



ACOUSTICAL EVALUATION OF STATION UPGRADES

PSE&G WEST ORANGE SWITCHING STATION West Orange, New Jersey

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SUMMARY

PSE&G proposes to modify equipment and systems at the West Orange Switching Station in West Orange, NJ to modernize the site. The site is within a mixed-use area of the township, but there are some residential uses in the vicinity. Analyses show that steady site sound emissions currently comply with applicable code limits at nearby noise-sensitive receptors. When the site upgrades are complete, steady sound emissions will remain the same at noise-sensitive receptors and continue to be below noise code limits. There is also no negative acoustical impact anticipated from this project.

INTRODUCTION

Ostergaard Acoustical Associates (OAA) carried out a variety of tasks in order to assist PSE&G with analysis of sound emitted by transformers and other steady noise sources at the West Orange Switching Station. Tasks included surveying and computer-based modeling of existing equipment and associated sound emissions, as well as modeling of future sound emissions with proposed improvements. Sound emissions are required to meet noise limits per State and local regulations. This report provides the results of these evaluations. Tasks for OAA were overseen by Michael Conaway, P.E., with assistance from OAA staff. The PSE&G representative coordinating this work is Eric Sudman, P.E.

Our assessment of existing sound emissions relies upon in-situ surveys of noise emitted by various on-site equipment. Predictions of future conditions rely upon manufacturers' sound ratings provided by PSE&G, as well as experience at other sites. Present and future steady sound emissions were evaluated using acoustical modeling software to conveniently sum sound emissions and graphically present the results.

Note that all acoustical modeling for this professional acoustical evaluation relied on analyses in octave frequency bands. However, in the interest of providing a concise report of findings, the results are provided using the most common metric of environmental sound, the A-weighted sound level. Full acoustical data in octave bands for all measurements and modeling are available upon request; these octave band data are consistent with the findings presented within this report.

SITE AND VICINITY

The West Orange Switching Station is located northwest of the intersection of Mount Pleasant Avenue (New Jersey State Route 10) and Prospect Avenue in the Township of West Orange, Essex County, New Jersey. The site is located at Block 155, Lot 26.01 and Block 1, Lot 26.01. The area around the site is mixed-use in nature, but a majority of the neighboring uses are commercial. Doctors' offices border the site to the west, while a commercial fitness center and additional doctor offices are north of the site. Prospect Avenue borders the site to the east; beyond this road are several commercial uses and potential residences. A golf course is south of the site beyond Mount Pleasant Avenue. Beyond commercial uses to the west and east are multi-family residences.

The site and commercial properties to the west and north are located in the O-R, Office Research, zone. Uses east of the site along Prospect Avenue are in the B-2, General Business, zone. The golf course to the south is in the R-2, One-Family Dwellings, zone. Residences beyond commercial uses to the west and east are in the PURD, Planned Unit Residential Development, zone.

The site is split into two distinct sections. In the northwestern corner of the site is Marion Drive Substation. This area of the site consists of two power transformers (labelled as T10 and T20), associated isolation walls, a feeder row, and two control houses. The two transformers, T10 and T20, have integral cooling fans to provide cooling when necessary. The southwestern control house has two wall-mounted HVAC units, with one unit on both the west and west facades. Marion Drive Substation is enclosed in its own fencing and is small compared to the entire site.

The switchyard comprises the remainder of the site and contains most of the electrical equipment. This area has six transformers (labeled as T1, T2, T3, 220-2, 220-3, and 220-4), two station light and power transformers (labelled as #1 SL&P and #2 SL&P), a feeder row, two control houses, a voltage regulation unit, an emergency generator, and a pump plant. Transformers T1, T2, and T3 contain pedestal fans, while the three other transformers have integral cooling fans. The two control houses have HVAC equipment associated with them. The 26kV control house has five HVAC units that are elevated above grade; these units are located on the north, east, and west facades. The main control house has four wall-mounted HVAC units; two units are on the north façade, while two units are on the south façade. The pump plant also has a ground-mounted HVAC unit along the south façade.

The site and vicinity are shown in Figure 1, which is based on aerial imagery obtained from Google Earth Pro software. The site is outlined in red, while existing isolation walls are outlined in light blue. Also shown in Figure 1 are pieces of major equipment.



Figure 1 — Aerial photo showing existing conditions at PSE&G West Orange Switching Station, West Orange, NJ. Also labeled are existing major equipment. The site property line is outlined in red. Existing isolation walls are shown in light blue.

Plans call for the upgrade of the site with new equipment and systems. All major pieces of existing equipment will remain, and there will be no changes made at Marion Drive Substation. Proposed plans call for installation of a switchgear enclosure near the southeastern corner of the site. The switchgear enclosure will have four exterior wall-mounted 3-ton HVAC units; one unit will be located near each of the corners of the enclosure, specifically on the north and south facades. The proposed site layout is shown in Figure 2; the equipment of Marion Drive Substation is excluded from Figure 2 for clarity.

New equipment and structures of acoustical importance include the following:

Future Equipment/System	Approximate Height above Grade (feet)	Acoustical Rating*
Switchgear enclosure	12½	-
3-ton wall-mounted HVAC units, north and south façades (each of 4)	7	Sound power level of 81 dB(A)

* All sound power levels are referenced to 1 picowatt.

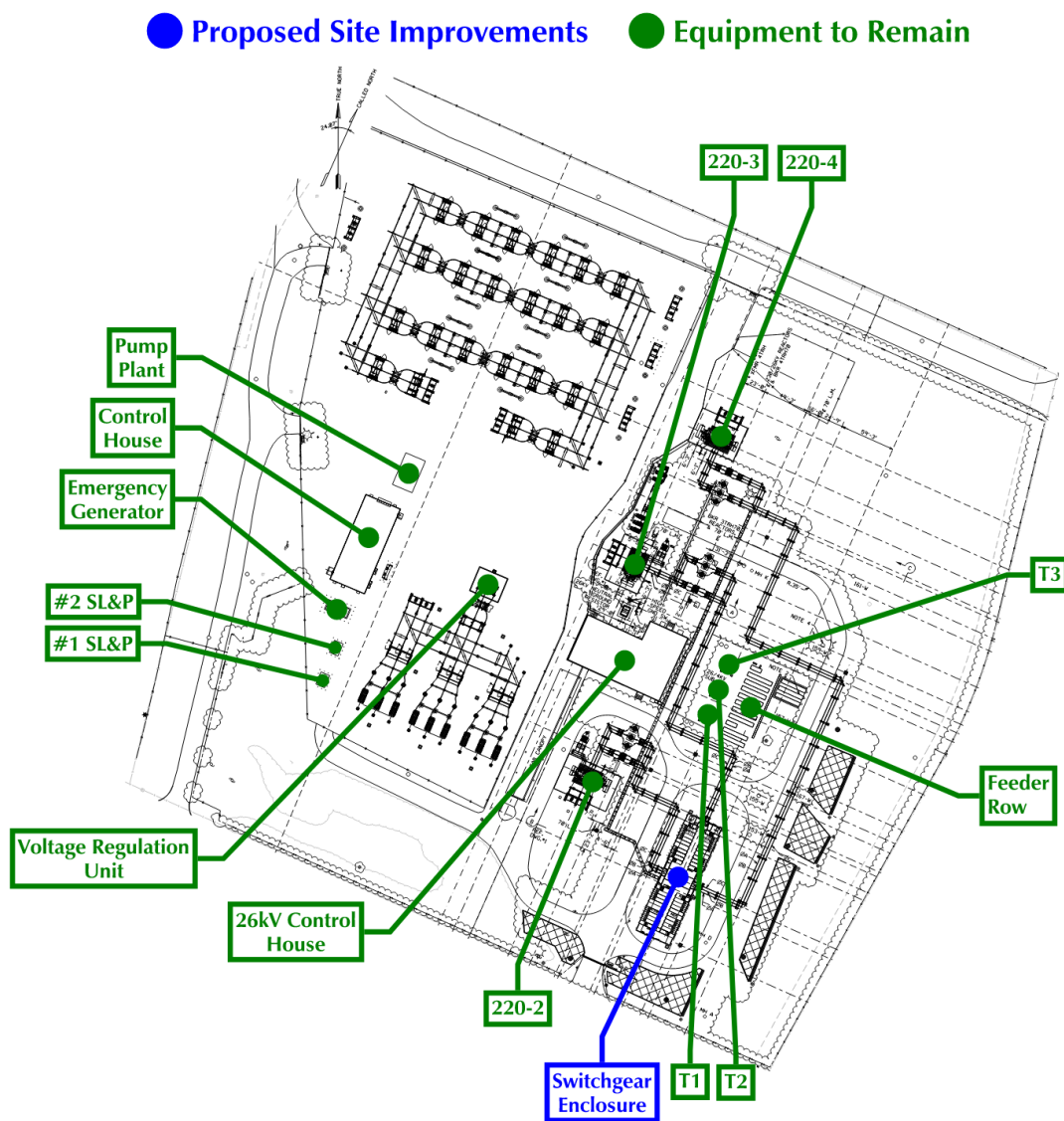


Figure 2 — PSE&G West Orange Switching Station, showing major equipment and systems to be added in blue and equipment to remain in green.

CRITERIA

The primary regulations governing sound emissions from the site are the State of New Jersey Noise Control Regulation, found at N.J.A.C. 7:29, and the West Orange code section 4-4: *Noise*.

In summary, the State Regulation limits steady sound as follows:

- ❑ At or within the property line of commercial receptors, emissions from the PSE&G site are limited to 65 dB(A).
- ❑ At or within the property lines of residences, site sound emissions are limited to 65 dB(A) during the daytime (0700-to-2200 hours) and 50 dB(A) at night (2200-to-0700 hours).
- ❑ There are corresponding limits in octave frequency bands associated with the 65 and 50 dB(A) limits.
- ❑ No limit applies at industrial receptors or intervening rights-of-way since there is no associated noise-sensitive use.

As stated above, regulatory limits apply at or within the property line of the receptor. Enforcement guidelines issued by the State[†] provide further direction indicating that compliance measurements are made at the location of the affected person. This is defined as a location where recreation, repose, and conversation may reasonably occur. In other words, it is most appropriate to evaluate site sound where a complaint may reasonably occur, such as at upper-story window elevations or at locations 5 feet above grade within landscaped and/or hardscaped residential property areas (e.g. lawns, decks, pools, patios, etc.). No limits apply at intervening roads or rights-of-way. Exceedance of code limits without a formal complaint does not automatically result in a violation of the code. Professional experience is often relied upon to determine the likelihood of a noise complaint.

West Orange Township discusses noise in Section 4-4: *Noise*. However, this code section is qualitative in nature with no quantitative limits. Therefore, the State regulation limits were relied upon as criteria for this sound study.

Since the site operates 24/7, site sound emissions should not exceed 50 dB(A) at nearby residential locations of reception. At nearby commercial properties, site sound should not exceed 65 dB(A). No limit applies at bordering rights-of-way.

[†] Guidelines for the Investigation of Noise Complaints Pursuant to the State of New Jersey *Noise Control* Regulation (N.J.A.C. 7:29) and the *Model Noise Control Ordinance*, 4 February 2022

EXISTING SOUND EMISSIONS

Experience indicates that transformer noise is typically characterized by “hum” at certain harmonics of the 60 Hz line frequency, typically 120 and 240 Hz, as well as broadband cooling fan noise that affects the mid-frequency ranges typified by the 500 and 1,000 Hz octave bands. Transformer hum is often spatially non-uniform so that levels can differ significantly with angular position around the transformer. These details are of interest when surveying transformer sound.

A daytime site visit was made to the site by OAA Senior Engineer Michael Conaway, P.E. in order to become familiar with existing conditions on-site and off-site, to survey sound emitted by individual noise sources of interest, and to measure existing site sound emissions from the switching station. The daytime site visit and sound survey were carried out on 30 April 2024. The daytime survey included 180 individual octave band spectra gathered on-site at strategically selected locations, most close to equipment, that were useful for calibrating the acoustical model of site sound emissions. These results are discussed in a subsequent section. Weather conditions during the survey were conducive to measurements, which included cloudy skies, a temperature of 58°F, and winds of 2-to-6 mph. The acoustical measurement system used for the survey is described in the Appendix.

The existing on-site transformers are served by either pedestal or integral cooling fans. All cooling fans for these pieces of equipment were forced ON during the sound survey with the exception of T1; the T1 pedestal cooling fans were unable to be operated. The HVAC units for the control houses are thermostatically controlled, and hence, were not able to be forced ON. These units operated as expected for this season. The purpose of having transformer fans ON is to evaluate conditions with the site contributing the highest sound emissions to the extent feasible.

An initial review of results from the daytime sound survey indicated that site sound at the boundaries of the site did not exceed 50 dB(A). However, there was some influence of measured sound levels by ambient sound in the area, such as noise from traffic flow on nearby roads. To evaluate existing site sound emissions at inaccessible locations of reception, as well as to examine future sound emissions after site improvements, an acoustical model was developed. This is discussed in the next section.

MODELING OF SOUND EMISSIONS

State-of-the-art software, CadnaA, was used to model steady PSE&G site sound emissions from continuously operating equipment. Beginning with the dimensions and strength of the noise sources, the model takes into account relevant parameters between the noise source and receptor positions of interest to predict how sound will propagate. In addition to distance attenuation, the model accounts for the effects of terrain, various types of ground cover, shielding by structures, and reflections from buildings. The acoustical model sums noise from multiple sources and analyzes sound propagation to multiple receptors. The model yields site sound emissions, which exclude ambient sound contributions and are directly comparable to code limits. All model calculations are carried out in octave frequency bands.

The strength of the noise sources for existing site equipment was determined from field-measured data from the daytime sound survey on 30 April 2024. Data were obtained via calibrated measurements near the transformers and other select equipment. As stated earlier, all operable transformer cooling fans were switched ON during the survey to simulate worst-case conditions. Data were generally acquired 1-foot from transformer surfaces and 6 feet from fans per NEMA Standards and were used to develop octave band sound power levels for each source. Sound power levels for HVAC equipment are based on manufacturer's data and were input into the model.

The modeling software provides colored A-weighted sound emission contours (in 1 dB increments) for an ear-height elevation typical of a standing observer, 5 feet above grade. The model also tabulates sound emissions for five select receptor locations. Receptors A, D, and E represent upper-story locations of reception for nearby residences, while Receptors B and C are at upper-story locations of reception for nearby commercial uses. Specifically, Receptors A and B are 20 feet above grade, while Receptors C through E are 15 feet above grade.

In the model, buildings and equipment are shown in white, and the site property is outlined in red. Isolation walls are shown in light blue. Note that a majority of elevation contour lines are visually hidden for clarity; only major elevation contour lines are shown in teal for ease of interpreting the colored sound level contours.

Existing Conditions

An acoustical model was developed for the sound contributed by the existing on-site equipment with all operable transformer cooling fans ON and all HVAC equipment ON. Figure 3 shows the results.

Results from Figure 3 show that modeled existing emissions for the as-found conditions agree well with field measurement results. Since there is good agreement between the model and on-site measurement locations, the model can be relied upon to predict sound emissions elsewhere. At Receptors D and E, the closest residences to on-site noise sources, emissions are 46 dB(A), 4 dB below the nighttime residential limit. At residences to the northwest, typified by Receptor A, emissions are 26 dB(A), well below the code limit. Maximum emissions at commercial properties are 48 dB(A), as shown at Receptor C. Site sound emissions meet the commercial 65 dB(A) limit by wide margins. It is worth noting that the gray, 50 dB(A) contour, which corresponds to the nighttime residential limit, does not extend past the property line in the direction of the residences. Model results show that emissions at all nearby receptors comply with applicable code limits.

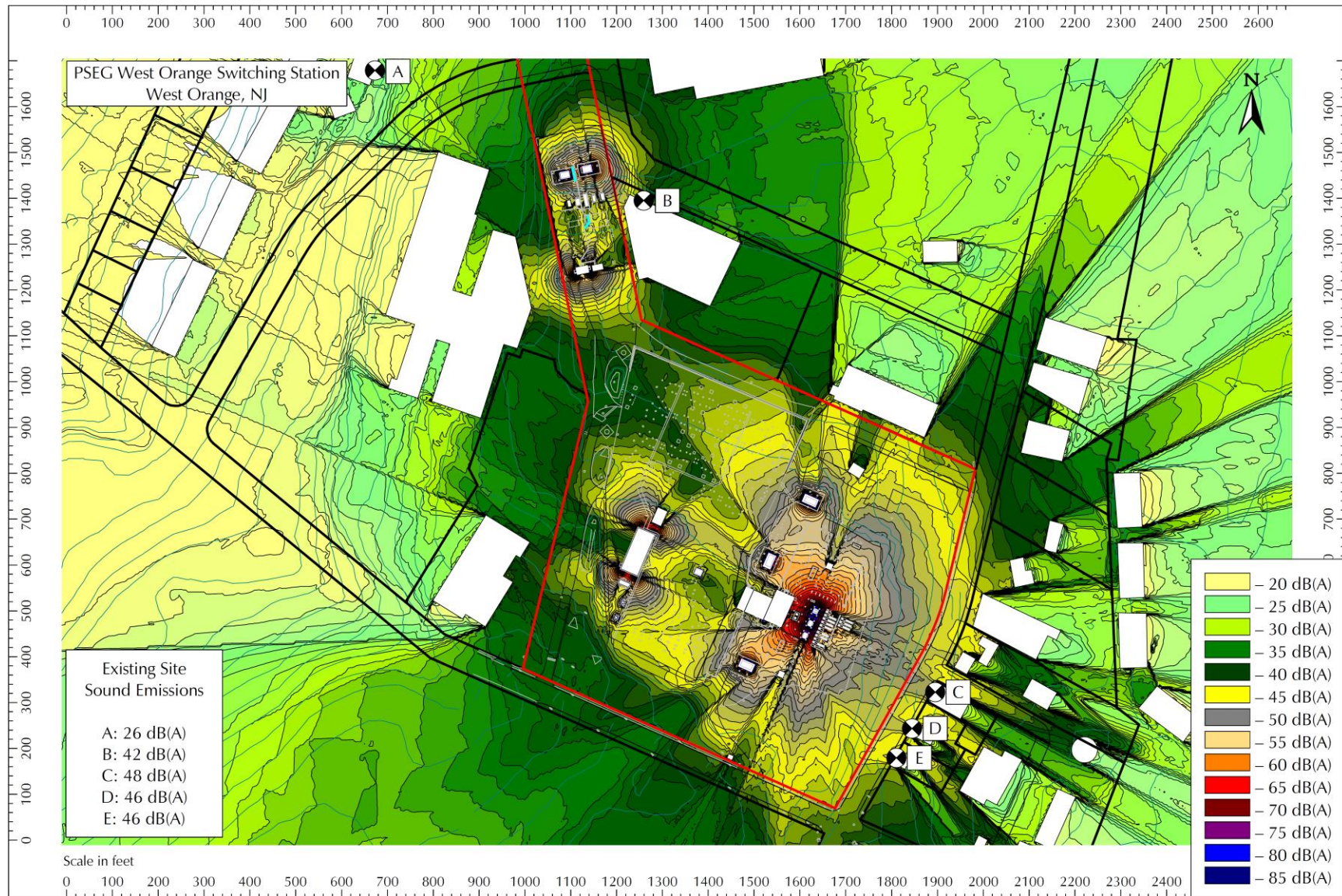


Figure 3 — Model of existing site sound emissions with HVAC equipment ON. Colored contours are A-weighted sound emissions 5 feet above grade. Receptors A and B are 20 feet above grade; Receptors C through E are 15 feet above grade.

Future Conditions

Proposed plans call for the installation of new equipment and systems. Detailed information on the new equipment was entered into the model. This information was discussed in a previous section.

Figure 4 provides the results of modeling the steady future sound emissions from the site with the new equipment operating with all HVAC equipment ON. Comparison of these results with the existing conditions in Figure 3 shows that future emissions remain the same at all nearby noise-sensitive receptors. At residential Receptors A, C, and D, emissions meet the code limit of 50 dB(A) by 4 dB. In the direction of commercial uses, maximum emissions meet the 65 dB(A) code limit by 17 dB or more. Note that, once again, the gray 50 dB(A) contour, does not extend past the property line in the direction of noise-sensitive receptors.

These results indicate that the future site layout will continue to comply with code limits, even after a conservative analysis with all HVAC equipment and transformer cooling fans operating. There is also full compliance in all octave frequency bands. While not presented in this report, site sound emissions during the cooler months with no HVAC equipment operating are expected to be lower in level at all nearby points of reception than what is shown in Figure 4.

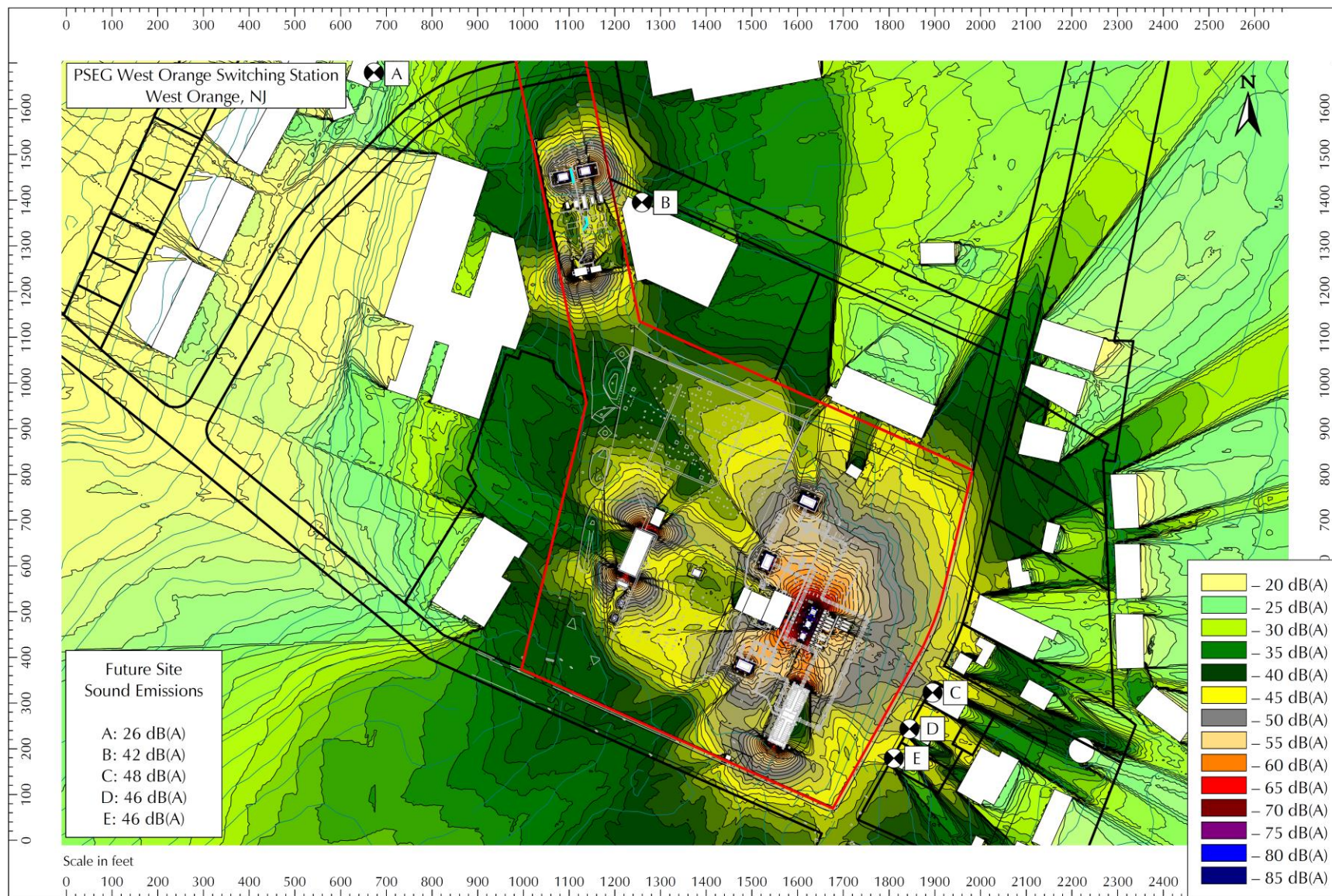


Figure 4 — Model of future site sound emissions with HVAC equipment ON. Colored contours are A-weighted sound emissions 5 feet above grade. Receptors A and B are 20 feet above grade; Receptors C through E are 15 feet above grade.

CONCLUSION

The proposed improvements at the existing West Orange Switching Station involve the installation of new switching equipment and systems. State noise code limits apply to site emissions. A survey of existing sound emissions indicated that site sound meets applicable code limits at select locations; acoustical model results of existing conditions confirm that applicable code limits are met at all receptors.

The future condition of the site will have new, modern equipment and systems installed. During worst-case operations with all transformer cooling systems and HVAC equipment operating, emissions will meet all applicable residential nighttime and commercial code limits. Specifically, emissions at noise-sensitive vantage points will remain the same. This future analysis is conservative, and there will be an additional margin of compliance during typical nighttime operations since HVAC equipment operation is cyclical. No negative acoustical impacts are expected from this project, and PSE&G site noise will not be a nuisance to any nearby noise-sensitive properties.

APPENDIX

DATA ACQUISITION AND ANALYSIS SYSTEMS

The measurement system used to obtain acoustical data consisted of an HBK random-incidence condenser microphone 4189, used in conjunction with a preamplifier, HBK Model ZC 0032, and a precision sound level meter and octave band analyzer, HBK Model 2250. A windscreen was used on the microphone to reduce wind noise. For each measurement, the sound level meter was handheld, at an elevation 5 feet above grade, at a typical ear height.

For the daytime on-site tests carried out close to equipment, the measurement technique used short averages, 10 seconds in duration. At the end of the measurement interval, the data were saved to internal memory for later analysis.

The entire system was calibrated before and after the measurements by means of a sound pressure level calibrator. The calibrator used was a HBK Model 4231, last calibrated by an outside calibration service within one year of the measurement date. The calibration is traceable to the National Institute of Standards and Technology. Calibration certificates are available upon request. The measurement system complies with the requirements for a Type 1 meter given in ANSI/ASA S1.4 (*Specification for Sound Level Meters*) and IEC 61672 (*Electroacoustics - Sound level meters - Part 1: Specifications*). Overall, the data included in this report can be considered accurate to within a 1-decibel range.

Software developed by HBK was used to recall the statistical octave band and A-weighted sound levels from the data provided by the analyzer. Microsoft Excel software was used to analyze the recalled data and perform acoustical calculations.