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Title:	**Summary of Noise Modeling Methodology and Results**
Project:	**BP Cherry Point Cogeneration**
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Introduction

Hessler Associates, Inc. has carried out a noise modeling study of the proposed BP Cherry Point Cogeneration plant in order to evaluate the likely sound levels due to facility operation at the 15 potentially sensitive receptor locations identified in an earlier site survey and noise impact analysis conducted by Golder Associates. Although the plant's noise emissions had already been modeled as a part of the Golder study, a completely new and independent assessment was undertaken that not only reflected the substantially different physical layout of the plant (wet cooling tower vs. an air cooled condenser) but also used different modeling software and all new source input data gathered from measurements of similar or identical equipment in operation at a number of existing facilities.

In addition to the new modeling, some further, longer duration ambient noise measurements were made at four of the closest potentially sensitive receptors in order to obtain a wider and more detailed picture of the background sound levels that currently exist in the vicinity of the project.

This memo briefly summarizes the new ambient survey results, the noise modeling methodology used and the expected impact of plant noise on the surrounding community.

Ambient Noise Monitoring

A new, up to date and more extensive background sound level measurement study was recently undertaken to examine the long term behavior of existing environmental sound levels at the nearest sensitive receptors. Four continuously recording noise monitors were set up at Receptors 7, 10, 11 and 14 (see Appendix K, Figure 2) to simultaneously measure environmental noise in 15 minute increments for a period of 60 hours beginning at 5:00 p.m. on April 8 and ending at 5:00 a.m. on April 11, 2003. The survey covered three nights, when the quietest levels normally occur, and two full days.

Four, ANSI Type 2 Rion NL-06 sound level meters were used in the survey. The instruments were housed in weather-proof cases fitted with an external microphone boom and located about 8 ft. above grade on utility poles close to each receptor point. Each microphone was covered with a windscreen with an integral moisture barrier. The instruments were calibrated before and after the survey and showed no significant drift. The weather during the first night of the survey and a portion of the last night was overcast with intermittent showers – not at all unusual for the region. The remaining time was mostly cloudy. Winds were generally light from the south throughout the survey.

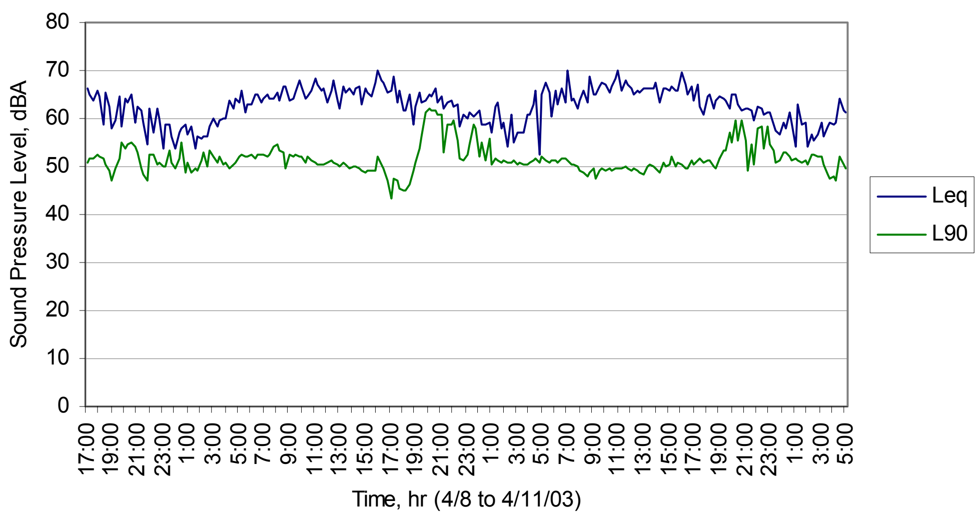
In general, the objective of any ambient sound level survey is to determine (as well as such a quantity can be determined within a practical timeframe) the minimum background sound level that is consistently present at each sensitive receptor and available to obscure or mask possible noise from a new source. If a new source is significantly louder than this consistent background level it will be perceptible and possibly disturbing whereas if the source level is close to or below the background its noise will not be audible.

Quantitatively, a new source that causes the total sound level to increase by 5 dBA is generally perceptible to most people with careful listening. When smaller cumulative increases occur or when the new source level is below the background the new source cannot be distinguished.

The most conservative measure of background noise is the L90 statistical level - or the sound level that is exceeded 90% of the sampling period. This quantity characterizes the true background level that occurs in the lulls between common sporadic events such as cars passing by or dogs barking. Essentially by definition, intermittent events like these do not occur on a continuous or consistent basis and are therefore not always present to mask a new and potentially disturbing noise source. Instead, the L90 quantifies the quiet periods between sporadic noises.

A number of statistical and other levels were recorded over each 15 minute period but the L90 and the average sound level (Leq) are of the most interest. The plots below illustrate these levels over the 60 hour survey period at each receptor.

Figure 1 Sound Pressure Levels vs. Time
Receptor 7, Jackson Road (Birch Bay Community Church)



At Receptor 7 northwest of the site (see Figure 1) the mean L90 level is relatively steady with an arithmetic average at 51 dBA. The Leq level is substantially higher, particularly during the day, since it is highly sensitive to intermittent noises - in this case, cars passing the measurement position on Jackson Road. At night the two curves almost converge as road traffic decreases.

In Figure 2 (on the following page) the L90 background level at Receptor 10 (Bay and Blaine Roads) north of the site is somewhat less steady and very gradually fluctuates over time. However, over the entire 60 hour period surveyed it is fair to say that the mean background value is about 40 dBA or slightly higher; the actual average is 42 dBA.

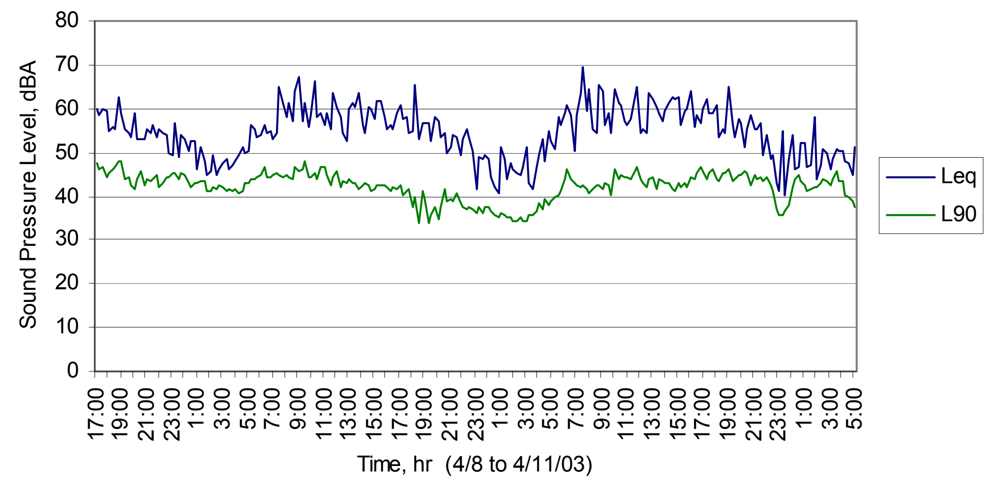


Figure 2 Sound Pressure Levels vs. Time
Receptor 10, Bay and Blaine Roads

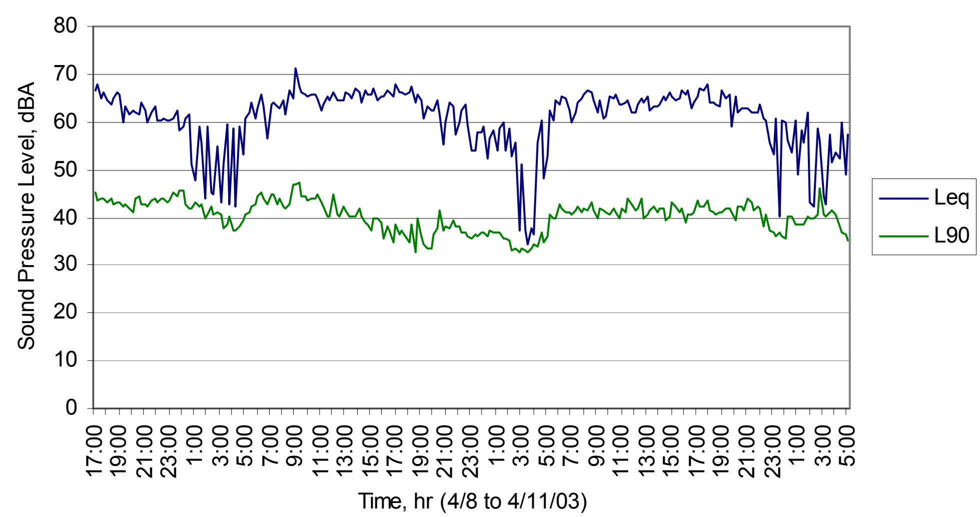
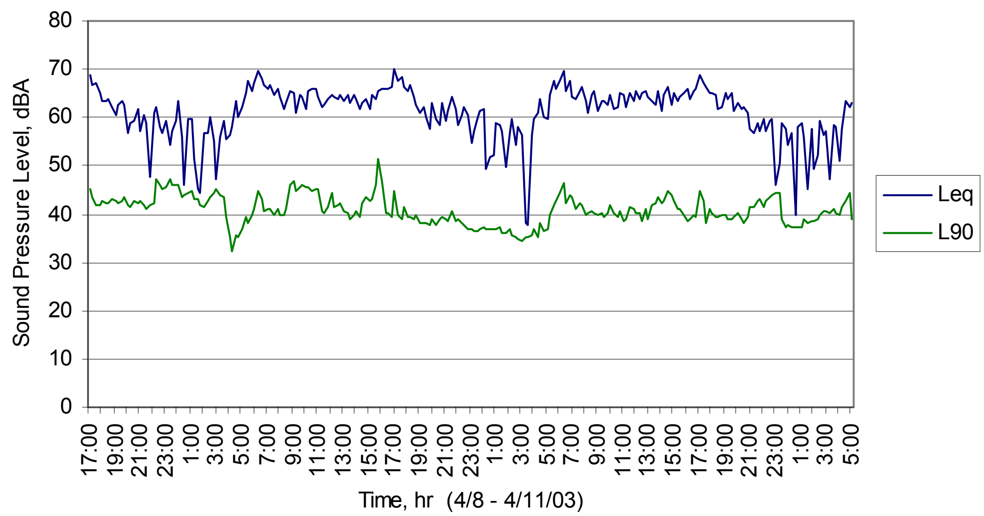


Figure 3 Sound Pressure Levels vs. Time
Receptor 11, Kickerville and Bay Roads

At Receptor 11 (Figure 3) also on Bay Road but further east (about 100 ft. from the intersection with Kickerville Road) very similar L90 levels are evident. Again a mean level of 40 dBA is an appropriate single number representation. Traffic at this intersection, characterized by the Leq, is relatively heavy and continuous during the day with a fair number of cars going by during every 15 minute interval. In the evening the frequency of car pass-bys decreases and around 3:00 a.m. each night there are several periods of calm without any traffic. In the absence of sporadic noise events all the statistical and average levels collapse to one value.

Figure 4 Sound Pressure Levels vs. Time
Receptor 14, Kickerville and Brown Roads



Finally, at Receptor 14 (Figure 4) at Kickerville and Brown Roads east of the project site a similar mean L90 of about 40 dBA is also apparent. The arithmetic average of all L90 values is 40.8 dBA, or 41 dBA for all intents and purposes.

In summary, the survey results indicate that over a substantial three day period (most similar surveys are shorter in duration) the existing L90 background sound levels at the nearest receptors remain reasonably constant. Consequently, the mean value of the all the measured values appears to be a fair representation of the ambient sound level that is consistently present at each location. These levels can be considered a datum against which the noise emissions of the future plant can be compared to assess the likelihood of any adverse impact. The following table summarizes the survey findings and lists a set of maximum plant sound levels that would avoid any adverse community impact under most normal circumstances. As noted above, any increase in ambient sound level of 5 dBA is barely perceptible and is therefore normally considered a non-adverse impact. Increases of less than 5 dBA are essentially inaudible.

Table 1 *Survey Results Summary and Plant Design Levels*

Location	Mean Measured L90 Background Level, dBA	Plant Design Level Limiting Total Increase in Ambient to 5 dBA, dBA	Nominal New L90 with Plant Operating at Base Load, dBA
Rec. 7 Jackson Rd.	51	54	56
Rec. 10 Bay and Blaine Rds.	42	45	47
Rec. 11 Bay and Kickerville Rds.	40	43	45
Rec. 14 Kickerville and Brown Rds.	41	44	46

If these plant design goals at the four closest receptors are met it can be reasonably concluded that plant noise will be lower and therefore inconsequential at all more distant receptors.

Modeling Methodology

Working from the ambient survey results and the plant design levels summarized above, a noise model of the facility was developed to predict operational noise levels at the nearest sensitive receptors and as a design tool to identify any necessary mitigation measures that might be needed to achieve the design targets. The commercial software program, Cadna/A ver. 3.0, developed specifically for power industry applications by DataKustik, GmbH (Munich, Germany) was used to model facility noise during normal base load operation. In general, a three-dimensional rendering of the facility is created directly from the site plan drawing by defining the height and extent of all equipment and significant structures making up the plant. Sound power level values are assigned to each source in a manner that best represents their actual acoustical performance. For example, building and HRSG walls are defined as vertical area sources and smaller sources such as pumps are characterized by point sources.

Based on these inputs the far field noise emissions of the plant are calculated in accordance with accepted standards. In particular, the program default standards – VDI (Verein Deutscher Ingenieure) 2714 *Outdoor Sound Propagation* and VDI 2720 *Noise Control by Outdoor Barriers* have been used in this evaluation. These standards take into consideration the following noise propagation factors.

- Mutual blockage between large pieces of plant equipment or buildings
- Noise attenuation due to distance
- Attenuation due to air absorption under fairly conservative conditions (10 deg. C/70% RH – conditions relatively favorable to noise propagation)
- Attenuation due to ground absorption, assuming moderate ground porosity (absorption coefficient of 0.75)
- Minor losses in certain directions due to the intermittent wooded areas around the project site (represented by a local ground absorption coefficient of 1.0 within each wooded area)
- Downwind conditions; i.e. each grid node or receptor location is assumed to be experiencing a wind of 3 m/s blowing from the facility to the point of calculation (per VDI 2714, equation (18))
- Source Directivity

Compared with distance loss, which is calculated with a simple and invariant formula, all of the other propagation effects in this list are typically quite small. For example, over a 1000 m propagation distance the loss from hemispherical wavefront spreading from a point source is 68 dB (in all frequency bands) whereas the loss from air absorption is on the order of 4 dB at 1 kHz. In general, the accuracy of any noise model is much more dependent on the quality of the input power levels than it is on the specific modeling program used or on the details of the propagation calculations. All of the equipment power levels used in this particular model were developed from firsthand field measurements of identical combustion and steam turbine units made at a number of different plants and from measurements of similar balance of plant equipment (cooling towers, pumps, transformers, etc.).

Although the source power levels themselves, gleaned from years of fieldwork, are proprietary, it can be said by way of validation that the accuracy of previous noise models of similar combined cycle plants have been satisfactorily verified from measurements of completed plants in actual operation. In most cases, the predicted levels are found to be slightly higher than the actual performance - evidently due to the conservative nature of the power level derivations and general modeling assumptions. It should be noted, however, that the sound levels predicted by the program in accordance with the standards mentioned above represent the expected emissions of the plant alone (exclusive of any off site background noise) under conservative but benign atmospheric conditions. Some variance above and below the nominal predictions is inevitable depending on the specific conditions occurring at any given time. These variances are largely a function of propagation path length; i.e. the potential influences from wind and temperature gradients increase with increasing distance from the plant. At the same time, however, the nominal magnitude of plant noise decreases with distance off-setting to some extent the potential perceptibility of atmospheric variance.

Model Results – A-weighted Sound Levels

The baseline sound levels due exclusively to the facility operating under normal, steady state, full load conditions were calculated at the 15 receptor locations identified in the original survey. Baseline means that source noise levels for all equipment in the plant were representative of typical equipment without any non-standard or unusual improvements specifically intended to reduce noise. Noise control features that are normally supplied by the manufacturer as standard, such as the combustion turbine inlet silencers and various turbine enclosures, were included in the analysis. The steam turbine structure below the operating deck is assumed to have enclosed sides per the existing plans.

The results of this calculation indicated that plant noise would be below the most stringent applicable industrial and residential regulatory limits at all locations but above the desired design limits in Table 1 at a few of the closer receptor locations. Moreover, it was clear from the model that a moderate reduction in HRSG stack noise would significantly lower the overall plant level at these locations. Consequently, a recommendation to add stack silencers with a nominal reduction of 10 dBA in stack sound power level was put forward, accepted and incorporated into the design. With this improvement total plant levels at some of the more critical locations were reduced by 3 to 4 dBA. Silencing the stacks also carries the additional benefit that stack noise is much less likely to adversely affect levels at receptors situated downwind from the facility. The high elevation of the stack exits makes their noise more susceptible to wind effects.

Table 2 summarizes the predicted A-weighted plant levels at each of the receptors (with quieted stack emissions) and compares the plant performance to the Washington State noise limits (WAC 173-60) and the ambient-based design levels.

Table 2 *Summary of A-weighted Receptor Levels due to Base Load Plant Operation (With Stack Silencer)*

Location (I) Industrial Zoning, (R) Residential Zoning	Expected Plant Level (Exclusive of any Background Noise), dBA	Most Stringent (Nighttime) Regulatory Limit, dBA	Plant Design Level for Non-Adverse Impact (from Table 1), dBA
Receptor 1 (I)	47	70	
Receptor 2 (R)	41	50	
Receptor 3 (I)	46	70	
Receptor 4 (I)	39	70	
Receptor 5 (I)	40	70	
Receptor 6 (I)	41	70	
Receptor 7 (R)	**40**	**50**	**(54)** Superceded by 50 dBA reg. limit
Receptor 8 (R)	34	50	
Receptor 9 (R)	38	50	
Receptor 10 (R)	**40**	**50**	**45**
Receptor 11 (R)	**39**	**50**	**43**
Receptor 12 (I)	60	70	
Receptor 13 (I)	48	70	
Receptor 14 (R)	**43**	**50**	**44**
Receptor 15 (R)	35	50	

As can be seen, all of the locations are expected to be well below the regulatory limits. In addition, the predicted performance at all of the four key locations evaluated in the recent survey are also significantly less than the no-impact design goals established above. In all cases, the anticipated cumulative impact is less than 5 dBA.

Table 3 shows the actual expected cumulative noise levels given the plant performance at the four receptors.

Table 3 *Expected Cumulative Noise Levels at the Nearest Receptors*

Location	Expected Plant Noise Level, dBA	Existing L90 Background Level, dBA	Expected New Cumulative Sound Level, L90, dBA	Expected Cumulative Impact Relative to Pre-existing L90 Background, dBA
Rec. 7 Jackson Rd.	40	51	51	0
Rec. 10 Bay and Blaine Rds.	40	42	44	2
Rec. 11 Bay and Kickerville Rds.	39	40	43	3
Rec. 14 Kickerville and Brown Rds.	43	41	45	4

Besides the four locations representative of the nearest sensitive receptors (7, 10, 11 and 14) essentially all of the other eleven points have little significance with respect to perceptibility or potential disturbance. Locations 1, 2, 3, 4, 5, 6, 12, and 13 are industrial or otherwise non-sensitive or vacant locations where plant noise will be irrelevant. Receptor 9, only a short distance north of Receptor 7 on the same road, is likely to have a similar ambient level in the vicinity of 50 dBA and should therefore be completely unaffected by a plant level of 38 dBA. The remaining two locations, 8 and 15, are potentially sensitive locations but they are distant from the site and predicted project noise levels are very low - 35 dBA or less. Consequently, no adverse impact is expected at those locations.

Model Results – C-weighted Sound Levels

The expected low frequency sound levels from the facility were also evaluated in the model. The lowest frequency bands and the overall C-weighted sound level at each receptor location are given in Table 4.

As indicated in Appendix B of ANSI B133.8 “Gas Turbine Installation Sound Emissions” the normal threshold of perceptibility for low frequency noise and vibration is a sound level of about 75 to 80 dBC. All of the receptors and particularly the residential receptors should experience C-weighted plant levels significantly below 75 dBC. This is a common result for combined cycle facilities, which seldom, if ever, produce problematic low frequency noise levels. Adverse environmental impacts due to low frequency noise are essentially confined to simple cycle combustion turbine installations.

Table 4 *Summary of Low Frequency Receptor Levels due to Base Load Plant Operation*

Location	Octave Band Center Frequency (Hz)				Total Level, dBC
	31.5	63	125	250	
Receptor 1 (I)	62.5	61.8	53.0	47.7	**63.8**
Receptor 2 (R)	57.7	57.7	49.2	42.9	**59.4**
Receptor 3 (I)	60.4	61.3	52.9	47.2	**62.8**
Receptor 4 (I)	56.5	56.8	47.8	41.5	**58.4**
Receptor 5 (I)	57.0	57.1	48.2	42.3	**58.7**
Receptor 6 (I)	57.1	57.3	48.6	42.8	**58.9**
Receptor 7 (R)	56.8	57.1	48.5	42.5	**58.7**
Receptor 8 (R)	52.3	52.9	43.7	36.6	**54.3**
Receptor 9 (R)	55.4	55.7	47.0	40.5	**57.3**
Receptor 10 (R)	56.8	56.9	48.3	42.3	**58.6**
Receptor 11 (R)	56.4	56.5	47.8	41.3	**58.2**
Receptor 12 (I)	71.6	70.9	64.9	57.8	**73.3**
Receptor 13 (I)	63.3	62.9	54.7	49.0	**64.8**
Receptor 14 (R)	59.4	59.3	50.2	44.8	**61.0**
Receptor 15 (R)	53.4	53.9	44.8	37.9	**55.4**