Operational Noise Compliance Assessment Study

Basin Electric Power Cooperative
Groton Generation Station
Groton, South Dakota

BASIN ELECTRIC POWER COOPERATIVE
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Burns & McDonnell
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September 2008

Operational Noise Compliance Assessment Study
Basin Electric Power Cooperative
Groton Generation Station
Groton, South Dakota

prepared for

Basin Electric Power Cooperative
Bismarck, North Dakota

September 2008

Project No. 49565

prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

EXECUTIVE SUMMARY

Burns & McDonnell Engineering Company Inc. (Burns & McDonnell) was contracted by Basin Electric Power Cooperative (BEPC) as a third party independent contractor to conduct an operational noise assessment study for the Groton Generation Station located near Groton, South Dakota. Measurements were taken when the facility was operating at full load (roughly 200 Megawatts [MW], 100 MW per turbine) throughout multiple testing periods. An ambient background measurement was taken prior to operation of the station.

The purpose of the noise assessment study was to document operational noise levels at the Groton Generation Station for comparison to the Public Utilities Commission (PUC) noise limits set for the facility. Burns & McDonnell personnel took noise measurements per the noise testing protocol that was previously accepted by the PUC and subsequently updated to account for two units at the facility. All sound pressure levels measured were below the permitted limits.

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1.0 INTRODUCTION

Burns & McDonnell Engineering Company Inc. (Burns & McDonnell) was contracted by Basin Electric Power Cooperative (BEPC) as a third party independent contractor to conduct an operational noise assessment study for the Groton Generation Station located near Groton, South Dakota. Existing noise sources in the vicinity of the plant include light vehicular traffic and miscellaneous insects and animals.

The objective of this noise assessment was to verify that the noise levels emanating from the Groton Generation Station were below the noise limits set by the Public Utilities Commission (PUC) for the facility. These limits were set for the nearest occupied residence to the Groton Generation Station, and are shown in Table 1.1.

Table 1.1: Specified Sound Level Limits

Time of Day	Limit (L_{10})
Daytime	60 dBA
Nighttime	55 dBA

The measurement point (MPR1) was chosen because it was directly between the facility and the closest residence at the PUC specified distance (100 feet from the residence). The ambient background noise level was measured at the same point. See Figure A.1 (in Appendix A) for the measurement point location. For all measurements, Burns & McDonnell personnel followed a noise testing protocol that was previously approved by the PUC, and subsequently updated to account for two units at the facility (see Appendix B).

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2.0 METHODOLOGY

The human response to sound is complex and is influenced by a variety of acoustic and non-acoustic factors. Acoustic factors generally include the sound's amplitude, duration, frequency content, and fluctuations. Non-acoustic factors typically include the listener's ability to become accustomed to the sound, the listener's attitude towards the sound and the sound source, the listener's view of the necessity of the sound, and the periodicity of the sound. As such, the human response to sound is highly individualized.

Amplitude and frequency physically characterize sound energy. Sound amplitude is measured in decibels (dB) as the logarithmic ratio of a sound pressure to a reference sound pressure of 20 micropascal (micropascal is the unit for sound pressure waves). This reference sound pressure corresponds to the typical threshold of human hearing. A 3 to 5 dB change in a continuous broadband noise is generally considered "just barely perceptible" to the average listener. Similarly, a 6 dB change is generally considered "clearly noticeable" and a 10 dB change is generally perceived as doubling (or halving) of the apparent loudness.

Frequency is measured in hertz (Hz), which is the number of cycles per second. The typical human ear can hear frequencies ranging from approximately 20 Hz to 20,000 Hz. Typically, the human ear is most sensitive to sounds in the middle frequencies (1,000 to 8,000 Hz) and is less sensitive to sounds in the low and high frequencies. As such, the "A-weighting" scale was developed to simulate the frequency response of the human ear to sounds at typical environmental levels. The A-weighting scale emphasizes sounds in the middle frequencies and de-emphasizes sounds in the low and high frequencies. Any sound level to which the A-weighting scale has been applied is expressed in A-weighted decibels (dBA).

Noise in the environment is constantly fluctuating, such as when a car drives by, a dog barks, or a plane passes overhead. Therefore, noise metrics have been developed to quantify fluctuating environmental noise levels. These metrics include the exceedance sound levels. The exceedance sound level, L_x, is the sound level exceeded "x" percent of the sampling period and is referred to as a statistical sound level. The most common L_x values are L_{ave}, L_{90}, L_{50}, and L_{10}. L_{ave} is the level of a constant sound over a specific time period that has the same sound energy as the actual sound over the same period. L_{90} is the sound level exceeded 90 percent of the sampling period. L_{90} represents the sound level without the influence of loud, transient noise sources and is therefore often referred to as the residual or background sound level. L_{50} is the sound level exceeded 50 percent of the sampling period. L_{10} represents the occasional louder noises and is often referred to as the intrusive sound level. The variation between the L_{90}, L_{50}, and L_{10} sound levels can provide an indication of the variability of the acoustical environment. If the acoustical environment is perfectly steady, all values are identical. A large variation between the values indicates the environment experiences highly fluctuating sound levels. For instance, near a roadway with frequent passing vehicles may cause a large variation in the measured statistical sound levels.

There are also objective factors to consider when determining the noise and how people may be affected by the noise. A noise spectrum that contains audible pure tones is typically more annoying than a spectrum with the same overall level but without the tones. It has been shown that when noise complaints were received regarding a power plant with measured noise levels under 45 dBA, the noise had some tonal components. Low frequency sound may also affect people subject to the noise. Pulsation or vibration may occur when the sound frequency 31.5 Hz and lower at residential locations.

During the noise measurements, Burns & McDonnell used a Larson Davis Model 824 Type I sound level meter that meets all ANSI instrument requirements for measuring sound pressure levels outdoors. The sound level meter was calibrated before each set of measurements and readings were compared to ensure accuracy. None of the calibration level changes exceeded ± 0.5 dB. A windscreen was used at all times on the meter to avoid wind interferences. The meter measured A-weighted Leq sound levels along with A-weighted octave band frequency sound levels for the operational noise levels. Table 2.1 displays a listing of general noise meter certifications for the equipment used in this study.

Table 2.1
General Noise Meter Certifications
(Burns & McDonnell Noise Equipment)

Instrument Name	Serial Number	Calibration Date	Recalibration Date	Procedures For Calibration
Larson Davis Monitor Model 824	1331	06/18/2008	06/18/2010	D0001.8046, ANSI S1.4-1983, IEC 651-1979 Type 1, IEC 804-1985 Type 1, IEC 1260-1995 Class 1, and ANSI S1.11-1986 Type 1D
Larson Davis Instrument Model 902	1853	06/18/2008	06/18/2010	D0001.8167
Larson Davis Microphone Model 2560	3166	06/19/2008	06/19/2010	D0001.8167
Larson Davis Calibrator Model CAL200	3009	06/17/2008	06/17/2010	D0001.8190

According to ANSI S12.18-1994, measurements should not be made when average wind velocity exceeds 11.86 miles per hour (mph). Also, cloudy, overcast, or nighttime conditions are preferred, but are not required. During readings for this study, the temperature ranged from 57 to 82 degrees Fahrenheit (°F). The wind speeds ranged from calm to 6 mph during the day and evening, and were calm overnight. The wind direction was from the north (from the house toward the plant) on August 4th and from the west on August 5th. Relative humidity ranged from 38 percent during the day to 87 percent in the early morning hours. Dense fog formed overnight, causing the range of visibility to fall to less than one-quarter mile by sunrise. All of the fog cleared by late morning. Atmospheric conditions at the time of testing would be considered adequate per ANSI guidelines.

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3.0 EXISTING NOISE ENVIRONMENT

A background sound level measurement was performed by Burns & McDonnell on August 29th, 2006, at approximately 9:50 a.m. to capture the ambient sound level in the vicinity of the Groton Generation Station (MPR1 in Figure A.1, Appendix A). Noise sources in the area, excluding the facility, have not changed; therefore, no additional background sound level measurements were taken for the Unit 2 noise analysis.

In 2006, a one-minute measurement sample was taken. The noise meter was mounted on a tripod 5 feet above ground. The measurement was taken during a period when the facility was not operating. Both the L_{eq} and L_{10} background noise levels were recorded at each octave band.

During the background reading in 2006, extraneous noises were noted. A truck drove by, and insects and animals were audible. Since these noises would normally occur in the area, they were not avoided. The dBA-weighted L_{eq} and L_{10} levels are given in Table 3.1. The overall background sound level measured was low, and is similar to what would typically be experienced in an agricultural area.

Table 3.1: Existing Ambient Noise Level

Point Number	Location	Reading Duration	L_{eq} (dBA)	L_{10} (dBA)
MPR1	100 ft from nearest residence	1 Min	42	44

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4.0 OPERATIONAL NOISE LEVELS

Daytime measurements were taken on August 4th, 2008, at 6:00 P.M., with additional daytime measurements taken on August 5th between 6:00 A.M. and 1:00 P.M. Nighttime measurements were taken from 10:00 P.M. on August 4th through 5:00 A.M. on August 5th. Burns & McDonnell personnel conducted operational noise level surveys while the facility was operating at roughly 200 Megawatts (MW) (full-load, 100 MW per turbine). Sound levels were measured at MPR1. One-minute measurement samples were taken in which steady-state sound levels were achieved. The measured daytime dBA-weighted L_{eq} and L_{10} levels are given in Table 4.1, and the measured nighttime dBA-weighted L_{eq} and L_{10} levels are given in Table 4.2. The limits for each timeframe are included in the appropriate table for reference. None of the values exceeded their respective limit.

Table 4.1: Measured Daytime Noise Levels at Nearest Residence

Time	L_{eq} (dBA)	L_{10} (dBA)	L_{10} Limit (dBA)	Comments
6:10 A.M.	52	53	60	Birds, light insects
6:14 A.M.	53	54	60	Birds, light insects
6:20 A.M.	54	55	60	Birds, light insects
6:22 A.M.	52	53	60	Birds, light insects
10:17 A.M.	49	53	60	Birds, insects, and 1 car
10:18 A.M.	45	48	60	Birds and insects
10:19 A.M.	48	51	60	Birds, insects, and 1 truck
10:20 A.M.	47	50	60	Birds and insects
1:48 P.M.	42	45	60	Birds and insects
1:49 P.M.	43	46	60	Birds, insects, and 1 car
1:50 P.M.	42	43	60	Birds and insects
1:51 P.M.	41	41	60	Birds, insects, and 1 truck
6:02 P.M.	44	47	60	Insects and birds
6:03 P.M.	46	50	60	Insects, birds, and 1 truck
6:04 P.M.	46	51	60	Insects, birds, and 1 car
6:05 P.M.	44	48	60	Insects, birds, and 1 car

Table 4.2: Measured Nighttime Noise Levels at Nearest Residence

Time	L_{eq} (dBA)	L_{10} (dBA)	L_{10} Limit (dBA)	Comments
9:51 P.M.	50	52	55	Insects and 2 cars
9:52 P.M.	46	47	55	Insects
9:53 P.M.	46	47	55	Insects
9:54 P.M.	46	47	55	Insects
11:55 P.M.	43	44	55	Insects
11:56 P.M.	45	46	55	Insects
11:57 P.M.	44	44	55	Insects
11:58 P.M.	44	44	55	Insects
2:07 A.M.	47	47	55	Insects
2:08 A.M.	47	48	55	Insects
2:09 A.M.	47	47	55	Insects
2:10 A.M.	48	48	55	Insects
4:15 A.M.	44	44	55	Insects
4:16 A.M.	45	45	55	Insects
4:17 A.M.	47	47	55	Insects
4:18 A.M.	47	48	55	Insects

Analysis of the lower frequencies of each reading was also completed. All values were below the levels necessary to create vibrations.

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5.0 CONCLUSIONS

All noise levels measured during the daytime and nighttime at the closest residence to the Groton Generation Station were below the specified PUC limits. The L_{eq} and L_{10} values were very similar for all measurement time periods. This indicates that noise from the facility occurs at a steady level, and fluctuations in sound level are not expected to occur. Additionally, analysis of the lower frequencies indicates that perceptible vibrations are not expected to occur at the nearest residence.

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APPENDIX A – MEASUREMENT POINT LOCATION

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Feet

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Figure A.1
Measurement Point Location
Groton Generating Station

Source: USDA NAIP 2006 Aerial Photography

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APPENDIX B – GROTON RESIDENTIAL NOISE PROTOCOL

Residential Compliance Testing Protocol

Groton Generation Station Unit 2

Basin Electric Power Cooperative Groton, South Dakota

June 2008

Residential Compliance Testing Protocol
Groton Generation Station
Unit 2

Prepared for:

Basin Electric Power Cooperative
Bismark, North Dakota

June 2008

BURNS & McDONNELL ENGINEERING COMPANY

ENGINEERS-ARCHITECTS-CONSULTANTS

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APPENDICES

1.0 SCOPE

The procedures herein define the methods that will be used to measure and evaluate the sound emissions from the General Electric (GE) scope of supply equipment for the Groton Generation Station with the addition of the second combustion turbine (Unit 2) at the nearest occupied, existing residence not owned by Basin Electric Power Cooperative. The resulting final A-weighted L_{10} sound levels, after corrections for environmental influences, instrumentation tolerances and measurement uncertainties, will be compared to the specified sound level limits as provided in Appendix A.

Unit 1 and Unit 2 are General Electric (GE) LMS100 Gas Combustion Turbines (CT) with exhaust stacks that operates in simple cycle mode. The summary noise report will include the measured noise levels at the nearest occupied, existing residence to the Groton Generation Station from the contractor supplied turbine, exhaust stack, and other equipment.

The following industry standards were used in the development of this procedure: ANSI S1.4, ASTM C423, ANSI S12.36, ANSI S12.34, ANSI B133.8, ISO 6190, ISO/DIS 8297, ANSI S1.11, ANSI S1.6, ANSI S1.40, and ANSI/ASME PTC 36. Any deviations from this test procedure that may significantly impact the intent of this procedure must be documented in the summary report.

2.0 INSTRUMENTATION

2.1 General

2.1.1 Sound Level Meter

Sound level measurements shall be made with a sound level meter that meets the requirement of the latest revision of ANSI S1.4 for a Type 1, Precision Sound Level Meter. A one-half-inch microphone is recommended. The sound level meter shall have the capability of determining the equivalent A-weighted sound level over a specified measurement period. An Order 3 extended-range octave-band filter set that meets the requirements of the latest revision of ANSI S1.11 shall be used to make measurements. An acoustical calibrator that meets the requirements of the latest revision of ANSI S1.40 shall be used.

A microphone windscreen shall be used for all measurements. The windscreen shall not affect the response of the sound level meter by more than ± 0.5 decibel (dB) at frequencies below 2,000 Hertz (Hz) and ± 1.0 dB at frequencies from 2,000 Hz to 10,000 Hz.

2.1.2 Anemometer/Weather Instruments

Instrumentation shall be used to monitor wind speed, wind direction, temperature, and relative humidity.

2.2 Calibration

Instruments shall be acoustically calibrated using a sound level calibrator or pistonphone of known sound pressure level and accuracy of ± 0.5 dB. The standard reference sound pressure shall be 20 micropascals.

Calibrations shall be performed before and after each measurement series and upon any significant change in recording conditions (i.e. battery change operation). The calibration frequency shall be 1,000 Hz. The calibrator shall be checked annually to verify compliance with the U.S. National Institute of Standards and Technology specifications.

A calibration level change exceeding ± 1.0 dB will require that the measurement series be repeated.

3.0 TEST PROCEDURE

3.1 General

3.1.1 Qualifications

Sound level measurements shall be measured by qualified personnel.

3.1.2 Technique

Sound level measurements shall be made with the sound level meter mounted on a tripod or held in the hand of the observer in such a way that the microphone is at least one-half meter from the observer's body, with the microphone pointed at the proper angle relative to an imaginary line to the source. The angle of incidence of the sound on the microphone shall be as specified by the manufacturer as that angle for which the microphone has the most uniform frequency response. The observer shall not stand between the microphone and the source, and shall stand behind and to one side of the microphone.

Care shall be exercised to assure that the measurement position is free from excess reflections due to walls, columns, or other equipment, and from significant shadowing effects. Care shall also be taken to minimize the effects of vehicles and other non-Basin Electric Power Cooperative extraneous noise sources.

The A-weighting filter network shall be used for all sound level measurements.

The equivalent A-weighted sound level, octave bands, and L_{10} values shall be recorded at the measurement location for all steady sounds. If the measured operating sound level fluctuates over a wide range during the period of observation, the reading shall be taken again. The observation periods shall be long enough to obtain a representative sound level reading at the nearest residence. Measurements shall be taken during daytime and nighttime. Measurements shall be taken for a minimum of four measurement periods during the day and four measurement periods during the night. Measurement periods shall be spaced at least two hours apart with four measurements taken during each measurement period. Care shall be taken to eliminate (as much as is practicable) extraneous noises from sources other than Unit 2 and associated equipment. The daytime periods may start as follows: 6 AM, 10AM, 2 PM, and 6 PM, but should be adjusted accordingly to not coincide with noises emitting activities near the facility. The nighttime periods should start as follows: 10PM, Midnight, 2 PM, and 4 AM, but should be adjusted accordingly to not coincide with noise emitting activities near the facility.

The “slow” meter characteristic shall be used with the sound level meter. The measured Environmental Sound Level in each octave band with center frequencies from 31.5 to 8,000 Hz will be recorded. The “fast” time weighting characteristic may be used to check that interfering events are not influencing the sound level measurements.

All equivalent A-weighted sound levels and L_{10} levels shall be visually observed and recorded by reading the digital or analog output of the sound level meter. The data may also be documented on a graphics printer to provide a permanent record of the measured sound level.

All final sound level data shall be reported to the nearest dB.

3.1.3 Unit 1 and Unit 2 Operation During Noise Testing

The residential sound level measurements shall be made with both units (Unit 1 and Unit 2) operating at baseload under steady state conditions for one set of measurements, and may operate at other loads for a second set of measurements.

All turbine enclosure and package doors shall be in their normally closed positions during all sound tests.

Care should be taken to minimize extraneous noise during the noise test that may impact the results of the test.

3.1.4 Background Sound Level Survey

Background equivalent A-weighted sound level measurements shall be obtained at each measurement location used for the operating sound level measurements at the same time periods as the daytime and nighttime measurements for the operational measurements. For the background sound level survey, the following conditions shall be met:

a) None of the supplied equipment, Unit 1, or Unit 2 should be in operation; and

b) Extraneous noises shall be excluded from the measurements as much as possible. Notes on extraneous noises shall be documented.

3.2 Residential Noise Test

The residential noise test will consist of sound level measurements near the closest residence (Appendix B).

3.2.1 Microphone Locations

3.2.1.1 Height

The microphone shall be located at a height of 5 feet (1.5 meters) above the ground.

3.2.1.2 Distance

The microphone shall be located not more than a distance of 100 feet (30.5 meters) in the horizontal plane towards Unit 1 and Unit 2 from the nearest residence, as shown in Appendix B. Distance shall be measured using a properly calibrated measuring device.

3.2.1.3 Location

Residential sound level measurements shall be made at a location that is free of reflective surfaces, not adjacent to other noise sources, has a clear line-of-sight to Unit 1 and Unit 2, as practicable, and is deemed a safe working environment for the field engineers.

3.2.1.4 Exclusions

Sound measurements shall not be made at locations that are affected by noise produced from equipment not considered to be part of this project unless appropriate corrections are applied to the measured data.

3.3 Atmospheric Conditions

If possible, sound measurements shall not be made when the average wind velocity during the measurement exceeds 7 mph (3 m/s) measured 5 feet (1.5 meters) above the ground.

Sound measurements shall not be made under any condition that allows the instrumentation to become wet (i.e. when raining or snowing).

3.4 Data Reporting

The following information shall be recorded and included in the test report.

3.4.1 Noise Testing

3.4.1.1 As a minimum, report the following Unit 1 and Unit 2 operating conditions during the noise testing:

a. Megawatt output

3.4.1.2 Report any non-standard operating conditions, including but not limited to the following auxiliary equipment:

a. Turbine enclosure exhaust fans and louver positions;

b. Mechanical package systems;

c. Electrical package air conditioning system;

d. Pumps and other equipment;

e. Fin fan cooler fan operation; and

f. Transformer cooling fan operation.

3.4.1.3 Date (including the day of the week) and time of measurements.

3.4.1.4 Extraneous noises that are not from the new combustion turbine project.

3.4.2 Acoustical Environment

3.4.2.1 Site plan showing all units on the contractor supplied equipment list and sound level measurement locations.

3.4.2.2 Identification of non-supplied equipment determined to be potential noise sources or that may affect the sound level measurements at any position.

3.4.2.3 Ambient conditions during sound level measurement periods including temperature, relative humidity, wind speed and direction and cloud cover (if any).

3.4.2.4 Name, manufacturer, model number, serial number, ANSI type and last calibration date of all sound measuring instrumentation utilized.

3.4.2.5 Names of all personnel who performed and/or observed the sound level measurements.

3.4.2.6 Relevant remarks on the subjective impression of noise (i.e. time variations of sound level, audible discrete tones, spectral content, background sound from other sources, etc.)

3.4.2.7 Any deviations from this test procedure that may significantly impact the intent of this procedure, as agreed upon by Owner and Contractor.

3.4.2.8 Extraneous noise noted during the measurement.

3.4.3 Sound Level Data

3.4.3.1 Observed L_{10} A-weighted sound level for each measurement taken.

3.4.3.2 Observed background L_{10} A-weighted sound levels for each measurement taken, with equipment not operating.

3.5 Test Method

3.5.1 Operational Sound Level Measurements

Sound level measurements shall be made at the proper location, height and distance in accordance with Section 3.2. Sound level measurements may be repeated two or more times during the daytime and nighttime in order to obtain a representative sound level for each period

Distances shall be determined with a tape measure or other measuring device and be accurate to within one-half foot (0.15 meters). If it is not feasible to make sound level measurements at the proper location, height, and distance, alternative locations may be selected as long as they are noted in the remarks associated with the data reporting.

3.5.2 Environmental Corrections for Measured Sound Levels

The environmental conditions that exist at a specific test location may have an effect on the measured sound levels. These environmental influences, which include background sound from nearby sources not in the contractor scope of supply and the effects of other structures, shall be evaluated. Corrections for these effects shall be made to all measured data in accordance with guidelines contained in the referenced documents.

3.5.2.1 Background Sound Level

The A-weighted background sound level shall be measured at the test location determined previously at the nearest occupied existing residence. Measurements shall be made in accordance with Section 3.1.4.

Background sound level measurements may be performed before or after operational sound level measurements are obtained.

Any measurements taken to determine background sound levels shall be exclusive of air craft, railway and to the extent possible, traffic noise. If background levels exceed the noise criteria specified in Appendix A, the measurement point may be moved to avoid extraneous noises.

4.0 REFERENCES

ANSI S1.4 – “Specification for Sound Level Meters”.

ASTM C423 – “Standard Test Method for Sound Absorption and Sound Absorption Coefficients y the Reverberation Room Method”.

“Measurement of Sound Absorption in Rooms”, *Journal of Acoustical Society of America*, Vol. 61, No. 2, February 1977.

ANSI S12.36 – “Survey Methods for the Determination of Sound power Levels of Noise Sources.”

ANSI S12.34 – “Engineering Methods for the Determination of Sound Power Levels of Noise Sources for Essentially Free-Field Conditions over a Reflecting Plane”.

ANSI B133.8 – “Gas Turbine Installation Sound Emissions”.

ISO 6190 – “Acoustics – Measurement of Sound Pressure Levels of Gas Turbine Installations for Evaluating Environmental Noise – Survey Method”.

ISO/DIS 8297 – “Acoustics – Determination of Sound Power Levels of Multi-Source Industrial Plants for the Evaluation of the Sound pressure Levels in the Environment – Engineering Method”.

ANSI S1.11 – “Specification for Octave Band and Fractional Octave Band Analog and Digital Filters”.

ANSI S1.6 – “Preferred Frequencies and Band Numbers for Acoustical Measurements”.

ANSI S1.40 – “Specification for Acoustical Calibrators”.
ANSI/ASME PTC 36 – “Measurement of Industrial Sound”.

APPENDIX A
SPECIFIED SOUND LEVELS

APPENDIX A

SPECIFIED SOUND LEVEL LIMIT AT NEAREST OCCUPIED, EXISTING RESIDENCE FOR GROTON GENERATION STATION

Time of Day	**Limit (L_{10})**
Daytime	60 dBA
Nighttime	55 dBA

APPENDIX B
MEASUREMENT POINT LOCATION

Source: USDA NAIP 2006 Aerial Photography

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Appendix B
Measurement Point Location
Groton Generation Station

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