WATERLOO PUMP STATION

(Dane County, Wisconsin)

NOISE IMPACT ANALYSIS

H&K Report No. 3083

H&K Job No. 4796

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REPORT SUMMARY

In this report, Hoover and Keith, Inc. (H&K) present the results of a noise impact analysis associated with the planned improvements at the existing **Waterloo Pump Station** (hereinafter referred to as "Station"), which is owned and operated by **Enbridge Energy, LP** (Enbridge). The planned improvements include the abandonment of the existing Station pump units and the construction of new Station pump units. The purpose of the acoustical analysis is to:

- Project the sound level contribution that would result from operating the new Station equipment, which consists of new pump units and auxiliary equipment.
- Determine noise control measures and noise requirements for proposed Station equipment to insure that the facility does not exceed 50 dBA at the Station property lines.

The following table depicts the estimated Station sound level contribution at the North, East, West and South property lines and the Dane County noise requirement:

Closest Property Lines	Distance to Center of Pump Building	Est'd Sound Contribution of Station (dBA)	Dane County Property Line Requirement (dBA)	Compliance with Dane County Requirement
North P.L (Pos. "N")	300 ft.	**43.4**	50	Yes
East P.L. (Pos. "E")	700 ft.	**34.8**	50	Yes
South P.L. (Pos. "S")	800 ft.	**34.0**	50	Yes
West P.L. (Pos. "W")	625 ft.	**35.3**	50	Yes

Sound Level Contribution of Proposed Station at Property Lines and Assessment to Dane County 50 dBA Requirement

In summary, the acoustical assessment indicates that if the recommended and/or anticipated noise mitigation measures are implemented, the noise attributable to the Station at the property lines would comply noise requirements stipulated by Dane County for the project.

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1.0 INTRODUCTION

In this report, Hoover and Keith, Inc. (H&K) present the results of a noise impact analysis associated with the planned improvements at the existing **Waterloo Pump Station** (hereinafter referred to as "Station"), which is owned and operated by **Enbridge Energy, LP** (Enbridge). The planned improvements include the abandonment of the existing Station pump units and the construction of new Station pump units. The purpose of the acoustical analysis is to:

- Project the sound level contribution that would result from operating the new Station equipment, which consists of new pump units and auxiliary equipment.
- Determine noise control measures and noise requirements for proposed Station equipment to insure that the facility does not exceed 50 dBA at the Station property lines.

2.0 DESCRIPTION OF SITE AND PROPOSED STATION

The Station is located in Medina Township, Dane County, Wisconsin and the Station is approximately 2 miles E-SE of town of Marshall. The surrounding area consists of agricultural lands and rural residences primarily level terrain.

Figure 1 (p. A-1) depicts the Station plot plan with the proposed new Station equipment, noting that the existing Station pump units and control systems are to be abandoned and removed. The proposed pump units include four (4) 6,000 HP electric motor driven pumps, an electrical substation, a Variable Frequency Drive ("VFD") Building ("VFD Building"), along with an adjacent Electrical Service Building ("ESB"). The motors/pumps of the motor-driven pumps and associated aboveground piping will be located inside an acoustically-insulated metal building ("Pump house Building"), and the VFD Building/ESB are anticipated to be "modular-type" buildings.

3.0 SOUND CRITERIA

Dane County has stipulated to Enbridge that the sound level attributable to the proposed Station cannot exceed 50 dBA at the Station property line.

For the reader's information, a summary of acoustical terminology and list of typical metrics used to measure/regulate environmental noise is provided in **Appendix C** (pp. C-1 to C-4).

4.0 ACOUSTICAL ASSESSMENT

The noise impact evaluation considers the noise produced by all significant sound sources associated with proposed Station that could impact the sound contribution at the Station property lines. A description of the analysis methodology and source of sound data is provided in **Appendix B** (p. B-3). The following sound sources are considered significant:

- Noise of electric motor-driven pump units that penetrates the Pump House building.
- Noise of aboveground piping (i.e., adjacent to the pumps) that penetrates the Pump House building.
- Noise associated with the electrical substation (e.g., transformers, etc.).
- Noise associated with the ESB Building.

Tables A-D (pp. B-1 to B-2) show the calculation (i.e., spreadsheet analysis) of the estimated octave-band SPLs and the A-wt. sound level at the North, East, South and West Property Lines contributed by the significant noise sources associated with the proposed facilities for standard day propagating conditions (i.e., no wind, 60 deg. F., 70% R.H.) and any shielding from buildings, terrain or foliage has been conservatively ignored. This spreadsheet analysis includes the potential noise reduction due to the anticipated and/or recommended noise control measures for equipment.

The following **Table 1** depicts the estimated Station sound level contribution at the property lines and the Dane County noise requirement:

Closest Property Lines	Distance to Center of Pump Building	Est'd Sound Contribution of Station (dBA)	Dane County Property Line Requirement (dBA)	Compliance with Dane County Requirement
North P.L (Pos. "N")	300 ft.	**43.4**	50	Yes
East P.L. (Pos. "E")	700 ft.	**34.8**	50	Yes
South P.L. (Pos. "S")	800 ft.	**34.0**	50	Yes
West P.L. (Pos. "W")	625 ft.	**35.3**	50	Yes

Table 1: Sound Level Contribution of Proposed Station at Closest Property Lines and Assessment to Dane County 50 dBA Requirement

In summary, the acoustical assessment indicates that if the recommended and/or anticipated noise mitigation measures are implemented, the noise attributable to the Station at property lines would comply noise requirements stipulated by Dane County for the project.

5.0 NOISE CONTROL REQUIREMENTS

The following section provides recommended noise control measures and equipment noise specifications along with other assumptions that may affect the noise generated by the facility.

5.1 Pump House Building

Building Structure

- As a minimum, walls/roof should be constructed with exterior steel of 22 gauge and interior layer of 6-inch thick unfaced mineral wool (e.g., 6.0-8.0 pcf uniform density) covered with a 24 gauge perforated liner. Thermal insulation, such as "R-19", should not be used as a substitute for the 6.0-8.0 pcf material.

- Personnel entry doors should have a minimum STC-38 sound rating and could include door glazing if a 2' x 2' maximum view port is employed (e.g., 1/2 inch thick laminated glazing or double pane safety glass). Doors should seal well with the doorframe and be self-closing.

- No windows, skylights or "open" louvers should be installed.

- All voids and openings in the building walls resulting from penetrations should be patched and well sealed. Building construction details shall be consistent with a high performance acoustical building.

- Each overhead sectional roll-up door, as a minimum, should be a 20 gauge insulated type design (e.g., 20 gauge exterior with a 22 gauge backskin with insulation core) and should be completely weather-stripped.

Building Ventilation

- The building ventilation system should be designed to properly ventilate (and cool) the building and equipment during maximum outside ambient temperatures with all personnel and equipment doors closed. Personnel and/or equipment doors will only be opened during maintenance activities.

- The A-wt. sound level for each ventilation inlet should not exceed **40 dBA** at **50 feet** from the building penetration (i.e., inlet louver, acoustic inlet hood, etc.). The A-wt. sound level for each ventilation exhaust outlet should not exceed **40 dBA** at **50 feet** from the building penetration (i.e., exhaust louver, exhaust hood, etc. A ridge vent

shall not be utilized. Each ventilation inlet and exhaust outlet shall assume that the following sound pressure levels exist inside the pump house building at and adjacent to the ventilation equipment:

SPLs per Octave-Band Center Freq. & A-Wt. Level

31.5	63	125	250	500	1000	2000	4000	8000	dBA
75	80	85	85	85	80	80	75	65	87

- As a minimum, air-supply fans used for ventilation should include a metal boot enclosing the fan; a minimum 36-inch length exterior silencer and a weather hood lined with acoustical insulation. Assuming separate roof exhaust vents will be utilized, each roof exhaust vent, as a minimum, should include a 36-inch length silencer (i.e., baffle-type design) mounted between the building surface and vent/hood (i.e., in the ventilator throat).

5.2 VFD System Cooling Exhaust Air and associated Components

Air Exhaust System for VFD: It is anticipated that the air exhaust of each VFD cooling system will be exhausted via an opening located on the ESB building wall (via a louver). Based on this design, the A-wt. sound level generated from the air exhaust opening of the VFD air exhaust system (including any noise control) should not exceed **40 dBA** at **50 feet**. It is recommended that a 5-ft. length (min.) parallel-baffle silencer should be installed in-line with the VFD air exhaust ductwork, preferably in the VFD exhaust ducting located inside the ESB Building. If it is not feasible to insert the recommended silencer in-line with the interior air exhaust ductwork, the silencer may have to be mounted on the exterior wall of the air exhaust opening. For reference, the following table lists the recently-measured A-wt. sound level and unweighted O.B. SPLs at 5 feet and 50 feet from the air exhaust opening of a typical “modular-type” VFD Building at another Enbridge pumping station.

Meas’d Sound Levels at 5 Ft. & 50 Ft. for VFD Air Exhaust Opening

Distance	31.5	63	125	250	500	1000	2000	4000	8000	A-Wt.
5 Ft.	76 dB	72 dB	78 dB	72 dB	70 dB	68 dB	68 dB	65 dB	58 dB	74 dBA
50 Ft.	64 dB	61 dB	65 dB	62 dB	60 dB	57 dB	56 dB	52 dB	46 dB	63 dBA

Other Equipment/Components: The A-wt. sound level of each wall-mounted AC unit should not exceed **40 dBA** at a distance of **50 feet** from the equipment during operation. In addition, for the ESB Building, assuming wall openings will associated with the building air ventilation system, it may be necessary to employ acoustical-type louvers and/or other type of noise control measures to reduce the noise of internal equipment (e.g., VFDs, etc.) that radiates through any building ventilation openings.

5.3 Substation

Low noise transformers shall be employed. It is recommended that provision for an absorptive barrier between the substation and the closest property lines is incorporated in the detailed design in the event the sound of the substation becomes problematic.

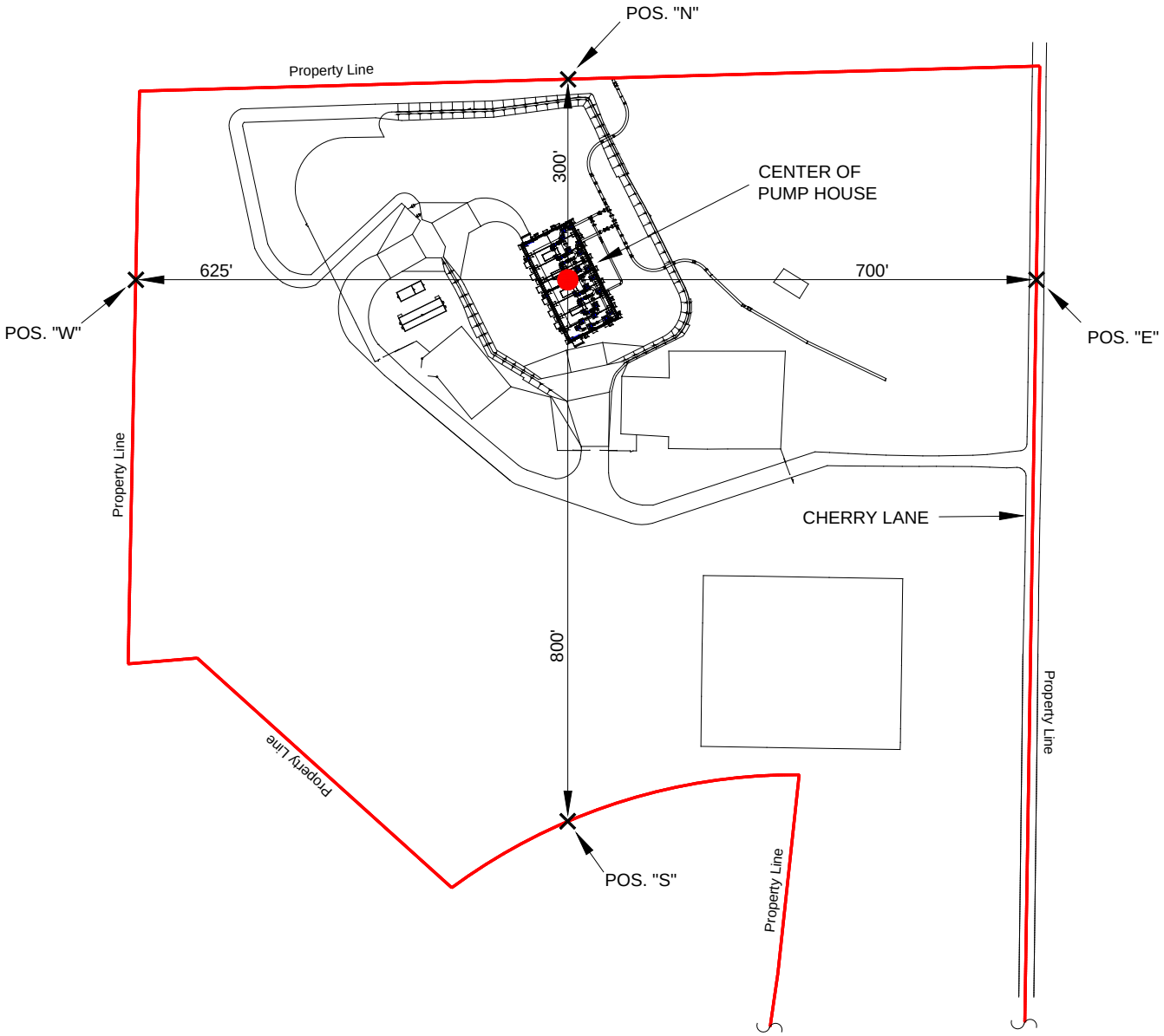


Figure 1: **Waterloo Pump Station Plot Plan**

Source No. & Dist (Ft)	SOURCE PWL & EST'D. SOUND LEVEL CONTRIBUTIONS AT SPEC. DISTANCE	PWL or SPL in dB Per Octave-Band Center Freq. (Hz)									A-Wt. Level
		31.5	63	125	250	500	1000	2000	4000	8000	
1)	PWL of Unenclosed Pumps & Piping (1 unit)	102	104	108	112	108	107	104	102	97	112
	PWL of 4 Units	108	110	114	118	114	113	110	108	103	118
	NR of Pump House Building	-6	-10	-16	-26	-36	-36	-36	-36	-36	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
225	Hemispherical Radiation	-45	-45	-45	-45	-45	-45	-45	-45	-45	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	0	-1	-2	-3	
	Source Sound Level Contribution	57	55	53	47	33	32	29	26	19	42
2)	PWL of Building Air Supply Fans (w/silencer)	91	95	91	87	75	69	65	63	58	81
	Atten. Of Additional Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
225	Hemispherical Radiation	-45	-45	-45	-45	-45	-45	-45	-45	-45	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	0	-1	-2	-3	
	Source Sound Level Contribution	46	50	46	42	30	24	20	17	10	36
3)	PWL of VFD Vent. Noise / AC Noise	95	92	94	92	90	88	86	82	75	93
	NR of VFD Exh. Silencer	-2	-3	-6	-14	-24	-28	-28	-22	-15	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
325	Hemispherical Radiation	-48	-48	-48	-48	-48	-48	-48	-48	-48	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	0	-1	-2	-4	
	Source Sound Level Contribution	45	41	40	30	18	12	9	10	8	27
4)	PWL of Substation	85	88	90	78	72	65	60	55	50	77
	NR of Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
450	Hemispherical Radiation	-51	-51	-51	-51	-51	-51	-51	-51	-51	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-1	-3	-6	
	Source Sound Level Contribution	34	37	39	27	21	14	8	1	0	26
Est'd Total Contribution of Proposed Station		**58**	**57**	**54**	**48**	**35**	**33**	**29**	**26**	**20**	**43.4**

Table A: Est'd Contribution from Proposed Station at North P.L. (Pos. "N")

Source No. & Dist (Ft)	SOURCE PWL & EST'D. SOUND LEVEL CONTRIBUTIONS AT SPEC. DISTANCE	PWL or SPL in dB Per Octave-Band Center Freq. (Hz)									A-Wt. Level
		31.5	63	125	250	500	1000	2000	4000	8000	
1)	PWL of Unenclosed Pumps & Piping (1 unit)	102	104	108	112	108	107	104	102	97	112
	PWL of 4 Units	108	110	114	118	114	113	110	108	103	118
	NR of Pump House Building	-6	-10	-16	-26	-36	-36	-36	-36	-36	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
625	Hemispherical Radiation	-54	-54	-54	-54	-54	-54	-54	-54	-54	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-5	-9	
	Source Sound Level Contribution	48	46	44	38	24	22	19	14	5	33
2)	PWL of Building Air Supply Fans (w/silencer)	91	95	91	87	75	69	65	63	58	81
	Atten. Of Additional Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
625	Hemispherical Radiation	-54	-54	-54	-54	-54	-54	-54	-54	-54	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-5	-9	
	Source Sound Level Contribution	37	41	37	33	21	14	10	5	0	27
3)	PWL of VFD Vent. Noise / AC Noise	95	92	94	92	90	88	86	82	75	93
	NR of VFD Exh. Silencer	-2	-3	-6	-14	-24	-28	-28	-22	-15	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
875	Hemispherical Radiation	-57	-57	-57	-57	-57	-57	-57	-57	-57	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	-1	-1	-3	-7	-12	
	Source Sound Level Contribution	36	32	31	21	9	2	0	0	0	18
4)	PWL of Substation	85	88	90	78	72	65	60	55	50	77
	NR of Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
450	Hemispherical Radiation	-51	-51	-51	-51	-51	-51	-51	-51	-51	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-1	-3	-6	
	Source Sound Level Contribution	34	37	39	27	21	14	8	1	0	26
Est'd Total Contribution of Proposed Station		**49**	**48**	**46**	**40**	**27**	**24**	**19**	**15**	**8**	**34.8**

Table B: Est'd Contribution from Proposed Station at East P.L. (Pos. "E")

Source No. & Dist (Ft)	SOURCE PWL & EST'D. SOUND LEVEL CONTRIBUTIONS AT SPEC. DISTANCE	PWL or SPL in dB Per Octave-Band Center Freq. (Hz)									A-Wt. Level
		31.5	63	125	250	500	1000	2000	4000	8000	
1)	PWL of Unenclosed Pumps & Piping (1 unit)	102	104	108	112	108	107	104	102	97	112
	PWL of 4 Units	108	110	114	118	114	113	110	108	103	118
	NR of Pump House Building	-6	-10	-16	-26	-36	-36	-36	-36	-36	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
675	Hemispherical Radiation	-54	-54	-54	-54	-54	-54	-54	-54	-54	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-5	-9	
	Source Sound Level Contribution	48	46	44	37	23	22	18	13	3	32
2)	PWL of Building Air Supply Fans (w/silencer)	91	95	91	87	75	69	65	63	58	81
	Atten. Of Additional Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
675	Hemispherical Radiation	-54	-54	-54	-54	-54	-54	-54	-54	-54	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-5	-9	
	Source Sound Level Contribution	37	41	37	32	20	14	9	4	0	27
3)	PWL of VFD Vent. Noise / AC Noise	95	92	94	92	90	88	86	82	75	93
	NR of VFD Exh. Silencer	-2	-3	-6	-14	-24	-28	-28	-22	-15	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
750	Hemispherical Radiation	-55	-55	-55	-55	-55	-55	-55	-55	-55	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	-1	-1	-2	-6	-10	
	Source Sound Level Contribution	38	34	33	22	10	4	1	0	0	19
4)	PWL of Substation	85	88	90	78	72	65	60	55	50	77
	NR of Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
550	Hemispherical Radiation	-53	-53	-53	-53	-53	-53	-53	-53	-53	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-4	-8	
	Source Sound Level Contribution	32	35	37	25	19	12	6	0	0	24
Est'd Total Contribution of Proposed Station		**48**	**47**	**45**	**39**	**26**	**23**	**19**	**14**	**7**	**34.0**

Table C: Est'd Contribution from Proposed Station at South P.L. (Pos. "S")

Source No. & Dist (Ft)	SOURCE PWL & EST'D. SOUND LEVEL CONTRIBUTIONS AT SPEC. DISTANCE	PWL or SPL in dB Per Octave-Band Center Freq. (Hz)									A-Wt. Level
		31.5	63	125	250	500	1000	2000	4000	8000	
1)	PWL of Unenclosed Pumps & Piping (1 unit)	102	104	108	112	108	107	104	102	97	112
	PWL of 4 Units	108	110	114	118	114	113	110	108	103	118
	NR of Pump House Building	-6	-10	-16	-26	-36	-36	-36	-36	-36	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
575	Hemispherical Radiation	-53	-53	-53	-53	-53	-53	-53	-53	-53	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-4	-8	
	Source Sound Level Contribution	49	47	45	39	25	23	19	15	6	34
2)	PWL of Building Air Supply Fans (w/silencer)	91	95	91	87	75	69	65	63	58	81
	Atten. Of Additional Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
575	Hemispherical Radiation	-53	-53	-53	-53	-53	-53	-53	-53	-53	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-2	-4	-8	
	Source Sound Level Contribution	38	42	38	34	22	15	10	6	0	28
3)	PWL of VFD Vent. Noise / AC Noise	95	92	94	92	90	88	86	82	75	93
	NR of VFD Exh. Silencer	-2	-3	-6	-14	-24	-28	-28	-22	-15	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
425	Hemispherical Radiation	-50	-50	-50	-50	-50	-50	-50	-50	-50	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	0	-1	-1	-3	-6	
	Source Sound Level Contribution	43	39	38	28	15	9	6	7	4	24
4)	PWL of Substation	85	88	90	78	72	65	60	55	50	77
	NR of Noise Control	0	0	0	0	0	0	0	0	0	
	Misc. Atten.	0	0	0	0	0	0	0	0	0	
875	Hemispherical Radiation	-57	-57	-57	-57	-57	-57	-57	-57	-57	
	Atm. Absorption (70% R.H., 60 deg F)	0	0	0	0	-1	-1	-3	-7	-12	
	Source Sound Level Contribution	28	31	33	21	15	7	1	0	0	20
Est'd Total Contribution of Proposed Station		**50**	**49**	**47**	**40**	**27**	**24**	**20**	**16**	**9**	**35.3**

Table D: Est'd Contribution from Proposed Station at West P.L. (Pos. "W")

ANALYSIS METHODOLOGY AND SOURCE OF SOUND DATA

In general, the predicted sound level contributed by the pumping station equipment was calculated as a function of frequency from estimated unweighted octave-band ("O.B.") sound power levels ("PWLs") for each significant sound source. The following summarizes the acoustical analysis procedure for the Station:

- Initially, unweighted O.B. PWL values of the significant noise sources were determined from equipment manufacturer's sound data and/or actual sound level measurements performed by H&K at similar type of equipment/components expected for this facility.

- Then, expected noise reduction (NR) or attenuation in dB per O.B. frequency due to any noise control measures, hemispherical sound propagation (discussed in more detail below*) and atmospheric sound absorption (discussed in more detail below**) were subtracted from the unweighted O.B. PWLs to obtain the unweighted O.B. SPLs of each noise source. The sound attenuation effect due to shielding by buildings and/or enclosures has been conservatively ignored. The sound attenuation effect due to foliage or land contour was not considered in the analysis since there is probably minimum attenuation due to foliage.

- Finally, the resulting estimated unweighted O.B. SPLs for all noise sources associated with the Station (with noise control and other sound attenuation effects) were logarithmically summed, and the total O.B. SPLs for all noise sources were corrected for A-weighting to provide the estimated overall A-wt. sound level contributed by the Station at the Property Line.

*Attenuation due to hemispherical sound propagation: Sound propagates outwards in all directions (i.e., length, width, height) from a point source, and the sound energy of a noise source decreases with increasing distance from the source. In the case of hemispherical sound propagation, the source is located on a flat continuous plane/surface (e.g., ground), and the sound radiates hemispherically (i.e., outward, over and above the surface) from the sound source. The following equation is the theoretical decrease of sound energy when determining the resulting SPL values of a noise source at a specific distance ("r") of a receiver from the estimated PWL values:

> Decrease in SPL ("hemispherical propagation") from a noise source = **20*log(r) – 2.3 dB**
> where "r" is distance of the receiver from the noise source.

Attenuation due to air absorption: Air absorbs sound energy, and the amount of absorption ("attenuation") is dependent on the temperature and relative humidity (R.H.) of air and frequency of sound. For example, the attenuation due to air absorption for 1000 Hz O.B. SPL is approximately **1.5 dB per 1,000 feet for standard day conditions (i.e., no wind, 60 deg. F. and 70% or 50% R.H.).

The estimated unweighted O.B. PWLs of the motor-driven pumps, piping, substation equipment and any other site equipment were estimated from field sound measurements by H&K on similar equipment and/or from sound data provided by the equipment manufacturer.

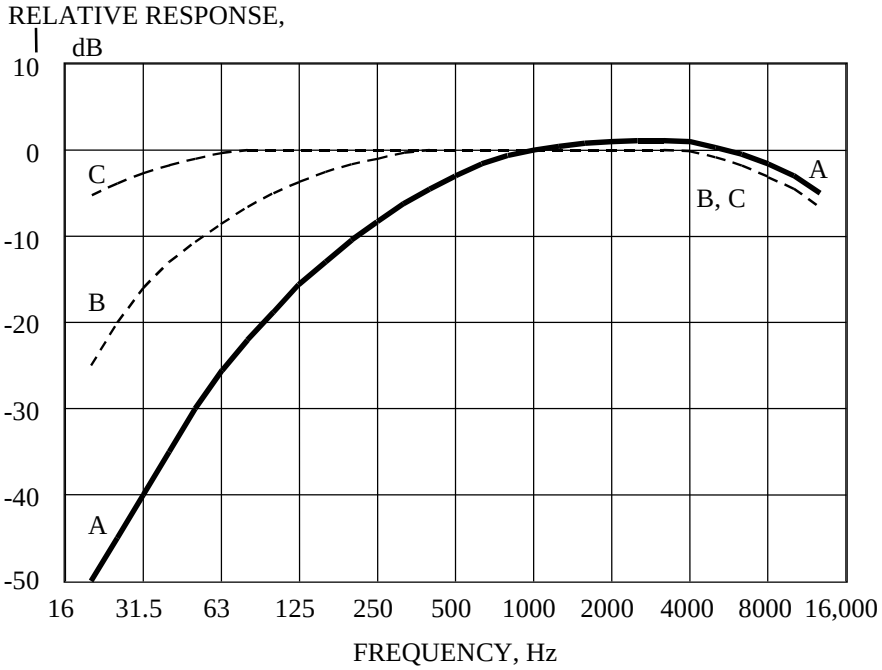
Summary of Acoustical Terminology, Typical Metrics for Regulating Environmental Noise and Sound Levels for Typical Activities

(1) Decibel (dB): A unit for expressing the relative power level difference between acoustical or electrical signals. It is ten times the common logarithm of the ratio of two related quantities that are proportional to power. When adding dB or dBA values, the values must be added logarithmically. For example, the logarithmic addition of **35 dB** plus **35 dB** is **38 dB**.

(2) A-Weighted Sound Level (dBA): The A-wt. sound level is a single-figure sound rating, expressed in decibels (Re 20 μPa), which correlates to the human perception of the loudness of sound. The dBA level is commonly used to measure industrial and environmental noise since it is easy to measure and provides a reasonable indication of the human annoyance value of the noise. The dBA measurement is not a good descriptor of a noise consisting of strong low-frequency components or for a noise with tonal components.

The A-weighted curve approximates the response of the average ear at sound levels of 20 to 50 decibels. The following are the relative response of A-weighted filter per octave band frequency, and a graph/curve is provided that shows a graphical representation of the A-wt. filter response per frequency (in Hz).

31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1,000 Hz	2,000 Hz	4,000 Hz	8,000 Hz	16,000 Hz
-39.4 dB	-26.2 dB	-16.1 dB	-8.6 dB	-3.2 dB	0 dB	+1.2 dB	+1.0 dB	-1.1 dB	-6.6 dB



(3) Human Perception of Change in Sound Level

- A **3 dB** change of sound level is barely perceivable by the human ear
- A **5 or 6 dB** change of sound level is noticeable
- If sound level increases by **10 dB**, it appears as if the sound intensity has doubled.

(4) Background or Ambient Noise: The total noise produced by all other sources associated with a given environment in the vicinity of a specific source of interest, and includes any Residual Noise.

(5) Sound Pressure Level (L_p or SPL): Ten times the common logarithm to the base 10 of the ratio of the mean square sound pressure to the square of a reference pressure. Therefore, the sound pressure level is equal to 20 times the common logarithm of the ratio of the sound pressure to a reference pressure (20 micropascals or 0.0002 microbar).

(6) Octave Band SPL: Sound is typically measured in frequency ranges (e.g., high-pitched sound, low-pitched sound, etc.) that provides more meaningful sound data regarding the sound character of the noise. When measuring two noise sources for comparison, it is better to measure the spectrum of each noise, such as in octave band SPL frequency ranges. Then, the relative loudness of two sounds can be compared frequency range by frequency range. As an illustration, two noise sources can have the same dBA rating and yet sound completely different. For example, a high-pitched sound concentrated at a frequency of 2000 Hz could have the same dBA rating as a much louder low-frequency sound concentrated at 50 Hz.

(7) Daytime Sound Level (L_d) & Nighttime Sound Level (L_n): L_d is the equivalent A-weighted sound level, in decibels, for a 15 hour time period, between 07:00 to 22:00 Hours (7:00 a.m. to 10:00 p.m.). L_n is the equivalent A-weighted sound level, in decibels, for a 9 hour time period, between 22:00 to 07:00 Hours (10:00 p.m. to 7:00 a.m.).

(8) Equivalent Sound Level (L_{eq}): The equivalent sound level (L_{eq}) can be considered an average sound level measured during a period of time, including any fluctuating sound levels during that period. In this report, the L_{eq} is equal to the level of a steady (in time) A-weighted sound level that would be equivalent to the sampled A-weighted sound level on an energy basis for a specified measurement interval. The concept of the measuring L_{eq} has been used broadly to relate individual and community reaction to aircraft and other environmental noises.

(9) L-Percent Sound Levels: The L percent levels (e.g., L_{50}, L_{90} & L_{10}) refer to the A-wt. sound levels that are exceeded for 90, 50 and 10 percent of the time, respectively, during a measurement period. For example, the 90-percentile exceeded sound level, designated to as L_{90}, is the A-wt. sound levels that are exceeded for 90 percent of the time and is considered the typical lowest anticipated sound levels. The range between the L_{10} and L_{90} values usually provides a good indication of the variability of the sound levels during the period of measurement.

(10) Sound Level Meter (SLM): An instrument used to measure sound pressure level, sound level, octave-band SPL, or peak sound pressure level, separately or in any combinations thereof. The measured weighted SPL (i.e., A-Wt. Sound Level or dBA) is obtained by the use of a SLM having a standard frequency-filter for attenuating part of the sound spectrum.

(11) Sound Power Level (L_W or PWL): Ten times the common logarithm of the ratio of the total acoustic power radiated by a sound source to a reference power. A reference power of a picowatt or 10^{-12} watt is conventionally used.

(12) Tone: A tone is a sound sensation-having pitch, which is a listener's perception of the frequency (for example, the higher the frequency, the higher the pitch). For a measured sound spectrum, a tone is represented as a "peak" in the spectrum curve. Noise that contains significant tones is considered a tonal type of noise.

(13) List of Common Environmental (i.e., Man-Made & Natural) Noise Sources: For reference, the following **Table** presents a list of some common environmental (i.e., man-made and natural) noise sources as compared to the estimated sound level of the pumping station at the closest NSAs. Note that inside a typical house, the noise level of an outdoor noise source is approximately **15 to 20 dB** quieter (i.e., house typically provides at least **15 to 20 dB** noise reduction).

Type of Noise Source	Approx. A-Wt. Sound Level	Approximate Distance To Noise Source
Lawn mower (outdoor)	50 – 55 dBA	150 to 200 feet
Passenger cars @ 50 – 60 mph (outdoor)	50 – 55 dBA	250 to 300 feet
Residential AC unit (outdoor)	50 – 60 dBA	40 to 50 feet
Residential AC unit (outdoor)	35 – 45 dBA	200 to 250 feet
Chemical plant (outdoor)	40 – 50 dBA	½ mile from plant
Cicadas (outdoor, summertime @ night)	50 – 55 dBA	General area of insects
Window AC unit (indoor)	50 – 60 dBA	5 to 20 feet
TV @ normal listening level (indoor)	60 – 70 dBA	10 to 15 feet
Vacuum cleaner (indoor)	70 – 75 dBA	10 to 15 feet

List of Some Common Environmental Noise Sources compared to Station Sound Level at Closest NSAs

SOUND LEVELS FOR TYPICAL ACTIVITIES **REFERENCE AND COMMUNITY RESPONSES**

Subjective Human Response and Conversation	Home and Industrial (Indoor Noise)	**dBA Scale (Level)**	Community and Traffic (Outdoor Noise)	Reference Loudness	Community Reaction To Outdoor Noise
		-- 140 --	Aircraft Carrier		
Threshold of Pain			Military Jet Aircraft		
		-- 130 --			
			Large Siren at 100 Ft.		
			Jet Takeoff at 200 Ft.	16 Times	
	Rock Band (Max.)	**-- 120 --**		as Loud	
Threshold of			Thunderstorm Activity		
Discomfort	Discotheque (Max.)			8 Times	
		-- 110 --	Elevated Train	as Loud	
	Symphonic Music (Max.)				
Maximum Vocal Effort			Auto Horn at 5 Ft.	4 Times	
	Industrial Plant	**-- 100 --**		as Loud	
Very Loud			Compacting Trash Truck		
	Newspaper Printing Rm.			2 Times	
Shouting in Ear		**-- 90 --**	Heavy Truck at 25 Ft.	as Loud	Vigorous Action
	Food Blender				and Law Suits
	Symphonic Music (Typ.)		Motorcycle at 25 Ft.	Reference	
Shouting		**-- 80 --**		Loudness	Threats of
	Garbage Disposal		Small Truck at 25 Ft.		Legal Action
Very Annoying	Alarm Clock		Heavy Traffic at 50 Ft.		Appeals to Officials
		-- 70 --		1/2 as Loud	Widespread
Moderately Loud	Vacuum Cleaner		Avg. Traffic at 100 Ft.		Complaints
	Electric Typewriter				
Normal Conversation		**-- 60 --**		1/4 as Loud	Sporadic Complaints
	Air Conditioner at 20 Ft.				
			Light Traffic at 100 Ft.		No Reaction,
	Typical Office	**-- 50 --**		1/8 as Loud	Although Noise
Quiet					is Noticeable
	Living Room		Typical Suburban Area		
	Bedroom	**-- 40 --**			
			Birdsong		
Very Quiet	Library				
		-- 30 --			
Soft Whisper	Broadcasting Studio		Rural Area		
				Just Audible	
		-- 20 --			
				Threshold	
		-- 10 --		of Hearing	
Hoover & Keith Inc. (Consultants in Acoustics)					
11391 Meadowglen, Suite D					
Houston, Texas 77082		**-- 0 --**			

End of Report