Memorandum

BURNS McDONNELL

Date: July 3, 2018

To: NECEC Noise Permitting Team

From: Gabriel Weger and Chris Howell, Burns & McDonnell

Subject: Independent Review of the Sound Assessment for NECEC

Tech Environmental, Inc. (TE) completed an independent peer review of the acoustic impacts of the New England Clean Energy Connect (NECEC). The purpose of the review was to determine if the sound assessment submitted for NECEC was reasonable and technically correct according to standard engineering practices, and to determine if the Maine DEP can use the information to draw conclusions about compliance of the NECEC with the Maine Noise Regulations.

One question James Beyer asked was, "Does a DC line produce a different sound level than an AC line." AC and DC transmission lines produce similar types of sounds. However, the amplitudes of the sound levels produced are different for each type of line. Table 5-1 of the application provides the audible noise levels at the edge of the right-of-way during fair and foul weather conditions for each of the AC lines (345-kV AC H-Frame, and 345-kV AC Lattice Structure) and DC lines (320 kVDC). The worst-case sound levels for each type of line are shown under the "75 feet from center of structure" heading.

TE provided several comments and information requests in their review. The requests along with Burns & McDonnell's responses are provided below:

1. Tonal noise with regards to local ordinances.

[TE Remarks]

If a proposed noise source generates Tonal Sound, a type of noise contained in the Maine Noise Regulations but not in the local ordinances, then those local ordinances will not be applied "in lieu of" the Maine Noise Regulation. Thus, establishing if NECEC sound sources will create Tonal Sound is important in evaluating the Application. As discussed below, transmission line noise is undoubtedly Tonal Sound. The information on Tonal Sound from the substations is incomplete.

[Burns & McDonnell Response]

At the direction of CMP's legal counsel, Pierce Atwood, it was established that the local noise ordinance would take precedent over the MDEP noise regulation requirements, provided the local sound level limits are within 5 dB of the MDEP sound level limits, and addresses the same types of noises. Whether the ordinance addresses tonal noise or not, would not factor into the consideration.

Because the standard is not more than 5 dBA higher than MDEP regulations, the local municipal standard is applicable. Though there is some ambiguity about whether the noise ordinance "limits or addresses the various types of noises contained in this regulation or all the types of noises generated by the development," it seems reasonable to rely on MDEP's past conclusions on Site Law permit applications (e.g. CMP's Maine Power Reliability Program projects) that the provision does not apply when the local standard is applicable. Thus, it is reasonable to conclude that the MDEP's Site Law noise rule, including its "tonal penalties" provision, does not apply to those NECEC substations within municipalities having local noise ordinances. Tonal noise is not a type of noise but, rather, is a quality of noise. This is consistent with other approved applications that MDEP has reviewed in the past.

2. Transmission line noise.

[TE Remarks]

We recommend the Department request the following additional information regarding the transmission line noise assessment:

1. Update the assessment to include tonal noise and discussion of the 5-dBA Tonal Sound Penalty.
2. Provide supporting documentation from the acoustic modeling.
3. List all property boundaries (show on maps, identify land owners) where the 345-kV, AC transmission line broadband sound levels under wet conductor conditions are predicted to exceed 40.0 dBA without a tonal noise penalty.
4. Provide a mitigation strategy for each instance in Item 3.

[Burns & McDonnell Response]

Audible noise (AN) from the transmission lines is generated in two ways. The first is a 120-Hz hum (i.e., $2f$ noise) that is associated with magnetic-field caused vibrations in the lines and is directly related to the amount of voltage carried on the line. Because the voltage on the line does not change, the $2f$ noise does not change. The second mechanism for a transmission line to generate noise happens at higher frequencies associated with corona on the lines. Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line when the voltage gradient exceeds a certain critical value. In a small volume near the surface of the conductors, energy and heat are dissipated, and some of this energy is released in the form of pressure fluctuations that result in AN. Corona-generated AN can be characterized as a hissing, crackling sound, and is not considered to be tonal. Corona-generated AN is of concern primarily for high-voltage transmission lines operating at voltages of 345 kV and higher.

The Bonneville Power Administration (BPA) Corona and Field Effects Program was used to calculate the expected AN from the transmission lines. The model calculates total AN based on data from actual field surveys, and laboratory tests. The surveys would measure total noise from a variety of transmission lines and conductor combinations. The measured transmission line AN would include both $2f$ and corona noise. Therefore, the model predictions account for both $2f$ and corona generated AN.

AN associated with $2f$ and corona may be of similar amplitude during fair weather conditions. Coronal noise typically increases during foul weather conditions, but $2f$ noise will remain constant regardless of meteorological conditions. Studies have shown that tonal noise is difficult to measure and is generally not warranted.[1] Because tonal noises are not expected during foul weather periods when AN would be loudest, there is no need to apply a tonal penalty to the predicted values presented in the NECEC Site Law Application.

In general, the AN levels for the transmission lines and conductors were modeled based upon conservative assumptions and/or program defaults for conditions relating to the operation of existing transmission lines and for the expected conditions of the new, 345 kV AC and 320 kV DC transmission lines, during fair and foul weather conditions. General model inputs are as follows:

INPUT	DC Line Values	AC Line Values
Number of Phases	2	3
Total Number of Conductors	4	5
Pole-Ground Voltage	+/- 320 kV DC	345 kV AC
Wind Velocity	2.0 mi/hr	2.0 mi/hr
Rain Rate	1.0 in/hr	1.0 in/hr
Altitude	1100 ft	400 ft
Vertical Height of Audible Noise Microphone	5 ft	5 ft
Conductor Sag	28.60 ft	28.60 ft
OPGW Sag	8.64 ft	8.64 ft
OHSW Sag	7.42 ft	7.42 ft
OPGW Diameter	1.974 in	1.974 in
OHSW Diameter	0.433 in	0.433 in
Bundle Center Midspan Height	34 ft	32 ft
Number of Subconductors	2	2
Subconductor Diameter	1.545 in	1.545 in
Bundle Spacing	18 in	18 in
Line-Ground Voltage	320 kV DC	209.145 kV AC
Phase Angle	0	A,B,C top to bottom/left to right
Phase Current	1,200 MVA	2,626 MVA
ROW Width	200 ft	200 ft

[1] V. L. Chartier and R. D. Stearns. "Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines." IEEE Transactions on Power Apparatus and Systems, Vol. PAS-100, No, IT January 1981, pp. 121-129.

Because it would be impractical to analyze every portion of the transmission line for every distance and conductor combination, worst-case and conservative conditions were selected for the analysis. As noted in the report, transmission line conductor AN levels at the edges of the various ROWs, in fair weather conditions, will be well below the applicable noise limits. The maximum AN levels at the edge of ROW under fair weather conditions are expected to be approximately 28 dBA. The potential 120-Hz hum portion of the transmission line noise would be generated during fair weather conditions, along with minimal corona noise, if any. The 120-Hz hum would not increase due to a change in weather conditions, as it is not dependent on moisture in the air. This tonal portion of the transmission line AN would be well below any applicable regulation, even with a 5-dB penalty added.

The non-tonal portion of transmission line AN, corona, varies with weather conditions. Moisture in the air increases AN associated with corona effects. The expected maximum AN produced by a typical conductor at the closest edge of ROW, under foul weather/wet conditions, is expected to be approximately 41 dBA. The increase from the 28-dBA fair weather sound level is due to the increase in corona noise. The 120-Hz hum or the tonal portion of the AN would not increase under foul weather. Therefore, the AN level under foul weather/wet conditions would not be tonal as defined by the MDEP, since it would be dominated by the corona noise, if not the ambient noise. No tonal penalty would be added to the measured sound level under these conditions, the transmission line AN is expected to be below the applicable State or local sound level regulation identified along the transmission line path, and therefore no mitigation is required or proposed.

3. Merrill Road Substation.
[TE Remarks]
We recommend the Department request the following additional information regarding the Merrill Road Substation noise assessment:

1. Provide the ground factor "G" used in the CadnaA modeling.
2. Provide octave band sound power levels for all noise sources used in the acoustic modeling.
3. Provide the CadnaA-predicted octave band sound levels, by source and the total, at receptor PL-5 and discuss why a Tonal Sound is, or is not, produced at that receptor.

[Burns & McDonnell Response]
The ground factor for the CadnaA modeling was 0.5 for all areas. The City of Lewiston Code of Ordinances Appendix A Section 19 does not address tonal noise. Octave band sound levels are not required by the ordinance and would not assist in determining compliance. The modeled overall sound levels for each sound source are provided in Table 5-8 of the NECEC Site Law Application. Octave band sound levels modeled for the noise emitting equipment were based on

historical projects' equipment of similar size. The equipment octave bands would likely change based on the vendor selected and their supplied sound data; however, the overall sound levels would be specified to meet those provided in the application. Equipment vendors have not been selected at this point in the project.

4. Larrabee Road Substation.
[TE Remarks]
We recommend the Department request the following additional information regarding the Larrabee Road Substation noise assessment:

1. Provide the ground factor "G" used in the CadnaA modeling.

[Burns & McDonnell Response]
The ground factor for the CadnaA modeling was 0.5 for all areas.

5. Fickett Road Substation

[TE Remarks]
We recommend the Department request the following additional information regarding the Fickett Road Substation noise assessment:

1. Provide the ground factor "G" used in the CadnaA modeling.
2. Provide octave band sound power levels for all noise sources used in the acoustic modeling.
3. Provide the octave band CadnaA model results, by source and the total, at Receptors PL-1 and PL-2, and discuss why a Tonal Sound is, or is not, produced at those receptors. Clearly explain where a 5-dB penalty has, or has not, been added to the table results.

[Burns & McDonnell Response]
The ground factor for the CadnaA modeling was 0.5 for all areas. Octave band sound levels are not required by the ordinance and would not assist in determining compliance. The modeled overall sound levels for each sound source are provided in Table 5-15 of the NECEC Site Law Application. Octave band sound levels modeled for the noise emitting equipment were based on historical projects' equipment of similar size. The equipment octave bands would likely change based on the vendor selected and their supplied sound data; however, the overall sound levels would be specified to meet those provided in the application. Equipment vendors have not been selected at this point in the project.

At locations PL-1 and PL-2, Dry Air Cooler noise dominates substation-generated sound. Though some cooling fans can be tonal in nature, the equipment vendor, ABB, provided sound data for the dry air coolers that established the units would not emit tonal sounds. Therefore, a tone would not be present at these locations and a tonal penalty would not need to be applied.

6. Coopers Mills Road Substation

[TE Remarks]

We recommend the Department request the following additional information regarding the Coopers Mills Road Substation noise assessment:

1. Provide the ground factor "G" used in the CadnaA modeling.
2. Verify the three existing transformers were included in the CadnaA model, or redo the acoustic modeling with the three existing transformers added to the proposed new sound sources.
3. Provide a firm commitment to construct the two sound walls described in the Response to Information Request #8, or equivalent sound mitigation.

[Burns & McDonnell Response]

The ground factor for the CadnaA modeling was 0.5 for all areas. The three existing sources mentioned are included in the model, along with six (6) air-cooled shunt reactors and three (3) sets of capacitor banks. The existing source sound levels are provided in the table below.

The two sound walls may be necessary for compliance depending on the final design of the substation. If required, the sound walls' final design will be appropriate such that modeling will demonstrate compliance with the sound level limits at the property line.

Equipment	Modeled Sound Level
Transformer 1	82 dBA SPL at 3 feet
Transformer 2[a]	68 dBA SPL at 3 feet
Transformer 3[a]	65 dBA SPL at 3 feet
Capacitor Banks (3)	80 dBA SWL
Reactors[b] (6)	87 dBA SWL

(a) Source sound levels established by field measurements at Coopers Mills Substation.
(b) Sources based on reactor sound data from Albion Road Substation which has the same units.