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Subject Predicted Noise Levels For Various Proposed Event Sites
Birdwood Mansion and Golf Course, Charlottesville, VA
Acentech Project No. 631469

Dear Ms. Cruz:

I understand that you have proposed three outdoor event locations, which may support up to 200 guests. All locations have largely unobstructed views to some of the neighbors, particularly those closest residential neighbors to the East and West of the property. This goal of this report is to predict the sound level at the pertinent property lines and compare those levels with the county's noise ordinance.

EXECUTIVE SUMMARY

Based on the results from our sound propagation model, all three event sites are predicted to meet the county's noise ordinance and be below 60 dBA at the property line.

Of the three proposed sites, Site A appears to have the lowest overall impact to sound level at the entire property line (≤ 46 dBA). Site C appears to have the highest impact on sound levels (≤ 55 dBA), but is focused largely at the Northern property line, which abuts route 250 and commercially zone property across the street. The sound level predictions are shown in Figures 3 – 5.

The model was verified with data from an earlier propagation loss measurement. This verification showed that the model provided a prediction closely mirroring that of the measurement, and was well within the model's margin of error.

A brief glossary is included at the end of this letter.

REVIEW OF REQUIREMENTS

Albemarle County Noise Ordinance

The Albemarle County code includes regulations for noise[1], which outline the necessary equipment, measurement procedure, and performance standard that must be met. The daytime[2] performance standard for sound levels is defined as an average sound pressure level of 60 dBA for rural, residential, and public receiving zone boundaries and 65 dBA for commercial receiving zone boundaries. The nighttime performance standard is defined as 55 dBA for residential/rural and 65 dBA for commercial boundaries.

[1] Albemarle County Code, Chapter 18, Section 4.18
[2] The county defines daytime as 7AM to 10PM and nighttime as 10PM to 7AM.

The neighbors to the North are zoned commercial and the neighbors on your Eastern, Western, and Southern boundaries are zoned residential. Because the residential performance standard is lower than commercial, that will be the limiting factor.

SOUND LEVEL PREDICTIONS

Typical Amplified Music Sound Levels

Our experience has shown that typical sound levels on the dance floor of an event with amplified music often ranges between 85 dBA and 100 dBA. For reference, 85 dBA is about the level of a loud film in a movie theater, while 100 dBA would be similar to a dance club or louder fitness class, but quieter than a rock concert. Note that these levels could fall in a wider range based on the performer/presenter's tastes and their client's wishes. However, we feel that this range is representative and offers a good starting point for our review.

For our analysis, we have assumed a sound level of 85 dBA at a distance of 50 feet from the loudspeakers, at what might be considered the edge of the dance floor. This sets the levels on our assumed dance floor ranging from 85 dBA at 50 feet to over 100 dBA near the loudspeakers, right within our defined range.

For reference, this is the same sound level demonstrated during my site visit on February 28th. Our collective impression of that demonstration was that the sound level at 50 feet was quite loud, and possibly louder than necessary.

The specific music played at the event sites will dictate the frequency content of the reproduced sound. For example, some music is bass heavy, while other music is not. While we cannot predict the music that will be played, experience has shown us that most music has a frequency distribution similar to pink noise, where each octave band has a similar sound level. For prediction purposes, we have assumed a pink noise sound level distribution.

Proposed Event Sites

Because you are considering three event sites, we will need to predict sound levels at the property line for each. Figure 1 shows the approximate locations of the event sites, each circled and labeled in red. This background graphic was pulled from the Albemarle County GIS webpage[3] and is used as the background for later figures in this report.

Propagation Loss Measurements

The original plan to predict event sound levels at the property line was to measure actual propagation loss and apply that data to the source level defined above. This process would require the measurement of propagation loss from each proposed site to a handful of locations along the property line boundary. However, accurately measuring the propagation losses requires the generation of very loud noise at each proposed event site. We started this process and at the first measurement location, we were asked to stop as the activity was affecting nearby residents. To be clear, the sound levels generated were above expected event sound levels and could be considered much more annoying due to the tonal nature of the noise being generated.

To be more accommodating to the community, we decided to create a computer model for predicting sound levels at the property line. Our follow-up meeting with the county concluded that this approach might also be better received by the community and administrators. The model is capable of generating sound level contour maps similar to what they have seen from the cellular industry and will provide a more complete picture of the predicted sound levels.

Modeling Process

You have provided us with a detailed AutoCAD model of your planned site, including buildings, elevation contours, and property boundaries. We were able to use this data in our noise model of your site for the purposes of sound level prediction. We use a software package called CadnaA to build a model, predict

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[3] http://gisweb.albemarle.org/gpv_51/Viewer.aspx

noise levels, and present that data. CadnaA is a widely recognized and accepted noise propagation modeling software that follows ISO 9613-2 [4].

Buildings near the source are defined to mimic the actual site conditions, which provide reflection and shielding in sound propagation. The elevation contours provide the necessary topographic information to aid in predicting spreading, ground absorption, shielding, and diffraction. Sound sources are added at their proposed locations and given the defined sound level, directivity, and height from the ground.

Atmospheric attenuation of sound is somewhat influenced by temperature and relative humidity, but does not have a large impact on our results. This is because lower frequencies and higher frequencies do not behave the same for a given set of conditions. Because your proposed event sites are outdoors we expect they will primarily be in use during fair weather, so we have assumed a typical temperature of 80°F and a relative humidity of 70%. Landscaping such as trees and bushes were excluded from the model since the effects of these objects would be small and the prediction less accurate due to their sparsity on the site and seasonal variations.

Noise Contour Maps

A noise contour map is a way of graphically representing the sound level of a particular site. They allow the reviewer to quickly determine the approximate sound level at any given location, and determine compliance or impact at those locations. In our model, the sound levels on the noise contour maps are calculated on a 2-meter x 2-meter grid at a height of 1.5 meters. Sound levels are represented with bands of color that indicate a range of sound levels. For our purposes, each color band represents a 5 dBA range, with individual contour lines (black) within each range to represent 2.5 dBA steps. It is possible to further refine the map to show finer steps and ranges, but interpreting the data becomes more difficult when interpreting smaller color shifts and additional contour lines.

Discrete receiver locations were added to the model and scattered around the property line. These receivers provide a table of numbers, rather than leaving interpretation up to the reviewer. Receivers can be seen in Figure 1 and are identified as Rxx, where xx is a number.

Verifying the Model

While our initial propagation loss measurements were not completed, we did complete a measurement for a single location near proposed event site A. We replicated the configuration of this specific measurement in our noise model to verify that the prediction is similar to the actual measurement. The loudspeaker was placed at a height of 8' in the middle of event site A and oriented towards 285° from North (~West by North). The results of this verification are shown in the following table.

	50' From Loudspeaker Sound Pressure Level	At Property Line, West of Site A Sound Pressure Level
Measured	101 dBA	74 dBA
Predicted	101 dBA	74 dBA

These results shows that the noise prediction model is performing similar to the actual propagation loss measurements. Note that we expect a margin of error around ±3 dB in our predictions per ISO 9613-2, even though the verification results do not demonstrate that error.

Figure 2 shows the noise contour map for the model verification configuration. Loud sound are shown in blue, then transition to red, then green, as they propagate from the source. This noise contour map is more extreme than the proposed event site maps due to the direction the loudspeaker is facing and the very high sound level used for this propagation loss measurement. It has been included here to provide a reference that demonstrates graphically how loud our initial test was, which you can then compare to the noise contour maps for the proposed event sites.

[4] International Standards Organization 9613-2, Attenuation of Sound during Propagation Outdoors.

Proposed Event Site A

The loudspeakers are placed at a height of 8', roughly 10' apart, approximately 20' from the house, and oriented towards 195° from North (~South by West). The source level has been set to have a sound level of 85 dBA at 50' from the loudspeakers.

Figure 3 includes a noise contour map for event site A. Recall that the noise ordinance limit during the day, for residential boundaries, is 60 dBA. This contour map shows that levels exceeding the ordinance only occur as far away as the golf training facility (the red color band represents 60 – 65 dBA). Reading the contours bands along the boundary line shows that sound levels are below 45 dBA nearly everywhere.

Figure 3 also includes a table that shows the calculated sound level at the 13 discrete receiver locations, which tell the same story as the contour map.

Proposed Event Site B

The loudspeakers are placed at a height of 8', roughly 10' apart, near the top of the proposed site, and oriented towards 195° from North (~South by West). The source level has been set to have a sound level of 85 dBA at 50' from the loudspeakers.

Figure 4 includes a noise contour map and receiver table for event site B. This contour map shows that levels exceeding the ordinance are quite far from the property line. Reading the contours bands along the property line, and reviewing the receiver table, the sound levels are below 50 dBA nearly everywhere. Levels on the East side are higher those due to Site A because of Site B's closer proximity and topography.

Proposed Event Site C

The loudspeakers are placed at a height of 8', roughly 10' apart, near the top of the proposed site, and oriented towards 195° from North (~South by West). The source level has been set to have a sound level of 85 dBA at 50' from the loudspeakers.

Figure 5 includes a noise contour map and receiver table for event site C. This contour map shows that levels exceeding the ordinance are quite far from the property line. Reading the contours bands along the property line, and reviewing the receiver table, the sound levels are at or below 55 dBA. Levels on the North side are highest due to closer proximity, topography, and reflections off buildings.

ADDITIONAL CONSIDERATIONS

Loudspeaker Orientation

Changes to the loudspeaker orientations defined for a given event site will change the noise contour map for that site. Subtle changes should not have a large impact on the contours, but you should make efforts to ensure that loudspeakers are oriented correctly, toward the Southern property line at roughly a South by West heading.

To demonstrate how a change in orientation can influence the noise contour map we have created a variation of the proposed event site A model from above. In this variation, the loudspeakers were oriented at 225° and 165° from North. Figure 6 shows the noise contour map and receiver table for this variation and should be compared directly with Figure 3 (which has properly oriented loudspeakers). Even with the 30° shift, making the total directivity pattern 60° wider, the noise ordinance is still met by a considerable margin with all property line sound levels predicted to be below 50 dBA. This suggests that subtle changes to loudspeaker orientation should not significantly change the sound levels at the property line.

Meteorological Conditions

In the model, we have ignored temperature inversions, wind speed, and wind direction. These variables require meteorological data specific to the site and further complicate the predictions. Note that temperature inversions, where a layer of warm air covers cooler surface air, typically only occur in the middle of the night when events will not be taking place. A review of typical weather conditions on Weather Spark[5] shows that

[5] https://weatherspark.com/y/20225/Average-Weather-in-Charlottesville-Virginia-United-States-Year-Round#Sections-Wind

the warmer months have a low average wind speed of around 4 mph, which is not be high enough to significantly change the downwind sound level; our model and predictions represent the prevailing wind conditions expected for this region. For reference, ISO 9613-2 states that a correction factor for wind is typically small and around 0 – 2 dBA. This correction would causes a reduction in the upwind sound level and an increase in the downwind sound level.

Ambient Noise

There is regular ambient noise at the site due to the continuous flow of traffic on Ivy Rd. We have not completed a study to characterize the amount of ambient noise at the site, so it is not being reported here. Note that ambient noise may very well be high enough to mask some amplified music noise at the property line.

Community Acceptance

A noise ordinance is not fully capable of characterizing a neighbor's acceptance of noise. We sometimes find, when neighbors become impacted, that additional considerations can be made to better address human acceptance of noise due to distant amplified music. These considerations can take the form of a lower overall level, providing a visible (but not necessarily noise blocking) separation from the event, defining specific levels that cannot be exceeded in a given frequency band (typically bass frequencies), or more extreme mitigation measures.

I hope this letter provides you with the information that you need at this time. If you have any questions, please feel free to contact me at byoder@acentech.com or 434.218.0759.

Sincerely,

Acentech Incorporated

Bill Yoder
Senior Staff Scientist

Cc: Fred Missel, Jim Wilson (UVA Foundation)
Valerie Long, Anne Yost (Williams Mullen)
Andy Carballeira (Acentech)

Encl: Figures 1 – 6

GLOSSARY OF ACOUSTICAL TERMS

We understand that acoustic terminology may be confusing. The following is a brief glossary of some acoustical terms used in this report that you may find useful.

Ambient Sound

The sound due to environmental, traffic, or other nearby sources that are unrelated to the source(s) being measured or characterized.

dB = decibels, dBA = decibels, A-weighted

Decibels (abbreviated dB) are used to measure the relative loudness of sound, based on a logarithmic scale. For reference, normal human speech is in the range of 65 decibels, painful rock music may be more than 110 decibels, while aircraft noise may be as loud as 130 decibels. A-weighting filters the sound in a way that is similar to human hearing, and hence dBA levels are often referenced in various acoustical standards. Note that a 10 dB increase in sound is associated with a perceived doubling in sound level.

Directivity

The pattern in which sound radiates from a given source. This could be spherical, hemi-spherical, or some other pattern. Directivity changes with frequency and is related to the size and shape of the source.

Frequency, Hz

The number of cycles or oscillations per second. Low frequency is associated with bass and are low pitch, while higher frequencies are high pitched.

Leq

The equivalent continuous sound level, or energy-average sound level, over a defined measurement period. Note that the sound level may be higher or lower during the measurement period.

Octave Band

An octave band is a frequency band where the highest frequency is twice the lowest frequency, and characterized by its center frequency. Bands are proportional in width, being wider at higher frequency.

Pink Noise

Noise in which each octave band has equal energy.

Propagation Loss

A reduction of sound energy due to distance, absorption, and other means.

Sound Pressure Level

This is the level used to characterize the loudness of a sound.

Temperature inversion

A reversal of the normal behavior of temperature near the ground. This occurs when a layer of warmer air covers a layer of cool air at the surface. This can allow sound to reflect off the warmer air and travel to a greater distance.

Tone, Tonal

A sound having a single, steady frequency or pitch.

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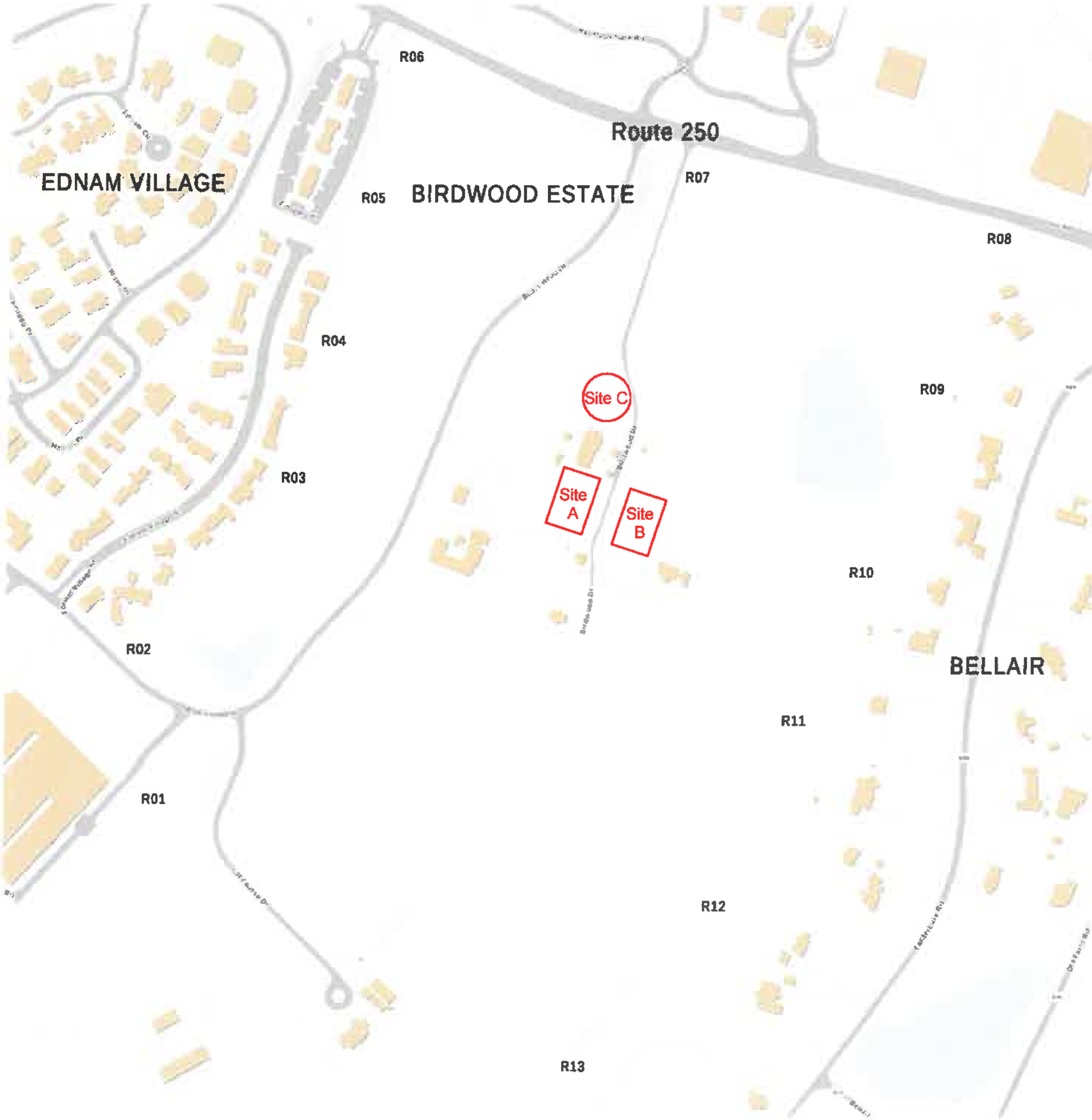
March 28, 2019

Figure 1:
Albemarle County GIS
Birdwood Estate, Proposed Event Sites



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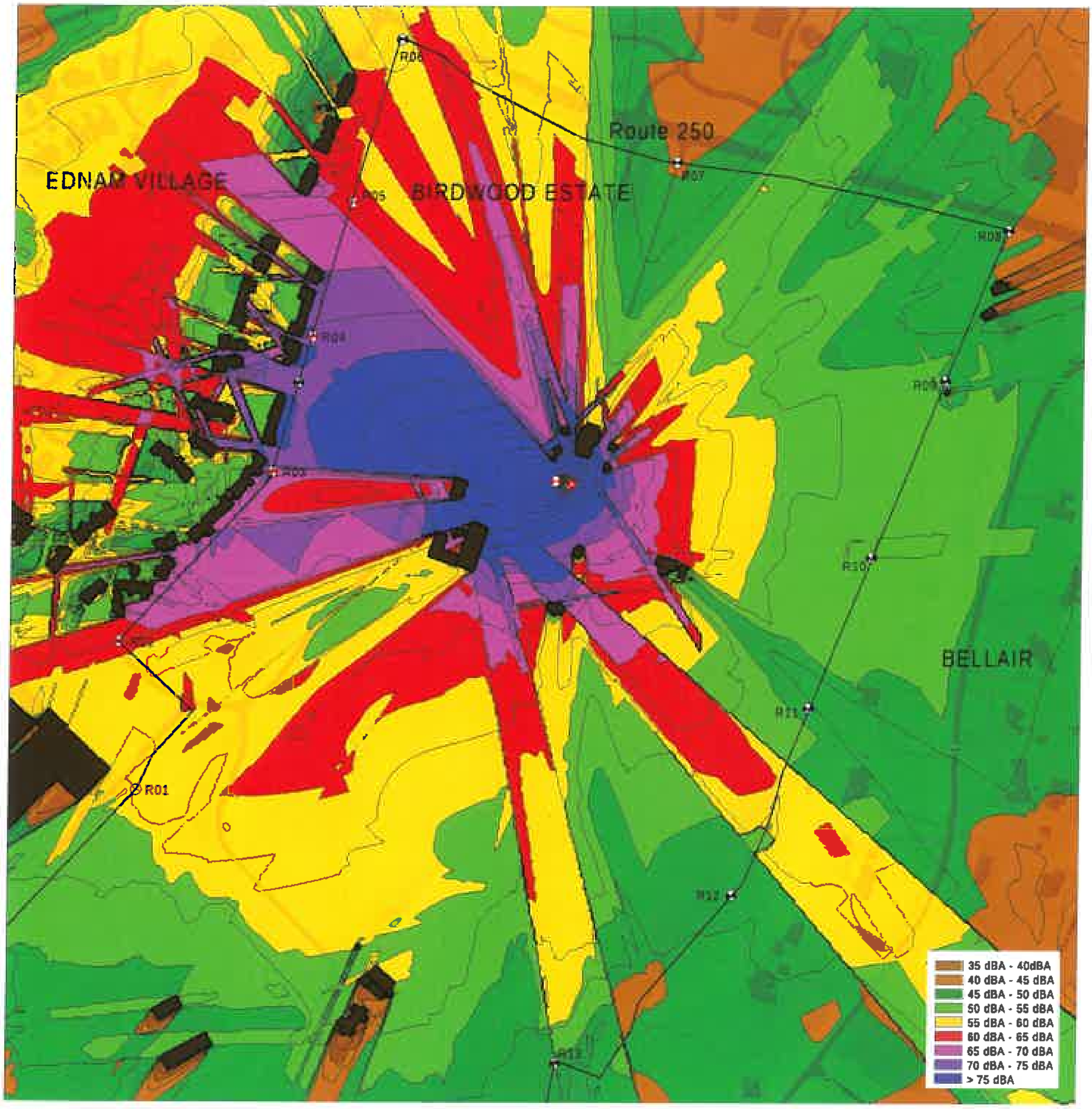
March 28, 2019

Figure 2:
Model Verification, Noise Contour Map



Receiver	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Sound Level	58 dBA	63 dBA	59 dBA	75 dBA	62 dBA	57 dBA	45 dBA	45 dBA	50 dBA	51 dBA	48 dBA	48 dBA	47 dBA

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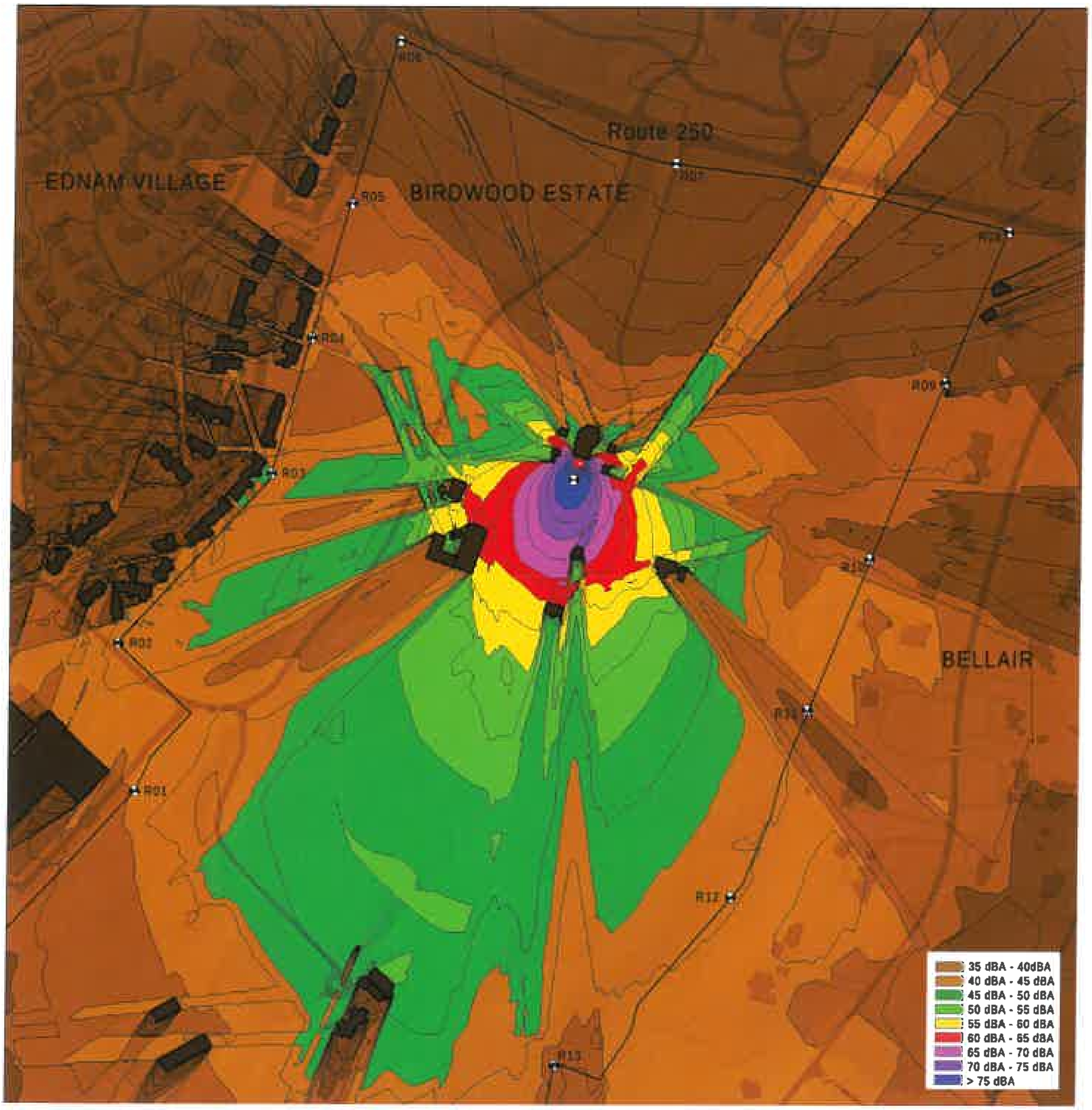
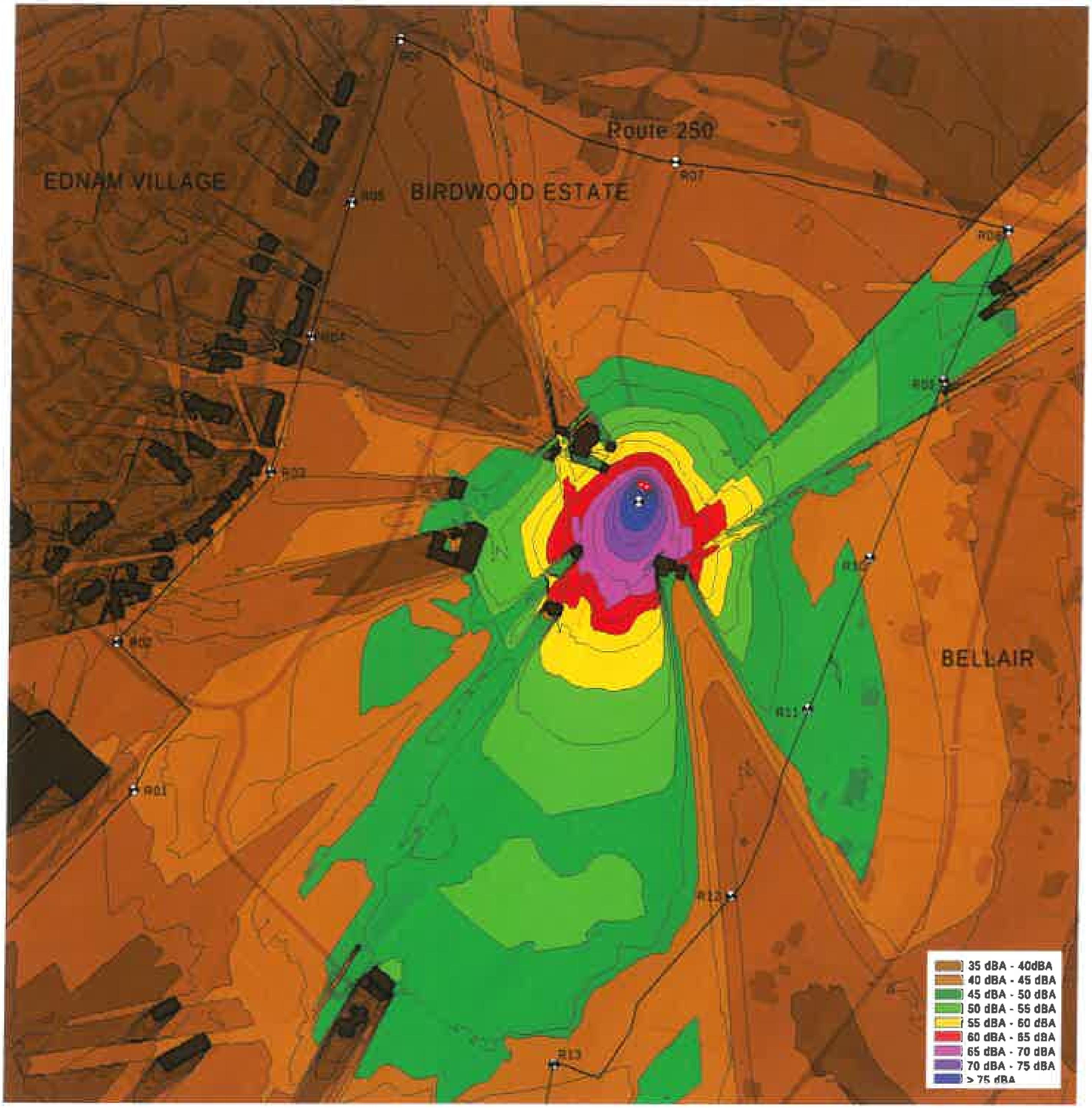
Figure 3:
Site A, Noise Contour Map



Receiver	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Sound Level	41 dBA	43 dBA	44 dBA	42 dBA	38 dBA	26 dBA	27 dBA	26 dBA	36 dBA	37 dBA	35 dBA	43 dBA	39 dBA

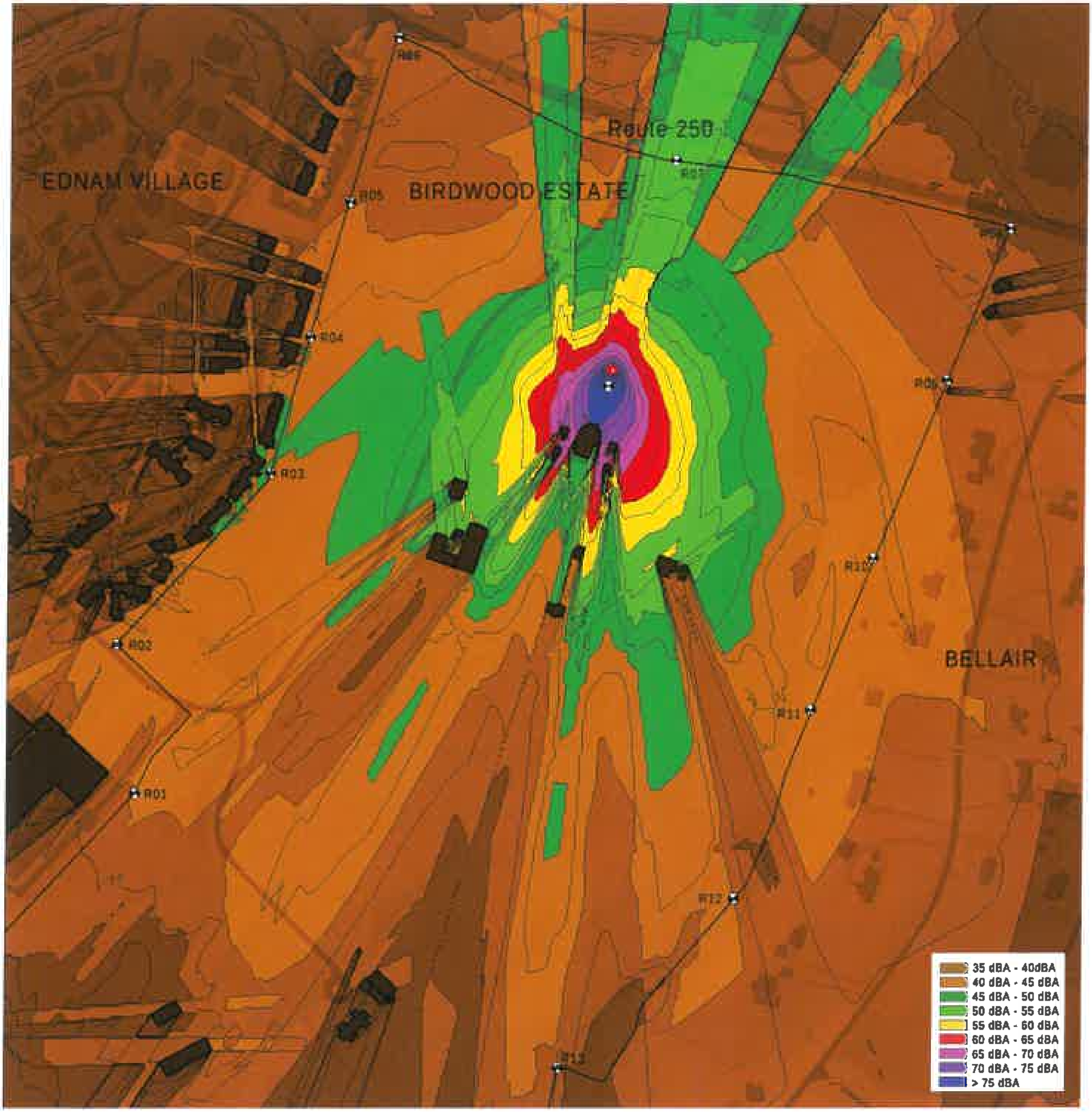
Figure 4:
Site B, Noise Contour Map



Receiver	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Sound Level	41 dBA	39 dBA	39 dBA	35 dBA	29 dBA	33 dBA	38 dBA	43 dBA	48 dBA	45 dBA	46 dBA	39 dBA	43 dBA

ATTACHMENT 13

Figure 5:
Site C, Noise Contour Map



Receiver	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Sound Level	42 dBA	41 dBA	45 dBA	45 dBA	40 dBA	36 dBA	55 dBA	35 dBA	33 dBA	42 dBA	43 dBA	41 dBA	36 dBA

Elise Cruz
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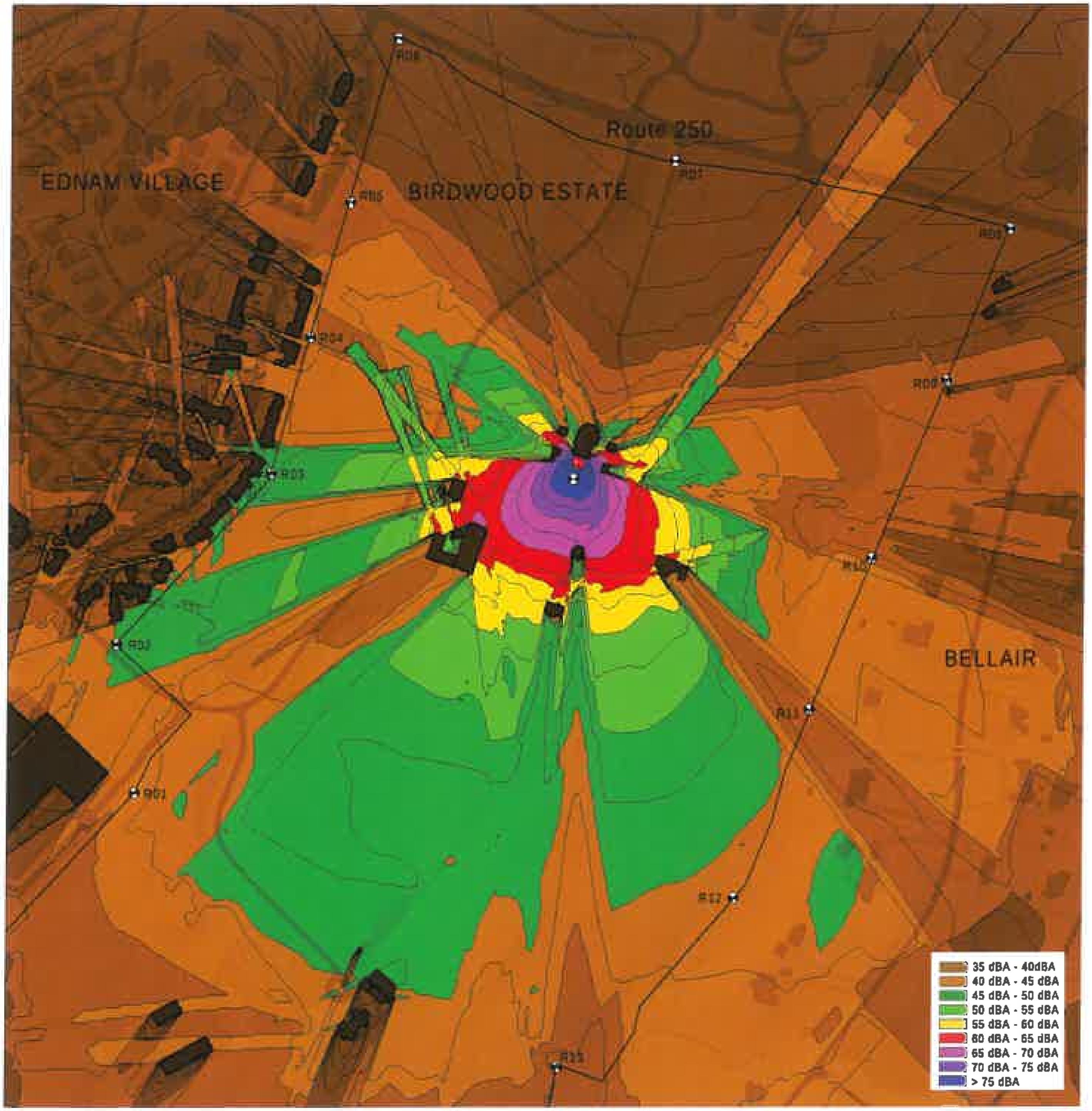
Figure 6:
Site A, 60° Spread Directivity, Noise Contour Map



Receiver	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	R11	R12	R13
Sound Level	42 dBA	46 dBA	48 dBA	44 dBA	39 dBA	27 dBA	26 dBA	26 dBA	37 dBA	39 dBA	37 dBA	44 dBA	37 dBA