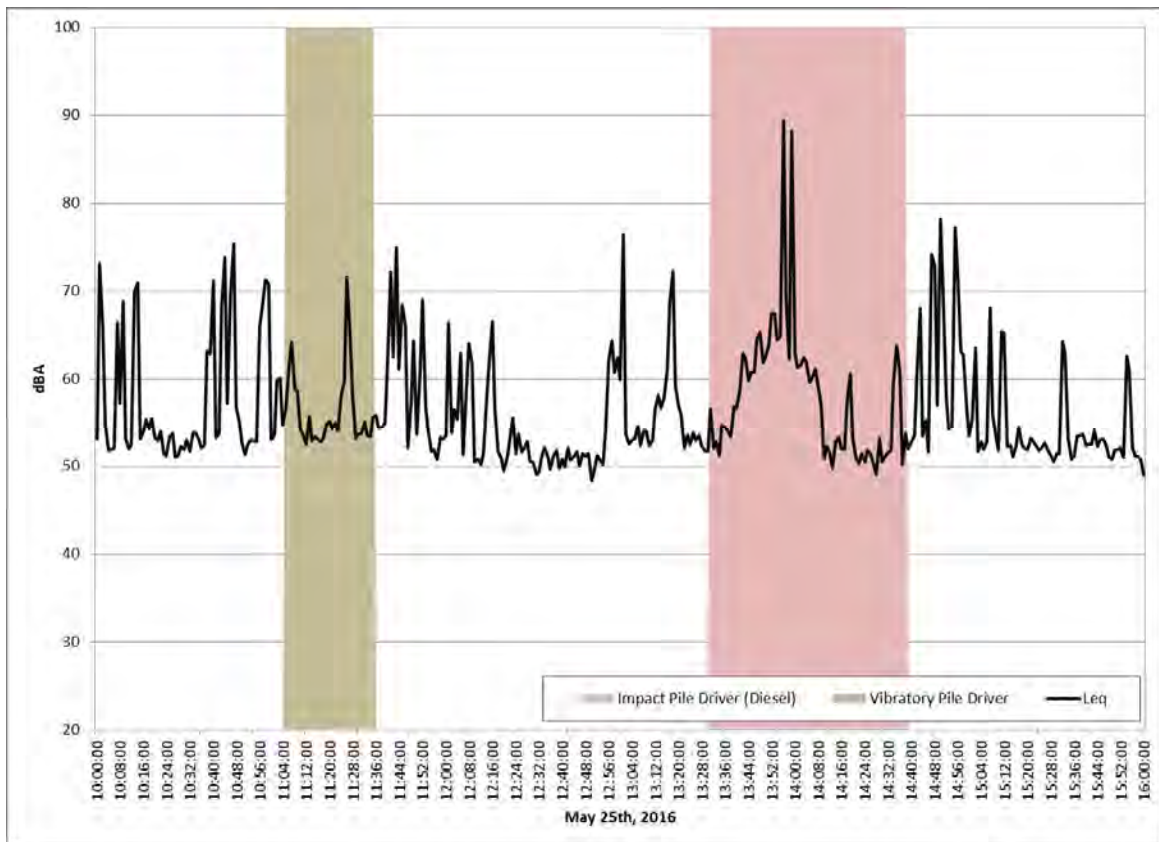


Figure 30. Pile 7 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.7 Pile Location 10

Test pile location 10 was set in the pile template and driven to depth via vibratory and hydraulic impact pile drivers on May 26, 2016. Figure 31 depicts the measurement locations for this pile. The meteorological conditions during the survey were a temperature of 61°F, wind speeds of 2 mph, humidity of 53 percent, and no precipitation.

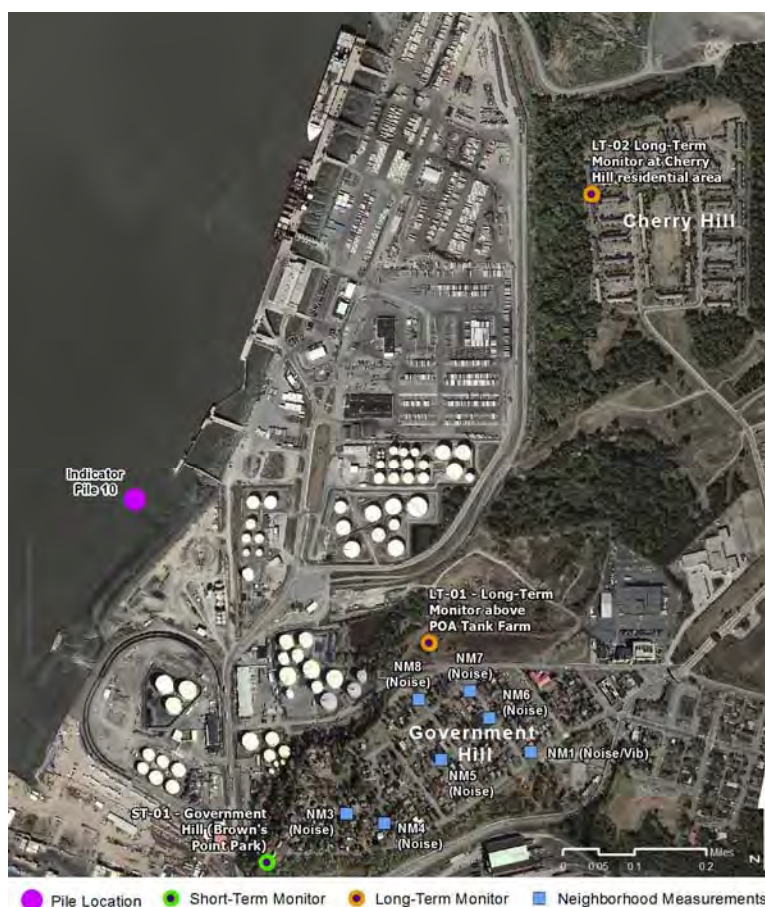


Figure 31. Pile 10 Measurement Locations

Table 8 provides a summary of measured sound levels from Pile 10 for both pile drivers used, and includes only data from when the pile driver was active. Short-term monitoring of vibratory pile driving was not conducted for Pile 10 or any pile driven thereafter because the initial results showed that sound levels from vibratory pile driving were well below the MOA limits. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. There were no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly) in the Government Hill or Cherry Hill neighborhood. Figure 32 and Figure 33 provide the time-history of the L_{eq} sound levels monitored at LT-1 and LT-2, respectively. The L_{eq} sound levels on these charts are 1-minute L_{eq} sound levels. When logarithmically averaged over the entire pile-driving period, they do not exceed 80 dBA L_{eq} (hourly).

Table 8. Pile 10 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L _{eq} | L _{min} | L _{max} | L ₁₀ | L ₅₀ | L ₉₀ |
|--------------------|---------------------|-------------------------|-----------------|------------------|------------------|-----------------|-----------------|-----------------|
| Vibratory | LT-01 | 2,411 | 65.1 | 47.6 | 84.3 | 68.6 | 54.3 | 50.6 |
| | LT-02 | 4,056 | 65.7 | 43.4 | 90.3 | 67.4 | 51.4 | 47.1 |
| Impact (hydraulic) | LT-01 | 2,411 | 57.1 | 44.6 | 75.3 | 61.4 | 53.5 | 49.2 |
| | LT-02 | 4,056 | 60.5 | 45.2 | 84.4 | 62.7 | 52.9 | 49.4 |
| | ST-01 | 2,844 | 61.0 | 48.5 | 79.6 | 63.5 | 57.2 | 54.0 |
| | NM01 | 3,460 | 50.6 | 42.2 | 73.5 | 52.1 | 47.1 | 44.7 |
| | NM01 (indoor) | 3,460 | 37.3 | 21.9 | 59.8 | 38.8 | 28.4 | 23.6 |
| | NM03 | 2,788 | 55.3 | 42.6 | 64.4 | 60.4 | 49.9 | 45.2 |
| | NM04 | 3,008 | 55.6 | 40.6 | 68.1 | 58.9 | 50.2 | 43.3 |
| | NM05 | 2,962 | 48.4 | 37.3 | 62.8 | 52.1 | 44.7 | 40.4 |
| | NM06 | 3,068 | 56.7 | 38.3 | 74.9 | 57.6 | 47.4 | 41.6 |
| | NM07 | 2,844 | 49.6 | 37.8 | 63.5 | 53.4 | 45.7 | 40.3 |
| | NM08 | 2,559 | 55.0 | 43.3 | 68.3 | 59.4 | 50.6 | 46.0 |

Note: NM = Neighborhood Measurement

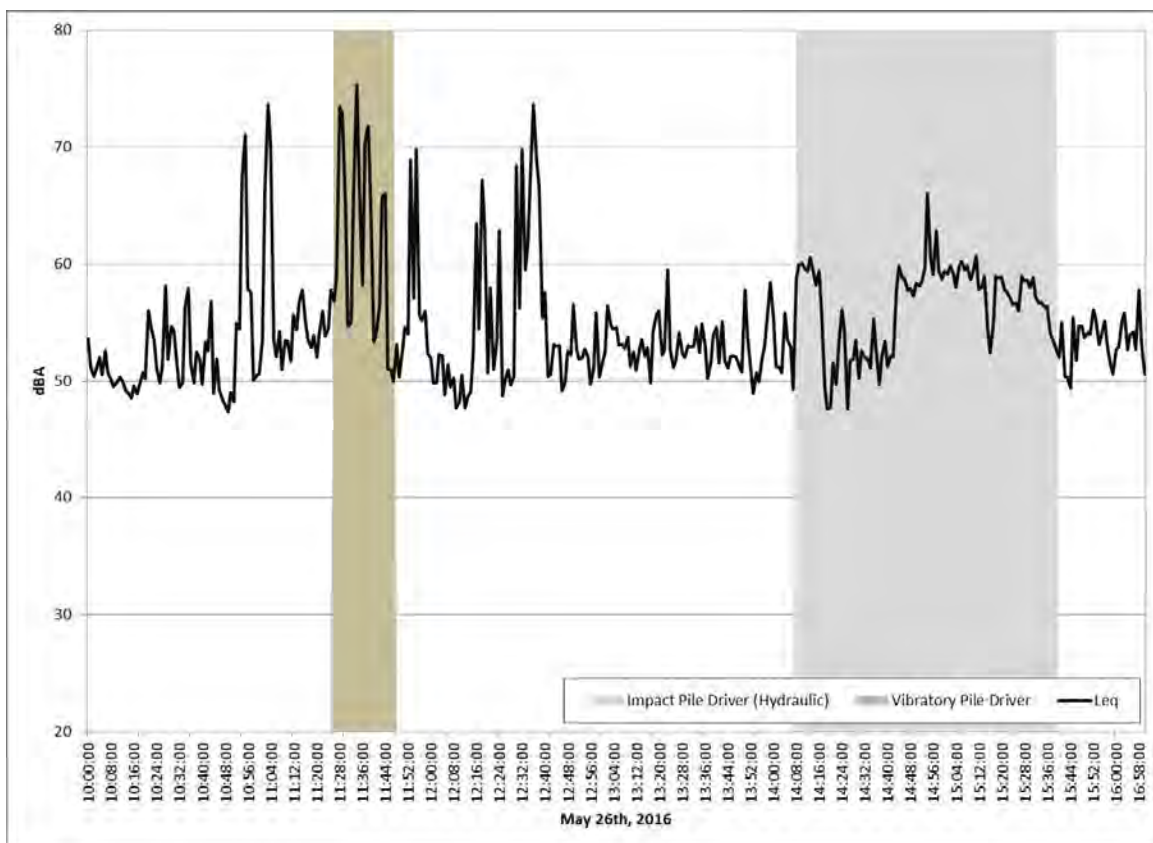


Figure 32. Pile 10 Time-history at the Government Hill Long-term Monitor (LT-01)

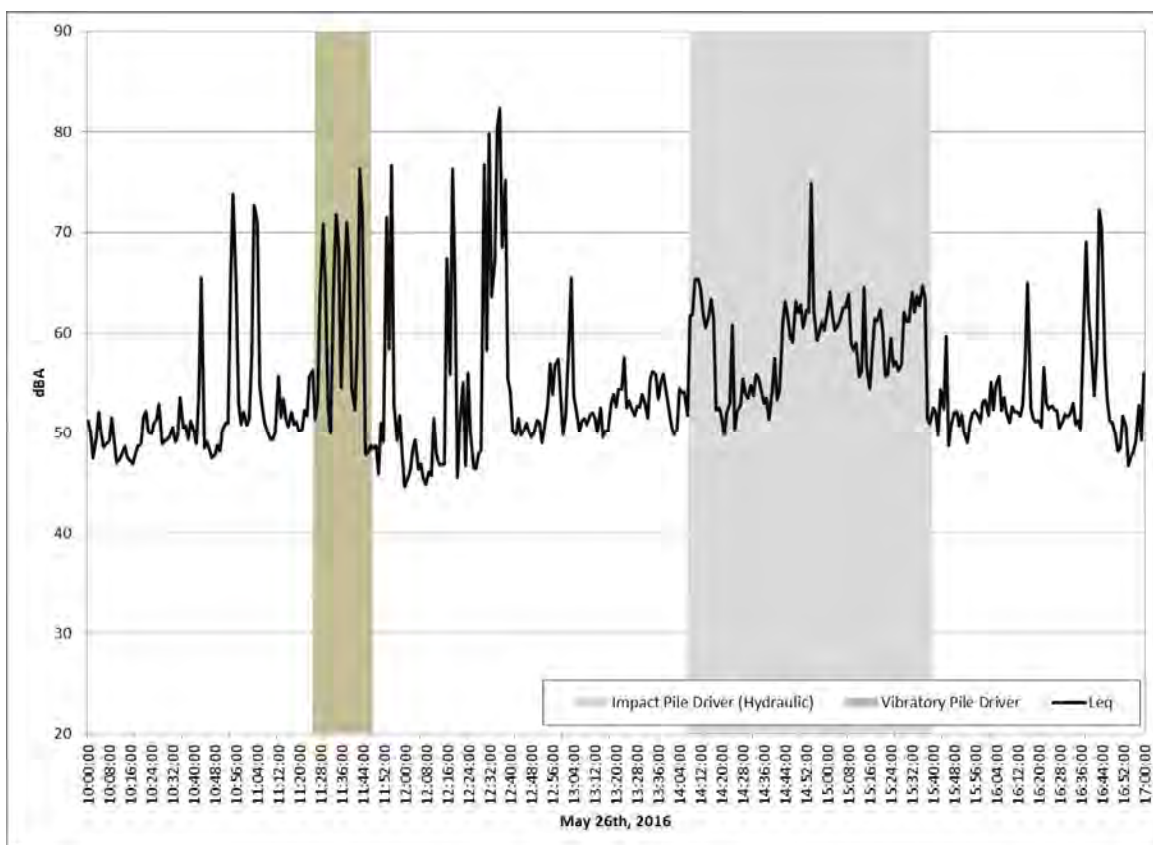


Figure 33. Pile 10 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.8 Pile Location 6

Test pile location 6 was set in the pile template and driven to depth via vibratory and diesel impact pile drivers on June 1, 2016. Figure 34 depicts the measurement location for this pile. The meteorological conditions during the survey were a temperature of 56°F, wind speeds of 2 mph, humidity of 61 percent, and no precipitation.

Table 9 provides a summary of measured sound levels from Pile 6 for the pile drivers used, and includes only data from when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. Due to a power failure at LT-01, no vibratory or impact pile-driving noise data were collected at the station. There were no monitored exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly). Figure 35 provides the time-history of the L_{eq} sound levels monitored at LT-02. The L_{eq} sound levels on this chart are 1-minute L_{eq} sound levels. At times, the 1-minute L_{eq} sound levels exceed 80 dBA; however, these are not considered exceedances of the MOA ordinance since they do not exceed 80 dBA L_{eq} (hourly) when logarithmically averaged over the entire pile-driving period.

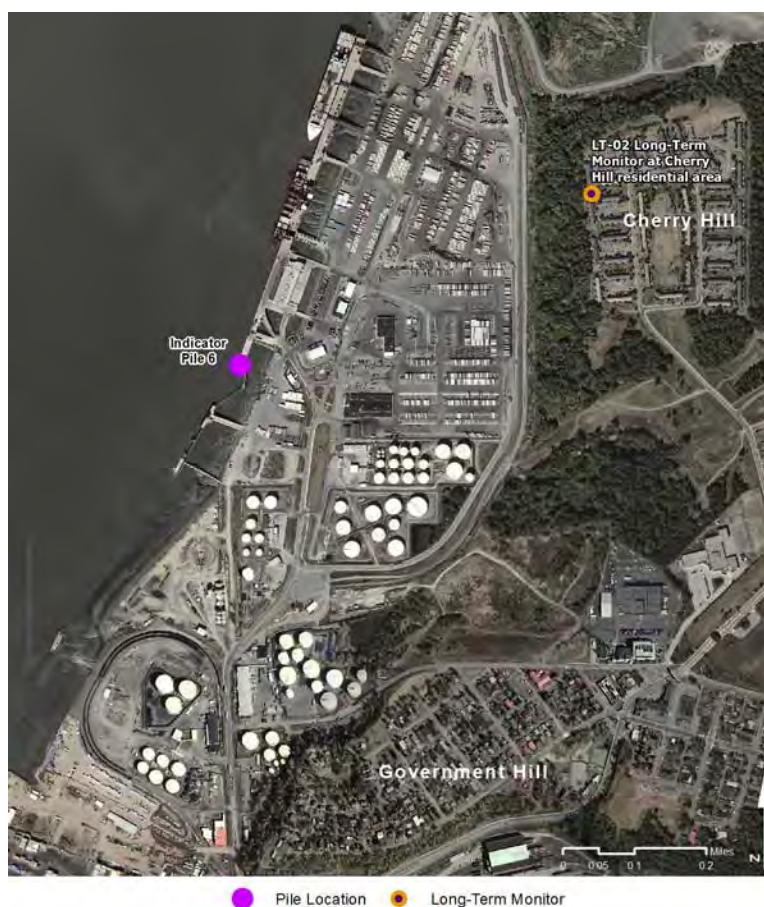


Figure 34. Pile 6 Measurement Locations

Table 9. Pile 6 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L _{eq} | L _{min} | L _{max} | L ₁₀ | L ₅₀ | L ₉₀ |
|------------------|---------------------|-------------------------|-----------------|------------------|------------------|-----------------|-----------------|-----------------|
| Vibratory | LT-02 | 2,844 | 52.1 | 40.8 | 70.6 | 53.8 | 48.8 | 45.3 |
| Impact (diesel) | LT-02 | 2,844 | 71.2 | 45.7 | 100.6 | 68.0 | 53.7 | 49.2 |

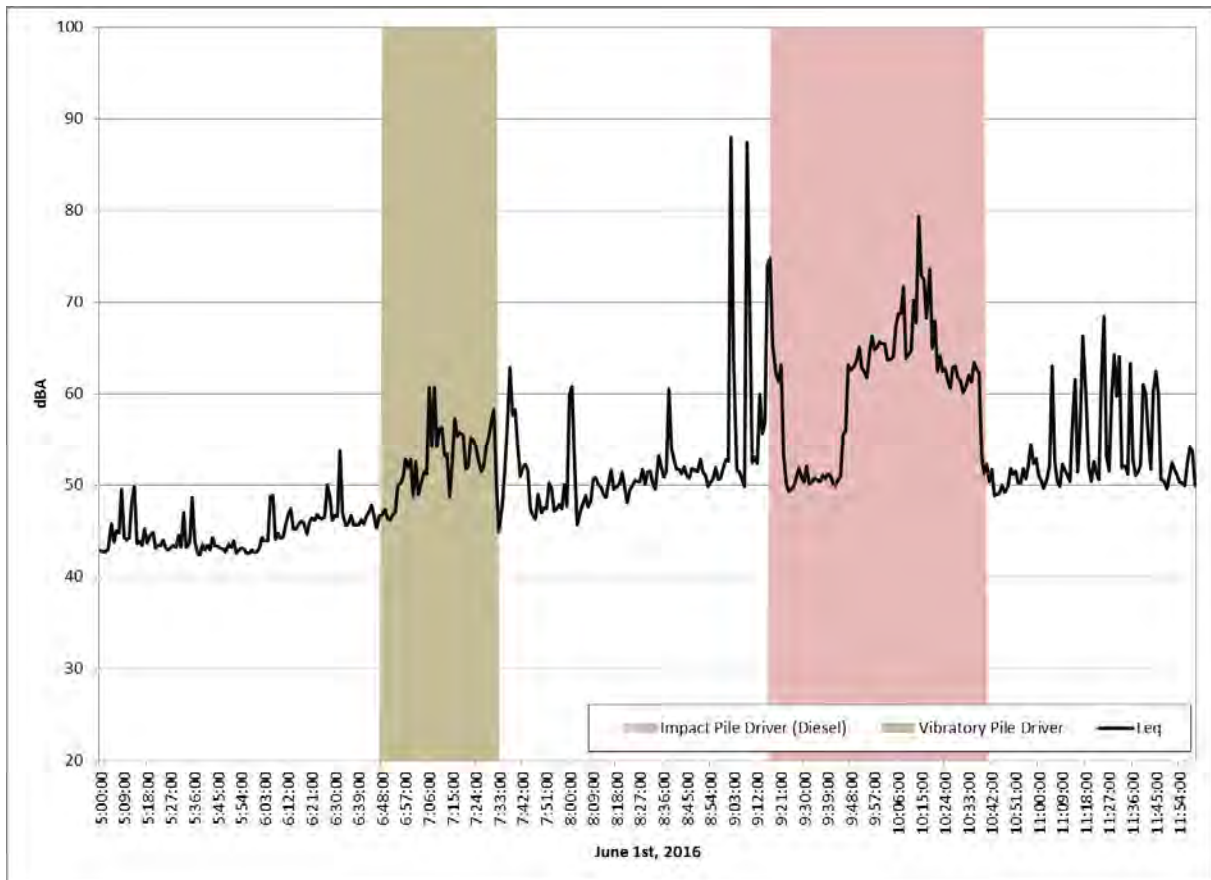


Figure 35. Pile 6 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.9 Pile Location 3

Test pile location 3 was set in the pile template and driven to depth via vibratory and hydraulic impact pile drivers on June 3, 2016. Figure 36 depicts the measurement location for this pile. The meteorological conditions during the survey were a temperature of 59°F, wind speeds of 2 mph, humidity of 60 percent, and no precipitation.

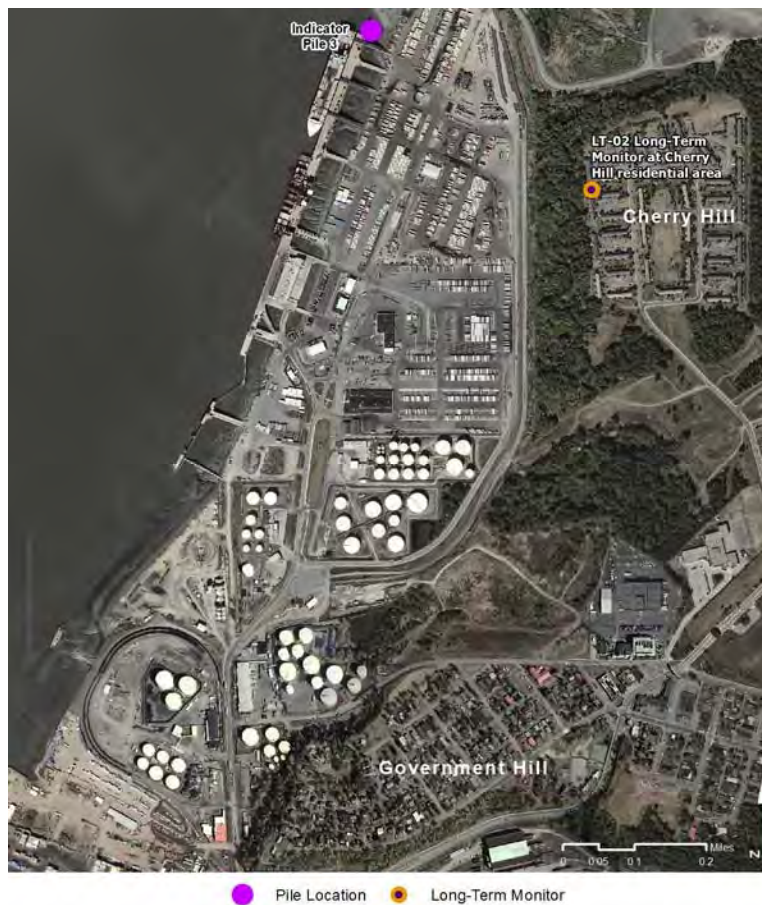


Figure 36. Pile 3 Measurement Location

Table 10 provides a summary of measured sound levels from Pile 3 for the pile drivers used, and includes only data when the pile driver was active. The vibration pile-driving effort took approximately 30 minutes, and the impact pile driving took approximately 1 hour. There were some intermittent breaks in each of these efforts (5–10 minutes) when the pile driver was adjusted by the contractor. Due to a power failure at LT-01, no vibratory or impact pile-driving noise was collected at the station. There were monitored no exceedances of the MOA construction noise limit of 80 dBA L_{eq} (hourly). Figure 37 provides the time-history of the L_{eq} sound levels monitored at LT-02. The L_{eq} sound levels on this chart are 1-minute L_{eq} sound levels. When logarithmically averaged over the entire pile-driving period, they do not exceed 80 dBA L_{eq} (hourly).

Table 10. Pile 3 Sound Levels

| Pile Driver Type | Monitoring Location | Distance to Pile (feet) | L_{eq} | L_{min} | L_{max} | L_{10} | L_{50} | L_{90} |
|--------------------|---------------------|-------------------------|----------|-----------|-----------|----------|----------|----------|
| Vibratory | LT-02 | 2,844 | 58.0 | 43.7 | 82.2 | 57.8 | 50.9 | 48.2 |
| Impact (hydraulic) | LT-02 | 2,844 | 66.5 | 46.2 | 97.5 | 63.9 | 53.6 | 50.1 |

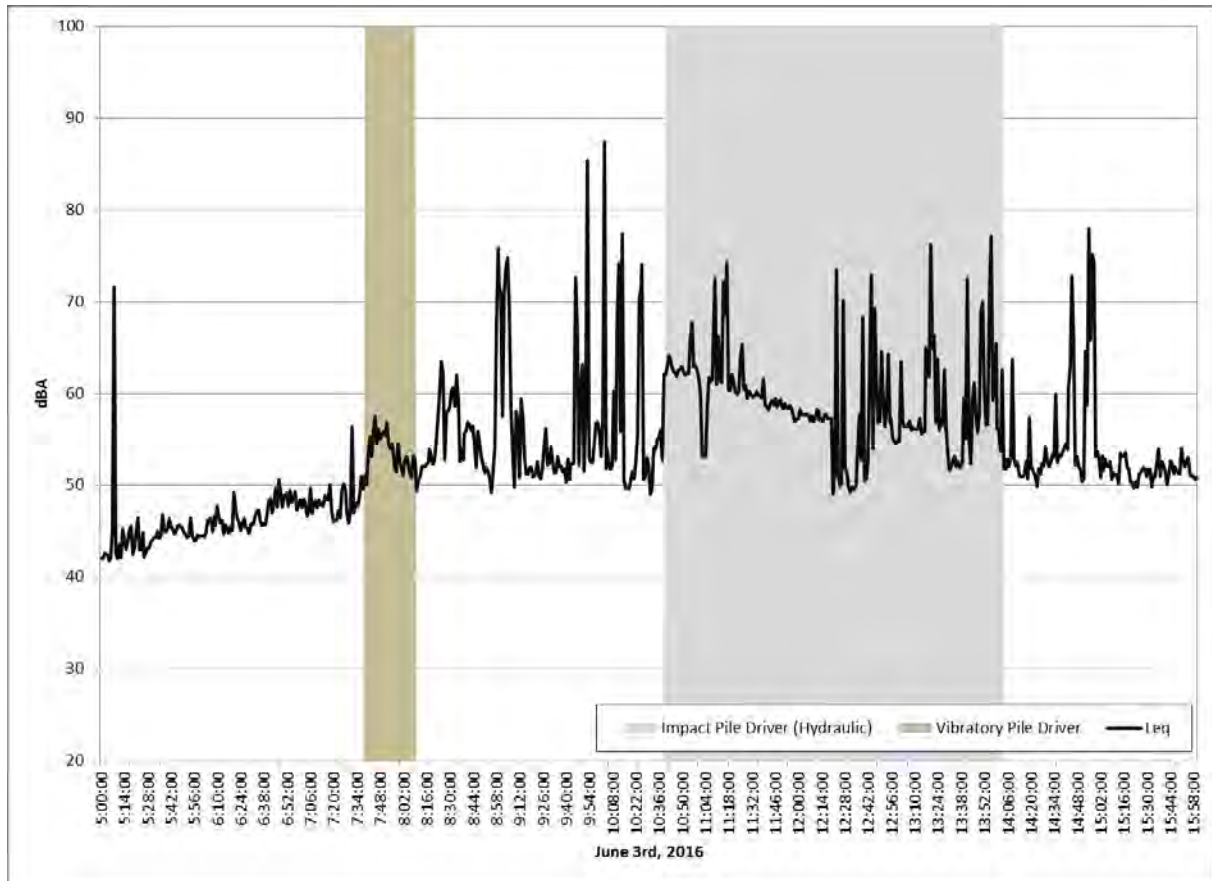


Figure 37. Pile 3 Time-history at the Cherry Hill Long-term Monitor (LT-02)

3.3.10 Discussion

Sound levels for the pile-driving effort were sometimes higher than the daytime baseline sound levels and sometimes they were lower. There are several reasons for this, including that the contribution of pile-driving noise to an already relatively elevated acoustic environment results in higher sound levels, generally in the range of 1–3 dBA over baseline. However, sometimes sound levels were lower than the daytime baseline. This generally is related to the absence of other sound sources such as aircraft overhead, railroad activity, and busier roadway traffic time periods such as rush hour or heavy truck traffic, or loading and/or unloading ships docked at the POA.

Meteorological conditions can affect how sound propagates with distance; however, meteorological conditions during the pile driving effort were relatively consistent, specifically:

- Temperatures ranged from 46 to 65°F;
- Average wind speeds ranged from 1 to 3 mph;
- No precipitation; and
- Relative humidity ranged from 45 to 77 percent.

These meteorological conditions did not greatly affect propagation of pile driving noise because they were not substantially different from one another. For example, higher wind speeds of approximately 10 mph did not persist during pile driving, which may have acted to aid in the propagation of sound over distance. Similarly there were no temperature inversions that could affect propagation of pile driving

noise over distance. For comparison purposes, monitored daytime meteorological conditions when pile driving did not occur included:

- Temperatures ranging from 40 to 69°F;
- Average wind speeds ranging from 0 to 6 mph;
- Zero to 1 inch of precipitation; and
- Relative humidity ranging from 21 to 93 percent.

Nevertheless, the following general conclusions have been identified via the monitoring data:

- Pile-driving noise levels were within the range of monitored baseline sound levels, which indicates that pile-driving noise was similar to levels that already exist in the neighborhoods from sources such as aircraft overhead, roadway traffic, rail operations, and noise from other POA activity.
- Vibratory pile driving was found by field technicians to be mostly inaudible over baseline sound levels in either neighborhood.
- Impact pile driving was readily audible during either diesel impact pile driving or during hydraulic impact pile driving; however, hydraulic impact pile-driving noise levels were loudest.
- Low-frequency noise (e.g., below 200 Hz) was most pronounced when piles were driven using the hydraulic impact pile driver followed by the diesel impact pile driver.

The low-frequency content of impact pile driving represents the biggest difference relative to daytime baseline sound levels. Figure 38 and Figure 39 are spectral charts of octave-band monitoring data for each of the pile drivers used, compared to the daytime baseline levels collected at LT-01 and LT-02. Included on these charts is the threshold of human hearing by octave band. The hydraulic impact pile driver was the noisiest pile driver used in the TPP and was consistently above the daytime baseline from 12.5 Hz to 2,000 Hz. Data indicated that the diesel impact pile driver noise was very similar to baseline sound levels, which matches what was experienced by field technicians. Vibratory pile drivers were almost the same as baseline sound levels at LT-02; however, at LT-01 it appears that there was more low-frequency content from the vibratory pile-driving effort. In a review of field notes and recordings of other sound sources, such as tank farm construction within the POA, these are the likely cause of the elevated low-frequency content during vibratory pile driving at LT-01.

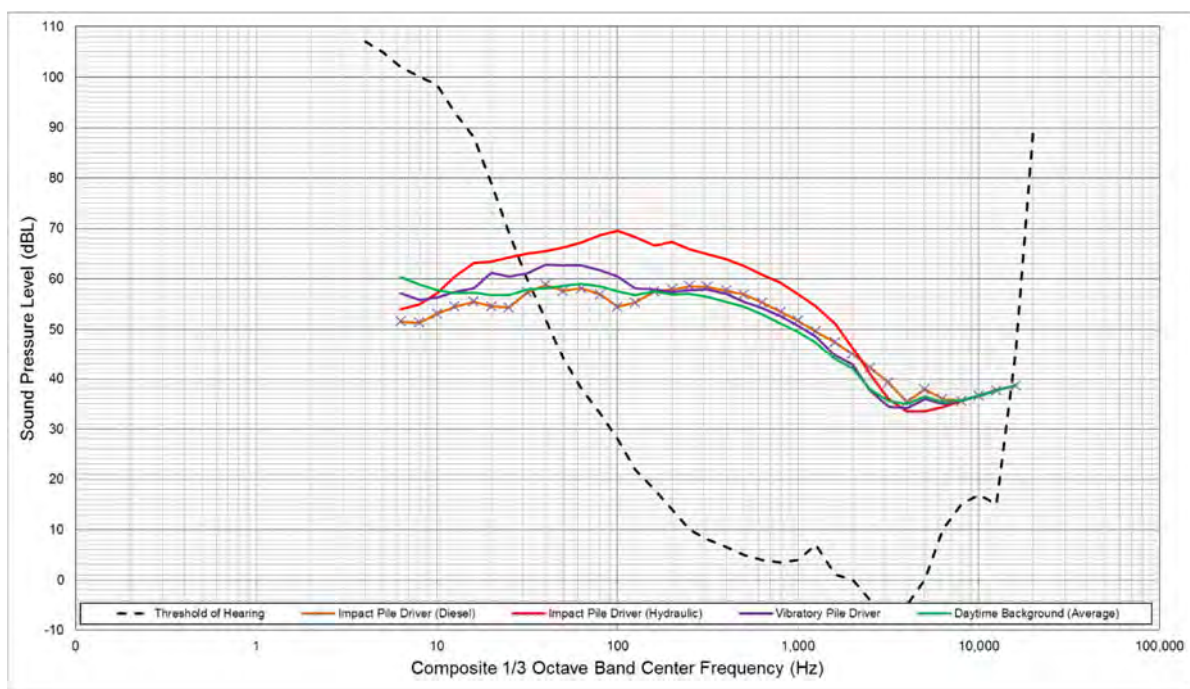


Figure 38. Monitored Spectral Sound Levels at Government Hill Long-term Monitor (LT-01)

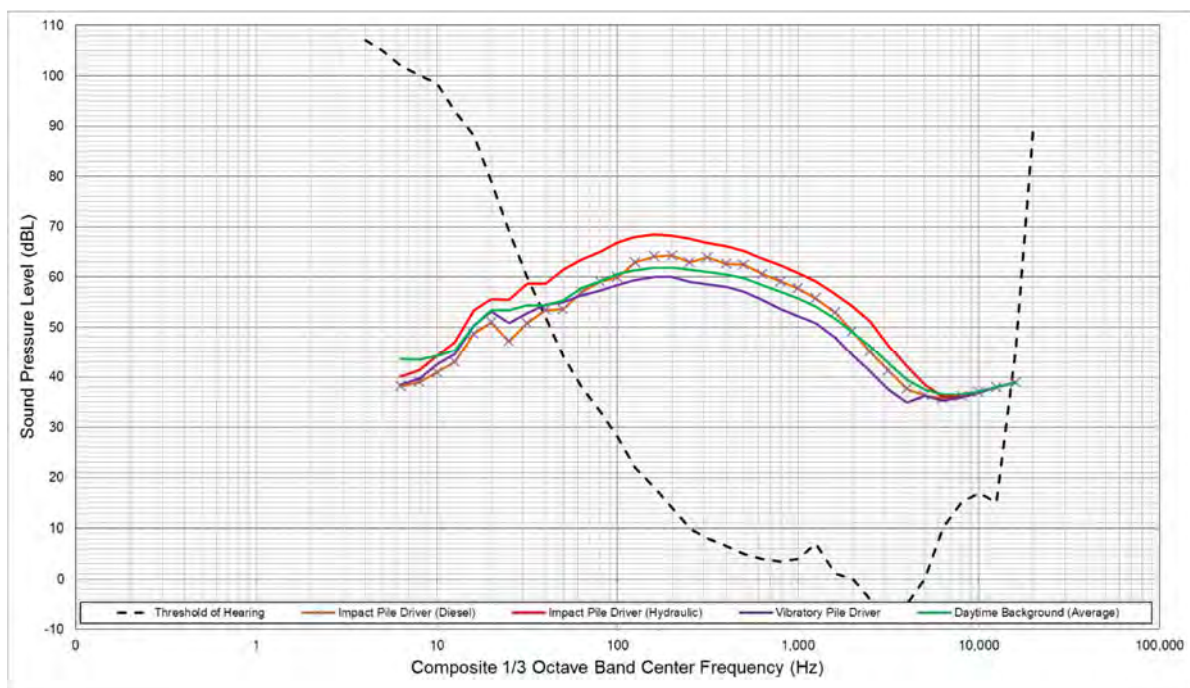


Figure 39. Monitored Spectral Sound Levels at Cherry Hill Long-term Monitor (LT-02)

3.4 Noise Measurements (Port of Anchorage Tenants)

Four pile-driving test sites were evaluated (Indicator Piles 4, 5, 7, and 8), as shown on Figure 8. Because pile driving took place on a barge and this assessment was for shore-based activities, no measurements were collected at the source. The intent was to characterize potentially hazardous noise exposures to shore-based workers and work activities on the POA property. Due to scheduling conflicts, sound levels during pile-driving operations at Pile 8 were not measured.

Baseline, outdoor sound level readings ranged from 58.2 to 73 dBA L_{eq} . This wide range is due to the presence of other noise-producing equipment in the area such as loaders, vehicles, and aircraft. Measurements collected during vibratory hammer operations fell within the baseline noise range, and, as such, vibratory operations were determined to not present a hazardous noise risk. Levels from the pile drivers (both hydraulic and diesel) ranged from 90.5 dBA at the shoreline to baseline levels at distances exceeding 500 feet from the driver. Table 11 summarizes pile-driving noise levels and baseline sound levels collected during this assessment.

Laboratory calibration sheets are included in Appendix A.

Table 11. Summary of In-air Noise Measurements (POA Tenants)

| Date | Indicator Test Pile No. | Location * | Baseline/ Vibratory Drilling/ Impact (hammer) Driving | Level (dBA L_{eq}) | Additional Noise Sources |
|-------|-------------------------|----------------------------------|--|-----------------------|--|
| 05/03 | 8 | A – 150 feet (shoreline) | Baseline | 63.0 | Waves, barge crane noise |
| 05/03 | 8 | B – 275 feet pad | Baseline | 62.7 | Barge crane noise |
| 05/03 | 8 | A – 150 feet (shoreline) | Vibratory | 70.7 | Loader (70 feet away), barge crane noise |
| 05/03 | 8 | B – 275 feet pad | Vibratory | 67.7 | Loader (20 feet away), barge crane noise |
| 05/12 | 4 | C – 200 feet (shoreline) | Baseline | 66.5 | |
| 05/12 | 4 | D – 500 feet | Baseline | 67.0 | Refrigeration truck |
| 05/12 | 4 | E – TOTE building | Baseline | 72.1 | |
| 05/12 | 4 | C – 200 feet (shoreline) | Hydraulic hammer | 90.5 | |
| 05/12 | 4 | D – 500 feet | Hydraulic hammer | 84.2 | Refrigeration truck |
| 05/12 | 4 | E – TOTE building | Hydraulic hammer | 76.5 | Vehicle traffic |
| 05/12 | 4 | F – POA mechanic shop | Hydraulic hammer | 79.3 | Vehicle traffic |
| 05/12 | 4 | G – TOTE mechanic shop | Hydraulic hammer | 77.0 | Vehicle traffic |
| 05/12 | 4 | H – 400 feet (Trestle 3) | Hydraulic hammer | 85.1 | |
| 05/12 | 4 | I – POA headquarters | Hydraulic hammer | 63.4 | |
| 05/12 | n/a | I – POA headquarters | Baseline | 68 | C-130 taxiing |
| 05/18 | 5 | J – 175 feet (shoreline) | Baseline | 64.8 | Barge crane noise |
| 05/18 | 5 | K – 350 feet | Baseline | 67.0 | Barge crane noise |
| 05/18 | 5 | L – 200 feet (equipment trailer) | Baseline | 73.0 | Barge crane noise |
| 05/18 | 5 | M – 300 feet Intertek office | Baseline | 68.4 | Barge crane noise, running truck |
| 05/18 | 5 | J – 175 feet (shoreline) | Diesel hammer | 90.1 | Barge crane noise |
| 05/18 | 5 | K – 350 feet | Diesel hammer | 85.7 | Barge crane noise |

| Date | Indicator Test Pile No. | Location * | Baseline/ Vibratory Drilling/ Impact (hammer) Driving | Level (dBA L _{eq}) | Additional Noise Sources |
|-------|-------------------------|---|--|------------------------------|--------------------------|
| 05/18 | 5 | L – 200 feet (equipment trailer) | Diesel hammer | 88.4 | Barge crane noise |
| 05/18 | 5 | M – 300 feet Intertek office | Diesel hammer | 87.8 | Barge crane noise |
| 05/18 | 5 | M – 300 feet Intertek office (interior) | Diesel hammer | 48.7 | |
| 05/25 | 7 | N – 150 feet (shoreline) | Diesel hammer | 65.4 | Barge crane noise |
| 05/25 | 7 | O – 300 feet | Baseline | 58.2 | Barge crane noise |
| 05/25 | 7 | P – dredging trailer - exterior | Baseline | 58.2 | |
| 05/25 | 7 | P – dredging trailer - exterior | Baseline | 40.0 | |
| 05/25 | 7 | N – 150 feet (shoreline) | Baseline | 90.2 | Barge crane noise |
| 05/25 | 7 | O – 300 feet | Diesel hammer | 84.7 | Barge crane noise |
| 05/25 | 7 | P – dredging trailer - exterior | Diesel hammer | 85.6 | |
| 05/25 | 7 | P – dredging trailer - exterior | Diesel hammer | 39.6 | |

* Location identifiers shown on Figure 8.

Note: TOTE = TOTE Maritime (formerly Totem Ocean Trailer Express).

Three potential areas of concern for POA tenants and workers were evaluated through this assessment: impact noise, exposure of POA workers to noise, and potential effects of repetitive noise on POA personnel.

Impact noise: The maximum impact noise generated by the pile-driving operations was identified as 90.5 dBA L_{eq}. This measurement was collected at the shoreline, which is the closest POA personnel can get to the noise source—the pile-driving barge.

Noise levels collected inside facilities near the pile-driving test locations do not indicate any exposures of concern. Existing structures and facilities abate any potential hazardous noise well below any regulatory or nuisance level. Note that nuisance levels are subjective and can vary greatly from one person to another, but generally are those sound levels that annoy the public or are found to be disruptive.

3.5 Short-term Ground-borne Vibration Measurements

Ground vibration measurements were collected to identify whether ground vibration from pile-driving activities could damage structures or be perceived in the Government Hill and Cherry Hill neighborhoods. For Indicator Piles 5, 2, 7, and 10, vibration levels were monitored in two general locations:

- Within approximately 100 feet of pile-driving activities; and
- Within public rights-of-way near residences at ST-01, ST-02, ST-03, ST-04, NM01, and NM02.

One additional vibration measurement was collected in the basement of a Government Hill residence where a homeowner had indicated suspected vibration levels associated with the TPP. Table 12 provides the PPV monitored during each monitored vibratory and impact pile-driving event. Additionally, baseline PPVs are provided for those locations monitored in proximity to the pile drivers. The results in Table 12

indicate that vibration levels were not of sufficient strength from pile driving at POA to be perceptible and are well below any structural damage criteria for buildings in the area.

Table 12. Summary of Ground-borne Vibration Measurements

| Date | Indicator Test Pile No. | Location | Distance from Pile (feet) | Baseline/ Vibratory Drilling/Impact (hammer) Driving | Level (PPV) | Potential for Building Damage | Human Perception Assessment |
|-------|-------------------------|-----------|---------------------------|--|-------------|-------------------------------|-----------------------------|
| 05/18 | 5 | Near pile | 300 | Baseline | 0.005 | None | Not perceptible |
| 05/18 | 5 | Near pile | 300 | Vibratory pile driver | 0.012 | None | Not perceptible |
| 05/18 | 5 | Near pile | 300 | Impact pile driver (diesel) | 0.020 | None | Not perceptible |
| 05/18 | 5 | ST-02 | 2,941 | Vibratory pile Driver | 0.004 | None | Not perceptible |
| 05/18 | 5 | ST-02 | 2,941 | Diesel hammer | 0.004 | None | Not perceptible |
| 05/19 | 2 | Near pile | 300 | Baseline | 0.003 | None | Not perceptible |
| 05/19 | 2 | Near pile | 300 | Vibratory pile driver | 0.016 | None | Not perceptible |
| 05/19 | 2 | Near pile | 300 | Impact pile driver (diesel) | 0.034 | None | Not perceptible |
| 05/19 | 2 | ST-03 | 2,642 | Vibratory pile driver | 0.005 | None | Not perceptible |
| 05/19 | 2 | ST-03 | 2,642 | Diesel hammer | 0.005 | None | Not perceptible |
| 05/19 | 2 | ST-04 | 2,976 | Diesel hammer | 0.005 | None | Not perceptible |
| 05/25 | 7 | Near pile | 200 | Baseline | 0.003 | None | Not perceptible |
| 05/25 | 7 | Near pile | 200 | Vibratory pile driver | 0.015 | None | Not perceptible |
| 05/25 | 7 | Near pile | 200 | Impact pile driver (Diesel) | 0.084 | None | Not perceptible |
| 05/25 | 7 | NM01 | 3,425 | Vibratory pile driver | 0.003 | None | Not perceptible |
| 05/25 | 7 | NM01 | 3,425 | Diesel hammer | 0.006 | None | Not perceptible |
| 05/25 | 7 | NM02 | 3,376 | Diesel hammer | 0.008 | None | Not perceptible |
| 05/25 | 7 | ST02 | 2,704 | Diesel hammer | 0.008 | None | Not perceptible |
| 05/26 | 10 | Near pile | 500 | Baseline | 0.005 | None | Not perceptible |
| 05/26 | 10 | Near pile | 500 | Vibratory pile driver | 0.022 | None | Not perceptible |

| Date | Indicator Test Pile No. | Location | Distance from Pile (feet) | Baseline/ Vibratory Drilling/Impact (hammer) Driving | Level (PPV) | Potential for Building Damage | Human Perception Assessment |
|-------------|--|------------------|--|---|------------------------|--|--|
| 05/26 | 10 | Near pile | 500 | Impact pile driver (hydraulic) | 0.018 | None | Not perceptible |
| 05/26 | 10 | NM01 | 3,460 | Vibratory pile driver | 0.007 | None | Not perceptible |
| 05/26 | 10 | NM01 (indoor) | 3,460 | Impact pile driver (hydraulic) | 0.007 | None | Not perceptible |
| 05/26 | 10 | NM02 | 3,270 | Impact pile driver (hydraulic) | 0.009 | None | Not perceptible |
| 05/26 | 10 | ST-01 | 2,844 | Impact pile driver (hydraulic) | 0.007 | None | Not perceptible |

4 Summary and Next Steps

The following sections provide summaries of noise and vibration impact conditions and potential next steps.

4.1 Community Noise and Vibration Considerations

Monitored noise levels from pile driving did not exceed the MOA code limit of 80 dBA L_{eq} (hourly), and vibration from pile-driving activity is not perceptible in the Cherry Hill and Government Hill neighborhoods. Sound levels in the Government Hill neighborhood during pile-driving activities ranged from 56 to 73 dBA L_{eq} according to the long-term monitoring effort. In the Cherry Hill neighborhood, sound levels ranged from 54 to 78 dBA L_{eq} . The loudest monitored pile driver sound levels were associated with the hydraulic impact pile driver followed by the diesel impact pile driver. Vibratory pile driver sound levels were measurable, but were lower than impact pile driver sound levels and generally blended in with the existing sound sources.

To minimize potential impacts strictly from a noise perspective, use of the diesel impact pile driver to the extent practicable instead of the hydraulic impact pile driver would result in lower community noise exposure levels.

Vibration monitoring data show that all ground-borne vibration levels are below levels considered perceptible at residential neighborhoods in the vicinity of POA and are not of sufficient strength even near the piles being driven to pose a structural damage concern at POA. However, observations by some neighborhood property owners of vibration from pile driving could be the result of airborne low frequency noise rattling structures/windows, thereby mimicking some of the characteristics of ground-borne vibration.

Monitored one-third-octave band sound levels at LT-01 and LT-02 were averaged for each pile driver type and the daytime period and plotted on spectral charts in Figure 38 and Figure 39, respectively. These charts also show that there is more acoustic energy focused in the lower audible, and inaudible frequencies for the impact pile drivers—especially the hydraulic impact pile driver.

A next step for the data collected as part of this effort could be detailed analysis of the low frequency (generally below 200 Hz) content monitored. This analysis would be useful to identify why some residents have identified ground-borne vibration concerns, which appear instead to be attributed to low frequency impact pile-driving noise.

In addition, comparisons between the various measurement data sets relative to the locations of pile driving could be analyzed to determine attenuation rates in the area. This will be useful to inform the larger APMP effort. This analysis would also help address community noise concerns since the POA would be able to state more definitively what pile-driving noise would be like throughout the neighborhood during the larger effort and to what extent it can be minimized via mitigation.

It is also recommended that public engagement be continued to discuss noise impacts in the affected neighborhoods, especially based on real-life noise exposure experiences associated with the TPP. If noise impacts from future APMP construction are determined to be of concern, noise mitigation measures could be evaluated to determine if received noise levels could be effectively reduced. Although somewhat limited based on project conditions (highly elevated, crane-mounted impact hammer), noise mitigation measures such as acoustic blankets and newly emerging industry applications could be investigated to determine if/how they might help reduce pile-driving noise in nearby neighborhoods. Acoustic blankets have been previously shown to reduce pile-driving noise by up to 15 dBA depending on the application.

Finally, permanent noise monitoring units sited at locations representative of the neighborhoods (i.e., the long-term monitoring locations) and a complaint resolution system may be of use to the POA as the APMP proceeds. The data collected at these stations could help in evaluating complaints received from the public and in identifying potential strategies to reduce pile-driving noise levels. Data collected at these stations should include meteorological conditions during pile driving efforts. This data would be useful for identifying anomalous meteorological conditions that may aid in the propagation of pile driving noise, such as high wind speeds down wind of pile driving. Should these conditions occur, the POA could develop strategies for minimizing pile driving noise.

4.2 Port of Anchorage Tenant and Employee Noise Exposure

Noise measurements collected on shore during pile-driving operations do not meet the threshold for hazardous impact noise as defined by OSHA, nor do these levels exceed occupational exposure standards. However, personnel who are required to be at the shoreline all day (e.g., wildlife observers) are advised to take precautions to minimize the impacts of the pile-driving noise. Precautions can include remaining in vehicles with windows closed or wearing approved personal protective equipment such as ear protection. No one on shore would need hearing protection, but wearing any noise-approved hearing protection would reduce potential effects of noise exposure.

5 References

- Caltrans (California Department of Transportation). 2005. *Transportation and Construction-Induced Vibration Guidance Manual*. Available at: <http://www.dot.ca.gov/hq/env/noise/pub/vibrationmanFINAL.pdf> (accessed July 15, 2016).
- EPA (U.S. Environmental Protection Agency). 1974. *EPA Identifies Noise Levels Affecting Health and Welfare*. Press release. Available at: <https://www.epa.gov/aboutepa/epa-identifies-noise-levels-affecting-health-and-welfare>. April 2, 1974.
- FTA (Federal Transit Administration). 2016. *Transit Noise and Vibration Impact Assessment*. FTA-VA-90-1003-06. May 2016.
- MOA (Municipality of Anchorage). 2006. *Anchorage Noise Ordinance, Anchorage Municipal Code 15.70*. Available at: https://www.municode.com/library/ak/anchorage/codes/code_of_ordinances (accessed July 15, 2016).
- OSHA (Occupational Safety & Health Administration). 1974. *Occupational noise exposure*. 29 CFR 1910.95, U.S. Department of Labor. Available at: https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9735 (accessed August 3, 2016).

Appendix A Noise and Vibration Monitoring Equipment Laboratory Calibration Sheets

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~Certificate of Calibration~

3149 East Kemper Rd.
Cincinnati, OH 45241
Ph : 513-351-9919
Fax: 513-458-2172
www.modalshop.com

Manufacturer: PCB
Model Number: 377B02
Serial Number: LW135962
Asset ID:
Description: Free-Field Microphone

Customer: TMS Rental
Address:

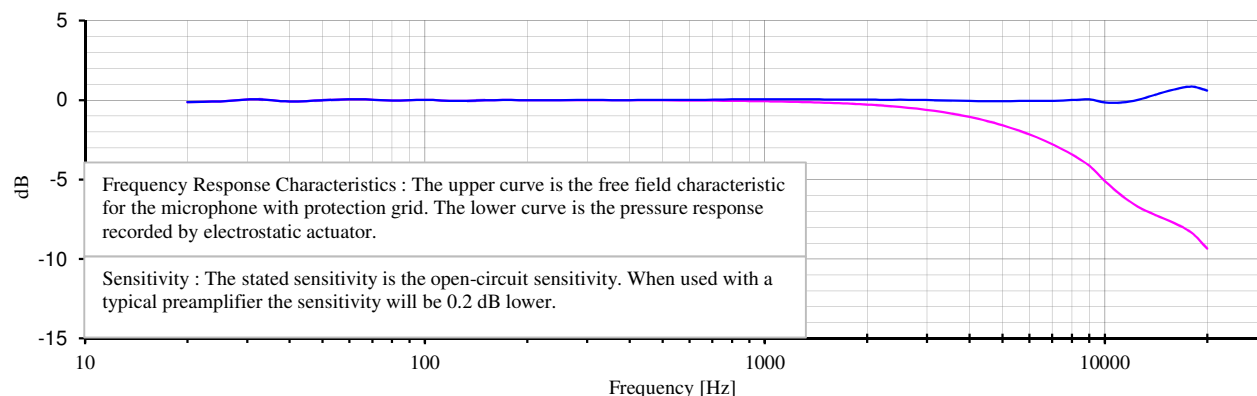
Calibration Date: May 05, 2016 11:09:09
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-25.74 -25.82 dB re. 1V/Pa
51.64 51.19 mV/Pa

Temperature: 74 (23) °F (°C)
Humidity: 36 %
Ambient Pressure: 988.3 mbar

Cal. Results: In Tolerance

Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.25 dB.

Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | -0.13 | 630 | 0.01 | 4500 | -0.07 | | |
| 25 | -0.08 | 800 | 0.04 | 5000 | -0.06 | | |
| 31.5 | 0.05 | 1000 | 0.04 | 5600 | -0.06 | | |
| 40 | -0.09 | 1120 | 0.05 | 6300 | -0.05 | | |
| 50 | -0.02 | 1250 | 0.04 | 7100 | -0.04 | | |
| 63 | 0.06 | 1400 | 0.05 | 8000 | 0.01 | | |
| 80 | -0.03 | 1600 | 0.03 | 9000 | 0.05 | | |
| 100 | 0.02 | 1800 | 0.03 | 10000 | -0.14 | | |
| 125 | -0.05 | 2000 | 0.03 | 11200 | -0.15 | | |
| 160 | 0.00 | 2240 | 0.02 | 12500 | 0.02 | | |
| 200 | 0.00 | 2500 | 0.02 | 14000 | 0.32 | | |
| 250 | 0.00 | 2800 | 0.01 | 16000 | 0.67 | | |
| 315 | 0.00 | 3150 | 0.00 | 18000 | 0.85 | | |
| 400 | 0.00 | 3550 | -0.03 | 20000 | 0.60 | | |
| 500 | 0.02 | 4000 | -0.05 | | | | |

Technician: Ed Devlin

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|-----------|
| GRAS | 40AG | 58094 | 9/22/2015 | 9/22/2016 |

Approval:



Calibration Lab

CALIBRATION CERT 2649.01



~Certificate of Calibration~

3149 East Kemper Rd.
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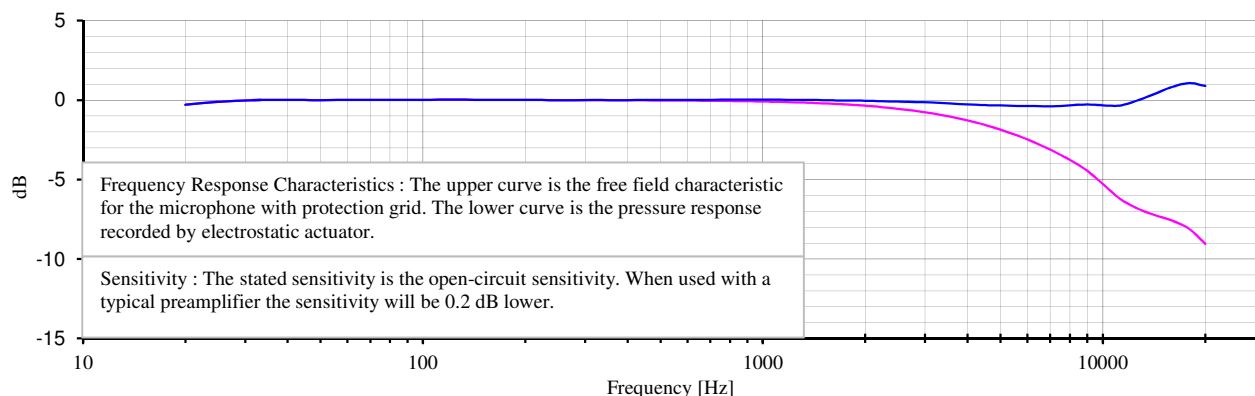
Manufacturer: PCB
Model Number: 377B02
Serial Number: LW138583
Asset ID: 49336
Description: Free-Field Microphone

Customer: TMS Rental
Address:
Calibration Date: Jun 10, 2015 10:06:16
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-25.71 -25.80 dB re. 1V/Pa
51.80 51.28 mV/Pa

Temperature: 72 (22) °F (°C)
Humidity: 46 %
Ambient Pressure: 990.4 mbar
Polarization Voltage: 0 VDC

Cal. Results: In Tolerance



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found/As Left In Tolerance

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | -0.30 | 630 | 0.00 | 4500 | -0.31 | | |
| 25 | -0.11 | 800 | 0.03 | 5000 | -0.34 | | |
| 31.5 | -0.01 | 1000 | 0.03 | 5600 | -0.36 | | |
| 40 | 0.02 | 1120 | 0.02 | 6300 | -0.38 | | |
| 50 | 0.00 | 1250 | 0.01 | 7100 | -0.39 | | |
| 63 | 0.02 | 1400 | 0.01 | 8000 | -0.34 | | |
| 80 | 0.01 | 1600 | -0.02 | 9000 | -0.28 | | |
| 100 | 0.01 | 1800 | -0.03 | 10000 | -0.33 | | |
| 125 | 0.03 | 2000 | -0.04 | 11200 | -0.34 | | |
| 160 | 0.01 | 2240 | -0.08 | 12500 | -0.06 | | |
| 200 | 0.01 | 2500 | -0.09 | 14000 | 0.34 | | |
| 250 | 0.00 | 2800 | -0.12 | 16000 | 0.83 | | |
| 315 | 0.00 | 3150 | -0.16 | 18000 | 1.07 | | |
| 400 | 0.00 | 3550 | -0.21 | 20000 | 0.89 | | |
| 500 | 0.02 | 4000 | -0.27 | | | | |

Technician: Wayne Underwood

Approval:

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|-----------|
| GRAS | 40AG | 9542 | 9/15/2014 | 9/15/2015 |



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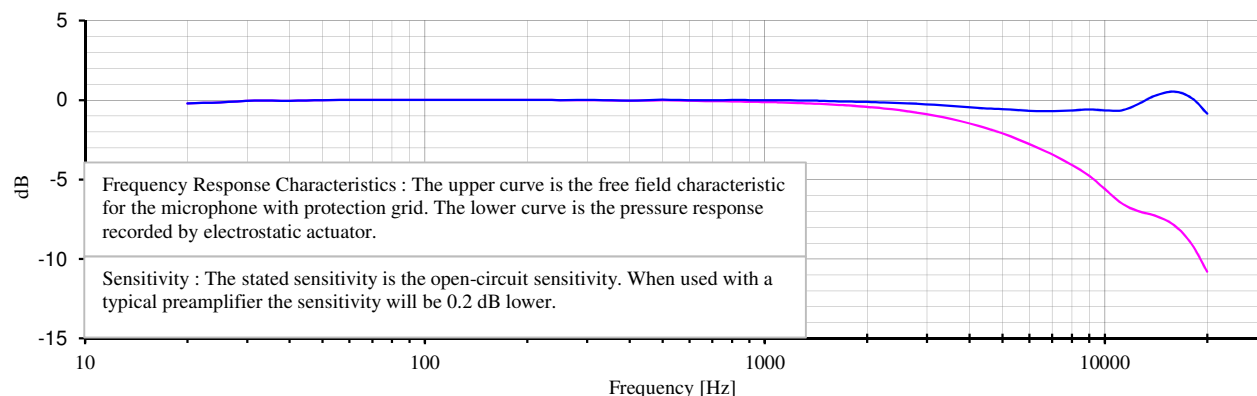
Manufacturer: PCB
Model Number: 377B02
Serial Number: LW137490
Asset ID: 52898
Description: Free-Field Microphone

Customer: TMS Rental
Address:
Calibration Date: Jul 20, 2015 14:20:03
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-25.01 -25.14 dB re. 1V/Pa
56.17 55.37 mV/Pa

Temperature: 71 (22) °F (°C)
Humidity: 53 %
Ambient Pressure: 988.6 mbar
Polarization Voltage: 0 VDC

Cal. Results: In Tolerance



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found/As Left In Tolerance

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | -0.21 | 630 | -0.01 | 4500 | -0.53 | | |
| 25 | -0.14 | 800 | 0.00 | 5000 | -0.57 | | |
| 31.5 | -0.04 | 1000 | -0.01 | 5600 | -0.63 | | |
| 40 | -0.04 | 1120 | -0.01 | 6300 | -0.68 | | |
| 50 | 0.00 | 1250 | -0.03 | 7100 | -0.69 | | |
| 63 | 0.01 | 1400 | -0.04 | 8000 | -0.65 | | |
| 80 | 0.01 | 1600 | -0.07 | 9000 | -0.59 | | |
| 100 | 0.02 | 1800 | -0.10 | 10000 | -0.64 | | |
| 125 | 0.00 | 2000 | -0.11 | 11200 | -0.65 | | |
| 160 | 0.01 | 2240 | -0.16 | 12500 | -0.26 | | |
| 200 | 0.01 | 2500 | -0.18 | 14000 | 0.27 | | |
| 250 | 0.00 | 2800 | -0.24 | 16000 | 0.54 | | |
| 315 | 0.01 | 3150 | -0.29 | 18000 | 0.13 | | |
| 400 | -0.03 | 3550 | -0.38 | 20000 | -0.85 | | |
| 500 | 0.02 | 4000 | -0.46 | | | | |

Technician: Wayne Underwood

Approval:

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|-----------|
| GRAS | 40AG | 9542 | 9/15/2014 | 9/15/2015 |



Calibration Lab

CALIBRATION CERT 2649.01

Page 1 of 1

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

| | | | | |
|----------------|-------------------|----------------|-------|-------|
| Manufacturer: | Larson Davis | Temperature: | 74.3 | °F |
| Model Number: | 831 | | 23.50 | °C |
| Serial Number: | 2229 | Rel. Humidity: | 25.97 | % |
| Customer: | TMS Rental | Pressure: | 992.7 | mbars |
| Description: | Sound Level Meter | | 992.7 | hPa |

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 22-Feb-16

Calibration Due:

Calibration Standards Used:

| Manufacturer | Model | Serial Number | Cal Due |
|--------------|---------------|---------------|-----------|
| Larson Davis | LDSigGen/2239 | 0760/0109 | 4/14/2016 |

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Andy McGuire

Signature:



The Modal Shop, Inc.
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Cincinnati, OH 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

| | | | | |
|----------------|-------------------|----------------|-------|-------|
| Manufacturer: | Larson Davis | Temperature: | 74.3 | °F |
| Model Number: | 831 | | 23.50 | °C |
| Serial Number: | 3556 | Rel. Humidity: | 25.97 | % |
| Customer: | TMS Rental | Pressure: | 992.7 | mbars |
| Description: | Sound Level Meter | | 992.7 | hPa |

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 23-Feb-16

Calibration Due:

Calibration Standards Used:

| Manufacturer | Model | Serial Number | Cal Due |
|--------------|---------------|---------------|-----------|
| Larson Davis | LDSigGen/2239 | 0760/0109 | 4/14/2016 |

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Andy McGuire

Signature:



The Modal Shop, Inc.
3149 East Kemper Road
Cincinnati, OH 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

| | | | | |
|----------------|-------------------|----------------|--------|-------|
| Manufacturer: | Larson Davis | Temperature: | 72.8 | °F |
| Model Number: | 831 | | 22.67 | °C |
| Serial Number: | 3142 | Rel. Humidity: | 38.4 | % |
| Customer: | TMS Rental | Pressure: | 1001.3 | mbars |
| Description: | Sound Level Meter | | 1001.3 | hPa |

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 28-Sep-15

Calibration Due:

Calibration Standards Used:

| Manufacturer | Model | Serial Number | Cal Due | Traceability No. |
|--------------|---------------|---------------|----------|------------------|
| Larson Davis | LDSigGen/2239 | 0760/0109 | 4/7/2016 | 2014-193220 |

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Andy McGuire

Signature:



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Phone: (513) 351-9919
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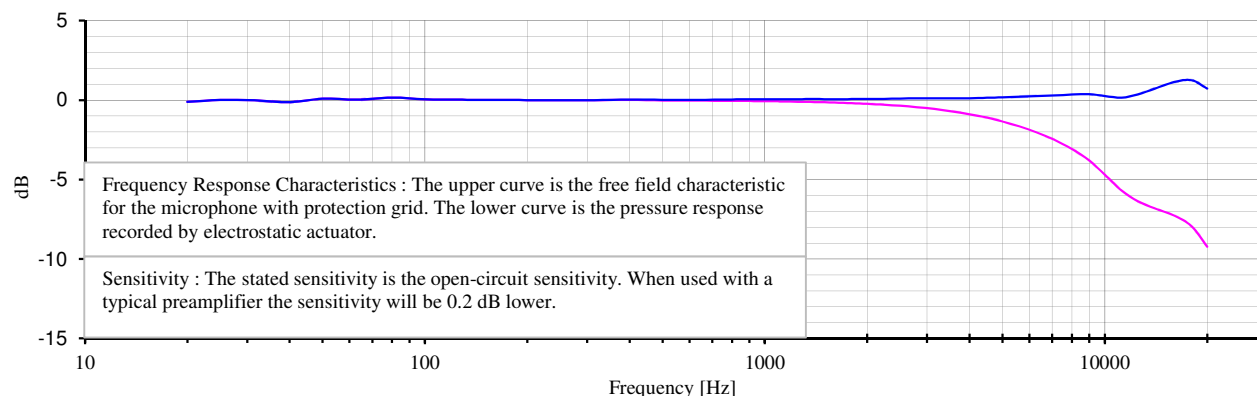
Manufacturer: PCB
Model Number: 377B02
Serial Number: LW132435
Asset ID:
Description: Free-Field Microphone

Customer: TMS Rental
Address:
Calibration Date: Feb 02, 2016 14:10:34
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-25.33 -25.40 dB re. 1V/Pa
54.11 53.73 mV/Pa

Temperature: 74 (23) °F (°C)
Humidity: 31 %
Ambient Pressure: 988.9 mbar
Polarization Voltage: 0 VDC

Cal. Results: In Tolerance



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.
This certificate may not be reproduced, except in full, without written permission.
This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.
Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.
Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | -0.11 | 630 | 0.01 | 4500 | 0.15 | | |
| 25 | 0.00 | 800 | 0.04 | 5000 | 0.17 | | |
| 31.5 | -0.01 | 1000 | 0.05 | 5600 | 0.22 | | |
| 40 | -0.13 | 1120 | 0.06 | 6300 | 0.25 | | |
| 50 | 0.08 | 1250 | 0.06 | 7100 | 0.29 | | |
| 63 | 0.03 | 1400 | 0.07 | 8000 | 0.35 | | |
| 80 | 0.16 | 1600 | 0.06 | 9000 | 0.38 | | |
| 100 | 0.05 | 1800 | 0.06 | 10000 | 0.25 | | |
| 125 | 0.02 | 2000 | 0.07 | 11200 | 0.16 | | |
| 160 | 0.01 | 2240 | 0.08 | 12500 | 0.36 | | |
| 200 | 0.00 | 2500 | 0.10 | 14000 | 0.72 | | |
| 250 | 0.00 | 2800 | 0.11 | 16000 | 1.14 | | |
| 315 | 0.00 | 3150 | 0.12 | 18000 | 1.25 | | |
| 400 | 0.03 | 3550 | 0.11 | 20000 | 0.73 | | |
| 500 | 0.02 | 4000 | 0.12 | | | | |

Technician: Ed Devlin

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|----------|
| GRAS | 40AG | 77606 | 9/1/2015 | 9/1/2016 |

Approval:



Calibration Lab

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~Certificate of Calibration~

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Manufacturer: PCB
Model Number: 377B02
Serial Number: LW135957
Asset ID: 48987
Description: Free-Field Microphone

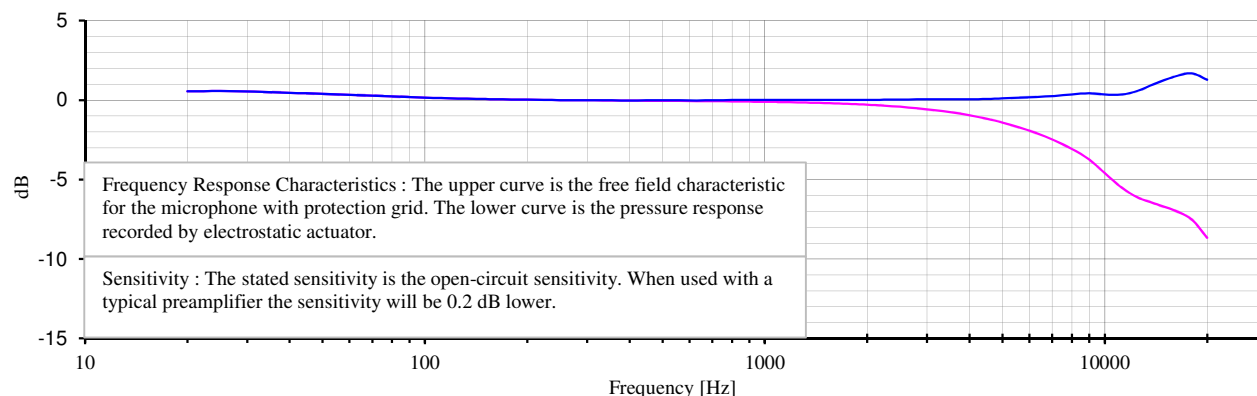
Customer: TMS Rental
Address:
Calibration Date: Jul 20, 2015 14:47:55
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-26.50 -26.61 dB re. 1V/Pa
47.32 46.72 mV/Pa

Temperature: 71 (22) °F (°C)
Humidity: 53 %
Ambient Pressure: 988.6 mbar

Cal. Results: In Tolerance

Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found/As Left In Tolerance

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | 0.55 | 630 | -0.02 | 4500 | 0.07 | | |
| 25 | 0.57 | 800 | 0.01 | 5000 | 0.11 | | |
| 31.5 | 0.53 | 1000 | 0.01 | 5600 | 0.15 | | |
| 40 | 0.45 | 1120 | 0.02 | 6300 | 0.20 | | |
| 50 | 0.39 | 1250 | 0.01 | 7100 | 0.26 | | |
| 63 | 0.31 | 1400 | 0.02 | 8000 | 0.36 | | |
| 80 | 0.22 | 1600 | 0.01 | 9000 | 0.43 | | |
| 100 | 0.16 | 1800 | 0.01 | 10000 | 0.35 | | |
| 125 | 0.10 | 2000 | 0.02 | 11200 | 0.34 | | |
| 160 | 0.06 | 2240 | 0.02 | 12500 | 0.58 | | |
| 200 | 0.02 | 2500 | 0.04 | 14000 | 1.02 | | |
| 250 | 0.00 | 2800 | 0.04 | 16000 | 1.47 | | |
| 315 | -0.01 | 3150 | 0.05 | 18000 | 1.68 | | |
| 400 | -0.02 | 3550 | 0.05 | 20000 | 1.28 | | |
| 500 | -0.01 | 4000 | 0.05 | | | | |

Technician: Wayne Underwood

Reference Equipment Used:

Approval:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|-----------|
| GRAS | 40AG | 9542 | 9/15/2014 | 9/15/2015 |



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Manufacturer: PCB
Model Number: 377B02
Serial Number: LW135957
Asset ID: 48987
Description: Free-Field Microphone

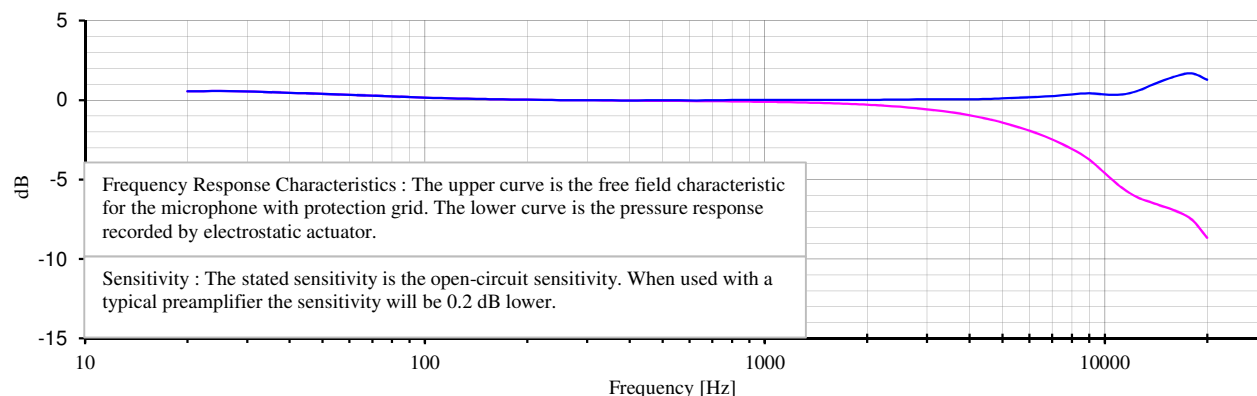
Customer: TMS Rental
Address:
Calibration Date: Jul 20, 2015 14:47:55
Due Date:

Sensitivity: 250 Hz 1 kHz
-26.50 -26.61 dB re. 1V/Pa
47.32 46.72 mV/Pa

Temperature: 71 (22) °F (°C)
Humidity: 53 %
Ambient Pressure: 988.6 mbar

Cal. Results: In Tolerance

Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found/As Left In Tolerance

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | 0.55 | 630 | -0.02 | 4500 | 0.07 | | |
| 25 | 0.57 | 800 | 0.01 | 5000 | 0.11 | | |
| 31.5 | 0.53 | 1000 | 0.01 | 5600 | 0.15 | | |
| 40 | 0.45 | 1120 | 0.02 | 6300 | 0.20 | | |
| 50 | 0.39 | 1250 | 0.01 | 7100 | 0.26 | | |
| 63 | 0.31 | 1400 | 0.02 | 8000 | 0.36 | | |
| 80 | 0.22 | 1600 | 0.01 | 9000 | 0.43 | | |
| 100 | 0.16 | 1800 | 0.01 | 10000 | 0.35 | | |
| 125 | 0.10 | 2000 | 0.02 | 11200 | 0.34 | | |
| 160 | 0.06 | 2240 | 0.02 | 12500 | 0.58 | | |
| 200 | 0.02 | 2500 | 0.04 | 14000 | 1.02 | | |
| 250 | 0.00 | 2800 | 0.04 | 16000 | 1.47 | | |
| 315 | -0.01 | 3150 | 0.05 | 18000 | 1.68 | | |
| 400 | -0.02 | 3550 | 0.05 | 20000 | 1.28 | | |
| 500 | -0.01 | 4000 | 0.05 | | | | |

Technician: Wayne Underwood

Reference Equipment Used:

Approval:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|-----------|
| GRAS | 40AG | 9542 | 9/15/2014 | 9/15/2015 |



Calibration Lab

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Page 1 of 1



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| | | | |
|----------------|---------------------|-------------------|-----------------------|
| Manufacturer: | Larson Davis | Asset ID: | |
| Model: | CAL200 | Calibration Date: | Jul 30, 2015 14:08:33 |
| Serial Number: | 10290 | Due Date: | |
| Description: | Acoustic Calibrator | Technician: | Ed Devlin |
| Customer: | TMS Rental | Approval: | <i>Ed Devlin</i> |

Calibration Results:

| | | |
|---|--------------|---------------|
| Measured SPL : 93.94 dB re. 20 μ Pa | Temperature: | 22 °C (72 °F) |
| Measured Frequency : 1,000.00 Hz | Humidity: | 47.40% |
| | Pressure: | 996.1 mbar |

Upon receipt for calibration, the instrument was found to be:
WITHIN the stated tolerance of the manufacturer's specification.

Note: **As Found / As Left: In Tolerance.**

Measurement uncertainty at 95% confidence level: 0.3 dB

The subject instrument was calibrated to the indicated specification using standards stated below or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the customer.

This calibration is traceable through : 683/281764-12

Notes:

The calibration was performed under operating procedures intended to implement the requirements of ISO 9001, ISO 17025 and ANSI Z540. Unless otherwise noted, the reported value is both "as found" and "as left" data. Calibration results relate only to the items calibrated. This certificate may not be reproduced, except in full, without written permission.


Reference Equipment Used:

| | | | | |
|---------------|--------------|---------------|------------------|-----------------|
| <i>Manuf.</i> | <i>Model</i> | <i>Serial</i> | <i>Cal. Date</i> | <i>Due Date</i> |
| GRAS | 40AG | 77606 | 9/15/2014 | 9/15/2015 |



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www.modalshop.com

| | | | |
|----------------|---------------------|-------------------|---|
| Manufacturer: | Larson Davis | Asset ID: | |
| Model: | CAL200 | Calibration Date: | Jul 30, 2015 14:05:16 |
| Serial Number: | 10290 | Due Date: | |
| Description: | Acoustic Calibrator | Technician: | Ed Devlin |
| Customer: | TMS Rental | Approval: |  |

Calibration Results:

| | | |
|--|--------------|---------------|
| Measured SPL : 113.91 dB re. 20 μ Pa | Temperature: | 22 °C (72 °F) |
| Measured Frequency : 1,000.00 Hz | Humidity: | 47.40% |
| | Pressure: | 996.1 mbar |

Upon receipt for calibration, the instrument was found to be:
WITHIN the stated tolerance of the manufacturer's specification.

Note: **As Found / As Left: In Tolerance.**

Measurement uncertainty at 95% confidence level: 0.3 dB

The subject instrument was calibrated to the indicated specification using standards stated below or to accepted values of natural physical constants. This document certifies that the instrument met the following specification upon its return to the customer.

This calibration is traceable through : 683/281764-12

Notes:

The calibration was performed under operating procedures intended to implement the requirements of ISO 9001, ISO 17025 and ANSI Z540. Unless otherwise noted, the reported value is both "as found" and "as left" data. Calibration results relate only to the items calibrated. This certificate may not be reproduced, except in full, without written permission.

Reference Equipment Used:

| | | | | |
|---------------|--------------|---------------|------------------|-----------------|
| <i>Manuf.</i> | <i>Model</i> | <i>Serial</i> | <i>Cal. Date</i> | <i>Due Date</i> |
| GRAS | 40AG | 77606 | 9/15/2014 | 9/15/2015 |



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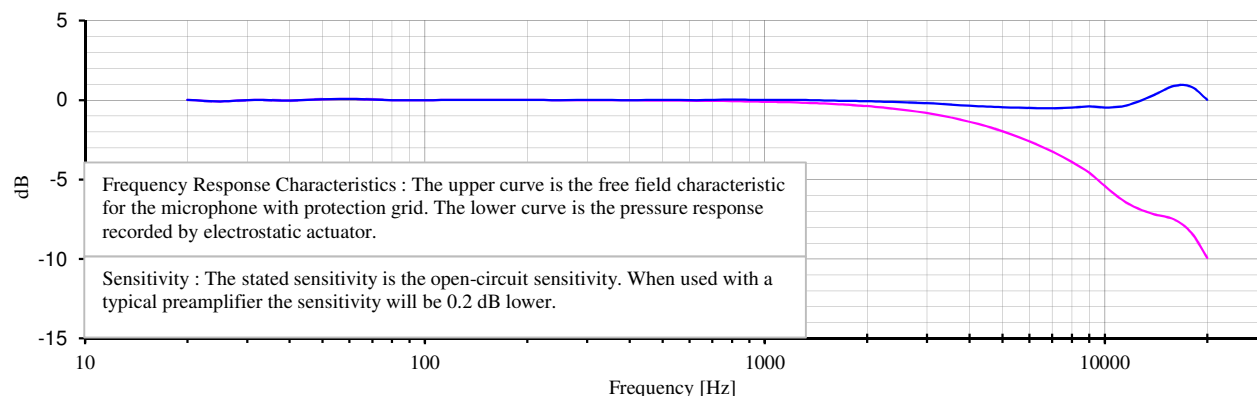
Manufacturer: PCB
Model Number: 377B02
Serial Number: LW138396
Asset ID:
Description: Free-Field Microphone

Customer: TMS Rental
Address:
Calibration Date: Feb 02, 2016 14:54:05
Due Date:

Sensitivity: **250 Hz** **1 kHz**
-24.52 -24.63 dB re. 1V/Pa
59.43 58.69 mV/Pa

Temperature: 74 (23) °F (°C)
Humidity: 34 %
Ambient Pressure: 986.6 mbar
Polarization Voltage: 0 VDC

Cal. Results: In Tolerance



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | 0.01 | 630 | 0.00 | 4500 | -0.40 | | |
| 25 | -0.08 | 800 | 0.03 | 5000 | -0.44 | | |
| 31.5 | 0.02 | 1000 | 0.01 | 5600 | -0.48 | | |
| 40 | -0.02 | 1120 | 0.02 | 6300 | -0.50 | | |
| 50 | 0.04 | 1250 | 0.00 | 7100 | -0.51 | | |
| 63 | 0.07 | 1400 | 0.00 | 8000 | -0.46 | | |
| 80 | 0.00 | 1600 | -0.04 | 9000 | -0.40 | | |
| 100 | -0.01 | 1800 | -0.05 | 10000 | -0.46 | | |
| 125 | 0.01 | 2000 | -0.07 | 11200 | -0.41 | | |
| 160 | 0.01 | 2240 | -0.10 | 12500 | -0.11 | | |
| 200 | 0.01 | 2500 | -0.13 | 14000 | 0.33 | | |
| 250 | 0.00 | 2800 | -0.17 | 16000 | 0.90 | | |
| 315 | 0.01 | 3150 | -0.22 | 18000 | 0.83 | | |
| 400 | 0.00 | 3550 | -0.29 | 20000 | 0.02 | | |
| 500 | 0.01 | 4000 | -0.36 | | | | |

Technician: Ed Devlin

Approval:

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|----------|
| GRAS | 40AG | 77606 | 9/1/2015 | 9/1/2016 |



Calibration Lab

CALIBRATION CERT 2649.01

Page 1 of 1

Certificate of Calibration and Conformance

This document certifies that the instrument referenced below meets published specifications per Procedure PRD-P263; ANSI S1.4-1983 (R 2006) Type 1; S1.4A-1985; S1.43-1997 Type 1; S1.11-2004 Octave Band Class 0; S1.25-1991; IEC 61672-2002 Class 1; 60651-2001 Type 1; 60804-2000 Type 1; 61260-2001 Class 0; 61252-2002.

| | | | | |
|----------------|-------------------|----------------|--------|-------|
| Manufacturer: | Larson Davis | Temperature: | 72.8 | °F |
| Model Number: | 831 | | 22.67 | °C |
| Serial Number: | 3386 | Rel. Humidity: | 38.4 | % |
| Customer: | TMS Rental | Pressure: | 1001.3 | mbars |
| Description: | Sound Level Meter | | 1001.3 | hPa |

Note: As Found / As Left: In Tolerance

Upon receipt for testing, this instrument was found to be:

Within the Stated tolerance of the manufacturer's specification

Calibration Date: 25-Sep-15

Calibration Due:

Calibration Standards Used:

| Manufacturer | Model | Serial Number | Cal Due | Traceability No. |
|--------------|---------------|---------------|----------|------------------|
| Larson Davis | LDSigGen/2239 | 0760/0109 | 4/7/2016 | 2014-193220 |

This Certificate attests that this instrument has been calibrated under the stated conditions with Measurement and Test Equipment (M&TE) Standards traceable to the National Institute of Standards and Technology (NIST). All of the Measurement Standards have been calibrated to their manufacturers' specified accuracy / uncertainty. Evidence of traceability and accuracy is on file at The Modal Shop and/or Larson Davis Corporate Headquarters. An acceptable accuracy ratio between the Standard(s) and the item calibrated has been maintained. This instrument meets or exceeds the manufacturer's published specification unless noted.

This calibration complies with ISO 17025 and ANSI Z540. The collective uncertainty of the Measurement Standard used does not exceed 25% of the applicable tolerance for each characteristic calibrated unless otherwise noted.

The results documented in this certificate relate only to the item(s) calibrated or tested. Calibration interval assignment and adjustment are the responsibility of the end user. This certificate may not be reproduced, except in full, without the written approval of The Modal Shop.

Technician: Andy McGuire

Signature:



The Modal Shop, Inc.
3149 East Kemper Road
Cincinnati, OH 45241
Phone: (513) 351-9919
(800) 860-4867
www.modalshop.com



~Certificate of Calibration~

3149 East Kemper Rd.
Cincinnati, OH 45241
Ph : 513-351-9919
Fax: 513-458-2172
www.modalshop.com

Manufacturer: PCB
Model Number: 377B02
Serial Number: 140262
Asset ID:

Description: Free-Field Microphone

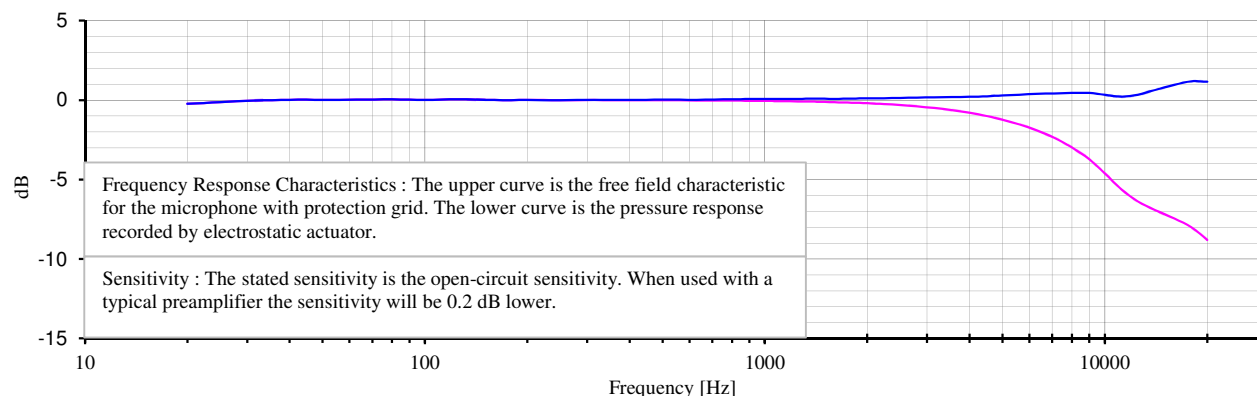
Sensitivity: **250 Hz** **1 kHz**
-27.10 -27.15 dB re. 1V/Pa
44.15 43.89 mV/Pa

Cal. Results: In Tolerance

Customer: TMS Rental
Address:

Calibration Date: Feb 02, 2016 12:28:10
Due Date:

Temperature: 74 (23) °F (°C)
Humidity: 30 %
Ambient Pressure: 992.7 mbar
Polarization Voltage: 0 VDC



Traceability: The calibration is traceable through 683/281764-12.

Notes: Calibration results relate only to the items calibrated.

This certificate may not be reproduced, except in full, without written permission.

This calibration is performed in compliance with ISO 9001, ISO 17025 and ANSI Z540.

Measurement uncertainty (250 Hz sensitivity calibration) at 95% confidence level: 0.30 dB.

Calibrated per procedure PRD-P204.

User Note: As Found / As Left: In Tolerance.

Frequency Response with reference to level at 250 Hz

| Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) | Frequency (Hz) | Upper (dB) |
|----------------|------------|----------------|------------|----------------|------------|----------------|------------|
| 20 | -0.24 | 630 | 0.02 | 4500 | 0.24 | | |
| 25 | -0.13 | 800 | 0.06 | 5000 | 0.29 | | |
| 31.5 | -0.03 | 1000 | 0.07 | 5600 | 0.34 | | |
| 40 | 0.02 | 1120 | 0.07 | 6300 | 0.39 | | |
| 50 | 0.02 | 1250 | 0.08 | 7100 | 0.42 | | |
| 63 | 0.02 | 1400 | 0.09 | 8000 | 0.45 | | |
| 80 | 0.05 | 1600 | 0.08 | 9000 | 0.46 | | |
| 100 | 0.01 | 1800 | 0.09 | 10000 | 0.33 | | |
| 125 | 0.05 | 2000 | 0.11 | 11200 | 0.22 | | |
| 160 | 0.00 | 2240 | 0.12 | 12500 | 0.34 | | |
| 200 | 0.00 | 2500 | 0.14 | 14000 | 0.63 | | |
| 250 | 0.00 | 2800 | 0.16 | 16000 | 0.96 | | |
| 315 | 0.01 | 3150 | 0.18 | 18000 | 1.19 | | |
| 400 | 0.00 | 3550 | 0.19 | 20000 | 1.15 | | |
| 500 | 0.03 | 4000 | 0.21 | | | | |

Technician: Ed Devlin

Approval:

Reference Equipment Used:

| Manuf. | Model | Serial | Cal. Date | Due Date |
|--------|-------|--------|-----------|----------|
| GRAS | 40AG | 77606 | 9/1/2015 | 9/1/2016 |



Calibration Lab

CALIBRATION CERT 2649.01

Page 1 of 1



Alaska Metrology and Calibration Services, Inc.

224 E. 54 th Avenue,
Anchorage, Alaska 99518
PH: (907) 929-8052 FAX: (907) 929-9361

Certificate No: AMCS47368

Certificate of Calibration (Measurements Sub-Contracted)

| | | |
|-----------------|--------------------------|---------------------------|
| For Instrument: | Quest Technologies QC-20 | Next Calibration Due Date |
| Description: | Sound Level Calibrator | March 02 2017 |
| Asset Number: | CH0002 | Serial Number: |
| | | QOF040002 |

CUSTOMER INFORMATION

CH2M HILL
160 West 68th Street
Anchorage, AK 99518

Customer Account Number: VEC001
Customer PO Number: 389966-MITCH
Customer Shop Location:

CALIBRATION INFORMATION

Calibration Date: March 02, 2016
Calibration Procedure: 56V982

Calibration Laboratory: SubContracted
Temperature: 20.00°C Humidity: 50% RH

Specifications Used: Manufacturer's Specifications
As-Found Condition:
Calibration Measurement Results: In Tolerance

As-Left Condition:
Calibration Measurement Results: In Tolerance
Calibration Void Seals Used: Internal: 0 External: 0

Certification:

This certificate is issued as a statement of the fact that the Instrument described above, met or exceeded the Specifications Used (listed above) at the time of Calibration.

The calibration activities described by this document were performed in compliance with ISO/IEC 17025:2005(E) and ANSI/NCSL Z540-1.

The calibration results recorded herein are applicable only to the instrument identified above. No statement or opinion regarding the applicability to any other instrument is expressed or implied.

This report shall not be reproduced without the written permission of Alaska Metrology & Calibration Services, Inc.

Standards Used for Calibration:

Alaska Metrology & Calibration Services utilizes Sub-Contractors who maintain calibration programs for all thier equipment used for calibrations that have a significant effect on the accuracy and/or validity of measurements.

Traceability of Measurements:

The calibration tests described by this certificate were conducted using Standards whose accuracies were calibrated by laboratories that can demonstrate traceability to the National Institute of Standards and Technology (NIST) and to the International System of Units (SI).

Uncertainty of Standard Applied/Reading:

As per NIST Technical Note 1297, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, the total expanded uncertainty (U) of the Standard Applied /Reading is the product of the Root-Sum-Squared value of the individual uncertainties of the Standards Used for Calibration (Uc) and a coverage factor (k). Using k=2 provides a 95% level of confidence. As per Alaska Metrology & Calibration Services policy, the ratio of the expanded uncertainty (U) of all Standard Applied/Readings to the Specifications the Customer's equipment is calibrated is greater than or equal to 4:1 (unless otherwise noted on the Certificate of Calibration).

COMMENTS

Calibrated by an Authorized Subcontractor.

SIGNATURES

Calibration Data Entry performed by:

Signature:

Michael Herath



**Certificate of Calibration**

Certificate No: 5127239QOF040002

Submitted By: ALASKA METROLOGY AND CALIBRAT
224 EAST 54TH AVENUE
ANCHORAGE, AK 99518

Serial Number: QOF040002

Date Received: 3/1/2016

Customer ID:

Date Issued: 3/2/2016

Model: QC-20 CALIBRATOR

Valid Until: 3/2/2017

Test Conditions:

Model Conditions:

Temperature: 18°C to 29°C

As Found: IN TOLERANCE

Humidity: 20% to 80%

As Left: IN TOLERANCE

Barometric Pressure: 890 mbar to 1050 mbar

SubAssemblies:

Description:

Serial Number:

Calibrated per Procedure: 56V982

Reference Standard(s):

| I.D. Number | Device |
|-------------|---------------------|
| ET0000556 | B&K ENSEMBLE |
| T00230 | FLUKE 45 MULTIMETER |

| Last Calibration Date | Calibration Due |
|-----------------------|-----------------|
| 4/8/2015 | 4/8/2016 |
| 2/4/2016 | 2/4/2018 |

Measurement Uncertainty:

+/- 1.1% ACOUSTIC (0.1DB) +/- 1.4% VAC +/- 0.012% HZ
Estimated at 95% Confidence Level (k=2)

Calibrated By:

JOSE MORALES

Service Technician

3/2/2016

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.



SUMMARY REPORT



WORK ORDER: 5127239

3/2/2016

Related Event Type

CALIBRATION - STANDARD

Model Name

1100 SLM

Serial Number

DBE120006

Performed By

JOSE MORALES

Repair Notes: Tested and calibrated unit.

CALIBRATION - STANDARD

QC-20 CALIBRATOR

QOF040002

JOSE MORALES

Repair Notes: Tested and calibrated unit.



Alaska Metrology and Calibration Services, Inc.

224 E. 54 th Avenue,
Anchorage, Alaska 99518
PH: (907) 929-8052 FAX: (907) 929-9361

Certificate No: AMCS47367

Certificate of Calibration (Measurements Sub-Contracted)

| | | |
|-----------------|-------------------------|---------------------------|
| For Instrument: | Quest Technologies 1100 | Next Calibration Due Date |
| Description: | Sound Level Meter | March 02 2017 |
| Asset Number: | CH20006 | Serial Number: |
| | | DBE120006 |

CUSTOMER INFORMATION

CH2M HILL
160 West 68th Street
Anchorage, AK 99518

Customer Account Number: VEC001
Customer PO Number: 389966-MITCH
Customer Shop Location:

CALIBRATION INFORMATION

Calibration Date: March 02, 2016
Calibration Procedure: 53V903

Calibration Laboratory: SubContracted
Temperature: 20.00°C Humidity: 50% RH

Specifications Used: Manufacturer's Specifications
As-Found Condition:
Calibration Measurement Results: In Tolerance

As-Left Condition:
Calibration Measurement Results: In Tolerance
Calibration Void Seals Used: Internal: 0 External: 0

Certification:

This certificate is issued as a statement of the fact that the Instrument described above, met or exceeded the Specifications Used (listed above) at the time of Calibration.

The calibration activities described by this document were performed in compliance with ISO/IEC 17025:2005(E) and ANSI/NCSL Z540-1.

The calibration results recorded herein are applicable only to the instrument identified above. No statement or opinion regarding the applicability to any other instrument is expressed or implied.

This report shall not be reproduced without the written permission of Alaska Metrology & Calibration Services, Inc.

Standards Used for Calibration:

Alaska Metrology & Calibration Services utilizes Sub-Contractors who maintain calibration programs for all thier equipment used for calibrations that have a significant effect on the accuracy and/or validity of measurements.

Traceability of Measurements:

The calibration tests described by this certificate were conducted using Standards whose accuracies were calibrated by laboratories that can demonstrate traceability to the National Institute of Standards and Technology (NIST) and to the International System of Units (SI).

Uncertainty of Standard Applied/Reading:

As per NIST Technical Note 1297, Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results, the total expanded uncertainty (U) of the Standard Applied /Reading is the product of the Root-Sum-Squared value of the individual uncertainties of the Standards Used for Calibration (Uc) and a coverage factor (k). Using k=2 provides a 95% level of confidence. As per Alaska Metrology & Calibration Services policy, the ratio of the expanded uncertainty (U) of all Standard Applied/Readings to the Specifications the Customer's equipment is calibrated is greater than or equal to 4:1 (unless otherwise noted on the Certificate of Calibration).

COMMENTS

Calibrated by an Authorized Subcontractor.

SIGNATURES

Calibration Data Entry performed by:

Signature:

Michael Herath

**Certificate of Calibration**

Certificate No: 5127239DBE120006

Submitted By: ALASKA METROLOGY AND CALIBRAT
224 EAST 54TH AVENUE
ANCHORAGE, AK 99518

Serial Number: DBE120006

Date Received: 3/1/2016

Customer ID:

Date Issued: 3/2/2016

Model: 1100 SLM

Valid Until: 3/2/2017

Test Conditions:

Model Conditions:

Temperature: 18°C to 29°C

As Found: IN TOLERANCE

Humidity: 20% to 80%

As Left: IN TOLERANCE

Barometric Pressure: 890 mbar to 1050 mbar

SubAssemblies:

Description:

MICROPHONE B&K 4936 1/2 IN. ELECTRET

Serial Number:

2513916

Calibrated per Procedure: 53V903

Reference Standard(s):

| I.D. Number | Device |
|-------------|--------------|
| EF000255 | QUEST-CAL |
| ET0000556 | B&K ENSEMBLE |

| Last Calibration Date | Calibration Due |
|-----------------------|-----------------|
| 12/15/2015 | 12/15/2016 |
| 4/8/2015 | 4/8/2016 |

Measurement Uncertainty:

$\pm 2.2\%$ ACOUSTIC (0.19dB) $\pm 1.4\%$ VAC $\pm 0.1\%$ VDC
Estimated at 95% Confidence Level (k=2)

Calibrated By:

JOSE MORALES

Service Technician

3/2/2016

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.



Certificate of Calibration

Certificate No: 5120515BBN070002

Submitted By: TTT ENVIRONMENTAL
4201 B STREET
ANCHORAGE, AK 99503

Serial Number: BBN070002
Customer ID:
Model: SOUNDPRO SE-2-1/1 SLM
Test Conditions:
Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Date Received: 7/6/2015
Date Issued: 7/8/2015
Valid Until: 7/8/2016

Model Conditions:

As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:

Description:

MICROPHONE QE 7052 1/2 IN. ELECTRET
TYPE 2 PREAMP

Serial Number:

33551
04070777

Calibrated per Procedure: 53V899

Reference Standard(s):

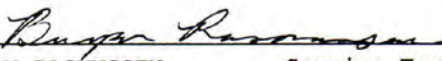
| I.D. Number | Device |
|-------------|---------------------|
| EF000138 | QUEST-CAL |
| ET0000556 | B&K ENSEMBLE |
| ET000304 | FLUKE 45 MULTIMETER |

| Last Calibration Date | Calibration Due |
|-----------------------|-----------------|
| 12/16/2014 | 12/16/2015 |
| 10/15/2014 | 10/15/2015 |
| 2/18/2015 | 2/18/2017 |

Measurement Uncertainty:

+/- 2.2% ACOUSTIC (0.19DB)
Estimated at 95% Confidence Level (k=2)

Calibrated By:


BRYAN RASMUSSEN Service Technician

7/8/2015

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.



Certificate of Calibration

Certificate No: 5120159BIK030008

Submitted By: TTT ENVIRONMENTAL
4201 B STREET
ANCHORAGE, AK 99503

Serial Number: BIK030008
Customer ID: N/A
Model: SCUNDPRO DL-2-1/3 SLM
Test Conditions:
Temperature: 18°C to 29°C
Humidity: 20% to 80%
Barometric Pressure: 890 mbar to 1050 mbar

Date Received: 6/16/2015
Date Issued: 6/23/2015
Valid Until: 6/23/2016

Model Conditions:

As Found: IN TOLERANCE
As Left: IN TOLERANCE

SubAssemblies:

Description: TYPE 2 PREAMP
MICROPHONE QE 7052 1/2 IN. ELECTRET

Serial Number:

0311 5528
38124

Calibrated per Procedure: 53V899

Reference Standard(s):

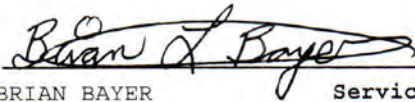
| I.D. Number | Device |
|-------------|--------------|
| EF000176 | QUEST-CAL |
| ET0000556 | B&K ENSEMBLE |

| Last Calibration Date | Calibration Due |
|-----------------------|-----------------|
| 12/16/2014 | 12/16/2015 |
| 10/15/2014 | 10/15/2015 |

Measurement Uncertainty:

+/- 2.2% ACOUSTIC (0.19DB)
Estimated at 95% Confidence Level (k=2)

Calibrated By:


BRIAN BAYER

Service Technician

6/23/2015

This report certifies that all calibration equipment used in the test is traceable to NIST, and applies only to the unit identified under equipment above. This report must not be reproduced except in its entirety without the written approval of 3M Detection Solutions.



SUMMARY REPORT

WORK ORDER: 5120159

6/23/2015

Related Event Type

CALIBRATION - STANDARD

Model Name

SOUNDPRO DL-2-1/3 SLM

Serial Number

BIK030008

Performed By

BRIAN BAYER

Repair Notes: firmware updated to 13H
unit passes all tests.

Calibration Certificate

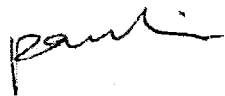
Part Number: 721A0401
Description: MicroMate System (ISEE)
Serial Number: UM6134
Calibration Date: July 23, 2015
Calibration Equipment: 714J7401

Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications

Instantel further certifies that the measurement instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology; or National Research Council of Canada. Evidence of traceability is on file at Instantel and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

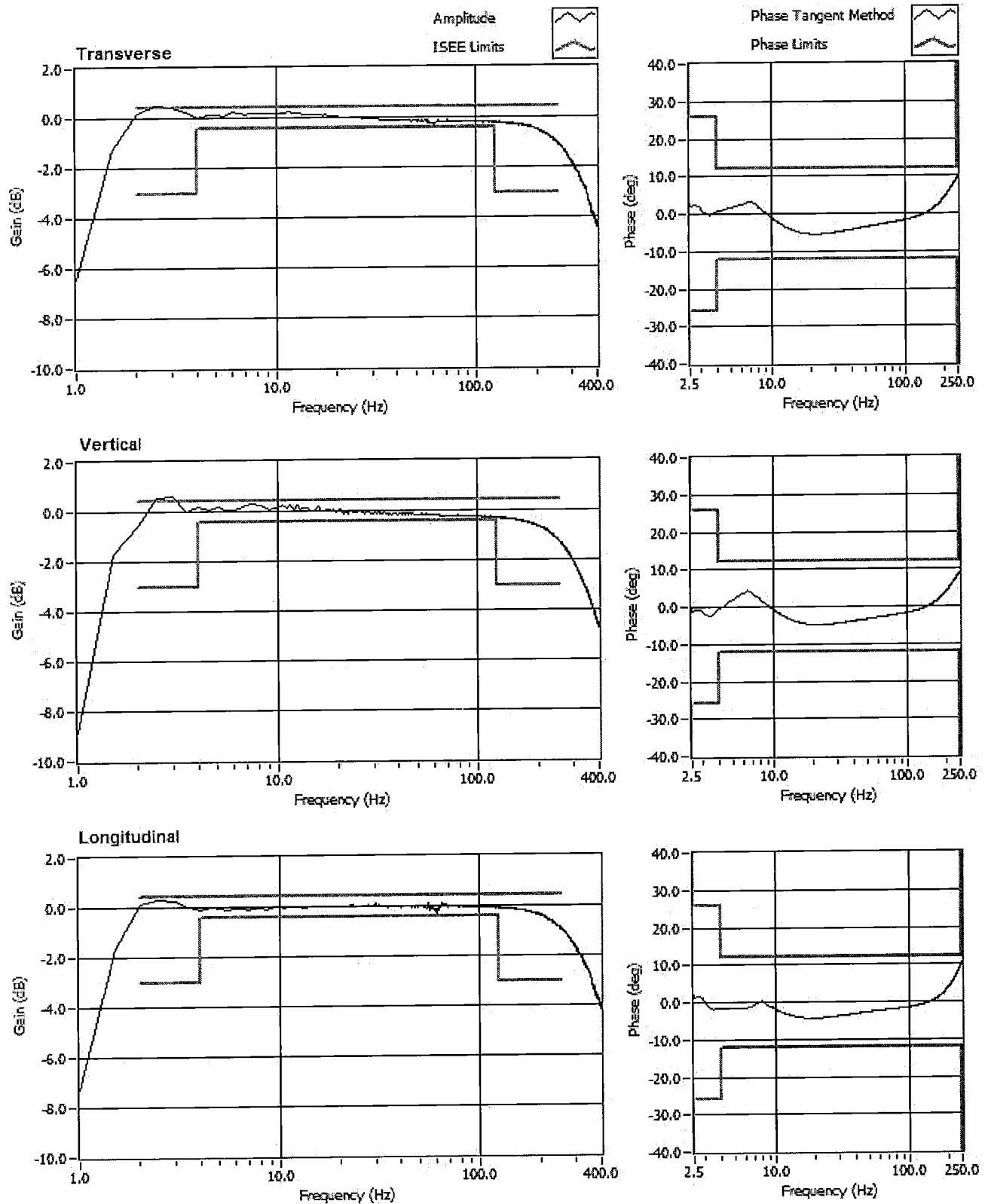
Please note that the sensor check function is intended to check that the sensors are connected to the unit, installed in the proper orientation and sufficiently level to operate properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an authorized service and calibration facility for annual calibration.

Calibrated By: 

Li Pan

 **Instantel**

Frequency Response of UM6134 (As Found)



Calibration Certificate

Part Number: 721A0401
Description: MicroMate System (ISEE)
Serial Number: UM6774
Calibration Date: April 11, 2016
Calibration Equipment: 714J7401

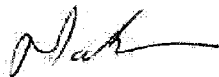
Instantel certifies that the above product was calibrated in accordance with the applicable Instantel procedures. These procedures are part of a quality system that is designed to assure that the product listed above meets or exceeds Instantel specifications

Instantel further certifies that the measurement instruments used during the calibration of this product are traceable to the National Institute of Standards and Technology; or National Research Council of Canada. Evidence of traceability is on file at Instantel and is available upon request.

The environment in which this product was calibrated is maintained within the operating specifications of the instrument.

Please note that the sensor check function is intended to check that the sensors are connected to the unit, installed in the proper orientation and sufficiently level to operate properly. This function should not be confused with a formal calibration, which requires the sensors be checked against a reference that is traceable to a known standard. Instantel recommends that products be returned to Instantel or an authorized service and calibration facility for annual calibration.

Calibrated By: _____



Vipulan Mathi

 **Instantel**

Frequency Response of UM6774 (As Found)

