November 16, 2015

File: 2407-14A

UBC Properties Trust
Suite 200, 3313 Shrum Lane
Vancouver, BC
V6S 0C8

Attention: Dave Poettcker

Dear Mr. Poettcker:

Re: UBC Transit Centre - Noise & Vibration Assessment

We understand UBC intends to build a new mixed-use development at the current bus exchange near the Student Union Building, incorporating student accommodation and a reconfigured bus exchange transit terminal. The purpose of this letter is to present the results of the noise modelling and vibration assessment for this project and potential mitigation options.

Scope of Assessment

Noise

The proposed student accommodation will overlook the reconfigured bus exchange transit centre. We understand that the bus exchange will generally only be active between 7 am and 10 pm. We understand the other significant noise source in the area is road traffic on Wesbrook Mall, located east of the site. The purpose of the noise assessment is to address

- the potential for annoyance and speech interference due to noise from the operation of the bus exchange at the site; and
- the overall noise exposure of the proposed housing (i.e., including noise due to traffic on Wesbrook Mall) in comparison to other parts of Vancouver.

The potential for sleep disturbance should also be considered if buses regularly access the site between 10 pm and 7 am.

Vibration

Based on the US Federal Transit Administration's *Transit Noise and Vibration Impact Assessment* and our own experience, we do not expect ground-bourne vibration from bus movements to be at a high enough level to have a significant impact on the proposed housing. However, we have considered the potential for noise-induced rattling of light-weight walls and ceilings within dwellings, which can occur when there are high levels of low frequency noise. This has been considered within the noise assessment.

Noise Criteria

We have reviewed a number of guideline documents to assist with determining appropriate noise criteria for the site, including the World Health Organization *Guidelines for Community Noise*, published in 1999. The WHO guideline suggests noise levels that will minimize annoyance due to noise in specific community environments including dwellings and outdoor areas. In addition to the WHO guidelines, we also considered the American Standard ANSI 12.9-2005/Part 4 *Noise Assessment and Prediction of Long-term Community Response,* which provides guidance on low frequency noise levels that minimize the potential for noise-induced rattling inside buildings.

We propose to use the WHO guideline noise levels and guidance provided in ANSI 12.9-2005/Part 4 as the criteria for the site. The proposed criteria for the development are summarized in Table 1 below. The noise criteria are based on the average noise level over the daytime period, which is defined as 7 am to 10 pm.

Table 1: Proposed Noise Criteria

Specific Environment	Recommended Criteria
Noise in outdoor living areas	55 dB L_{Aeq}[1]
Noise in dwellings	35 dB L_{Aeq}
Rattling in dwellings	70 dB L_{LF}[2]

[1] L_{Aeq} is the A-weighted, time-averaged sound pressure level, also called the equivalent sound level

[2] L_{LF} (low frequency sound pressure level) is defined as the sum of the 16, 31.5 and the 63-Hz octave band equivalent sound pressure levels

Noise Model

We modelled the proposed UBC Transit Centre, based on drawings provide by Dialog on September 21, 2015, to estimate bus noise levels at the facades of the proposed student accommodation and the outdoor area located above the bus exchange podium. The model was created in Cadna/A noise modelling software. Surrounding buildings were also modelled, including the unique angled surfaces

on the future Aquatic Centre. Sound reflections were also modelled to consider the effects of noise reflecting off of proposed and existing buildings.

Noise measurements of the existing UBC bus exchange area conducted in 2012 have been used to determine the bus noise emission levels for this model. The bus noise represents the measured daytime noise level from 7 am to 10 pm. The peak hours of operation for buses is between 7 am and 7 pm. During this time, the hourly noise levels fluctuate between 2 dB higher and 2 dB lower than the average daytime level we used for the modelling. The highest hourly noise level typically occurred in the early afternoon, around 2 to 3 pm.

An estimate of current traffic volume on Wesbrook Mall north and south of Student Union Boulevard were provided by Bunt & Associates via email on September 25, 2015. These were used to in the model to estimate facade noise levels due to traffic on Wesbrook Mall.

Results - Bus Exchange Noise Levels

Modelled Noise Levels

Figure 1 shows the predicted daytime bus exchange noise levels outdoors. Results for the storey with the highest noise exposure are shown.

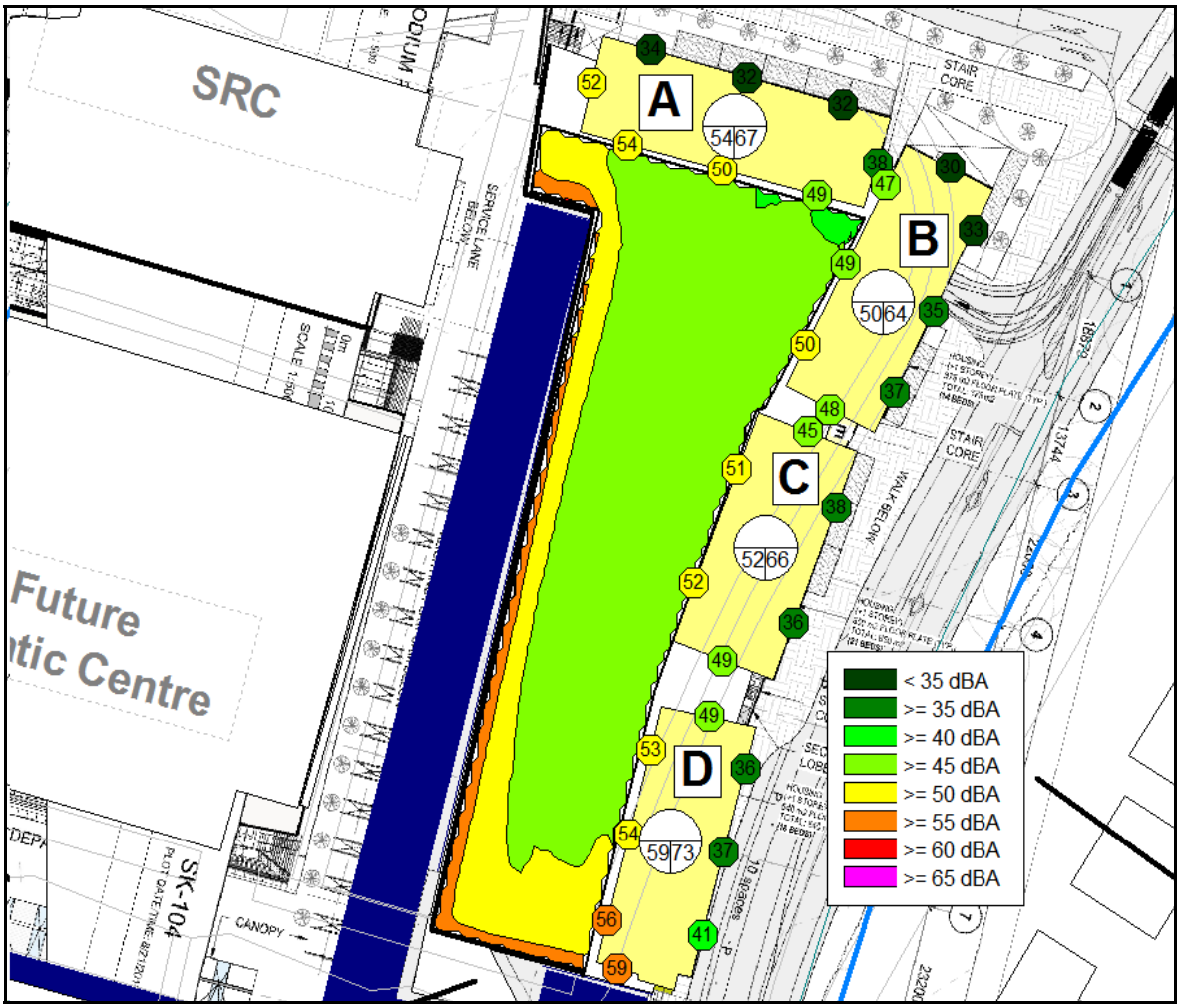

Figure 1: Daytime Bus Exchange Noise Levels

Figure 2 below provides an indication of how noise levels change at different floor heights.

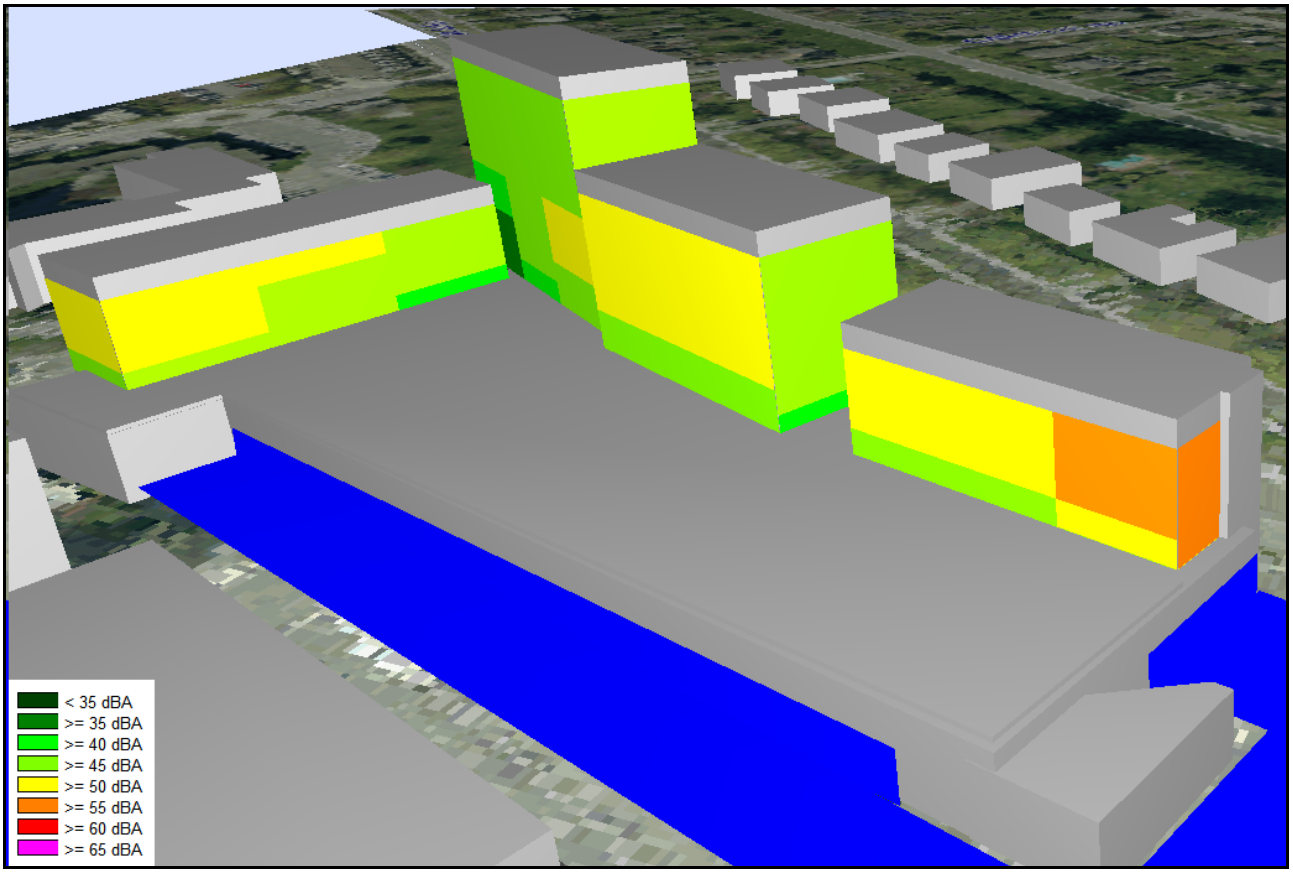

Figure 2: 3D View of Bus Exchange Daytime Noise Levels on Facades Facing Podium

Outdoor living area noise levels

As shown in Figure 1, the average daytime outdoor noise levels on the podium are generally expected to be less than 55 dB L_{Aeq}, with the exception of a strip around the edge of the podium that is between two and five metres wide. Landscaping or barriers could be used to prevent access to this area, although the predicted noise meets the criteria for most of the podium area.

Dwelling noise levels

The highest predicted facade noise level is 59 dB L_{Aeq} at Building D. Table 2 provides the expected average internal noise level for a typical bedroom with standard construction, taking the measured bus noise characteristics into account, with 2.2 m^2 glazing.

Table 2: Estimate of Internal Noise Levels

Facade Noise Exposure Facing Bus Exchange	Window	Estimated Internal Noise Level	Internal Noise Criteria
49 to 59 dB L_{Aeq}	Open window	34 to 49 dB L_{Aeq}	35 dB L_{Aeq}
	Closed window	< 33 dB L_{Aeq}	35 dB L_{Aeq}
63 to 73 dB L_{LF}	Open or closed window	< 70 dB L_{LF}	70 dB L_{LF}

For open windows, the average internal noise level is likely to exceed the proposed noise criteria at most of the facades facing the bus exchange. With windows closed, we expect that the noise criteria can be achieved with standard construction.

The predicted low frequency sound pressure level is below 70 dB L_{LF}, with the exception of Building D where the highest predicted noise level of 73 dB L_{LF} is predicted for the south facade. However, due to attenuation provided by the external facade, we expect the average internal noise to be less than 70 dB L_{LF} for all receivers.

Results - Overall Noise Levels

As requested, we have modelled the expected facade level including noise from bus exchange activity and also traffic on Wesbrook Mall.

Figure 3 below shows the predicted daytime noise level including noise from Wesbrook Mall and bus exchange activities. Figure 4 below provides an indication of how noise levels change at different floor heights on the east facades of the residential buildings. Nighttime noise emissions from Wesbrook Mall were predicted to be approximately 10 dBA lower than the daytime noise levels.

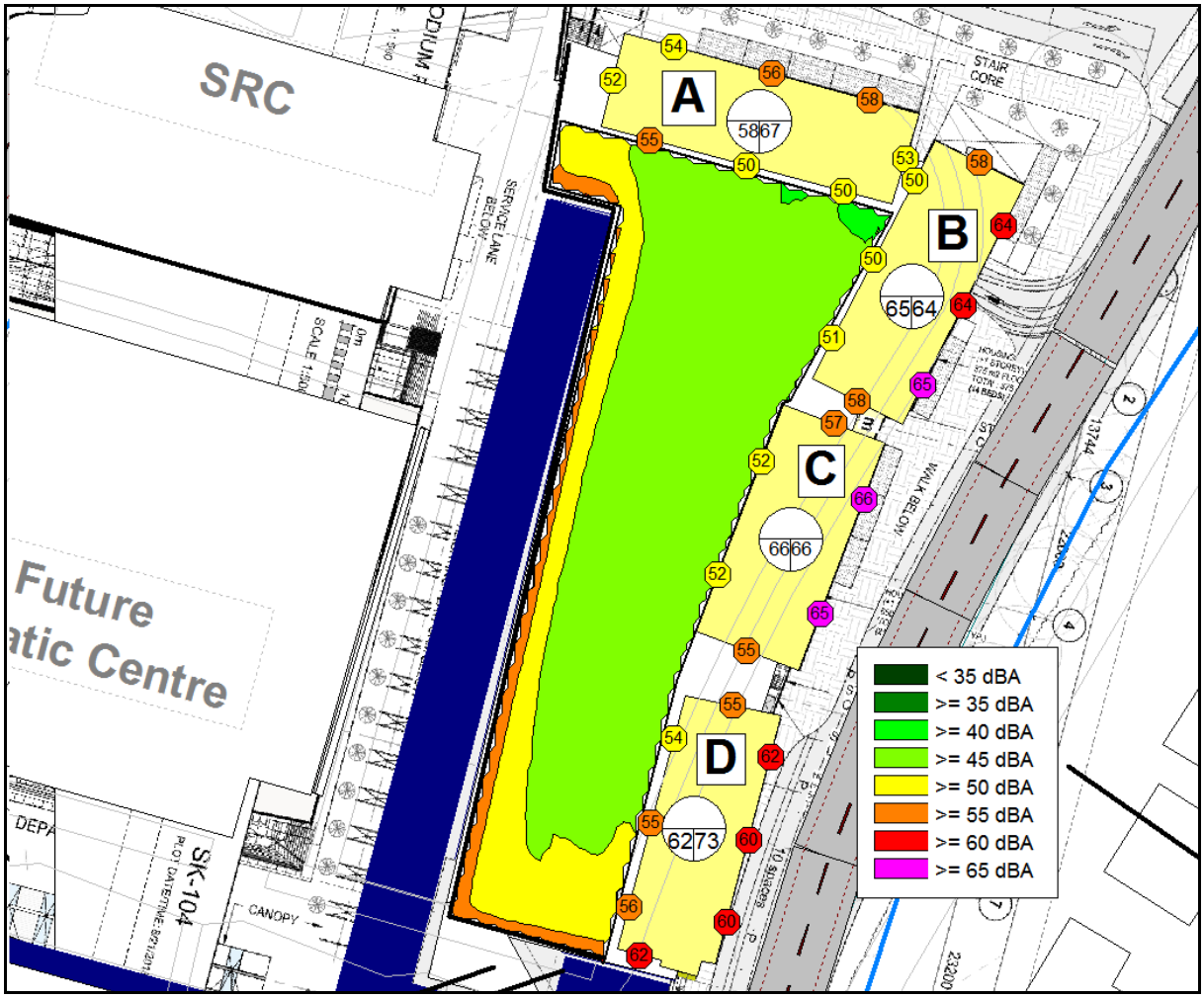

Figure 3: Average Daytime Noise Levels from Wesbrook Mall & Bus Exchange

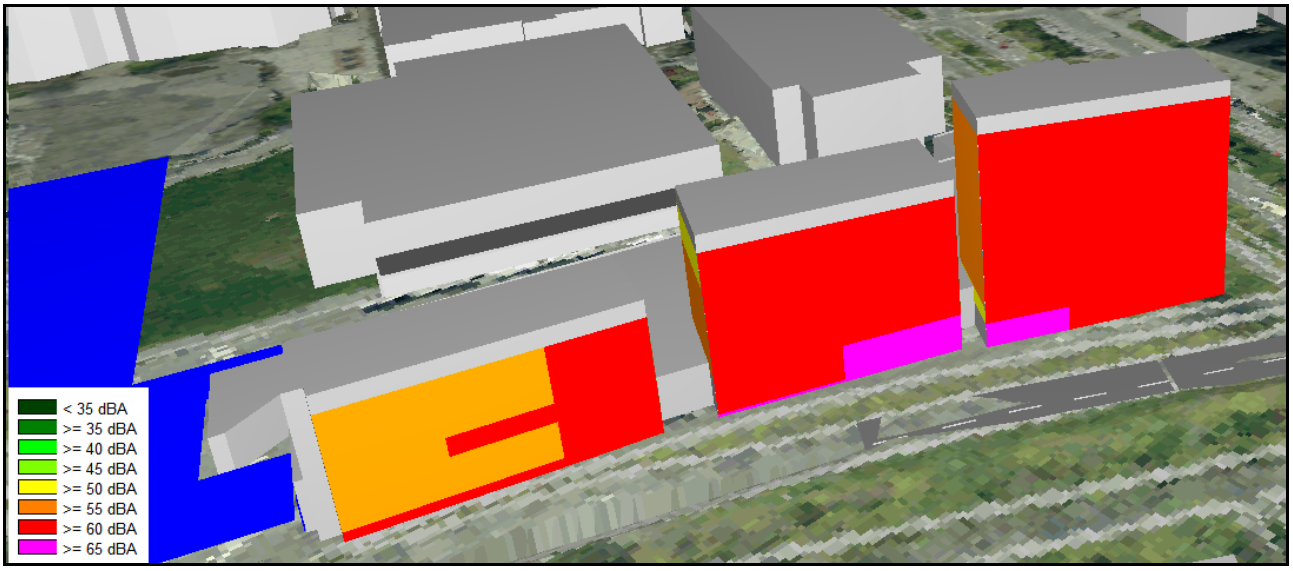

Figure 4: 3D View of Daytime Noise Levels on East Facade Including Noise From Wesbrook Mall

Reference Noise Levels

To provide context for the predicted daytime noise levels, we have provided a summary of noise levels at other areas of Greater Vancouver. Noise received from Wesbrook Mall is similar to noise from other significant residential arterial roads.

Table 3: Typical Traffic Noise Levels in Greater Vancouver

Location	**Example Roadways**	**Daytime Noise Level at Residential Facade**
Quiet residential subdivision		<55 dBA
Residential artery (typical 2 land road - non-truck route)	16th Ave east of Oak; Robertson Ave (Poco); Duthie Ave (Bby)	55-60 dBA
Significant residential arterial road (4 lane road, some trucks)	Davie Street; Prairie Ave; Royal Oak; Dunlevy; Rumble; East Pender off Boundary	60-65 dBA
Commuter road (4 lane truck route)	Broadway; Hastings; Nelson Street; Coast Meridian (Poco); Cambie; Smithe Street; 1st Avenue; Main Street; Kingsway (Bby); Edmonds Street; Lougheed Highway (Bby and Poco); 12th Avenue; Victoria Street	65-70 dBA
Heavily travelled commuter road; cross city connector; most highways	Knight Street; Smithe and Mainland; 6th Avenue; Kingsway (Vcr); Brunette, Front St (New West); Maryhill Bypass; 1st Ave at Clarke; SE Marine Drive; Hwy 91; Hwy 1	70-75+ dBA

We have included cross section noise maps for a proposed residential development located at 2060 Alma Street, Vancouver and for Building C of the proposed UBC development in Figure 5 below. Both buildings are exposed to similar traffic noise levels on the facade closest to the road.

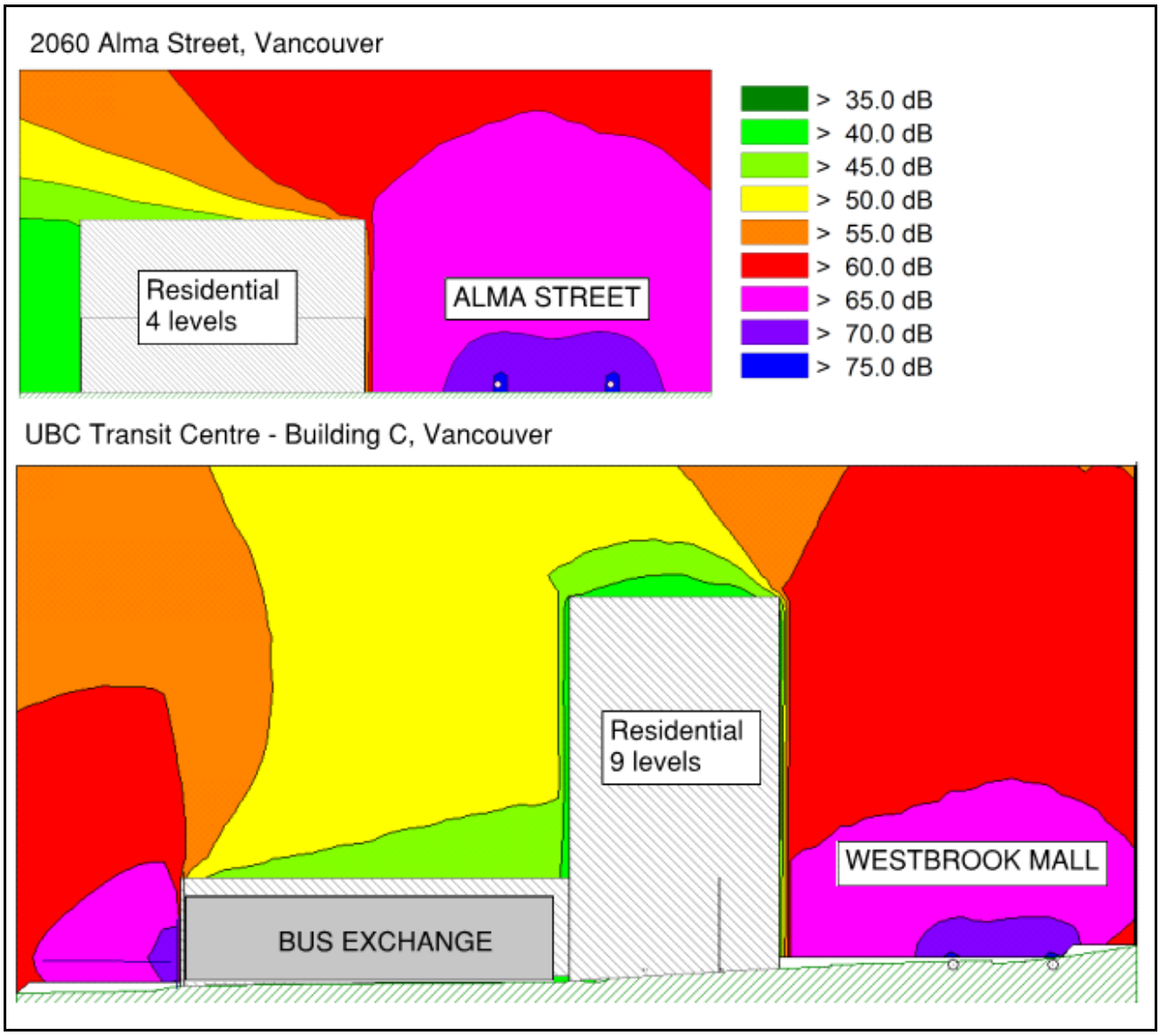

Figure 5: Cross Section Grid Noise Map for 2060 Alma Street and Building C at UBC Transit Centre

Mitigation Options

The primary methods to reduce noise levels are:

- increase set-back distance of noise source
- block line-of-sight between the noise source and the receiver with a solid object
- reduce the noise emissions from the source

Assuming the layout of the site can not be significantly changed, we have considered ways to block the line-of-sight or reduce the noise emissions from the source.

Podium Edge Barrier

As requested, we have considered the potential noise mitigation at the facade of the residential buildings that could be provided by installing a 6 foot or 8 foot barrier on the edge of the podium. The highest predicted noise level occurs on the south facade of Building D, which is only set back 2 metres from the south edge of the podium. As a result, there is no room for a barrier directly south of the most impacted facade and therefore a barrier would not be effective at reducing noise levels at this facade.

Window Configuration

Windows are typically the weakest acoustical component of a facade and are the transmission path that contributes the most to the internal noise level. With windows closed, we expect the internal noise level criteria to be achieved. However, for facades where the noise level is 45 dB L_{Aeq} or greater, there is the potential for the internal noise criteria to be exceeded when windows are open. One option to reduce internal noise levels while windows are open is specifying the windows to open facing away from the bus exchange area. The effectiveness will depend on what storey the window is on as well as how far the window is opened.

Bus Layover Soffit Acoustical Treatment

Acoustical treatment is not required in the bus layover based on our assumptions and modelling. However, acoustical treatment on the ceiling area, with greater than 50% coverage, could make the area more pleasant for bus drivers and the idling less obvious for people walking by the bus exchange by absorbing some of the sound in the space and therefore reducing the breakout noise levels. Potentially suitable products are summarized in Table 3.

Table 3: Potential Acoustical Ceiling Products

Manufacturer	Product	Description	Distributor	Contact
Rockfon	Facett	Lay-in tile, Add retention clips for wind updraft	Pacific West Systems Supply Ltd.	Neil Hisaoka 604-842-4557
Rockfon	Planostile Snap	Snap-in metal panel ceiling system	Cascadia Design Products	Chris Barton 604-739-0966
Echotrol	Secure	Perforated metal with PVC wrapped insulation behind	Western Noise Control	Izzy Gliener 1-800-661-7241
Acoustex	Plank	Wood fibre cementitious panels	Acoustex	Dennis Obratoski 604-720-0024

Conclusions and Recommendations

With regards to bus exchange noise, we expect that the internal noise criteria can be achieved using standard construction with closed windows. Criteria may be exceeded when windows are open at some units, but this is normal throughout Greater Vancouver and can be minimized by selecting casement windows that open away from the noise source.

Bus exchange noise predictions were based on daytime averaged noise measured at the existing exchange in 2012. Event noise from individual noisy buses would still have the potential to cause brief periods of speech interference or rattling of lightweight building elements.

Predicted noise levels on the facade facing Wesbrook Mall are higher than the bus exchange noise levels but are within the typical range expected for residential arterial roads. Modest facade construction upgrades are likely to be required on the Wesbrook Mall side of the development due to road traffic noise such as increasing glazing thickness. We note that there are numerous Greater Vancouver residential developments exposed to similar noise levels and the required upgrades are not expected to be overly onerous. The proposed design should be reviewed by an acoustic engineer at the development or building permit stage to confirm that internal noise criteria can be achieved with windows closed. We recommend that ventilation and thermal comfort also be considered with windows assumed closed.

We trust this information is satisfactory. Should you have any queries, feel free to contact us.

Sincerely,

BKL Consultants Ltd.
per:

B Martin

BKL Consultants Ltd.
per:

Mark Bliss, P.Eng., INCE