DEVELOPING THE PORT OF VANCOUVER'S PORT NOISE RATING METHODOLOGY

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1 Introduction

The Vancouver Fraser Port Authority manages Canada's largest port, the Port of Vancouver, encompassing federal port waters, lands, and shorelines in and around Vancouver, BC. In total, port-managed areas border 16 municipalities. As urban densification has increased near port operations, so too has the potential for port-related noise to disturb nearby communities.

Between 2013 and 2015, the port installed 11 permanent noise monitoring terminals (NMTs) along the north and south shores of the Burrard Inlet and at Roberts Bank to better understand port-related noise in nearby communities and address community noise concerns. Figure 1 below shows the location of each NMT. The NMTs continually log sound data in or near communities potentially affected by port noise.

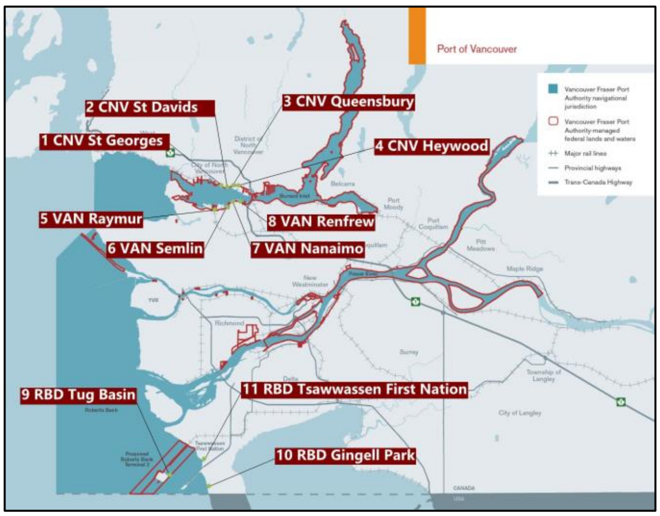

Figure 1: Port of Vancouver NMT Locations

In order to provide value from this data to the port and its stakeholders, BKL developed a Port Noise Rating (PNR) metric which relates the measured sound pressure levels to the potential annoyance in the surrounding population using noise modelling and census data. The PNR metric provides a useful way for the port to interpret the significance of measured noise levels, changes over time, and differences between NMTs.

2 Rationale

Although the NMT system continuously logs sound levels, the recorded data alone do not give much insight on how port noise is impacting the nearby residential communities. There are three shortfalls with only reviewing NMT sound levels: they do not necessarily represent community noise levels, they do not take into account the number of people in the vicinity, and they do not directly correlate with annoyance.

Due to practical considerations, the Port's NMTs are installed at varying distances from nearby residential communities. Some are installed in residential neighbourhoods while others are installed on or very close to Port properties including roads, railways and terminals. Hence, measured noise levels do not represent the overall noise exposure of the entire community represented by each NMT. Furthermore, the population density near each NMT varies, with some areas with single family housing and some with mid-rise multi-family residential.

The sound data recorded by the NMTs alone does not represent the annoyance caused by port-generated noise. The sound pressure level is not the only factor in how annoying noise is. The time of day and type of noise, or the quality of it, can also greatly affect how annoying the sound is perceived. Night noise is more disturbing than day noise. Furthermore, sound with tonal, impulsive, or excessive low-frequency content can all increase the level of annoyance. Noise levels adjusted for time of day and intrusive characteristics are called rating levels.

In light of these shortfalls, the PNR was developed to relate the measured sound pressure levels to potential annoyance in the surrounding residential communities through a methodology involving noise modelling, percent highly annoyed calculations, and census data.

3 Methodology

The PNR is the estimated number of people highly annoyed (*#HA*) using the day-evening-night equivalent sound level (L_{den}) rating metric, per ISO 1996-1:2016 [1], combined with census data, for each community area represented by each NMT. The ISO standard references outdoor noise levels at receiver locations, but the L_{den} at each residence in the surrounding neighbourhoods varies with distance from the dominant port noise sources and is not equivalent to the L_{den} logged at the NMTs. Therefore, those values need to be estimated before the PNR can be computed.

3.1 North and South Shore NMTs

At the north and south shores of Burrard Inlet, community noise levels from road traffic, rail traffic, and industrial activity within port lands are estimated for residences in the area surrounding each NMT using NMPB-Routes-96 [2], SRM II [3], and ISO 9613-2:1996 [4] standards implemented in Cadna/A noise modelling software. The models are used to estimate the sound level difference between each NMT location and nearby residences based on modelling

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assumptions developed for each of the major noise sources. In general, the models included residences with estimated L_{den} levels of approximately 50 dBA or greater. The residences represented by each NMT are divided into subgroups with similar noise exposures.

For each subgroup, a review of residential buildings and census average household size in the area is conducted to estimate the population. Only half of the residences are considered for multi-family buildings since only approximately half of the building facades would have direct exposure to port-related noise sources. The *#HA* is then calculated by multiplying the population and the corresponding *%HA* for each subgroup.

The sum of all the subgroups surrounding each NMT represents the total *#HA* or *PNR* for each NMT. The *PNR* for the entire north or south shore can also be calculated by summing the *PNR* from each NMT.

3.2 Roberts Bank NMTs

The same approach used for the north and south shores cannot be used for Roberts Bank due to the large distance between the port and the nearest residences, and because most port-related noise is quieter than local ambient noise levels in the nearest communities. One NMT is sited in Roberts Bank and two are sited in the community. Since noise complaints in this area have historically been related to low frequency noise, the *PNR* has been calculated considering the low frequency rating level per ANSI S12.9-2005 Part 4 [5].

A Cadna/A noise model was developed to predict monthly community noise levels. Each month, the noise sources in the model are calibrated to the noise levels measured at the RBD Tug Basin NMT and the C_{met} is calculated at 30-degree direction increments using the reported weather conditions and LfU Bayern method implemented in Cadna/A. After calibration, the L_{den} and L_{LF} are predicted at the residences and the *#HA* is calculated at each residence using census data. In general, the model includes the first two rows of residences facing Roberts Bank.

4 Discussion

The *PNRs* for each NMT has been calculated from monthly NMT data for more than 5 years now. Through comparing *PNRs* between sites and reviewing long-term trends, a number of observations were made during this time.

The *PNR* predicts where port-related noise is affecting the most people. The NMTs with the highest measured noise levels did not always yield the highest *PNRs* due to differences in population density and proximity to port noise sources. For example, a 5 dBA increase at the CNV St Georges NMT increased the *PNR* by about 15 whereas a similar increase at the VAN Semlin NMT increased by about 50. Thus, the PNR is able to show that similar noise increases could potentially cause much more impact at one site compared to another. Furthermore, at the CNV St Davids and Queensbury NMTs, the PNR has increased dramatically over the past few years due to large scale rezoning in the area which converted most single-family homes to multi-family dwellings.

At Roberts Bank, changes in *PNR* depended more on wind speed and direction and low frequency noise over measured L_{den} levels. The *PNR* could change even when L_{den} levels did not change noticeably. Some of the shipboard generators have much more low frequency noise than others, and due to the large distance between port noise sources and the residences, the sound propagation is significantly influenced by upwind versus downwind conditions.

5 Limitations

The NMTs are located near many noise sources that are related and unrelated to the port. As the *PNR* metric hinges on the modelled noise level differences between the NMT locations and residences, the accuracy of this approach depends on many noise source modelling assumptions necessitated by the complex noise environments that exist throughout the port's jurisdiction.

Currently, not all port noise sources are modelled in detail which affects the accuracy of *PNR* values. The accuracy of this approach could be improved by further studying the noise sources in the area, whether port-related or not. Additional NMTs could also be added so that modelled predictions are relied on less heavily to estimate noise levels at residences farther away from the current NMTs.

To predict annoyance more accurately, more adjustments can be incorporated to account for sound source character. While the evening and nighttime penalties are currently incorporated in the L_{den} rating, weekend, tonal and impulsive penalties are not included at this time. Further analysis would be required in order to incorporate these specific penalties.

Acknowledgments

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References

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