

Noise Monitoring Program

2022 Annual Noise Monitoring Report

Prepared for:



Vancouver Fraser Port Authority

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Prepared by:

BKL CONSULTANTS LTD.

File: 1924-23C-R1

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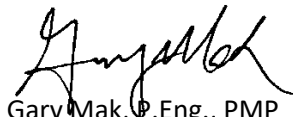
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List of Abbreviations

Abbreviation/Acronym	Definition
ANSI	American National Standards Institute
BKL	BKL Consultants Ltd.
BSI	British Standards Institute
dB	decibel
dBA	A-weighted decibel
Hz	hertz
ISO	International Organization for Standardization
<i>L_d</i>	daytime equivalent sound level (7 am to 7 pm)
<i>L_{den}</i>	day-evening-night equivalent sound level
<i>L_e</i>	evening equivalent sound level (7 pm to 10 pm)
<i>L_{eq}</i>	equivalent sound level
<i>L_n</i>	nighttime equivalent sound level (10 pm to 7 am)
LFN	low frequency noise
NMP	noise monitoring program
NMT	noise monitoring terminal

Introduction

Noise monitoring reports are produced annually as a part of the noise monitoring program being carried out by Vancouver Fraser Port Authority (VFPA). The purpose of this annual report is to provide the following:

- information on the noise monitoring program and latest improvements;
- documentation of noise levels and number of noise events recorded at each noise monitoring terminal (NMT) over the 36-month period from January 1, 2020, to December 31, 2022; and
- comments on any observable noise level or event trends at any of the NMTs.

A glossary covering relevant acoustical terminology is provided in Appendix A.

An introduction to sound and environmental noise assessment is provided in Appendix B.

Port Noise Monitoring Program

Local communities have raised concerns regarding noise impacts associated with port activities. Examples of port-related noise include ship engine noise, truck noise, rail noise, and safety sirens. VFPA recognizes that operations create noises that can negatively impact adjacent communities and has therefore invested resources into better understanding the operational conditions and types of noises that can disturb local communities.

VFPA implemented a long-term noise monitoring program (NMP) in 2014 that involved the installation of permanent noise monitoring terminals (NMTs) to continually record sound data in or near communities potentially affected by port noise. VFPA has retained Brüel & Kjær (2014 to 2019) and Seti Media (2019 to present) to provide noise monitoring instrumentation and support, and utilizes their web interfaces to manage both the field hardware and application software. Currently, the NMTs are connected to a Seti Media web console where NMTs are controlled and data is displayed, saved, and exported. VFPA uses noise monitoring data and the web-based system to improve its ability to work with port users and tenants to manage noise.

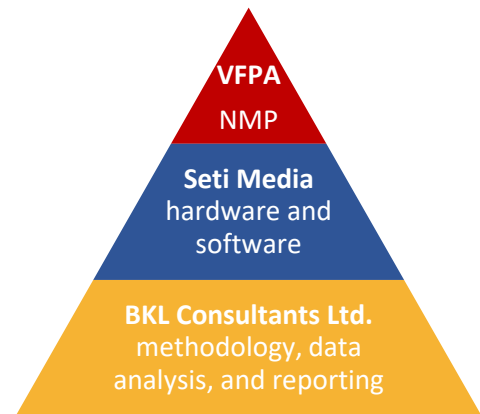


Figure 1 Roles and Responsibilities

BKL Consultants Ltd. (BKL), a Vancouver-based engineering firm that specializes in consulting services in acoustics, has been retained by VFPA to assist with managing and analyzing the data collected by the NMTs. BKL has been involved in developing the noise monitoring methodology, configuring the NMTs, exporting data from the web console, analyzing noise trends, and generating periodic noise reports.

Figure 2 illustrates some of the benefits of the NMP.

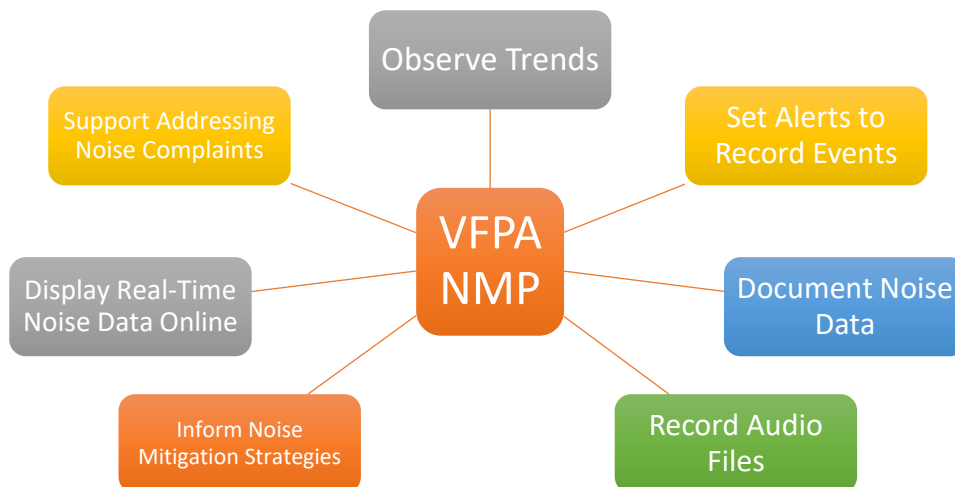


Figure 2 Noise Monitoring Program Benefits

Noise Monitoring Terminals

Noise Monitoring Terminals (NMTs) are sound level meters with the necessary accessories to allow for long-term and continuous noise monitoring at a location. They have the following characteristics:

- acoustic conformance to Class 1 requirements as defined by IEC 61672-1 (IEC 2013)
- a weather-proof and tamper-proof case that can be easily mounted to poles with a wide range of diameters
- a connection to permanent external power
- a battery that can provide temporary power during power outages
- a modem for data communications and streaming data to a web interface
- internal memory to back up most recent measurement data
- the capability of performing automatic internal calibration checks that include checking the microphone
- the capability of recording audio files to assist in remotely identifying noise events

In 2014, VFPA retained Brüel & Kjær to install NMTs in select locations. Eleven NMTs were installed at locations as shown in Figure 3 below. In summer 2019, all Brüel & Kjær NMTs were removed and VFPA retained Seti Media to install Larson Davis sound level monitors at the same locations.

CNV Queensbury and VAN Semlin were reinstalled later than the other NMTs due to coordination for securing new locations. CNV Queensbury was reinstalled in July 2020 at a new nearby location along the Spirit Trail approximately 125 metres southwest of the previous location; VAN Semlin was reinstalled in February 2021 at its previous location facing Cambridge Park for easier access.

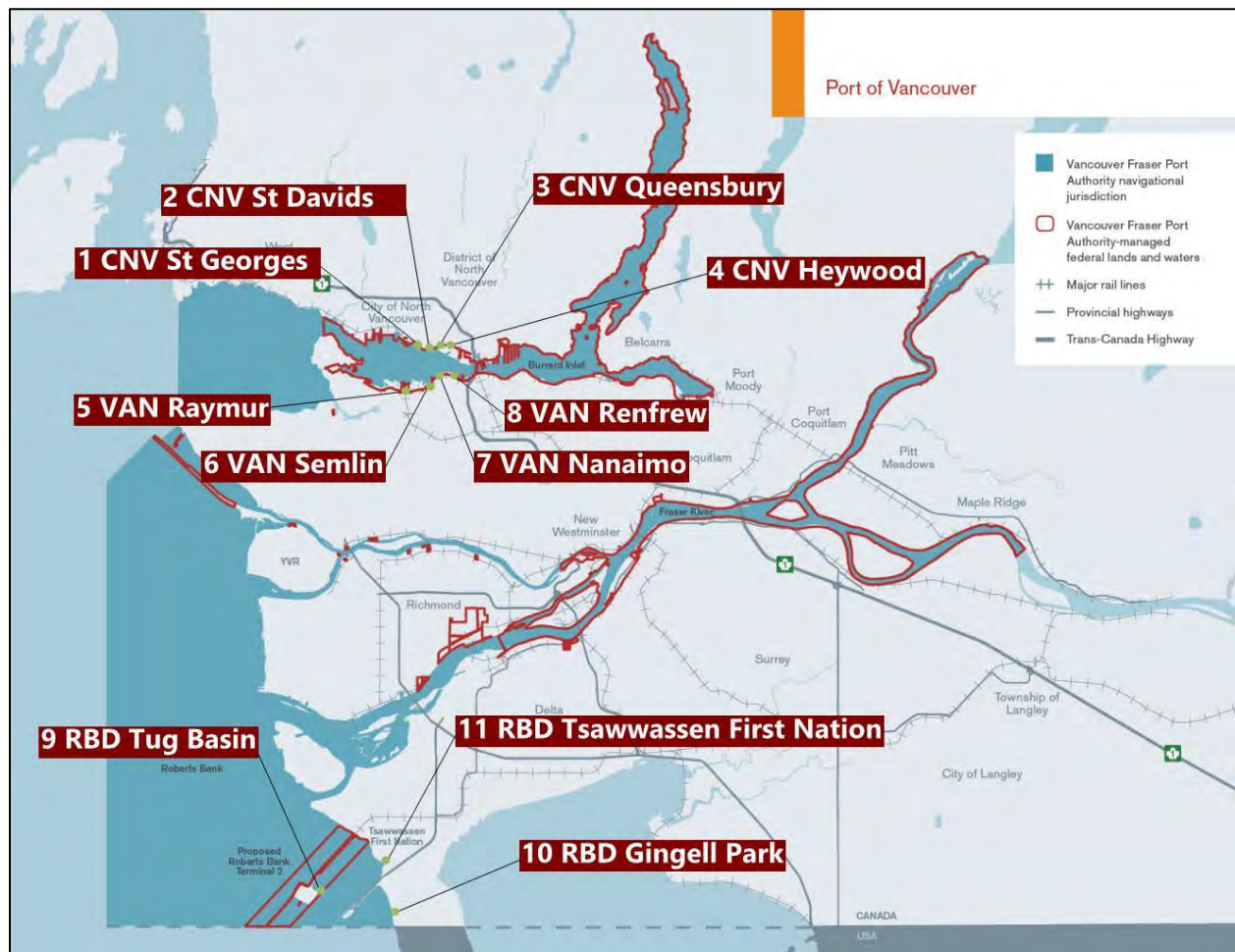


Figure 3 NMT Locations

Weather stations are also installed at one NMT per trade area: CNV St Davids for the north shore of Burrard Inlet, VAN Nanaimo for the south shore, and RBD Tug Basin for Roberts Bank. The weather data recorded from these three weather stations are shared with other NMTs in the same trade area.

Specific locations for each NMT were determined based on advice from technical experts along with community feedback. Efforts were made to locate each NMT to:

- be responsive to potential noise impacts identified by local residents and acoustical consultants; and
- meet operational constraints regarding land ownership, accessibility, site utilities, and security.

Some NMTs are not situated within the residential communities; the noise levels measured at these NMTs do not equate to noise levels experienced in the community. Each site is described in the Noise Monitoring Results section.

Seti Media Web Console

The Seti Media web console serves as the online control center for all the NMTs. Data from the NMTs are continuously streamed to the console. The application is used to view live and historical data, and export data.

While the web console is only accessible internally by VFPA, an online public website is available for viewing live and historical noise and weather data at each NMT, and listening to any audio clips recorded. Information about the web console and web access can be found at the following website: <http://www.portvancouver.com/port-dashboard/noise-monitoring/>.

Improvements are continually being made to the system to better track noise trends and events from port activities as the noise monitoring technology continues to be refined and developed.

Data Display

The Seti Media web console allows the user to select any NMT from a drop-down menu and display graphical information of the logged noise data. The details of the chart can be configured to show specific noise metrics, weightings, time range, and logging intervals.

Data Export

Additional details on noise and weather data that are not shown in the display can be exported to spreadsheet reports. These reports can be set up to be automatically generated at designated time intervals. While these data reports are only available internally to VFPA, upon request from the public or other stakeholders, they can be shared directly with interested parties.

Noise Alerts and Sound Clips

Noise alerts are set up internally by Seti Media. In the web console, noise alerts can only be reviewed. The alerts are set up to continually check the NMT data as it is logged for exceedances of particular static or dynamic noise thresholds. Alerts can be configured to monitor various noise metrics including equivalent, maximum, and minimum levels of broadband or frequency band-specific noise. When an exceedance occurs, an alert is created, and the alert name, time, location, exceeding value, and sound clip are recorded and documented. In this way, the web console can automatically log the occurrences of particular noise events, provided that it is adequately set up to flag the particular noise characteristics belonging to noise events of interest.

Noise Monitoring Reporting

Noise monitoring reporting includes the information summarized in Figure 4. The methodology used to define the noise levels and events is described in the sections below.

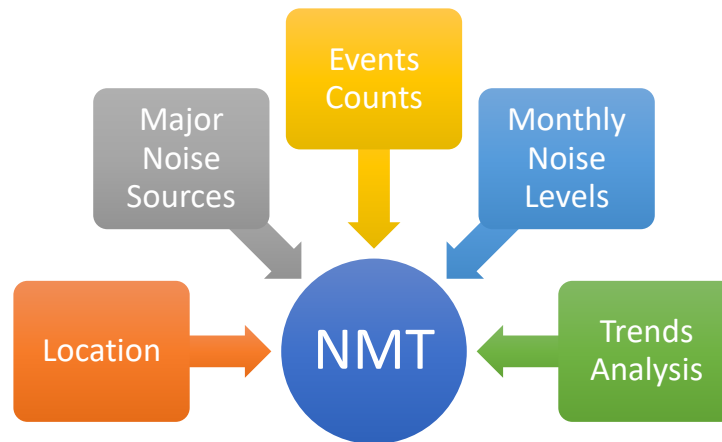


Figure 4 NMT Report Information

Noise Levels

While the decibel or A-weighted decibel is the basic unit used for noise measurement, specific sound metrics are used to appropriately quantify noise and its corresponding potential for disturbing the adjacent community. Figure 5 summarizes the two noise level metrics chosen for reporting in accordance with best practice (ANSI 2007, WG-AEN 2007). General noise theory and basic sound metrics can be found in Appendix B.

Day-Evening-Night Equivalent Sound Level, L_{den} (dBA)

- 24-hour time-averaged noise level commonly used to represent community annoyance when measured at community locations.
- 5 dBA penalty applied to evening period to represent increased community annoyance during evening periods (7 pm to 10 pm).
- 10 dBA penalty applied to night period to represent increased community annoyance during night periods (10 pm to 7 am).

Nighttime Equivalent Sound Level, L_n (dBA)

- Night period (10 pm to 7 am) time-averaged noise level commonly used to represent potential for sleep disturbance when measured at community locations.

Figure 5 Noise Monitoring Metrics

Noise Events

Alerts have been defined for each NMT for the purpose of warning against potential community noise complaints. The web console reviews the time-averaged noise data over 60-minute intervals during the day and over 15-minute intervals during the night, in accordance with British Standard BS 4142:2014, “Methods for rating and assessing industrial and commercial sound” (BSI 2014), and triggers alerts when higher-than-typical noise levels are recorded.

The alerts trigger when the measured noise level exceeds a pre-set threshold. The thresholds generally depend on the measured background noise level and modelled difference in noise level between the NMT location and the represented residential community. The process BKL used to calculate each threshold is summarized in Figure 6.

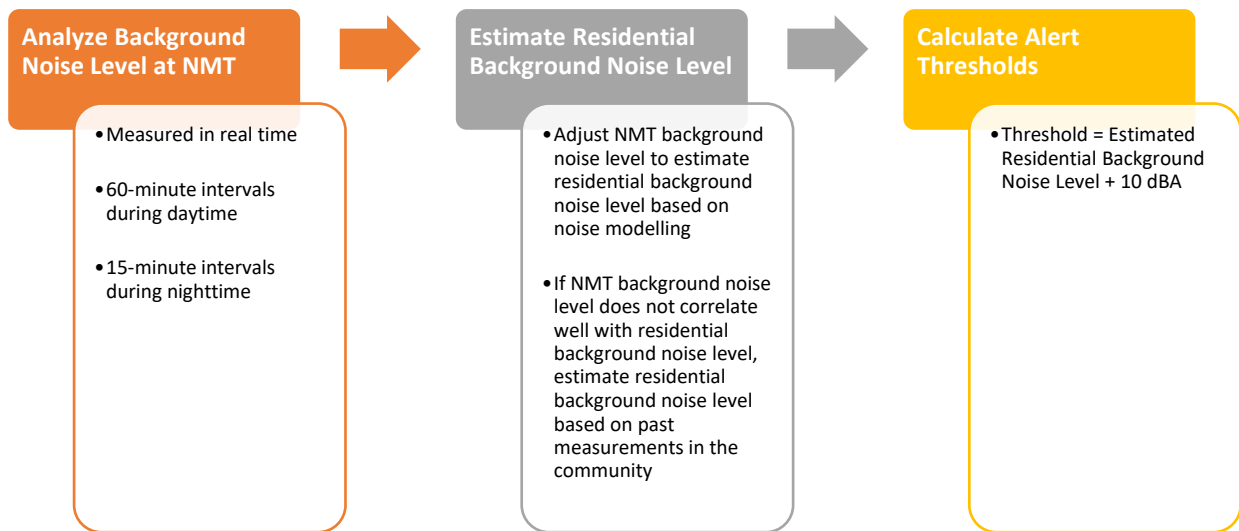


Figure 6 Process Used to Define Noise Events

At Roberts Bank, most port-related noise is quieter than local ambient noise levels in the nearest communities. Since high-frequency sound is more rapidly absorbed by the atmosphere compared to low-frequency sound, disturbance to these communities has typically been due to low-frequency noise (LFN) from sources such as shipboard generators. Hence, alerts for the Roberts Bank NMTs in the community are set to monitor LFN levels only and are validated by confirming that high levels of LFN were also measured simultaneously at the NMT located near the terminals.

Noise Monitoring Results

The data sheets on the following pages provide an overview of each NMT, a summary of the noise data and events logged since January 2020, a comparison of 2022¹ to 2021² noise levels, and commentary on any observable trends over the past 36 months. In 2021, VAN Semlin was offline between June 2019 and February 2021, due to delays in finding a suitable location for installation.

For the north shore NMTs (Locations 1 to 4), noise levels recorded in 2022 were similar to or slightly lower than those measured in 2021, except for CNV Heywood where noise levels have slightly increased. At CNV St Davids, the noise levels were unusually low for the months of April to June 2022. Minimal events were recorded, which is similar to 2021.

For the south shore NMTs (Locations 5 to 8), noise levels recorded in 2022 were similar to or slightly higher than those measured in 2021. Minimal events were recorded, which is similar to 2021, except for VAN Semlin where there were significantly more events during nighttime.

For the Roberts Bank NMTs (Locations 9 to 11), noise levels recorded in 2022 were similar or slightly lower than those measured in 2021. Minimal events were recorded, which is similar to 2021.

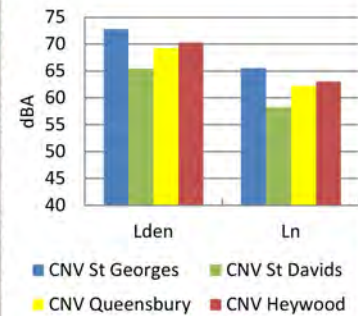
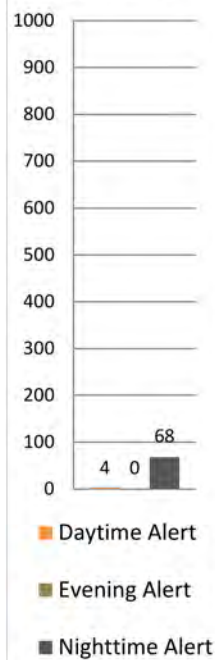
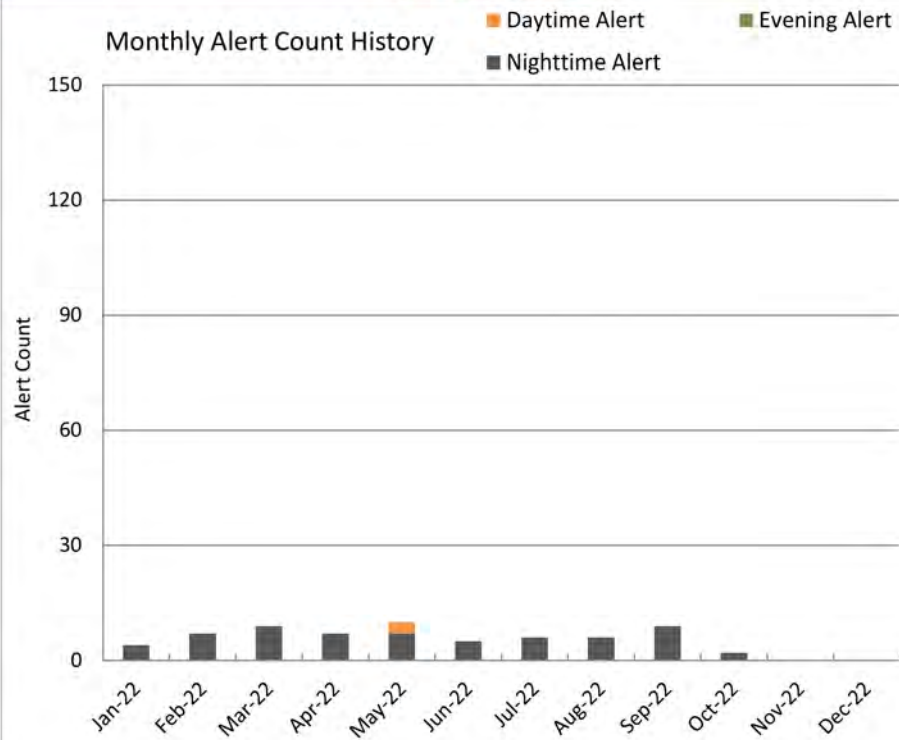
¹ The 2022 measurement period corresponds to noise levels measured from January 1, 2022, to December 31, 2022.

² The 2021 measurement period corresponds to noise levels measured from January 1, 2021, to December 31, 2021.

North Shore NMT Total

Notes:

- Most alerts were generated during nighttime at CNV St Georges and CNV Davids in 2022.
- No alerts were recorded during evening in 2022.
- No alerts were recorded in November and December 2022.


2022 Overall Noise Levels

2022 Alert Count

Monthly Alert Count History


North Shore - NMT Location 1: CNV St Georges

Location: Near intersection of St Georges Ave and Victory Ship Way, North Vancouver.

Dominant Noise Sources: Rail activity, substation fan, Esplanade Ave traffic, nearby trucks, and sandblasting at Vancouver Drydock.

Community Noise Levels Comparison: NMT noise levels are approximately four times (~20 dBA) louder than those experienced at nearest residences due to the close proximity of the rail line to the NMT and relative distance to nearest dwellings.



Event Commentary:

There were minimal alerts generated at this site and most alerts were generated during nighttime.

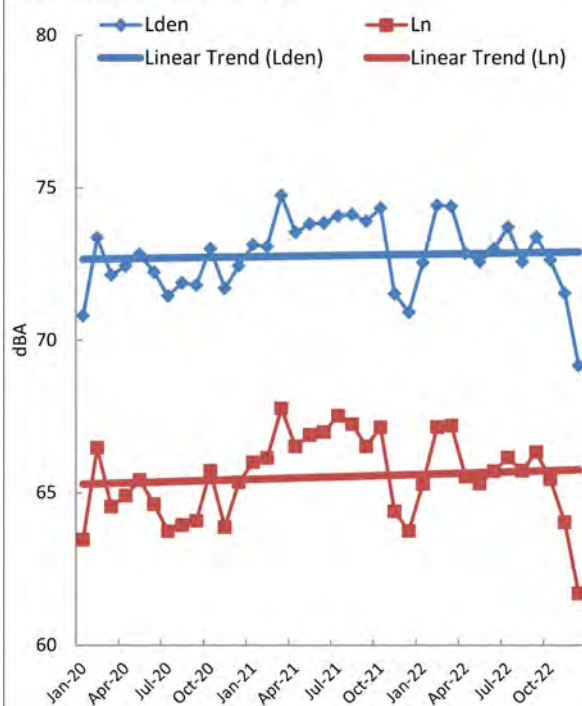
Noise Level Commentary:

In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden decreased by 0.5 dBA and Ln decreased by 1 dBA.

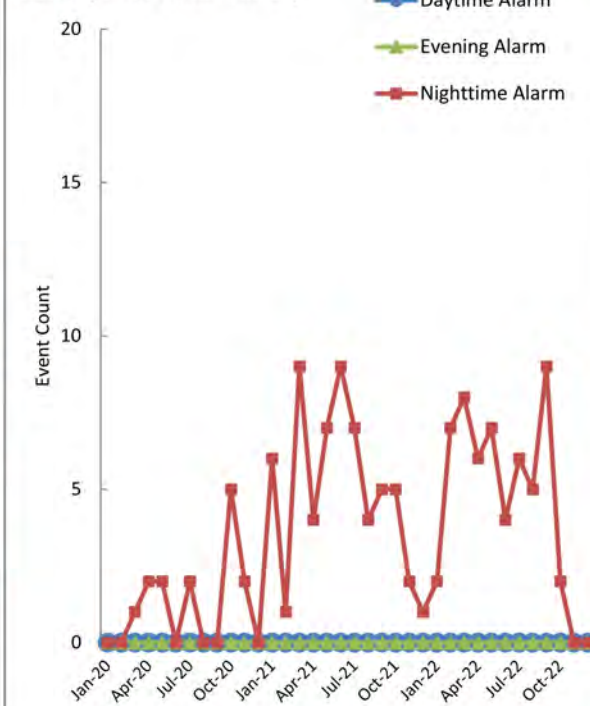
From January 2020 to December 2022 the long-term trend in Lden remained the same and Ln increased by 0.5 dBA.

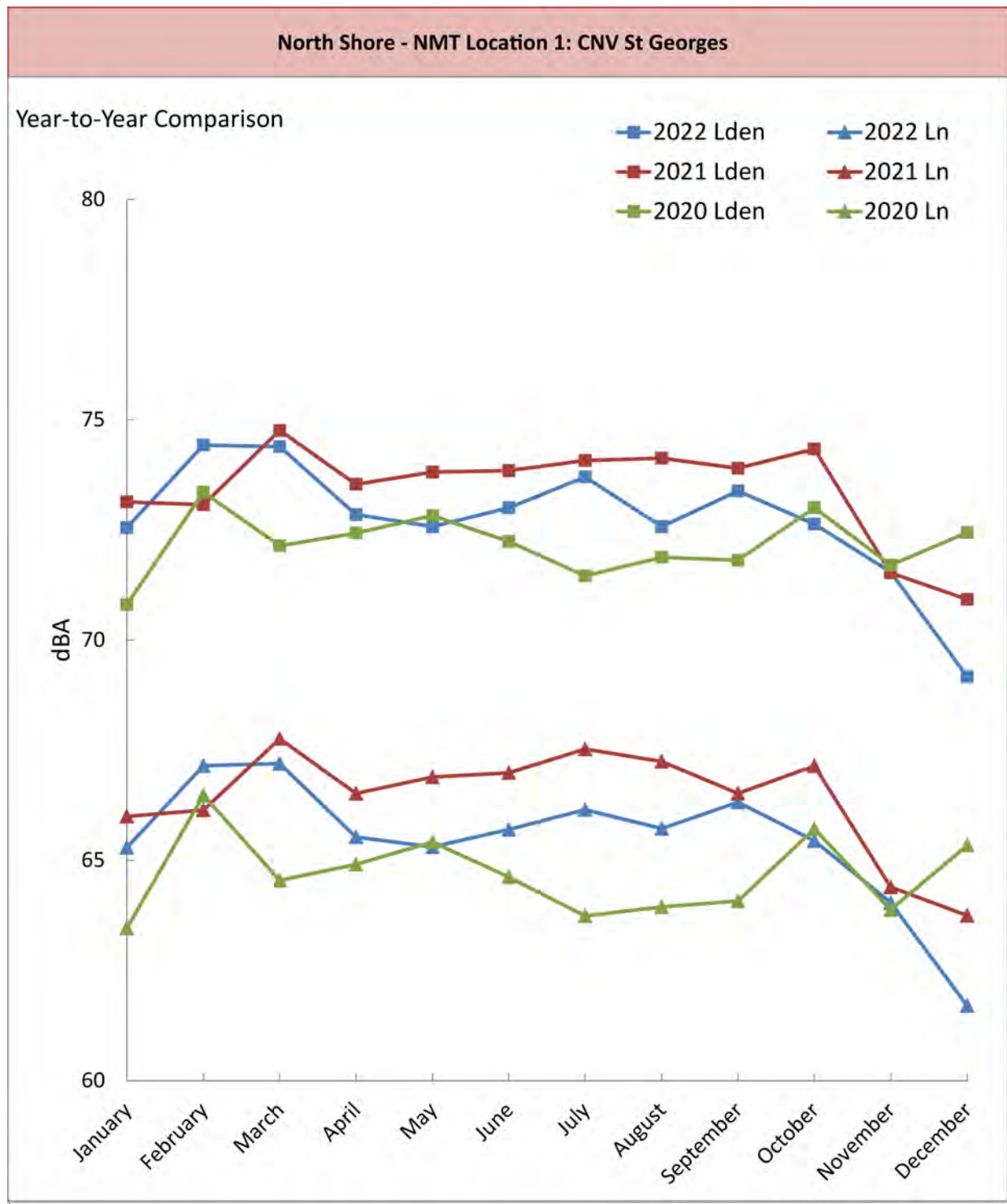


Monthly Noise Level History



Monthly Event Count History





North Shore - NMT Location 2: CNV St Davids

Location: Near intersection of St Davids Ave and Alder St, North Vancouver.

Dominant Noise Sources: Low Level Road traffic, rail activities (passbys, shunting, and rail squeal) and Richardson Terminal activity.

Community Noise Levels Comparison: NMT noise levels are very similar to those experienced at residences closest to the port.



No data available between July 1 and July 20, 2022.

Event Commentary:

There were minimal alerts generated at this site and most alerts were generated during nighttime. There was no clear trend for any of the alerts.

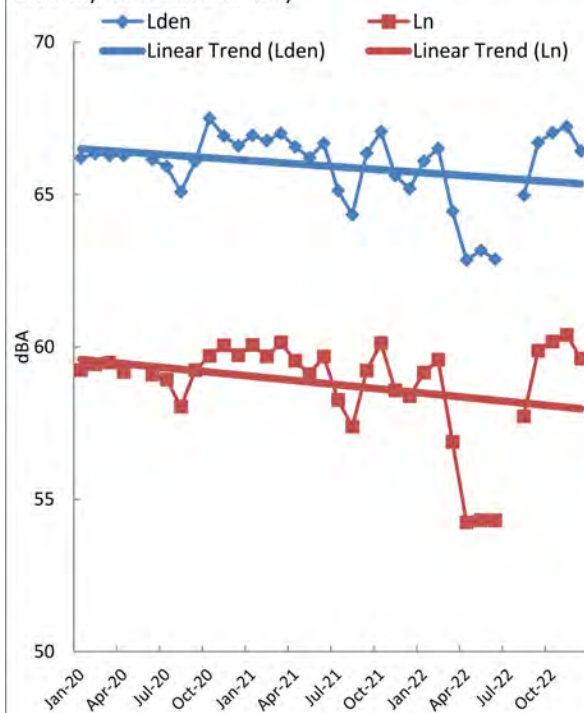
Noise Level Commentary:

In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden and Ln both decreased by 1 dBA.

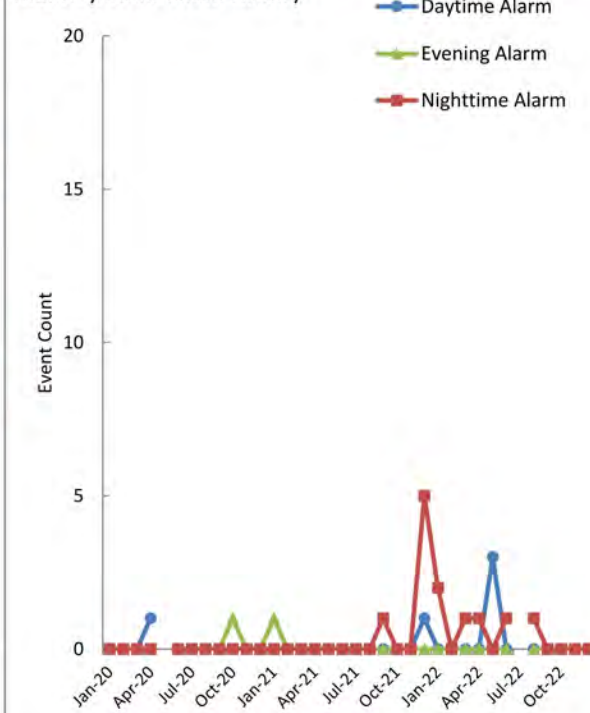
From January 2020 to December 2022 the long-term trend in Lden decreased by 2 dBA and Ln decreased by 2.5 dBA.



Monthly Noise Level History

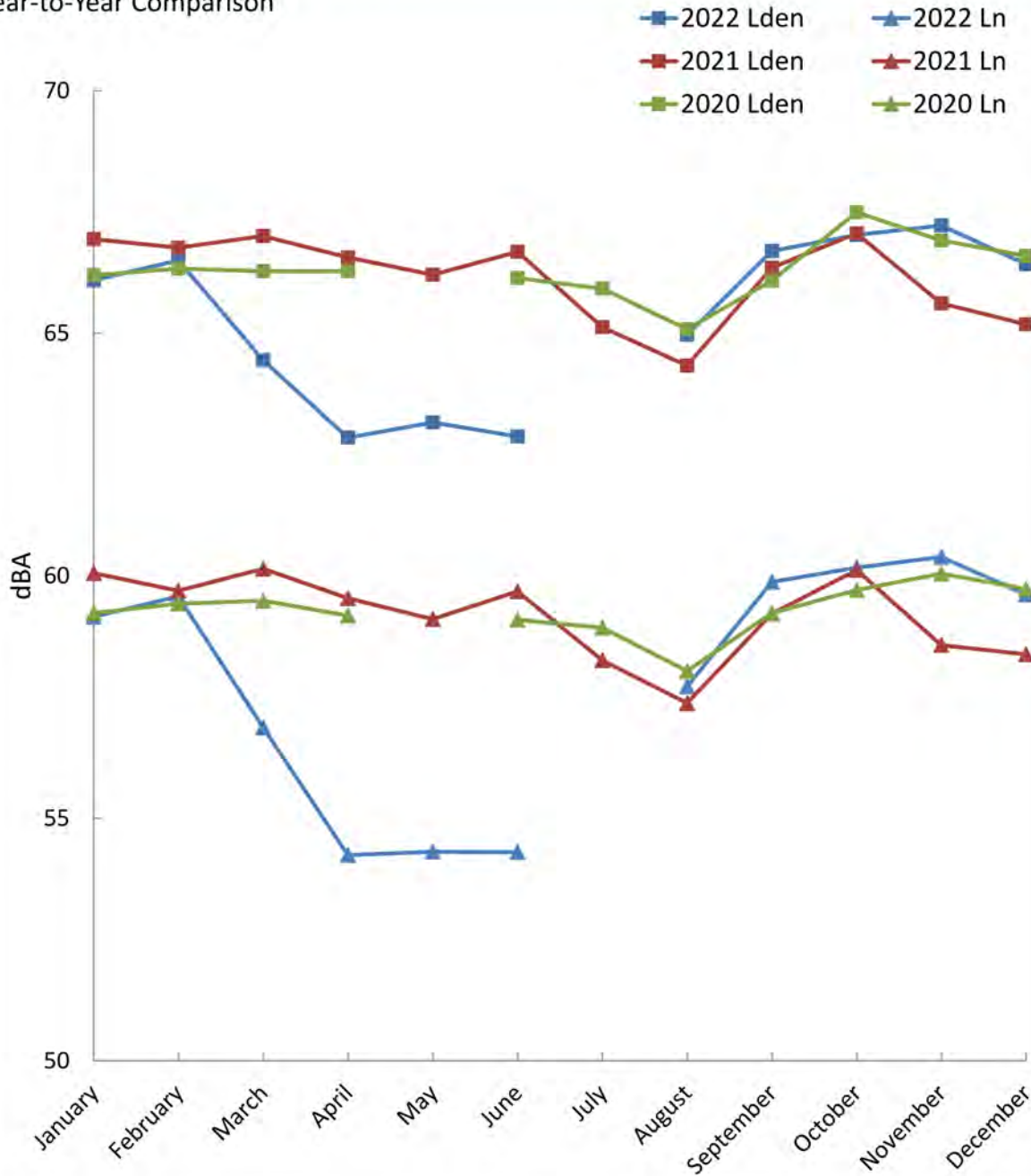


Monthly Event Count History



North Shore - NMT Location 2: CNV St Davids

Year-to-Year Comparison



North Shore - NMT Location 3: CNV Queensbury

Location: Spirit Trail near E 3rd Street and Queensbury Avenue, North Vancouver.

Dominant Noise Sources: Cargill Terminal activity, rail activities (passbys and rail squeal), Low Level Road traffic, and East 3rd Street traffic.

Community Noise Level Comparison: Noise levels at NMT are slightly higher (~4 dBA) than experienced at nearest residences.



No data available between January 2020 and July 2020.

Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:

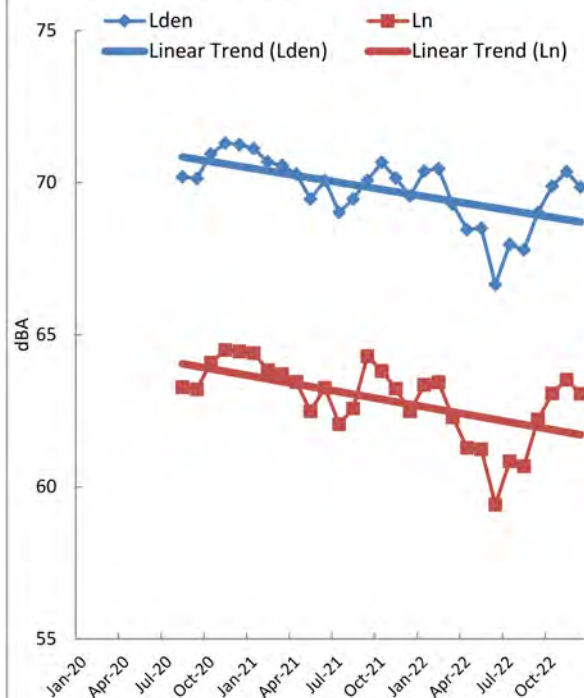
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden and Ln both decreased by 1 dBA.

From January 2020 to December 2022 the long-term trend in Lden decreased by 2.5 dBA and Ln decreased by 3 dBA.

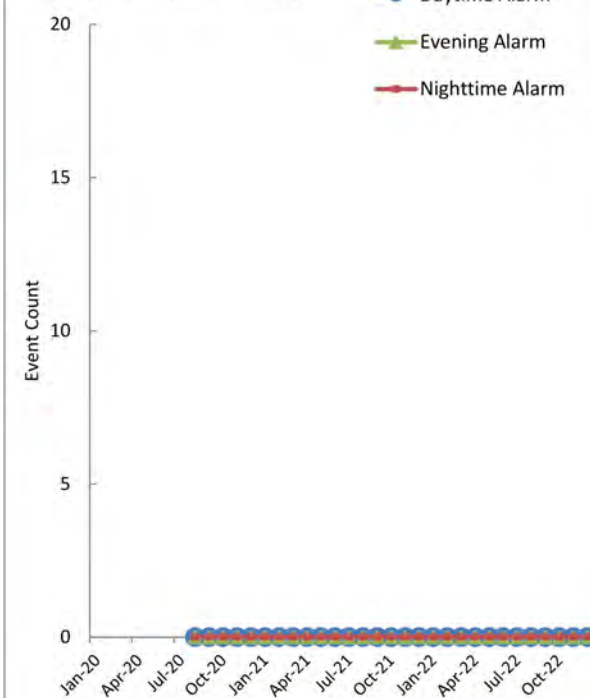
The measured noise level was lower than typical in June 2022. It appears that steady noise source became inactive during that time.

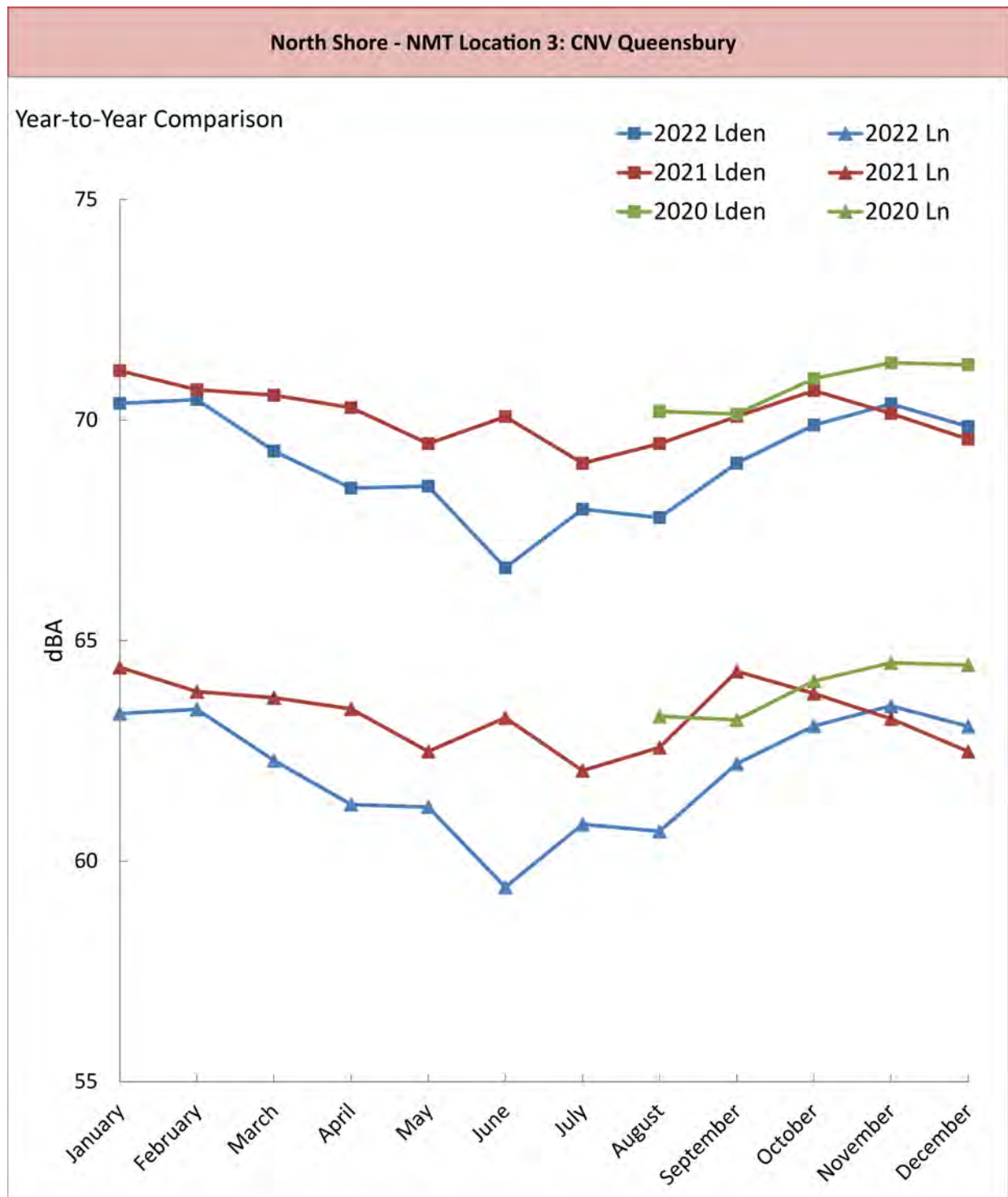


Monthly Noise Level History



Monthly Event Count History





North Shore - NMT Location 4: CNV Heywood

Location: Near intersection of Heywood St and 3rd St E, North Vancouver.

Dominant Noise Sources: East 3rd Street traffic, rail activities (shunts, rail squeal, passbys), Low Level Road traffic, Neptune Bulk Terminals and Cargill Terminal activity.

Community Noise Level Comparison: Noise levels at NMT are slightly higher (~3 dBA) than experienced at nearest residences.



Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

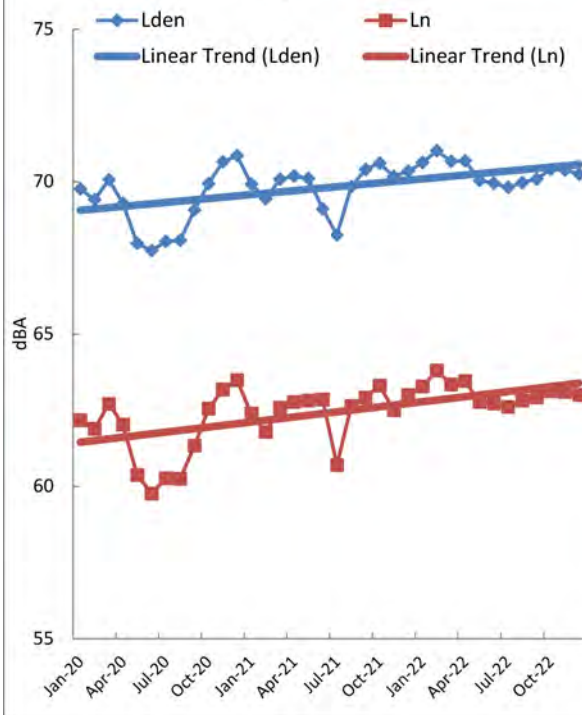
Noise Level Commentary:

In the past year, monthly noise levels did not fluctuate significantly. Compared to 2021 overall noise levels, the 2022 Lden and Ln both increased by 0.5 dBA.

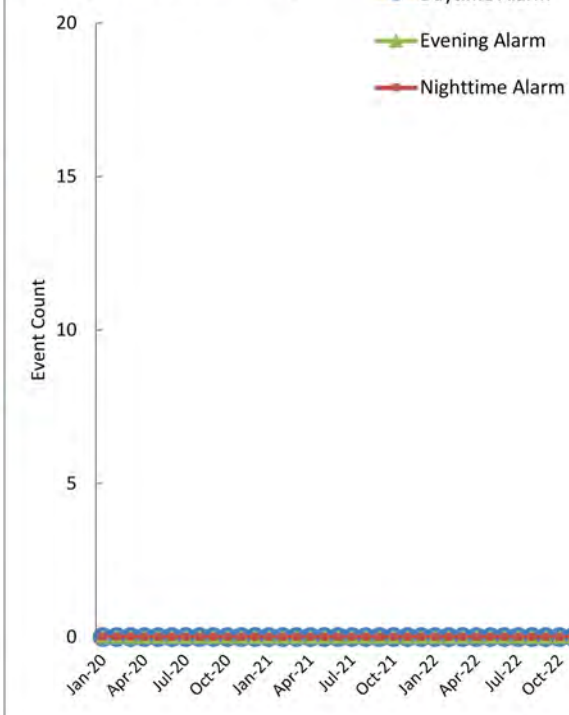
From January 2020 to December 2022 the long-term trend in Lden increased by 1.5 dBA and Ln increased by 2 dBA.

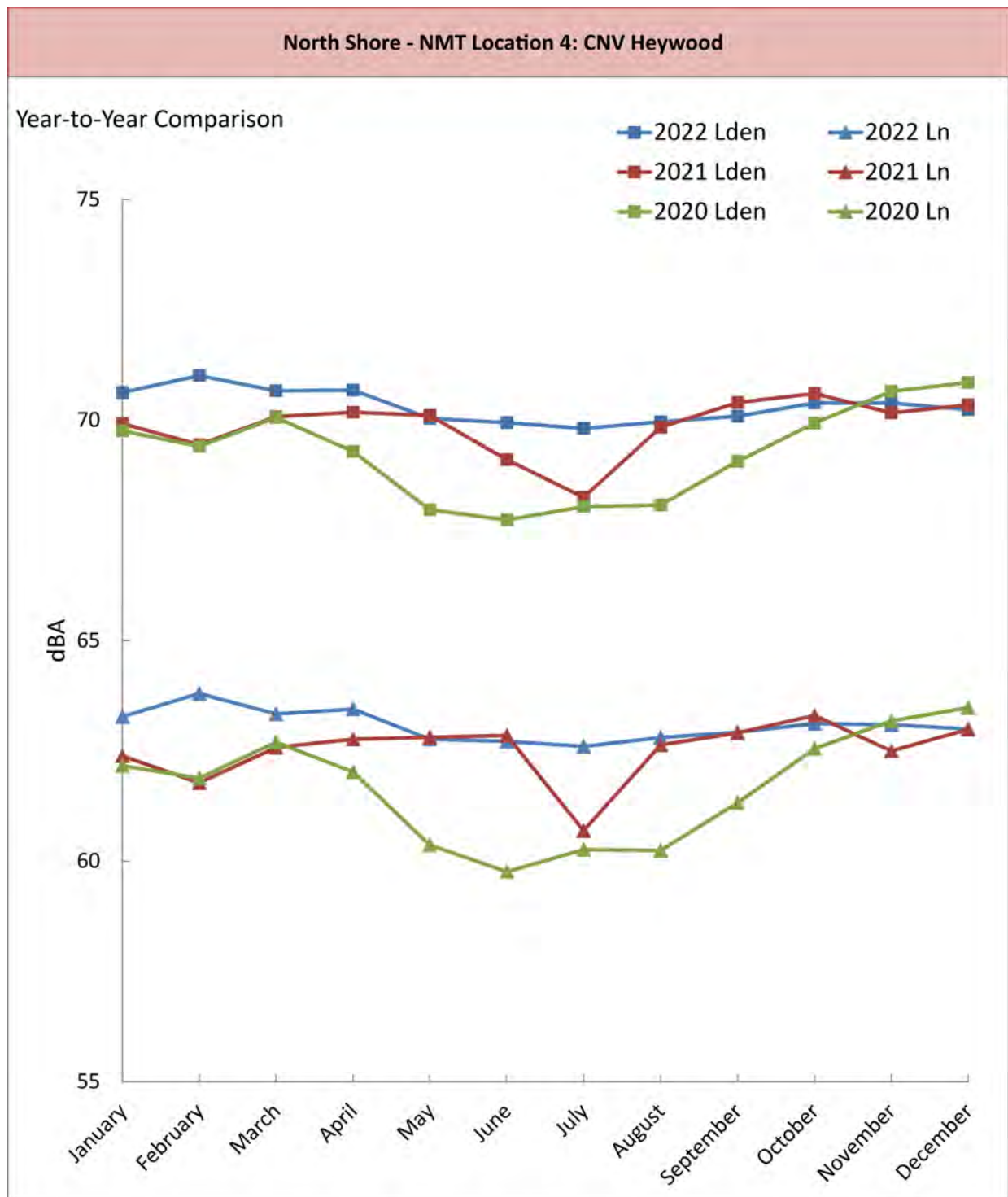


Monthly Noise Level History



Monthly Event Count History





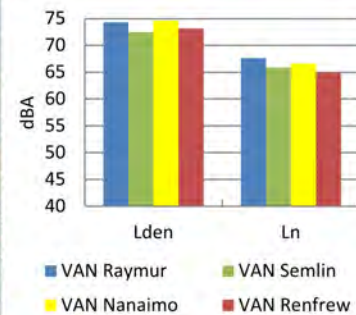
South Shore NMT Total

Notes:

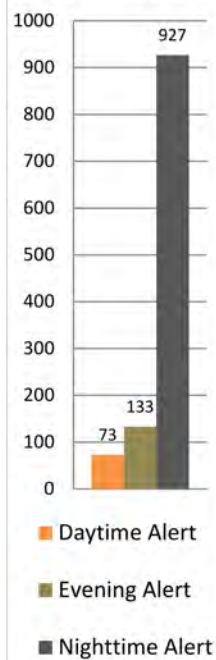
- There were significantly more alerts generated during nighttime in 2022. Most of the alerts were from VAN Semlin.



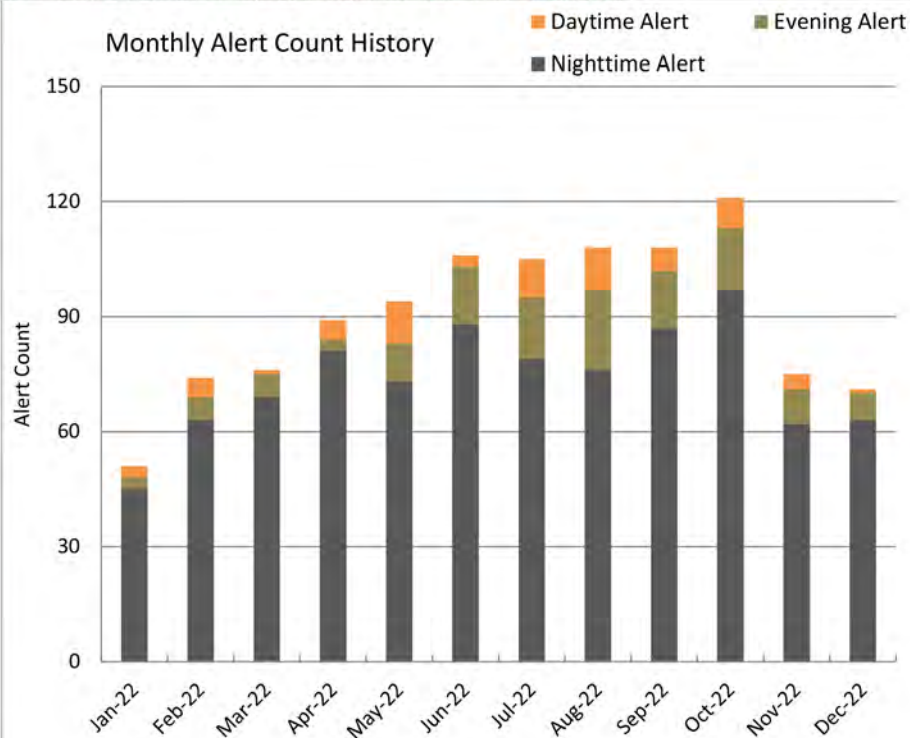
2022 Overall Noise Levels



2022 Alert Count



Monthly Alert Count History



South Shore - NMT Location 5: VAN Raymur

Location: Near Centennial Rd where it transitions to Stewart St, Vancouver.

Dominant Noise Sources: Rail activities (passbys, rail squeal) and Stewart St truck traffic.

Community Noise Level Comparison: Noise levels at NMT are approximately four times louder (~20 dBA) than those experienced at nearest residences due to the close proximity of Stewart Street and the rail lines to the NMT and relative distance to nearest dwellings.



No data available between June and July 2020.

Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

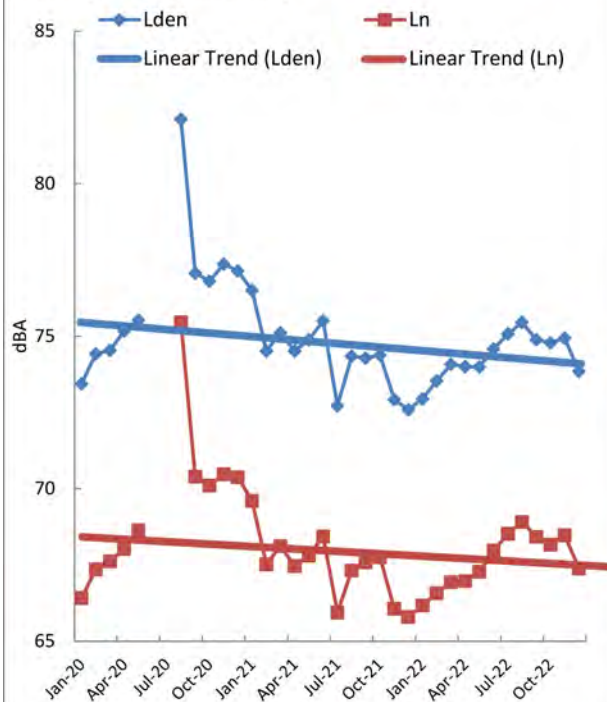
Noise Level Commentary:

In the past year, monthly noise levels did not fluctuate significantly. Compared to 2021 overall noise levels, the 2022 Lden decreased by 0.5 dBA and Ln did not change.

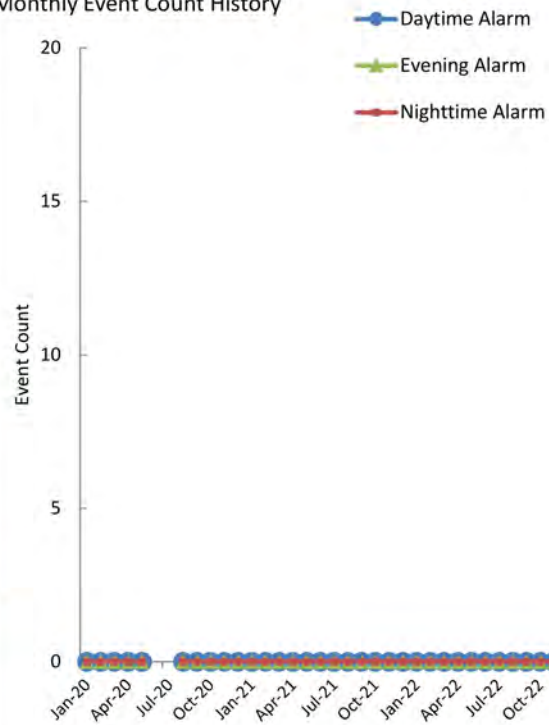
From January 2020 to December 2022 the long-term trend in Lden decreased by 0.5 dBA and Ln decreased by 0.5 dBA.

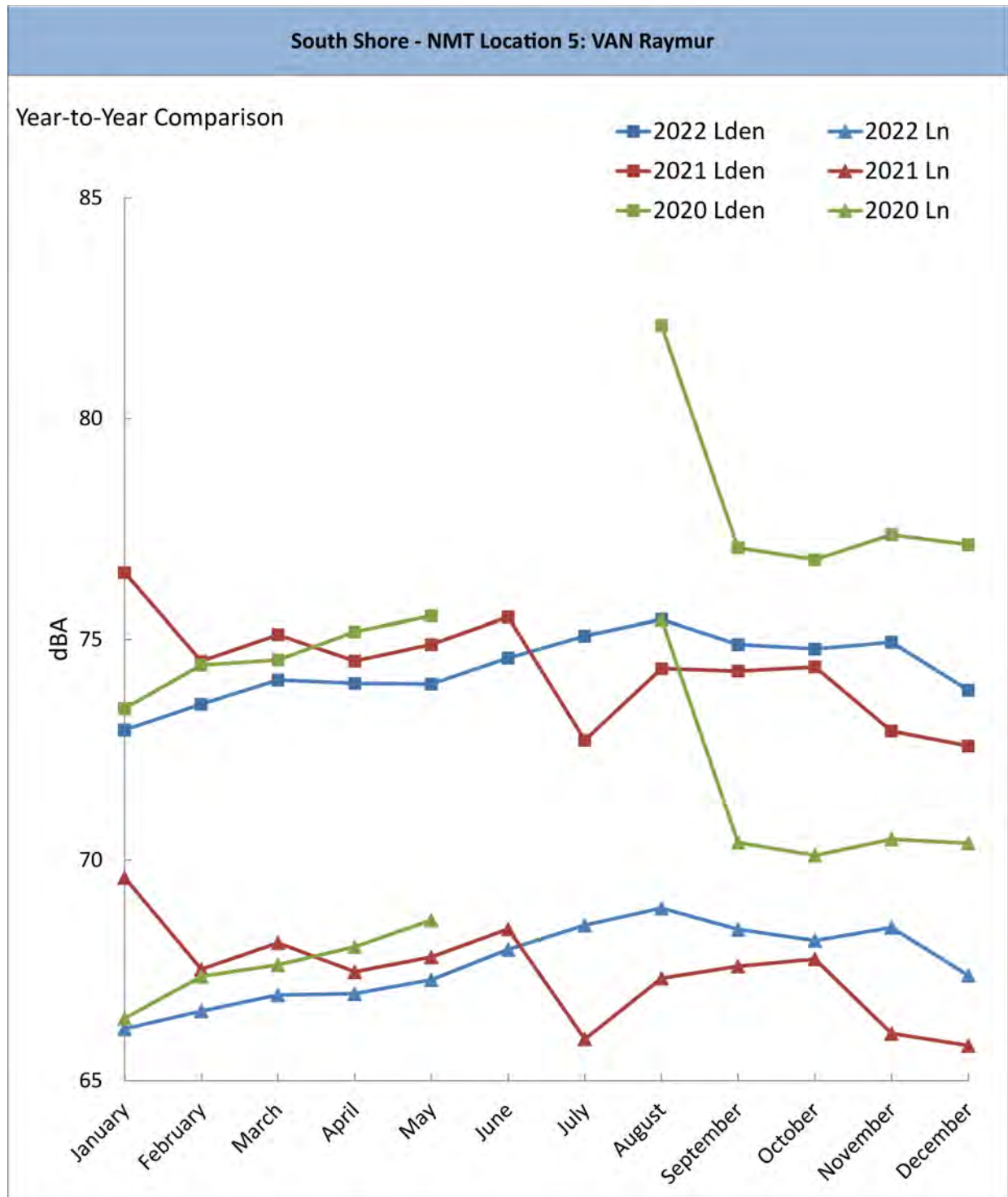


Monthly Noise Level History



Monthly Event Count History





South Shore - NMT Location 6: VAN Semlin

Location: Cambridge Park near Wall St, Vancouver.

Dominant Noise Sources: Rail activities (passbys, rail squeal) and Commissioner Street truck traffic.

Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.



No data available before March 2021, when the NMT was reinstalled; and, no data available between May 17 and May 20, 2021.

Event Commentary:

There were minimal alerts generated at this site during daytime and evening, and significantly more alerts generated during nighttime. There was no clear trend for any of the alerts.

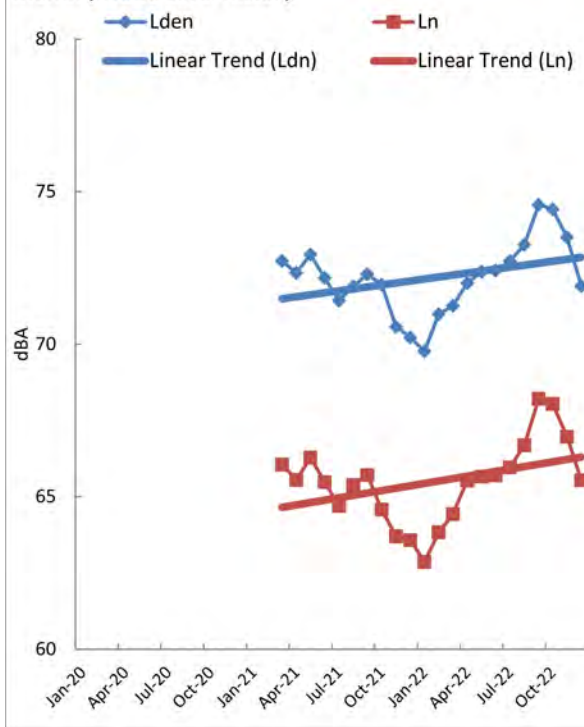
Noise Level Commentary:

In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden increased by 0.5 dBA and Ln increased by 1 dBA.

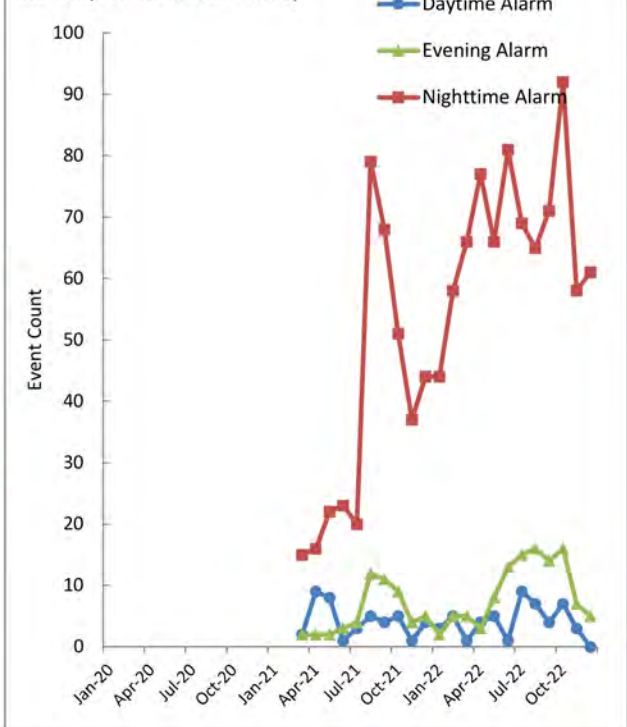
From January 2020 to December 2022 the long-term trend in Lden increased by 2.5 dBA and Ln increased by 3 dBA.

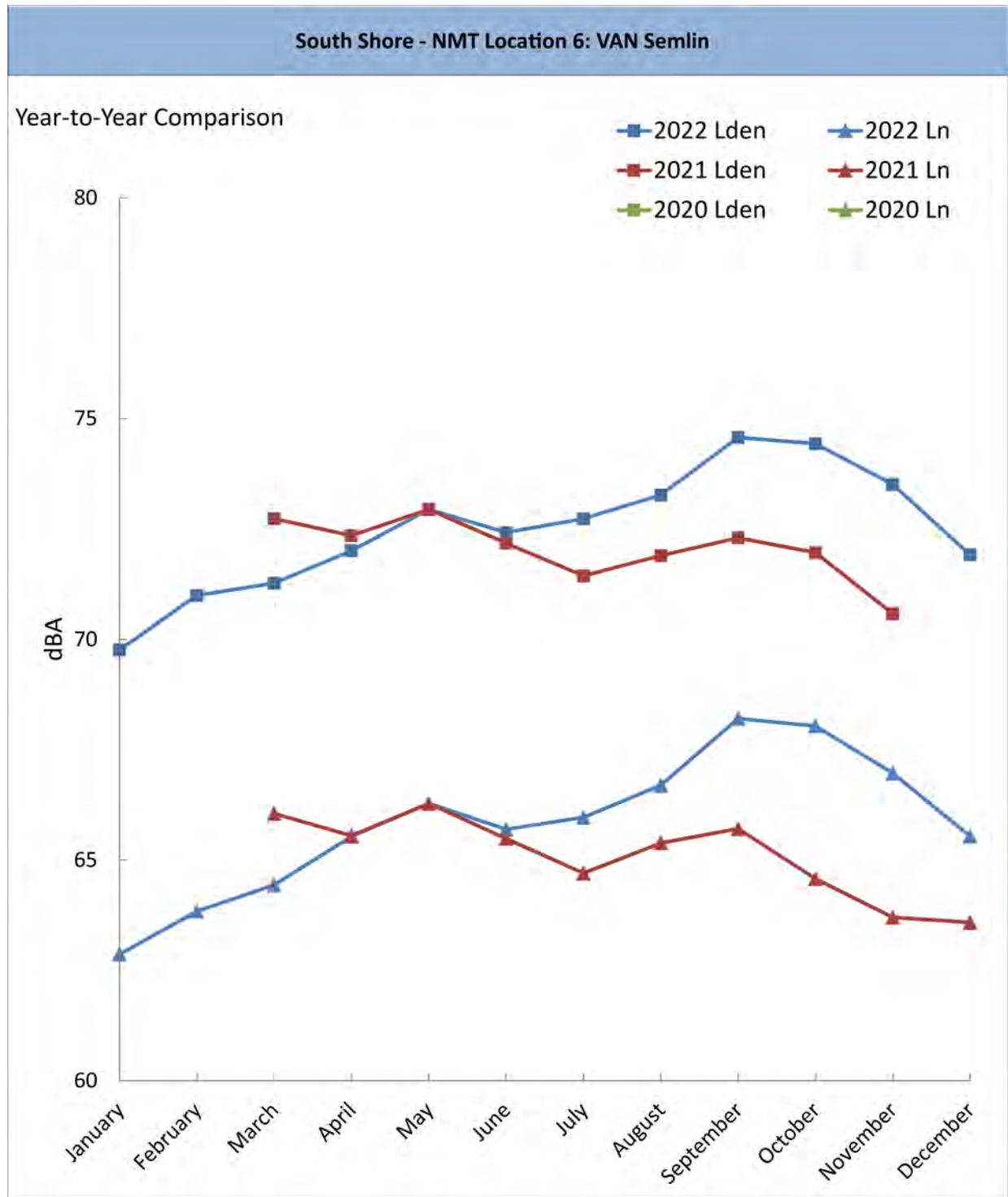


Monthly Noise Level History



Monthly Event Count History





South Shore - NMT Location 7: VAN Nanaimo

Location: Commissioner St near N Nanaimo St, Vancouver.

Dominant Noise Sources: Rail activities (passbys, rail squeal) and Commissioner Street truck traffic.

Community Noise Level Comparison: Noise levels at NMT are noticeably louder (~6 dBA) than those experienced at nearest residences.



No data available between March and May 2021.

Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

Noise Level Commentary:

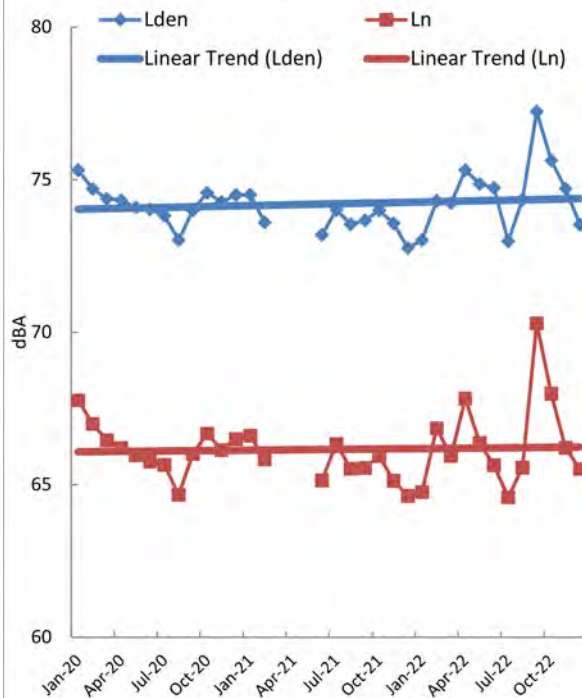
In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden and Ln both increased by 1 dBA.

From January 2020 to December 2022 the long-term trend in Lden increased by 0.5 dBA and Ln remained the same.

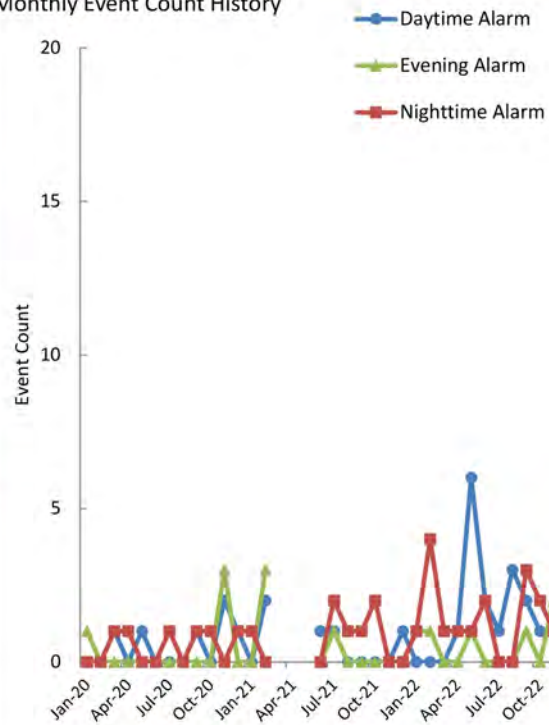
There were a number of noisy events lasting for less than 1 hour observed during daytime and nighttime in September 2022.

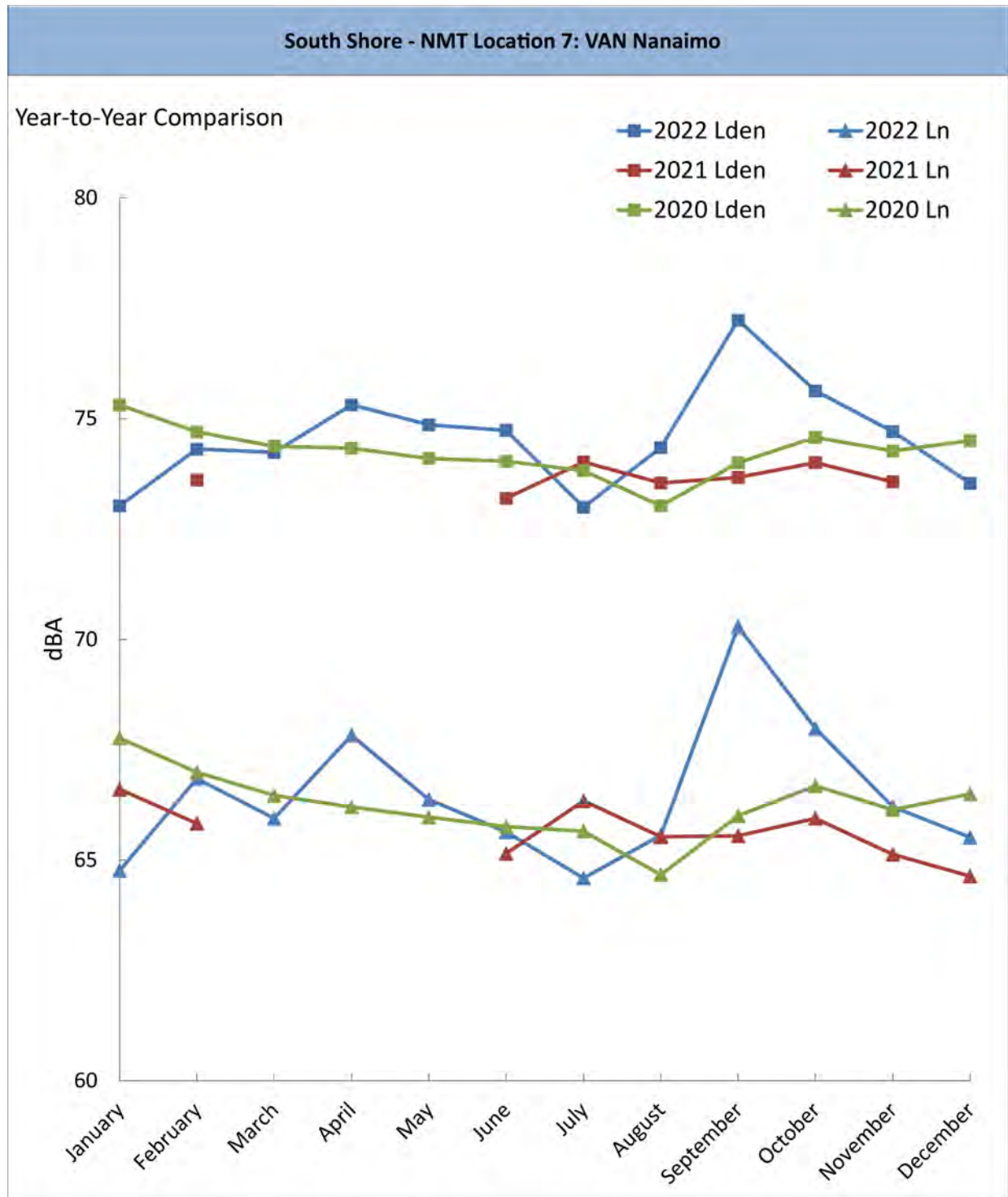


Monthly Noise Level History



Monthly Event Count History





South Shore - NMT Location 8: VAN Renfrew

Location: Commissioner St near N Renfrew St, Vancouver.

Dominant Noise Sources: Commissioner Street truck traffic accelerating away from gates, rail activities (passbys and rail squeal).

Community Noise Level Comparison: Noise levels at NMT are slightly higher (~3 dBA) than experienced at nearest residences.



Event Commentary:

There were minimal alerts generated at this site. Most alerts were generated during nighttime. There was no clear trend for any of the alerts.

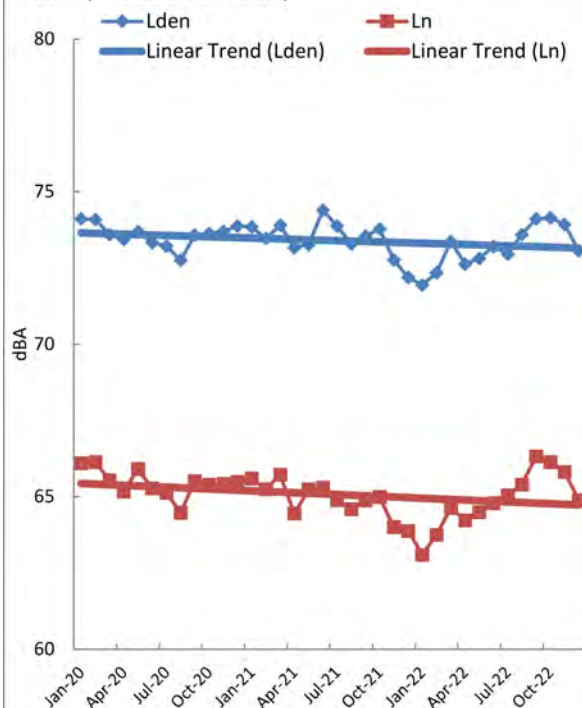
Noise Level Commentary:

In the past year, monthly noise levels did not fluctuate significantly. Compared to 2021 overall noise levels, the 2022 Lden decreased by 0.5 dBA and Ln did not change.

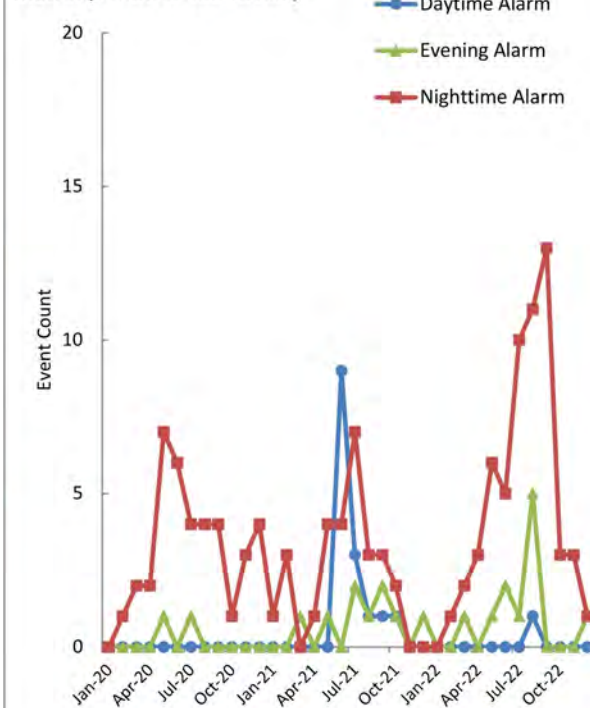
From January 2020 to December 2022 the long-term trend in Lden decreased by 0.5 dBA and Ln decreased by 0.5 dBA.

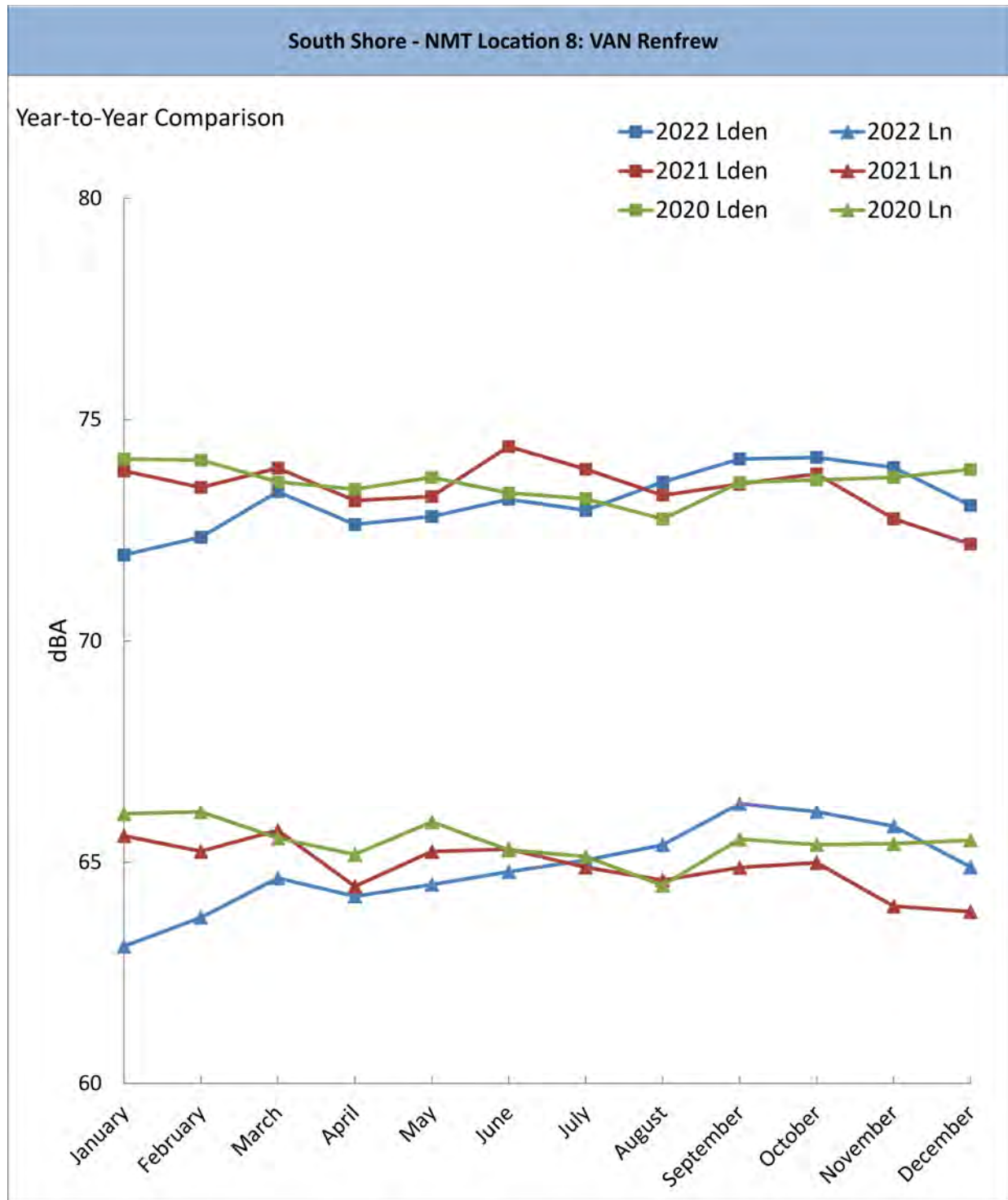


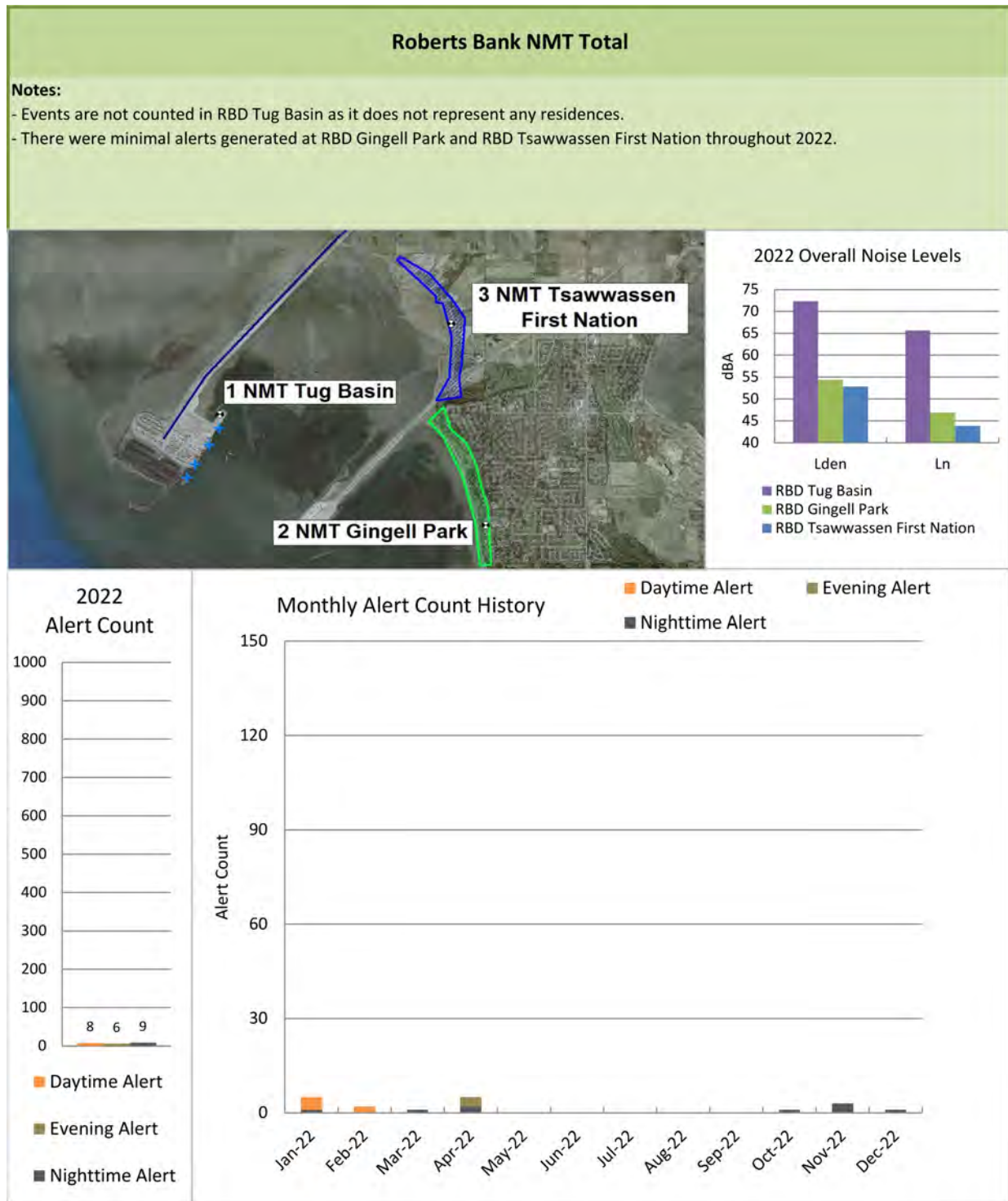
Monthly Noise Level History



Monthly Event Count History







Roberts Bank - NMT Location 9: RBD Tug Basin

Location: Northeast corner of Deltaport Terminals, Delta. Monitoring analysis began in Dec 2015.

Dominant Noise Sources: Deltaport Terminals activity.

Community Noise Level Comparison: Noise levels at NMT are significantly higher than those experienced at nearest residences as this NMT is located at the terminal.



Event Commentary:

Events are not counted at this NMT as it does not represent any residences. NMT is used to confirm port noise events for alerts generated at other RBD NMTs.

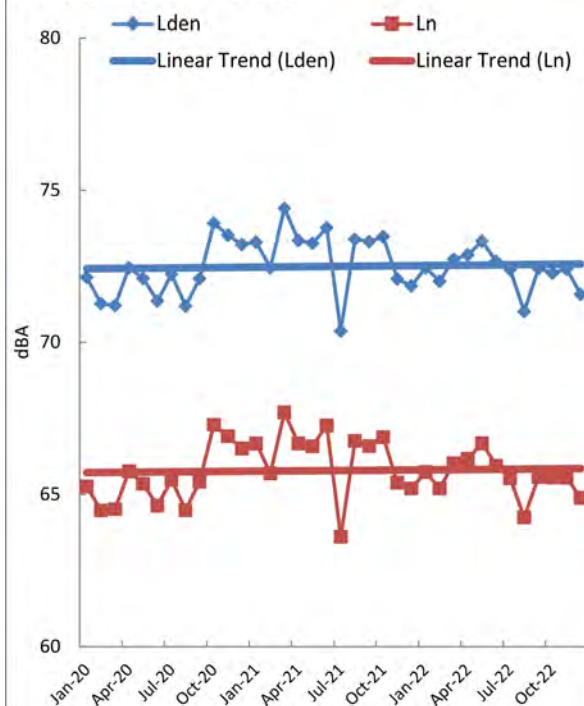
Noise Level Commentary:

In the past year, monthly noise levels did not fluctuate significantly. Compared to 2021 overall noise levels, the 2022 Lden and Ln both decreased by 0.5 dBA.

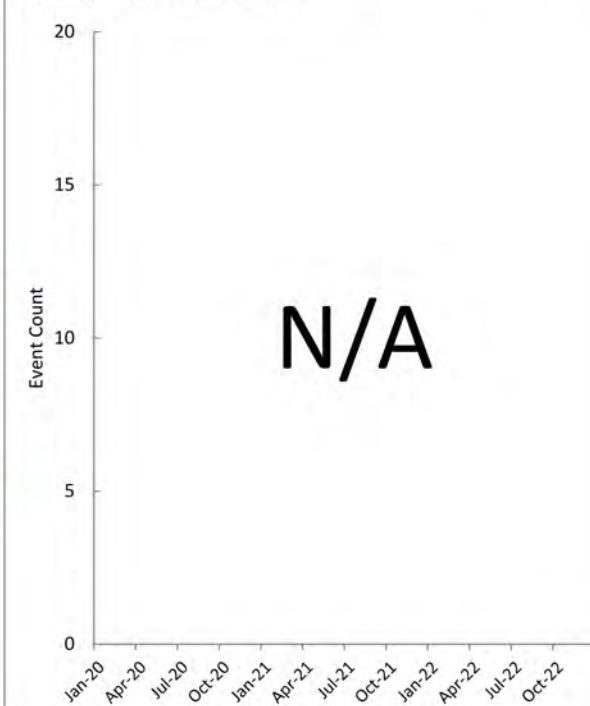
From January 2020 to December 2022 the long-term trend in Lden remained the same and Ln remained the same.

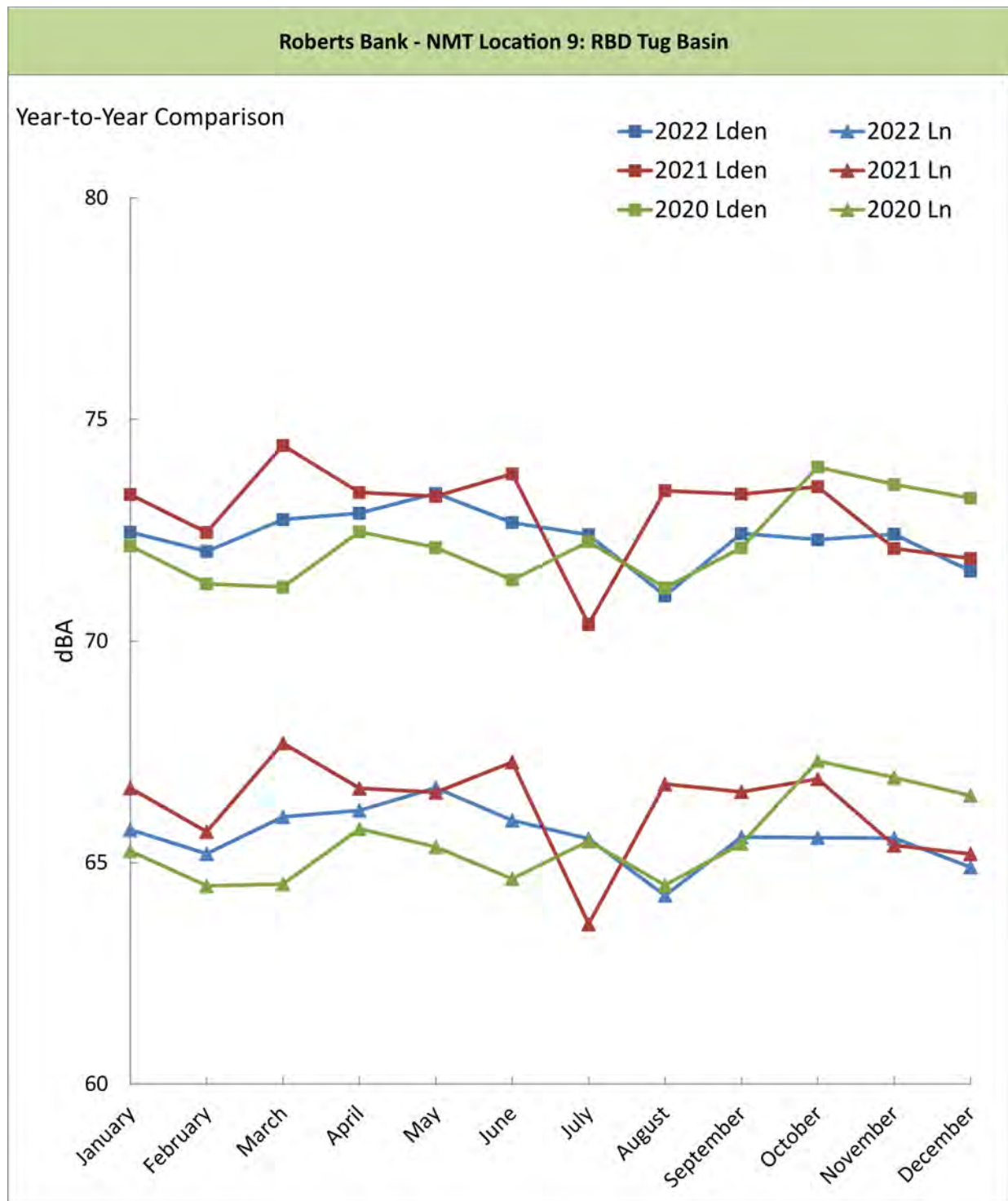


Monthly Noise Level History



Monthly Event Count History





Roberts Bank - NMT Location 10: RBD Gingell Park

Location: Fred Gingell Park near English Bluff Rd, Delta. Monitoring analysis began in Dec 2015.

Dominant Noise Sources: Local sources such as traffic, Tsawwassen Ferry, and Deltaport terminals activity.

Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.

Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

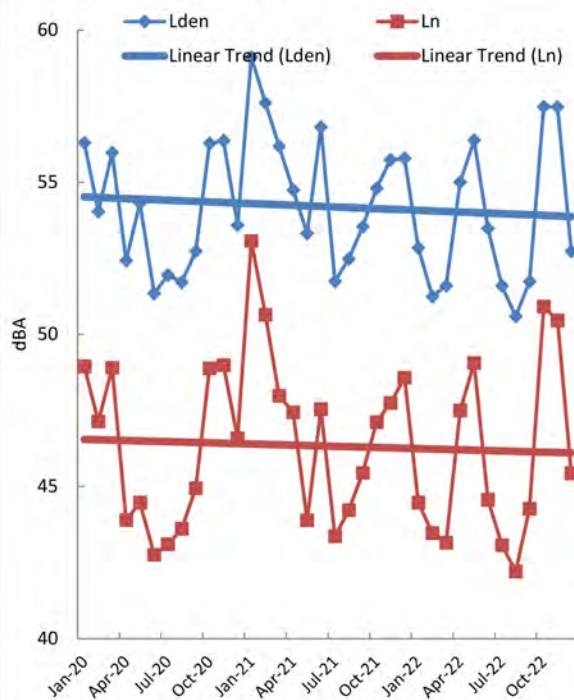
Noise Level Commentary:

In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden and Ln both decreased by 1.5 dBA.

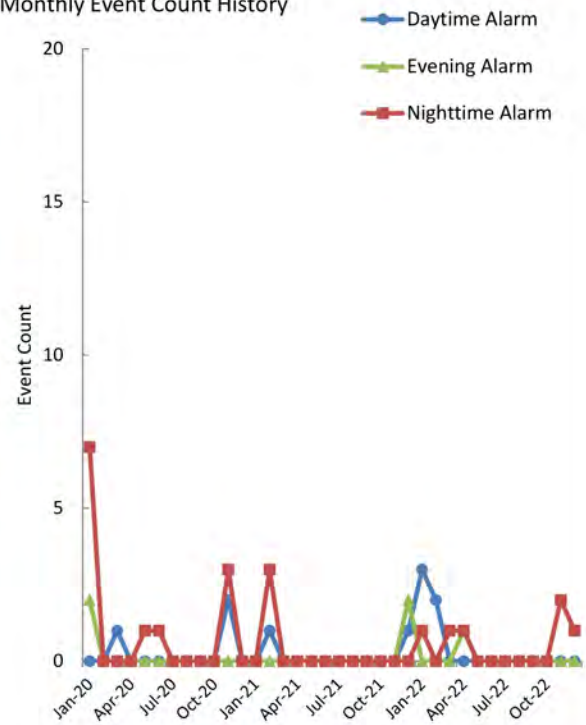
From January 2020 to December 2022 the long-term trend in Lden decreased by 0.5 dBA and Ln decreased by 0.5 dBA.

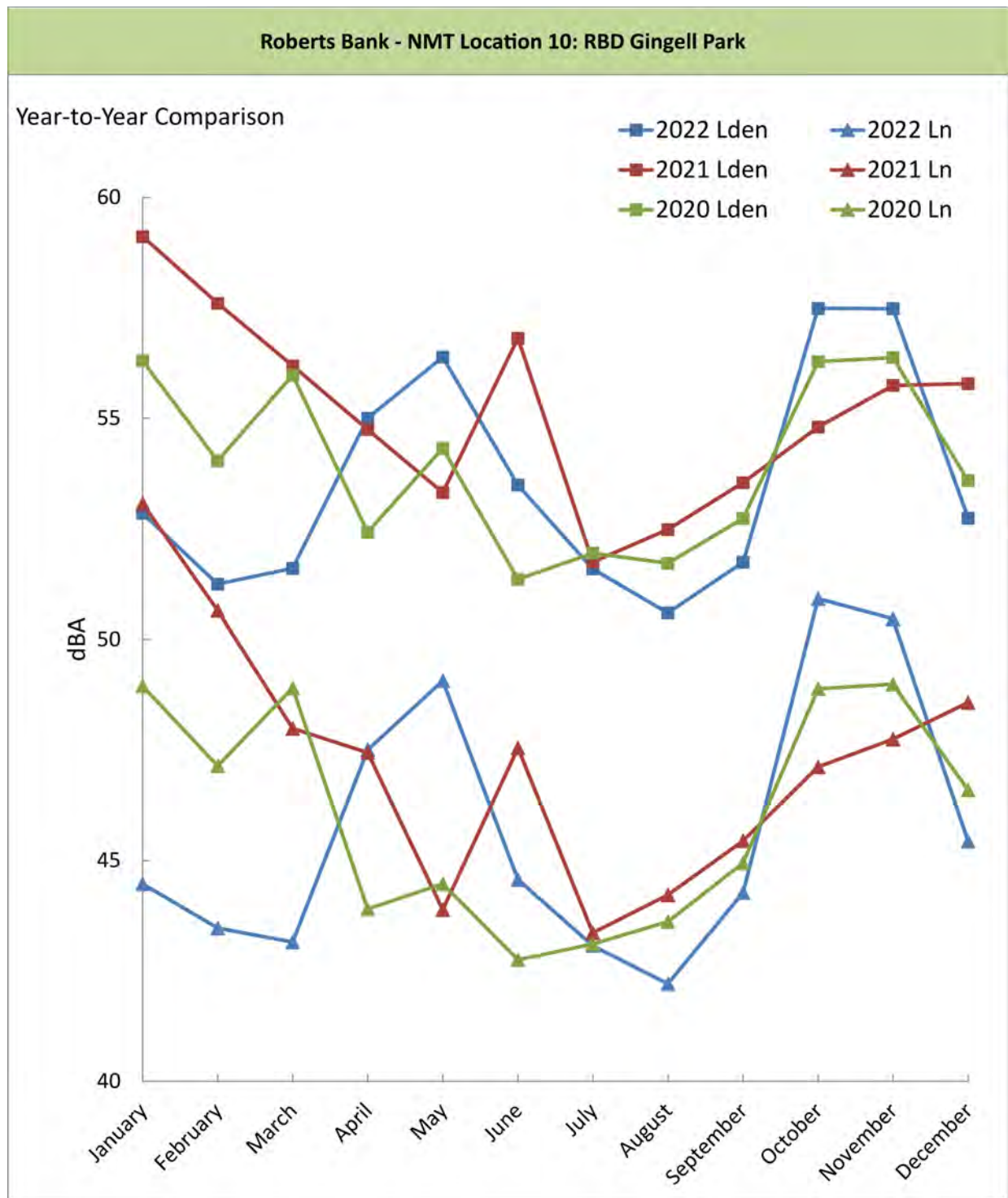


Monthly Noise Level History



Monthly Event Count History





Roberts Bank - NMT Location 11: RBD Tsawwassen First Nation

Location: Near intersection of Tsawwassen Dr N and Blue Heron Dr, Delta. Monitoring began in Feb 2016.

Dominant Noise Sources: Highway 17, Tsawwassen Ferry, and Deltaport terminals activity.

Community Noise Level Comparison: Noise levels at NMT are very similar to those experienced at nearest residences.



Event Commentary:

There were minimal alerts generated at this site. There was no clear trend for any of the alerts.

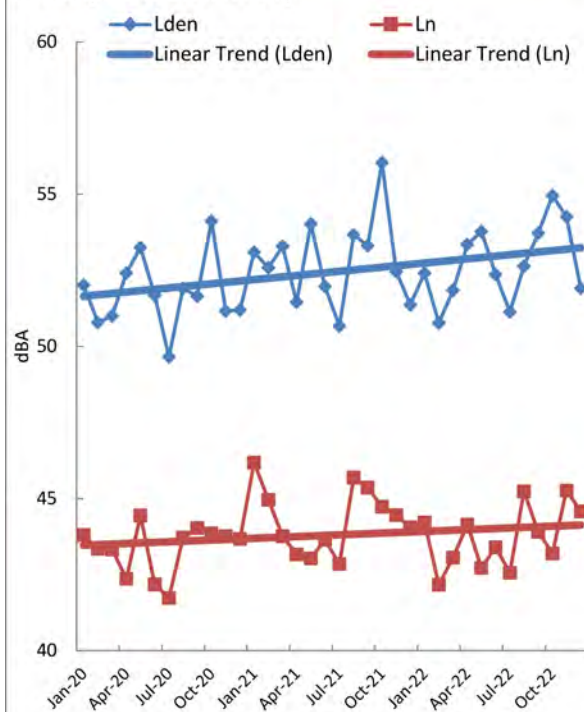
Noise Level Commentary:

In the past year, monthly noise levels had noticeable fluctuations. Compared to 2021 overall noise levels, the 2022 Lden did not change and Ln decreased by 0.5 dBA.

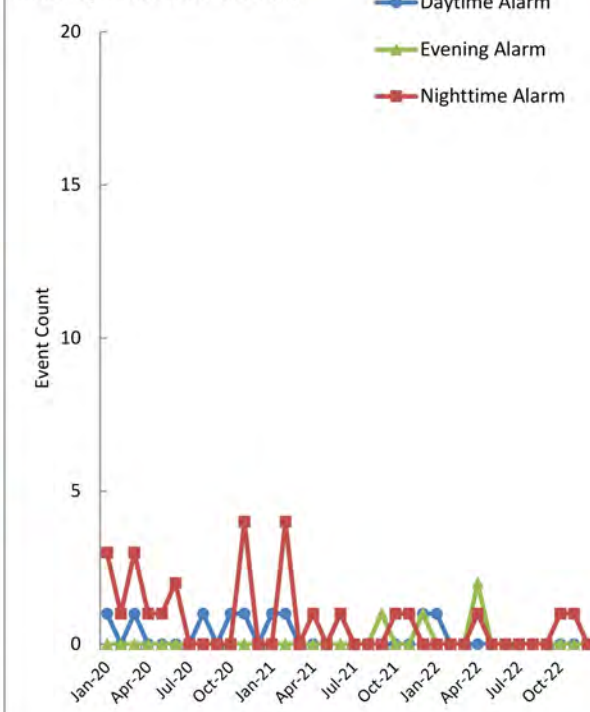
From January 2020 to December 2022 the long-term trend in Lden increased by 1.5 dBA and Ln increased by 0.5 dBA.

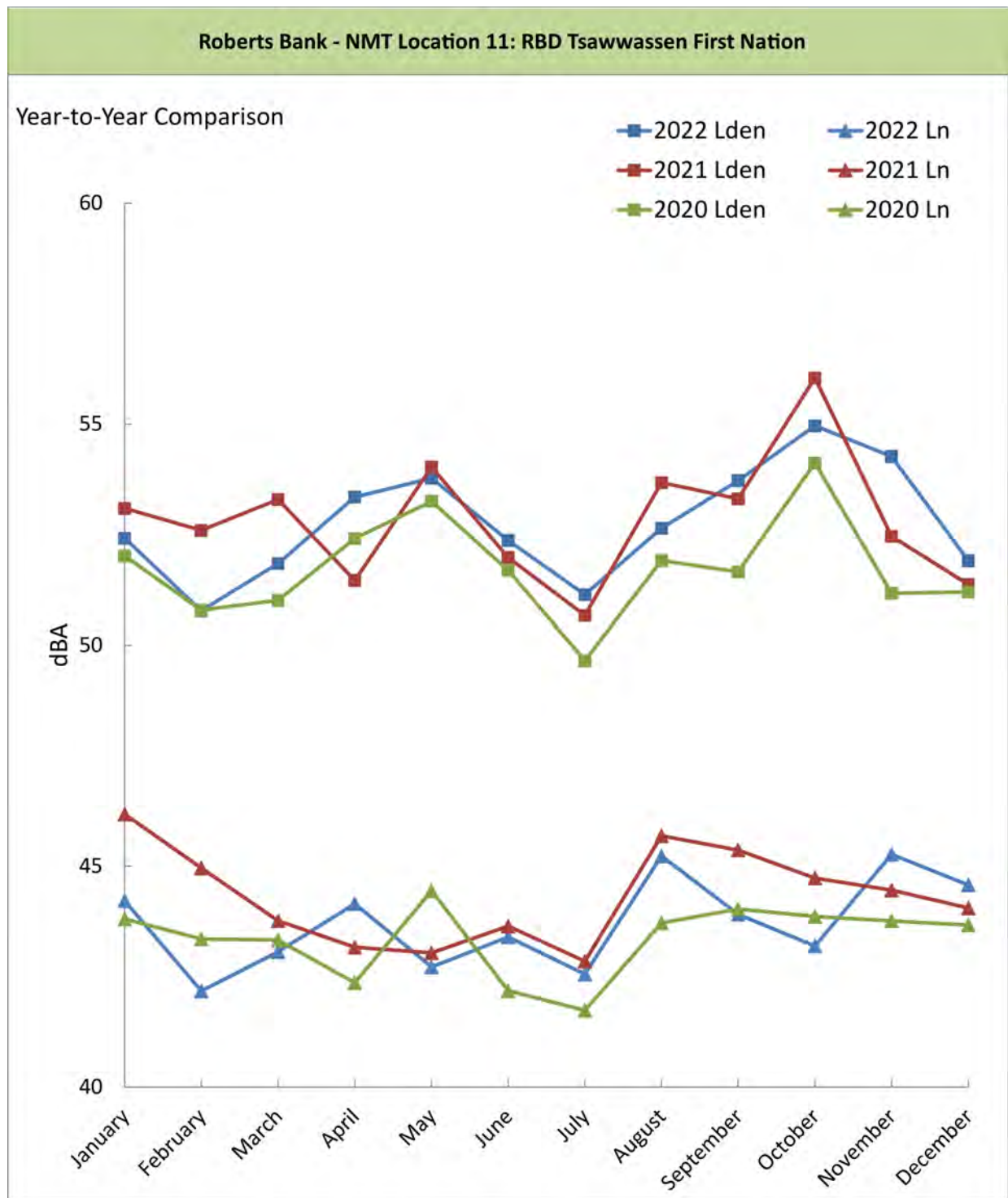


Monthly Noise Level History



Monthly Event Count History





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Appendix A: Glossary

A-weighting (dBA) – A standardized filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive.

background sound level (L_{90}) – A-weighted sound level that is exceeded for 90% of a given time interval.

day-evening-night equivalent sound level (L_{den}) – The sound exposure level for a 24-hour day calculated by logarithmically adding the sound exposure level obtained during the daytime (L_d) (7 am to 7 pm) to 5 times the sound exposure level obtained during the evening (L_e) (7 pm to 10 pm) and to 10 times the sound exposure level obtained during the nighttime (L_n) (10 pm to 7 am) to account for greater human sensitivity to evening and nighttime noise.

daytime equivalent sound level (L_d) – The equivalent sound level over daytime hours (7 am to 7 pm).

decibel (dB) – The standard unit of measurement for sound pressure and sound power levels. It is the unit of level which denotes the ratio between two quantities that are proportional to pressure or power. The decibel is 10 times the logarithm of this ratio. The reference pressure used for airborne sound is 20 μ Pa while the typical reference pressure used for underwater sound is 1 μ Pa.

equivalent sound level (L_{eq}) – The steady level that, within a specified time interval, would contain the same amount of energy as the actual time-varying level. Although it is, in a sense, an “average”, it is strongly influenced by the loudest events because they contain the majority of the energy.

evening equivalent sound level (L_e) – The equivalent sound level over evening hours (7 pm to 10 pm).

frequency – Analogous to musical pitch, the basic unit for measuring frequency is the number of cycles per second, or Hertz (Hz), where bass tones are low frequency/low Hertz values and treble tones are high frequency/high Hertz values. Audible sound occurs over a wide frequency range, from approximately 15 Hz to 20,000 Hz.

frequency spectrum – Distribution of frequency components of a noise or vibration signal.

Hertz (Hz) – The unit of acoustic or vibration frequency representing the number of cycles per second.

low frequency equivalent sound level (LLF) – The low frequency equivalent sound level as defined in ANSI S12.9 Part 4 – 2005 (ANSI 2005).

low frequency noise (LFN) – Sound containing frequencies of interest within the range covering the one-third octave bands from 10 Hz to 200 Hz.

metric – Measurement parameter or descriptor.

nighttime equivalent sound level (L_n) – The equivalent sound level over the nighttime hours (10 pm to 7 am).

noise - Noise is unwanted sound, which carries no useful information and tends to interfere with the ability to receive and interpret useful sound.

octave bands – A standardized division of a frequency spectrum in which the interval between two divisions is a frequency ratio of 2.

one-third octave bands – A standardized division of a frequency spectrum in which the octave bands are divided into thirds for more detailed information. The interval between center frequencies is a ratio of 1.25.

overall or total sound – Totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far, see below figure.

receiver – A noise-sensitive stationary position at which noise levels are received.

reference time interval – Time interval to which the rating level is referred, e.g., the reference time interval for the *Lden* is 24 hours.

residual sound – Sound remaining at a given position in a given situation when the specific sounds under consideration are suppressed, see below figure.

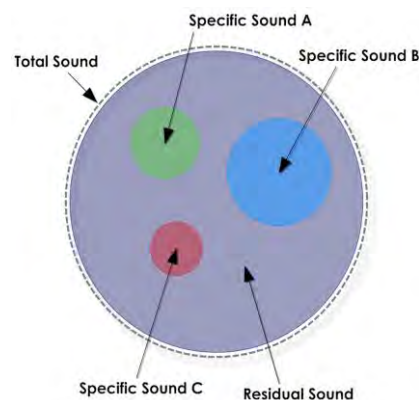
sound – The fluctuating motion of air or other elastic medium which can produce the sensation of sound when incident upon the ear.

sound level – The level of sound pressure measured with a sound level meter and one of its weighting networks. When A-weighting is used, the sound level is given in dBA.

sound level meter – An electronic instrument for measuring the sound level in accordance with accepted national or international standards.

sound source – The means by which a sound is produced through the vibration of a physical object.

specific sound – Component of the total sound that can be specifically identified and which is associated with a specific sound source, see below figure.



Relationship between Total, Specific, and Residual Sound

Appendix B: Introduction to Sound and Environmental Noise Assessment

General Noise Theory

The two principal components used to characterize sound are loudness (magnitude) and pitch (frequency). The basic unit for measuring magnitude is the decibel (dB), which represents a logarithmic ratio of the pressure fluctuations in air relative to a reference pressure. The basic unit for measuring pitch is the number of cycles per second, or hertz (Hz). Bass tones are low frequency and treble tones are high frequency. Audible sound occurs over a wide frequency range, from approximately 20 Hz to 20,000 Hz, but the human ear is less sensitive to low and very high frequency sounds than to sounds in the mid frequency range (500 to 4,000 Hz). “A-weighting” networks are commonly employed in sound level meters to simulate the frequency response of human hearing, and A-weighted sound levels are often designated “dBA” rather than “dB.”

If a continuous sound has an abrupt change in level of 3 dB it will generally be noticed while the same change in level over an extended period of time will probably go unnoticed. A change of 6 dB is clearly noticeable subjectively and an increase of 10 dB is generally perceived as being twice as loud.

Sound levels theoretically reduce by 6 dB every time the distance from a point source to the receiver is doubled due to geometric spreading of the sound energy. In practice, the propagation of sound can also be affected by the nature of the intervening terrain and ground cover, weather effects, sound reflections, etc.

Basic Sound Metrics

While the decibel or A-weighted decibel is the basic unit used for noise measurement, other indices are also used to describe environmental noise. The Equivalent Sound Level, abbreviated Leq, is commonly used to indicate the average sound level over a period of time. The Leq represents the steady level of sound which would contain the same amount of sound energy as the actual time-varying sound level. Although the Leq is an average, it is strongly influenced by the loudest events occurring during the time period, because these loudest events contain most of the sound energy. Another common metric used is the L90, which represents the sound level exceeded for 90% of a time interval and is typically referred to as the background noise level.

The Leq can be measured over any period of time using an integrating sound level meter. Some common time periods used are 24 hours, noted as the Leq24, daytime hours (07:00 to 19:00), noted as the Ld, evening hours (19:00 to 23:00), notes as the Le, and nighttime hours (23:00 to 07:00), noted as the Ln. As the impact of noise on people is judged differently during the daytime, evening and nighttime, 24-hour noise metrics have been developed that reflect this.

The day-evening-night equivalent sound level (Lden) is one metric commonly used to represent community noise levels. It is derived from the Ld, Le and Ln with a 5 dB penalty applied to the Le and a 10 dB penalty applied to the Ln to account for increased sensitivity to evening and nighttime noise.

Human Annoyance to Noise

Noise is generally defined as "unwanted sound", which carries no useful information and tends to interfere with activities or the ability to receive and interpret useful sound. The intrusiveness and potential disturbance caused by noise depends largely upon the background noise level that exists when the noise occurs. However, the response to noise is subjective and depends on other factors such as the absolute level of sound, the time of day, local attitudes to the premises and expectations for quiet by the individual.

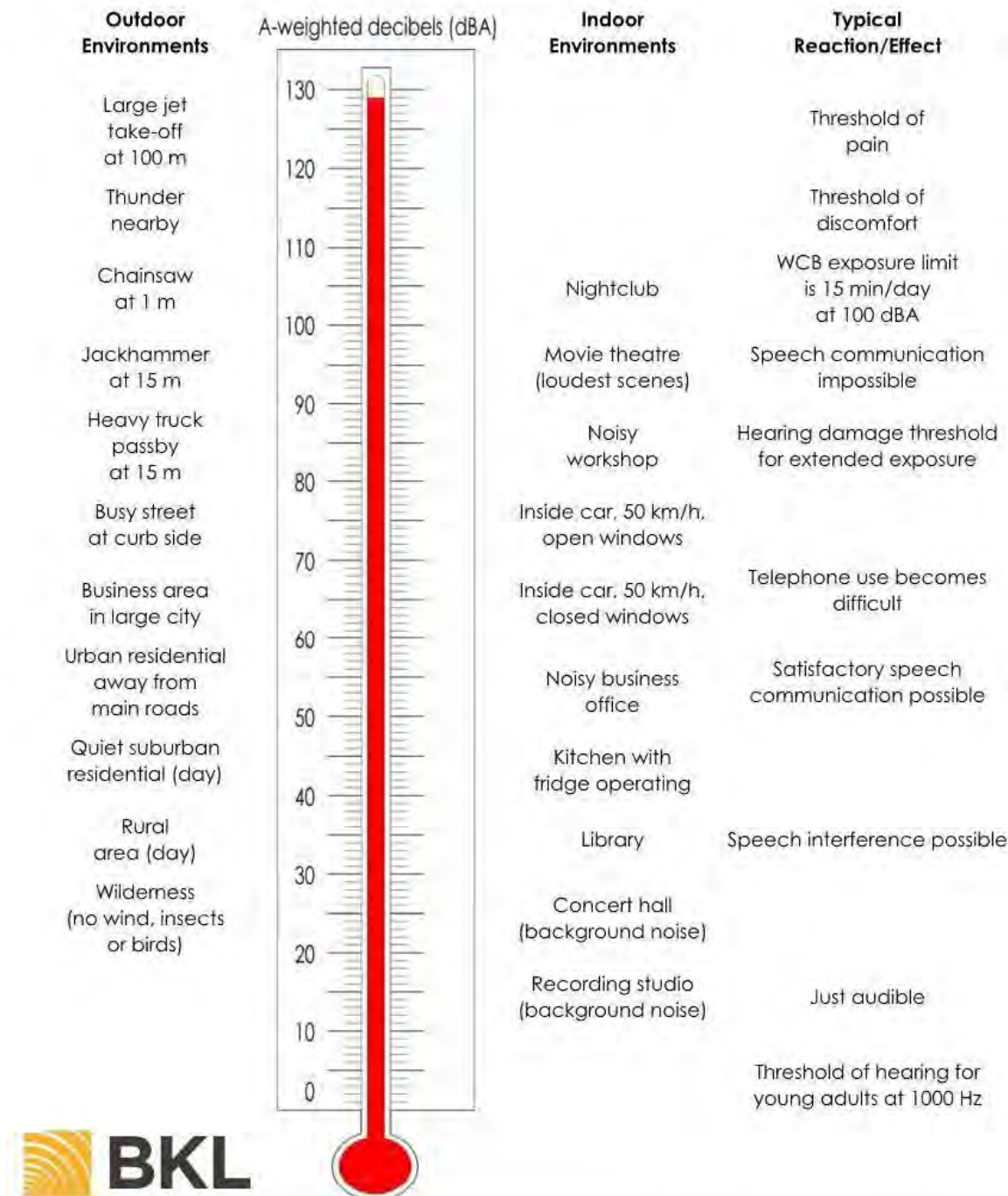
Studies have consistently shown that an increase in noise in a community will bring an increase to the amount of people who are highly annoyed (ISO 2016). However, the sound pressure level is not the only factor in how annoying noise is. The type of noise, or the quality of it, can also greatly affect how annoying the sound is perceived. In general, tonal, impulsive or sounds with excessive low frequency content can all increase the level of annoyance. These characteristics are often referred to as intrusive noise characteristics.

Reference Sound Levels

Commonly heard sound sources and associated typical sound levels are shown in the figure below:

Noise Thermometer

Common Noise Levels and Typical Reactions



Note: The sound levels shown are intended as a guide to allow the lay person to gauge the loudness, in a very approximate manner, of a particular noise level. The information provided is not intended to be used, and should not be used, to judge noise levels for the purpose of establishing compliance with standards or regulations, or in any legal proceedings.