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Compatibility of Outdoor Concerts in Urban Areas: Planning Case Study

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ABSTRACT

An urban planning case study will be presented where the conflict between proposed high-rise residential and a civic plaza with one of its intended uses as an outdoor concert venue in a downtown Vancouver area subject to redevelopment were highlighted using a detailed acoustic study. The developers proposed high-density residential and the City had prepared a business case for an adjacent outdoor performance/event venue with more than 30 performance primary events per year. Baseline noise monitoring, concert noise monitoring and outdoor sound propagation modelling using Cadna/A and Odeon software were used to determine the percentage of time where the acoustic environment would likely be acceptable to both the future audience and residents. The audience would be disturbed by the surrounding environmental noise if the performance was too quiet while the residents would be disturbed by the event noise if the performances were too frequent and too loud. While City Council has yet to make a final decision on what will ultimately be built, the study results led the City planners to significantly reconsider the programming of the plaza and recommend a predominantly small scale event/ performance focus.

1. INTRODUCTION

The City of Vancouver's downtown has one of the higher neighbourhood population densities in North America, so one can imagine that significant community noise impacts would be commonplace. One area currently under development with high potential for various noise impacts is the so-called Northeast False Creek (NEFC) area of downtown, shown in Figure 1.

The City has recently classified this area as an "event zone" in their noise bylaw[1] to reduce/manage community expectations for quiet since there is a high volume of road traffic and a large number of sports and concert events that occur at Rogers Arena and BC Place.

The City prepared a business model to develop a new outdoor civic plaza, adjacent to land with proposed new residential towers. A flexible plaza venue was proposed but the viability of the space depended on an assumed number of revenue generating events per year. Note that revenue generating events at outdoor plazas tend to be of the noisy type. City staff acknowledged that the proposed rezoning for adjacent residential may conflict with the desire to construct a new outdoor civic plaza and decided to study potential noise impacts in detail including mitigation options.

This paper summarizes two detailed noise impact assessments performed to assess the acoustic viability of the civic plaza from the point of view of the paying audience and the point of view of the surrounding existing and proposed residential.

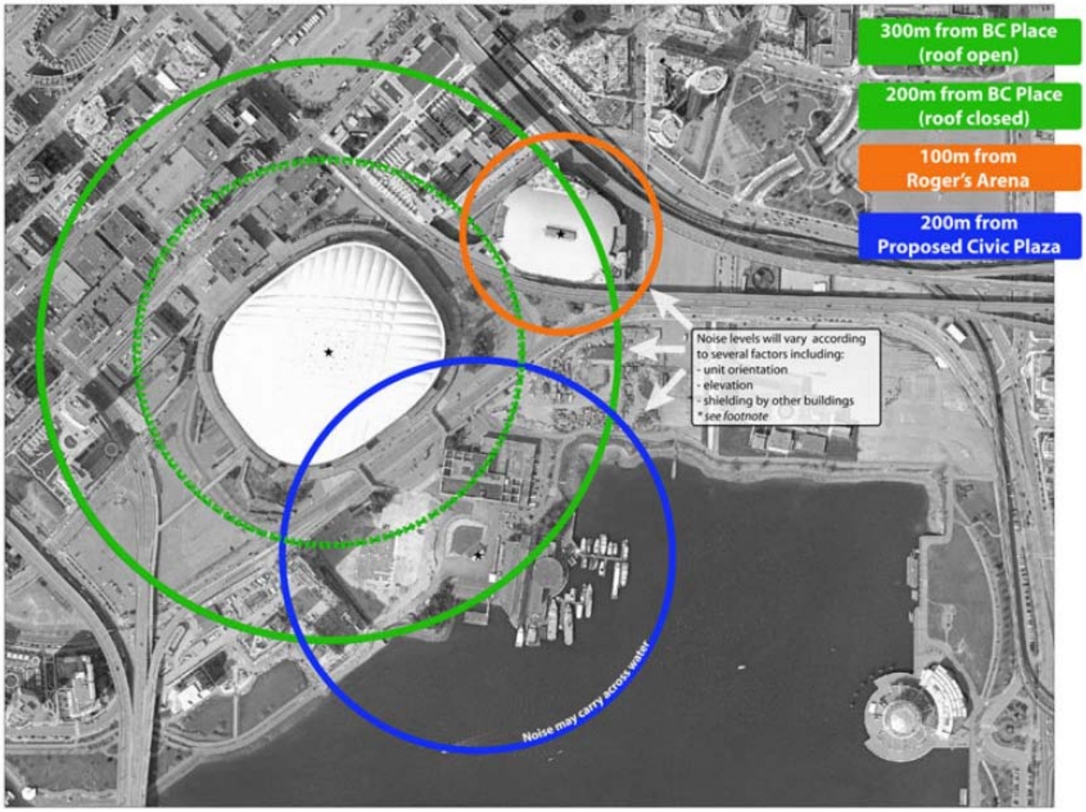


Figure 1: City of Vancouver Northeast False Creek (NEFC) area showing three major entertainment noise sources. The proposed civic plaza would be at the centre of the blue circle.

Since this was a planning study, there was some flexibility for assumptions relating to the design of the venue. Furthermore, the surrounding area had not yet been rezoned for residential so there was potentially additional flexibility in the location and design of future residential. The following five sections summarize the criteria, approaches, measurements and modelling assumptions made, with results from each point of view, and the final three sections combine the results and provide discussion and conclusions on the overall situation.

2. CRITERIA

The basic competing interests are that:

1. a) The audience wants to clearly hear the performance above the ambient noise
   b) The sound mixing desk operator generally has an absolute loudness target at the Front of House (FOH) mixing desk location
2. The surrounding community doesn't want to be disturbed by numerous performances throughout the year

A complicating factor is that music tends to be more disturbing than more neutral noise, such as noise from traffic on a busy road, at the same decibel level because of the "message" contained within the music and tones and rhythm that are harder for the brain to ignore.

Table 1 summarizes the criteria used. The 85 dBC design target at future residential was specifically chosen by the City for this project, with the assumption that indoor music noise levels would be reduced to 50 dBC or lower through the design of the building envelope.

Since both music and ambient sound fluctuate with time, the noise impact significance was rated using the percentage of time where the criteria would be exceeded. This required making assumptions on noise level statistics for both.

Table 1: The concert sound criteria were relative to the ambient noise for the audience and based on City entertainment noise criteria at residential locations.

	Concert Sound Criteria		
Receptor	Integration Time	Day	Night
Audience	n/a	>10 dBA above ambient[2]	
		Additional 5 dB penalty when ambient is music[3]	
Existing Residential	3 min	70 dBC outdoors[1]	65 dBC outdoors[1]
Future Residential	15 min	85 dBC outdoors	Not permitted

3. ASPECTS NEEDING ATTENTION FROM BOTH POINTS OF VIEW

Following are factors that may affect both concert audience and residential noise impacts from environmental sources and concert noise, respectively:

- Type of music
- Size and location of audience
- Audience floor rake
- Location and dimensions of intervening noise barriers and reflectors (buildings and purpose-built noise barriers)
- Ground effect
- Meteorological conditions

A. Type of Music

The type or genre of music is a critical factor since the audience criteria is relative to the loudness of the music. The two types of music discussed here are pop/rock and (amplified) symphonic/classical. Pop and rock music are assumed to be similar enough to be assessed in the same category. In general, audience sound levels are set to be very loud with limited dynamic range, that is, the quiet portions are still quite loud. Classical music has a very wide dynamic range, i.e. the quiet parts can be very quiet, although compressors could be used to reduce the dynamic range.

B. Size and location of audience, floor rake

Only two of the potential plaza orientations/options have been discussed here. The size and location of the audience and floor rake was chosen by the City with input from cultural, parks and recreation, acoustical and architectural disciplines. An amphitheatre design sculpted into the landscape could have had significant acoustic benefits but was not considered because of the desire to retain full views to the waterfront and flexible use of the plaza.

C. Noise barriers and reflectors

Information on the surrounding existing and proposed buildings was collected so that reflection and diffraction effects could be considered. No purpose built noise barriers, whether opaque or transparent, were considered because of potential visual impacts for patrons approaching the plaza.

D. Ground effect and meteorological conditions

Ground and weather effects were not considered to be significant but were included using standard best practice.

4. SOUND MEASUREMENTS

Table 2 describes the various sound measurements that were performed to make assumptions on performance and ambient sound level statistics and to calibrate the noise models. Table 3 summarizes the audience levels used for the criteria and model calibration. The dynamic range was indeed limited during the pop/rock concert. The active performance 15 minute L_{Ceq} varied by ±3 dBA relative to the L_{Ceq} for the concert duration. The symphony measurement duration was short but the L_{Aeq} measured was in agreement with another study's longer measurement[4].

Table 2: Sound level measurements were performed to make assumptions on typical sound levels and statistical distributions.

Source	Duration	Location	Description
Pop / rock concert	1.5 hrs	Deer Lake Park, Burnaby	2008 REM, Modest Mouse and The National concert
Symphonic concert	11 min	Deer Lake Park, Burnaby	2011 Vancouver Symphony Orchestra (amplified)
NEFC road traffic	72 hrs	Rogers Arena roof and Davie St near Pacific Blvd	2006 Rogers Arena 24 hr and 2003 Davie St 48 hr measurement
BC Place sports event	3 hrs	BC Place	2008 CFL football game
BC Place concert	4 hrs	Rogers Arena	2008 ZZ Top, Brooks & Dunn concert

Table 3: The event input data illustrates the high level and low dynamic range for typical pop/rock concerts and lower level and high dynamic range for symphonic concerts, resulting in very different ambient noise criteria.

Source	L_{Aeq} (dB), FOH	L_{Ceq} (dB), FOH	L_{A90} / L_{A99} (dB)	Ambient Noise Criteria
Pop / rock concert	97	108	86	< 76 dBA
Symphonic concert	82	85	58	< 48 dBA

5. NOISE IMPACT FROM THE AUDIENCE'S POINT OF VIEW

A. Approach

Following are additional factors that may affect concert audience noise impacts from environmental sources:

- Location of road traffic
- Hourly volume, truck percentage and speed of road traffic during the week and on weekends
- BC Place sports or concert events occurring simultaneously with civic plaza events, with BC Place roof open or closed
- Location and magnitude of other environmental sources (aircraft, rail, marine, other entertainment, construction, etc.)

Road traffic and BC Place noise assumptions were made based off of traffic information provided by the City, field noise measurements and previous acoustic studies. Aircraft and other potential environmental noise sources were excluded from this study.

B. Noise Model

Audience ambient noise predictions were made using Cadna/A, implementing ISO 9613[5] and NMPB-Routes-96[6] standards. The model geometry was defined using a Sketchup model provided by the City. A 3D view of the model is shown in Figure 2. Additional noise measurements were used to calibrate the BC Place and Rogers Arena roof noise sources. BC Place levels were predicted with both open and closed roof conditions and soccer crowd noise was assumed to be 3 dB lower than football crowd noise due to an assumed attendance reduced by 50%.

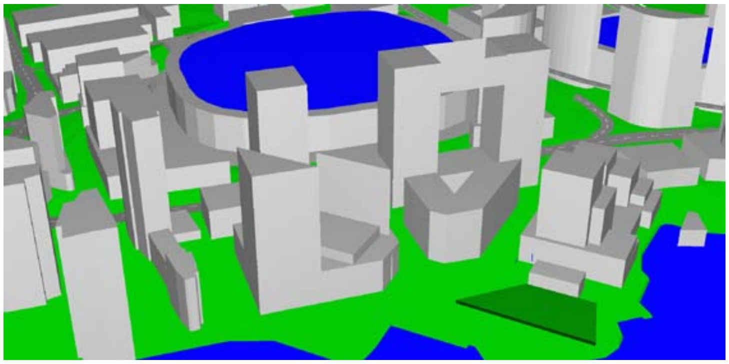


Figure 2: 3D view of Cadna/A noise model showing some of the modelled roads, BC Place, existing buildings, the proposed audience area in dark green and proposed building layout.

C. Results

The L_{Aeq} was predicted in the audience area for 12 ambient noise scenarios. Table 4 summarizes the predicted amount of time during an event where the criteria would be met. In reality, road traffic noise would also occur during BC Place events so the more restrictive values calculated for road traffic noise are more relevant. In summary, the typical pop/rock concert would be unaffected by ambient noise and the typical amplified symphonic concert would not be viable in this type of ambient noise environment.

Table 4: The predicted ambient noise impact on the audience is shown with results in terms of the percentage of event time where ambient noise would meet the audience criteria for each type of music.

Type of Music	Weekday midday road traffic	Weekday PM rush hour road traffic	Weekday evening road traffic	Weekend midday road traffic	Weekend PM rush hour road traffic	Weekend evening road traffic	BC Place football game roof closed	BC Place football game roof open	BC Place soccer game roof closed	BC Place soccer game roof open	BC Place concert roof closed	BC Place concert roof open
Pop / rock concert	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%	99%
Symphonic concert	1%	1%	1%	1%	1%	5%	80%	30%	95%	60%	25%	5%

6. NOISE IMPACT FROM THE RESIDENTS POINT OF VIEW

A. Approach

Following are additional factors that may affect residential noise impacts from concerts:

- Stage orientation
- Stage acoustics
- Stage monitor system
- Loudspeaker locations
- Loudspeaker acoustics
- FOH mixing console location

- Location of residences

The City provided two stage orientation options after receiving input from cultural, acoustical and architectural disciplines and indicated that the stage would be concrete with a fabric roof and no walls/shell. Figure 3 shows the two orientations. We assumed that an in-ear monitor system would be used.

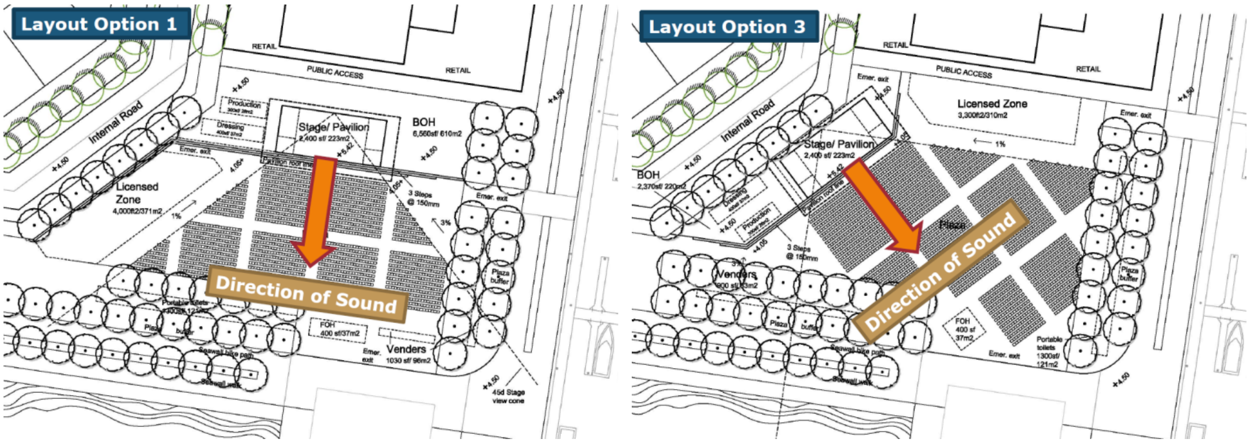


Figure 3: The two stage orientation options are shown with concert sound being directed either south over the water or southeast over the water.

This paper summarizes the results from an "improved" professional audio set up based on communications with two A/V consultants. The typical touring set up would have higher loudspeaker sound power levels due to using lower directivity arrays, non-optimized loudspeaker orientations and greater distances to the FOH position. It included two flown line arrays with higher directivity than typical, as shown in Figure 4, and a closer FOH position making an equilateral triangle between the loudspeakers and mixing console. Subwoofers were assumed to be cardoid arrays and located on the ground in front of the concrete stage to further improve directivity. As a result, the flown arrays could be directed downwards more and their sound power could be reduced for a given level at the mixing console. Three delay loudspeakers were added for the Layout Option 3 to provide sound coverage behind the FOH.

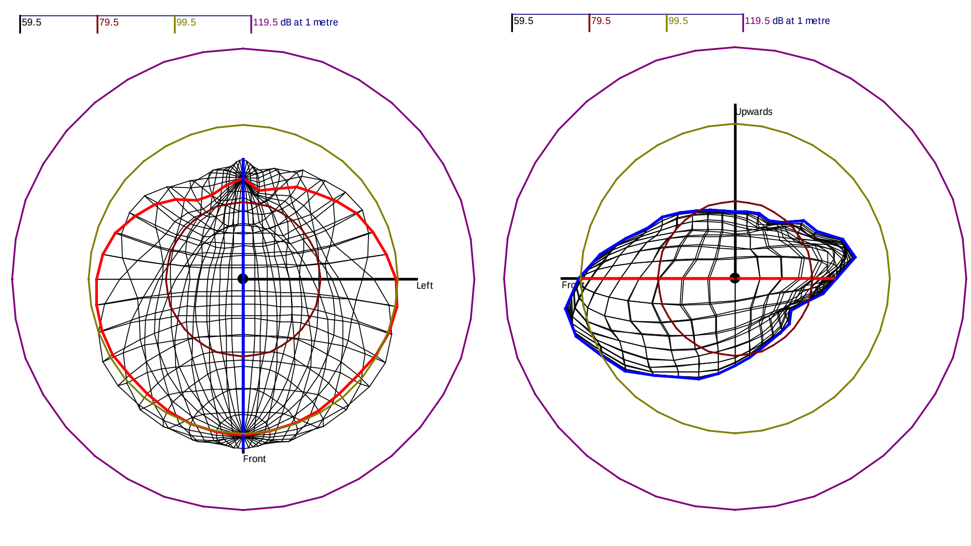


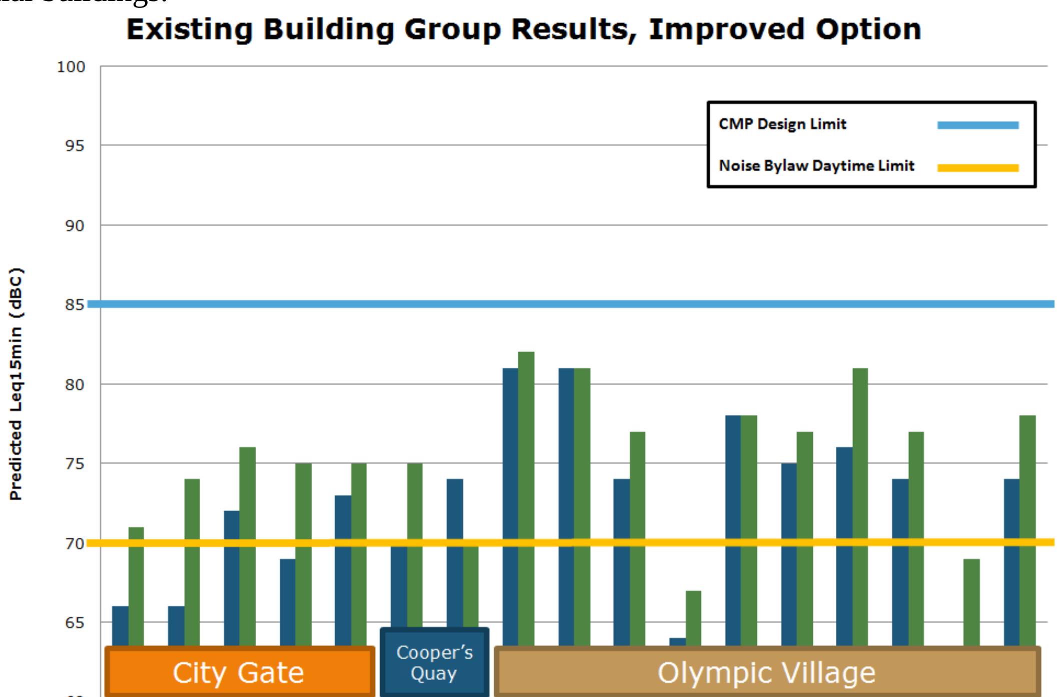
Figure 4: Plan and elevation views of the overall directivity are illustrated for the modelled line array.

B. Noise Model

In order to more accurately account for loudspeaker directivity, Odeon version 11 was used to model the proposed electro-acoustic system instead of Cadna/A. A Sketchup model provided by the City was used to define the geometry and absorption and scattering coefficients were set according to recommendations in the Odeon manual[7].

E. Results

Pop/rock concert noise predictions at existing residential receptors are shown in Figure 5 and at proposed residential receptors in Figure 6. Five building groups are shown. The improved loudspeaker system with closer FOH position reduced the predicted residential noise levels by an average of 8 or 9 dBC over predictions for a typical touring set up, depending on the stage option. However, as shown in Figure 5, numerous existing residences would still be above the noise bylaw limit and, as shown in Figure 6, one or more of the proposed residential building facades would be above the 85 dBC design limit. Table 5 summarizes the results in terms of the percentage of time where the criteria would be met at all modelled receptors in each group of residential buildings.



	R1	R2	R3	R4	R5	R6	R8	R9	R10	R40	R41	R42	R43	R44	R45	R46	R47
Opt1Opt	66	66	72	69	73	70	74	81	81	74	64	78	75	76	74	59	74
Opt3Opt	71	74	76	75	75	75	70	82	81	77	67	78	77	81	77	69	78

Figure 5: The predicted pop/rock concert noise at existing residences is shown above for two stage options.

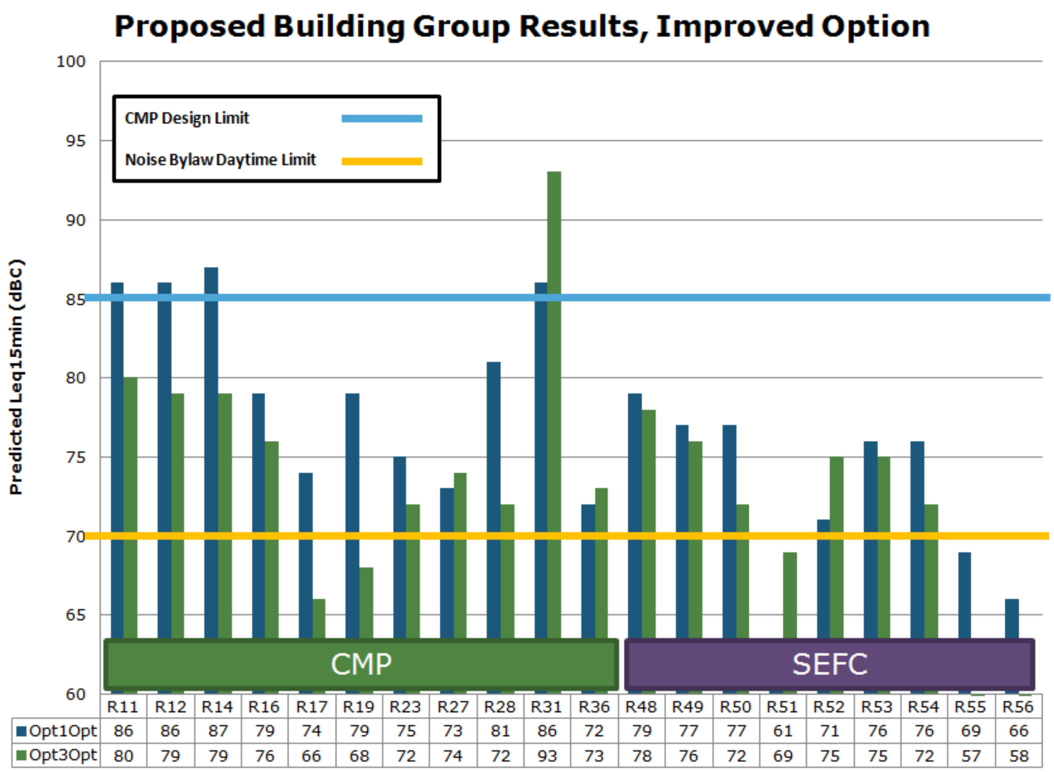


Figure 6: The predicted pop/rock concert noise at proposed residences is shown above for two stage options.

Table 5: The predicted concert noise impact on the surrounding community is shown with results in terms of the percentage of event time where concert noise would meet the residential criteria at all residences in each group for each type of music.

Type of Music	Option 1 Improved					Option 3 Improved				
	City Gate	Cooper's Quay	Olympic Village	CMP	SEFC	City Gate	Cooper's Quay	Olympic Village	CMP	SEFC
Pop / rock concert	0%	0%	0%	30%	100%	0%	0%	0%	0%/100%*	100%
Symphonic concert	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

* 0% if R31 building façade included in group or 100% if R31 building façade not included in group

7. COMBINED RESULTS

The results from each assessment were then combined and summarized in Table 6. This illustrates that pop/rock music that would be loud enough for the audience would be too loud for the surrounding residential and that symphonic music that would be quiet enough for the surrounding community wouldn't be loud enough for the audience.

Table 6: The predicted percentage of time where relevant criteria would be met at all receptors in each group for each type of music.

Type of Music	Audience	City Gate Residential	Concord Residential	Olympic Village Residential	CMP Residential	SEFC Residential
Pop / rock concert	99%	0%	0%	0%	0-100%	100%
Symphonic concert	1%	100%	100%	100%	100%	100%

8. DISCUSSION

Best practice was used to try to improve the acoustic compatibility as much as practically possible. However, there are always conflicting interests and compromises that need to be made and noise mitigation usually costs money that may or may not be available to the project. In this case, the following strategies, which were not pursued for various reasons, could have been used to improve the compatibility of the space:

- Use a deep amphitheatre style layout with a steep rake
- Add a stage shell
- Add a solid stage cover and extend over audience
- Use more compression during amplification of symphonic performances to reduce dynamic range and increase loudness during quiet portions of the performances
- Reduce bass levels during pop/rock performances
- Add a wall around venue to increase bass at FOH and audience
- Reduce audience area

Results were also presented to and supported by user groups (event organizers and technical experts) who tested the study's assumptions.

9. CONCLUSIONS

An acoustical consultant's intuition tells them that open air concerts are not compatible in noisy areas or adjacent to residential land use. On the other hand, when there is a will there is often a way. In this case, the City of Vancouver's design and flexible use program objectives for the plaza were directly at odds with the design interventions that would have been necessary to adequately address the acoustical problems, leading City staff to recommend changing the assumed plaza programming to a predominantly small scale event/performance focus.

ACKNOWLEDGEMENTS

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