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Wake Stone Triangle Quarry Expansion Acoustical Study

Prepared For:

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Table of Contents

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Executive Summary

A comprehensive environmental acoustical study was performed to evaluate noise potentially generated by the expansion of the Wake Stone Triangle Quarry located at 222 Star Lane in Cary, North Carolina. The quarry has been in operation since 1982. With approaching depletion of reserves in their existing pit (Pit 1), Wake Stone plans to expand to the adjacent RDUAA Odd Fellows Tract for opening of a second pit (Pit 2). Concern has been expressed for the possible noise consequences associated with the new pit expansion with respect to noise levels propagating through the adjacent William B. Umstead State Park (Umstead State Park).

In order to receive an expansion permit from the North Carolina Department of Environmental Quality (NCDEQ) Division of Energy Mineral and Land Resources (DEMLR), Wake Stone must demonstrate that noise from their new operations will not have a *"significantly adverse effect on the purposes of a publicly owned park, forest or recreation area"*.

To that end, this acoustical study was performed, taking into account the noise mitigation measures that Wake Stone has already publicly committed to install. The study was performed in accordance with the agreed and accepted methods described in *Wake Stone Noise Study Protocol* dated 9/2/20. Ambient and existing operational noise levels were measured throughout Umstead State Park, existing and future operational noise levels were modeled to compute the changes in noise level expected in the park, and the results were evaluated against commonly accepted definitions of significant noise impact, i.e. future noise levels should not increase by more than 10 decibels above existing noise levels.

The results of the acoustical study found that, under worst-case noise producing conditions, noise levels throughout Umstead State Park are expected to remain well below the 10-decibel relative increase limit definition. Thus, Wake Stone's expansion and operation of Pit 2 are <u>not</u> expected to cause a *significantly adverse* noise impact in the park. Some particular activities conducted in the new pit will be audible in portions of the park, just as they are today. However, future noise levels are expected to only increase by 0 to 3 decibels throughout the vast majority of the park.

The following report details the methodology, assumptions, noise measurement and modeling results, relevant criteria, findings and conclusions of the acoustical study.

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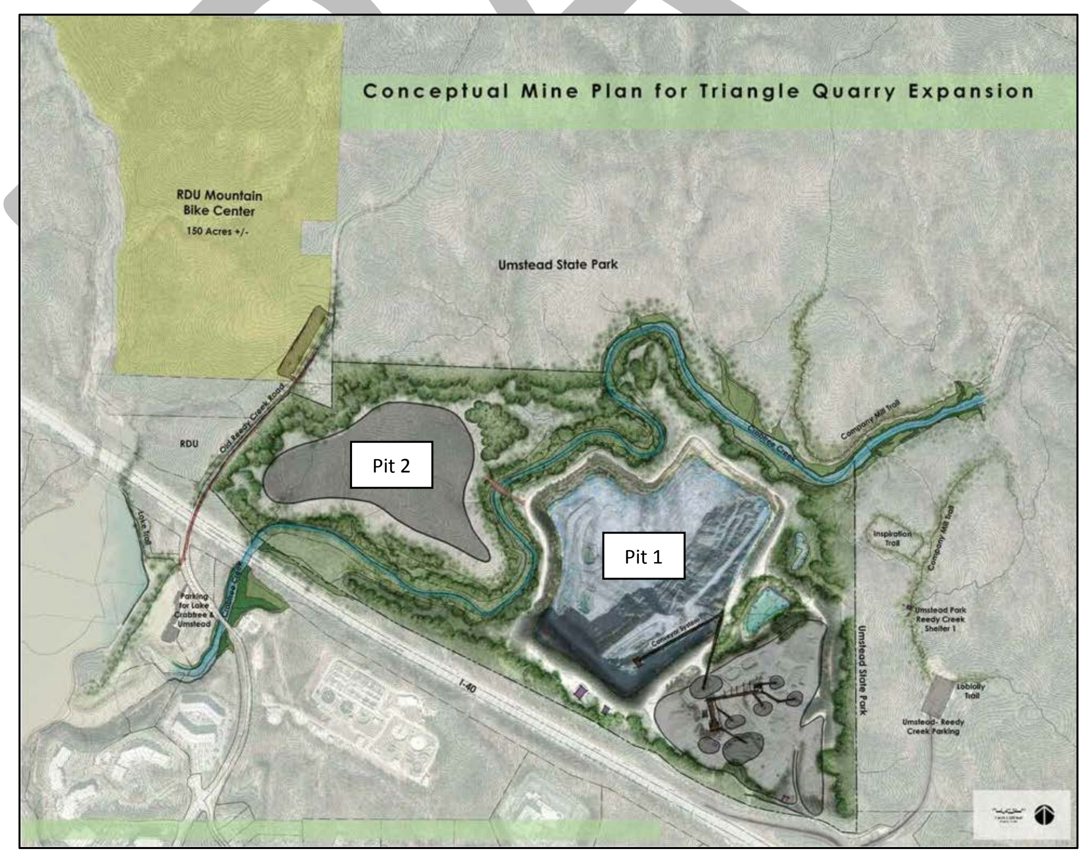
Project Description

Wake Stone Triangle Quarry is located at 222 Star Lane in Cary, North Carolina. The quarry has been in operation since 1982. With the approaching depletion of reserves in their existing pit (Pit 1), Wake Stone plans to develop a second pit (Pit 2) on the adjoining RDUAA Odd Fellows Tract, as shown in **Figure 1**. Concern has been expressed for the possible noise consequences associated with expansion of the new pit with respect to noise levels propagating through the adjacent Umstead State Park.

Once Pit 2 is approved for operation, the plan would include winding down and ceasing extraction operations in Pit 1 but to still make use of the surface equipment in its current location to process aggregate reserves excavated from Pit 2. Aggregate reserves in Pit 2 will be loosened using controlled blasting and then loaded in trucks for transport to the existing primary and secondary production plants. Thus in total, the only thing that's changing from a noise perspective is where the mobile noise sources will be located.

Typical heavy earth moving equipment currently used in Pit 1 and the existing plant and stockpile yard areas include bulldozers, backhoes, excavators, front end loaders, rock drills, rock crushers, feeders, vibrating screens, conveyors, haul trucks, graders, water trucks, pumps and man-lifts. Similar equipment will be used in Pit 2 also, with the exception of stationary equipment. Blasting is anticipated to be performed a couple times a week to loosen new material for excavation. Work hours are generally from 7 AM to 5 PM.

Figure 1. Wake Stone Triangle Quarry
Existing and Proposed Excavation Pits



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The Umstead State Park is a forest recreational area located immediately adjacent to the north and east of the Wake Stone Triangle Quarry. The area is a mature forest with approximately an even split between deciduous and conifer trees. Visitors have used the park since 1937 for hiking, bicycling, picnicking and seasonal camping. Various trails run through the park, with the majority of fixed sites (picnicking and camping) located relatively close to Wake Stone's existing facilities and operations in Pit 1. To that end, moving extraction operations to Pit 2 should be a noise benefit (i.e. reduction) for these picnic and camping sites. There is also one residence located along Old Reedy Creek Road immediately to the west of the new Pit 2 site at which noise levels would likely increase due to Pit 2 being located closer to the residence than exists today for Pit 1. Lastly, it should be noted that the park is bordered on the northwest by Raleigh Durham International Airport. Use of Runway 32-14 routes aircraft directly over Umstead State Park.

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Acoustical Terminology

As with any field of science, it is critical to understand and make proper use of technical terms and definitions that are used in the acoustical industry. Noise can be quantified in many different manners depending on its temporal/time, tonal/frequency, or magnitude/loudness properties.

Noise magnitude is expressed in units of ***decibels** (dB)* which is a logarithmic quantity comparing fluctuating air pressure to that of a standardized reference static air pressure of 20 micro-pascals (i.e. dB re: 20 µPa). For this reason the noise levels that humans hear are called *sound pressure levels*. Noise is expressed as a logarithmic quantity because humans are sensitive to relative changes in noise levels. To illustrate, humans can barely perceive a change in noise level of +/- 1 decibel, can likely perceive a change of +/- 3 decibels, can easily perceive a change of +/- 5 decibels, and will generally describe a change of +/- 10 decibels as a doubling or halving in level.

With respect to tonal qualities (frequency), a frequency weighting adjustment has been standardized to account for the human auditory response over the audible frequency range of approximately 20 Hz to 20,000 Hz. Humans are less capable of hearing low frequency sounds, exhibit a maximum sensitivity to tones in mid-frequency ranges, and are slightly less sensitive to high frequency sound as well. This frequency weighted adjustment is referred to as "A-weighting", with results expressed as ***A-weighted decibels**, or dBA.* Examples of A-weighted decibel levels for common outdoor and indoor noise sources are provided in **Figure 2**.

Another common practice is to separate a sample of noise into its spectral components by using frequency filters of known shape and bandwidth. This approach provides insights into the source and transmission characteristics of the noise and allows for identification of frequency ranges that contain the most acoustical energy. ***Octave band and third-octave band*** filters are typically used for this purpose because their bandwidths are a constant percentage of their center frequencies, and are better for mimicking how humans perceive discrete frequencies by providing finer resolution at lower frequencies.

Numerous metrics and indices have been developed to quantify the temporal characteristics (changes over time) of community noise that include the following:

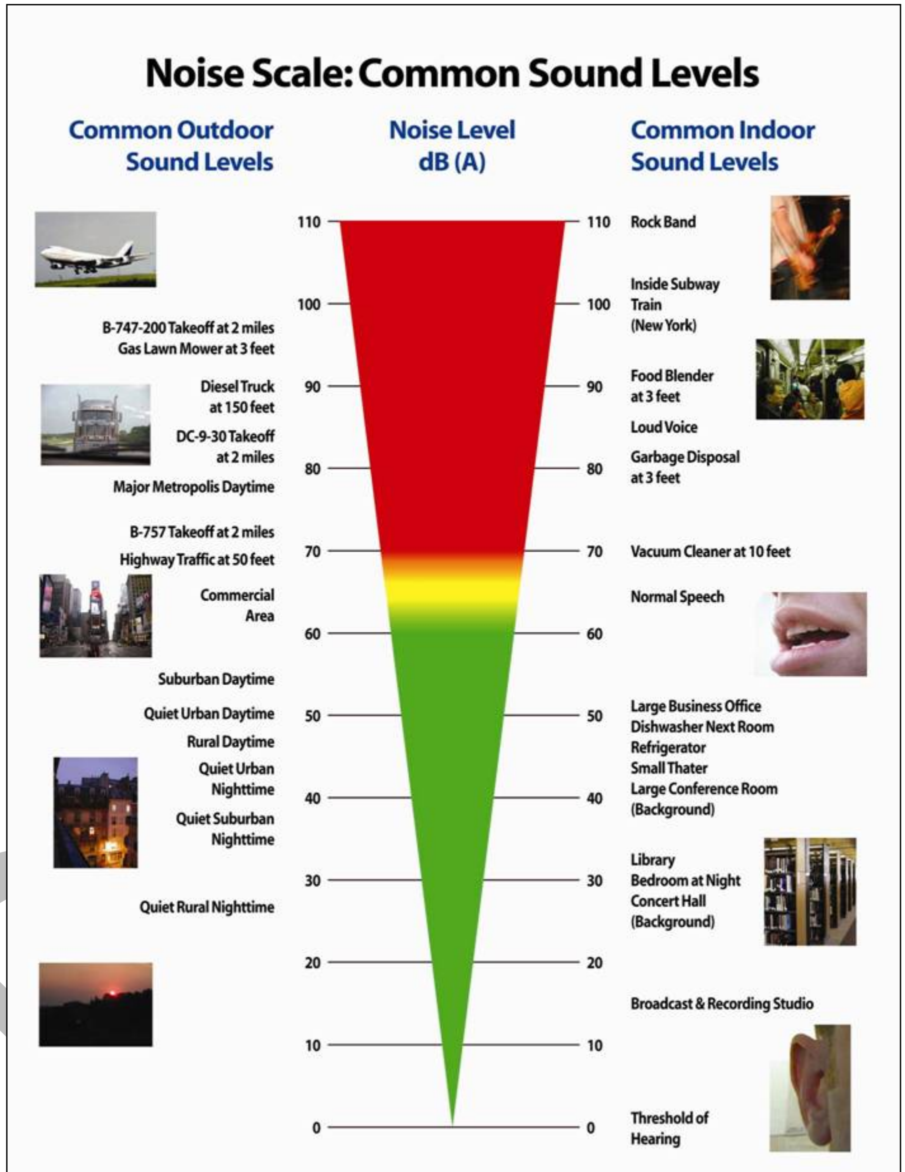
The ***Equivalent Sound Level**, or Leq*, is the energy-averaged single noise level that represents the same acoustic energy that was contained in the fluctuating noise level over a defined period of time. The Leq is useful for describing the "average" sound level over a defined period of time, and is expressed in dBA.

The ***Maximum and Minimum Sound Levels**, or Lmax and Lmin*, are the loudest and quietest instant sound levels occurring during a period of time. The Lmax is particularly useful for evaluating loud, impulsive noise events. Lmax and Lmin levels are expressed in dBA, however the root-mean-square (RMS) time constant of the sound level meter's detector has a significant effect on the measured levels. By International agreement, a sound level meter with an RMS response set to 'slow' (Lmaxs) has a rise time constant of 1 second, where a setting of 'fast' (Lmaxf) is about 8x faster with a rise time constant of only 0.125 seconds.

The ***Day Night Sound Level**, or Ldn*, is a 24-hour community noise metric in which a 10 decibel adjustment has been added to the measured hourly Leq levels from 10 PM to 7 AM to account for people's greater sensitivity to noise intrusion at night. The Ldn metric is used in many federal noise guidelines to assess the long-term effects of transportation sources.

The ***Sound Percentile Level**, or Ln*, expressed in dBA is a statistical representation of changing noise levels indicating that the fluctuating noise level was equal to, or greater than, the stated level for "n" percent of the time. For example, the L1, L10, L50, and L90 represent the noise levels exceeded 1%, 10%, 50%, and 90% of the time. The L10 is often used to identify impacts of transportation or construction noise sources, while the L90 is considered to represent steady background noise.

Figure 2. Common A-Weighted Decibel (dBA) Sound Levels



The ***Sound <u>Power</u> Level*** *(PWL)* of a noise source is the strength or intensity of noise that the source produces/emits regardless of the environment in which it is placed. Sound power is a property of the source, and therefore is independent of distance. The radiating sound power then produces a ***Sound <u>Pressure</u> Level*** *(SPL)* at any given point of interest which human beings perceive as audible sound. The sound pressure level is dependent on its environment (absorption, reflections, etc.) and its distance from the noise source. And even though both sound power and sound pressure are expressed in decibels (dB), they are not the same thing and should not be confused. Decibel levels of sound power are referenced to a power level of 1 pW, while decibel levels of sound pressure have a pressure reference level of 20 μPa.

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Regulatory Setting

According to the North Carolina Mining Act of 1971 administered by the North Carolina Department of Environmental Quality (NCDEQ) Division of Energy Mineral and Land Resources (DEMLR), Wake Stone must obtain a modification of their current Mining Permit in order to expand their operations. Wake Stone must demonstrate that noise from their new operations in Pit 2 will not have a *"significantly adverse effect on the purposes of a publicly owned park, forest or recreation area"*.

However, the Mining Act does not quantitatively define what is meant by *"significantly adverse effect"*. Thus, a task in this study involves research into the noise guidelines promulgated by other federal and state agencies with respect to noise impact for an outdoor park land-use. **Table 1** summarizes some of these other noise guidelines.

The natural soundscape is comprised of physical and biological sounds. Physical sound is created by wind, rivers, rock falls, etc., whereas biological sound is created by animals, birds and insects. Different habitats have specific soundscape characteristics depending on the climate, landscape and animal population. Evaluation of the level of impact on natural soundscape generated by human activity is dependent on the specific habitat in question.

The State of North Carolina does not regulate noise, so the responsibility is on the local governments. Noise ordinances of the counties where Wake Stone operations occur do not specifically mention noise criteria for parklands. In order to determine the noise criteria applicable for parklands, guidance documents published by various agencies were reviewed and the quantitative recommendations are summarized below.

Table 1. Various Noise Criteria for Parklands and Wilderness Areas

Guidance Source	Recommended Noise Criteria
US National Parks Services (NPS)	45 dBA L10 and 38 dBA L50
US Federal Highway Administration (FHWA)	57 to 67 dBA Leq(1hr)
US Federal Railroad/Transit Administrations (FRA/FTA)	+5 to +10 dBA Leq(h) above Ambient
US Federal Aviation Administration (FAA)	70 to 75 dBA Ldn
US Environmental Protection Agency (EPA)	70 dBA Leq(24hr) or 55 dBA Ldn
Federal Energy Regulatory Commission (FERC)	55 dBA Ldn and 49 dBA Leq
Federal Interagency Committee on Noise (FICON)	+5 dBA if Ambient is <60 dBA
	+3 dBA if Ambient is 60-65 dBA
	+2 dBA if Ambient is >65 dBA
World Health Organization (WHO)	50 to 55 dBA Leq
Washington State	55 dBA, 07:00AM to 10:00PM
	45 dBA, 10:00PM to 07:00AM
Minnesota State	65 dBA L10, 60 dBA L50, 07:00AM to 10:00PM
	55 dBA L10, 50 dBA L50, 10:00PM to 07:00AM

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The US National Parks Service (NPS) recommended noise criteria is mostly intended for non-metropolitan area national and state parks. Umstead State Park is located within an expanding metropolitan area. As such, stringent NPS recommended criteria of 45 dBA L10 and 38 dBA L50 is too conservative. The Federal Energy Regulatory Commission (FERC) guidance document *"Guidance Manual for Environmental Report Preparation, February 2017"* is intended for natural gas projects and pipelines. Section 4.9.2 of the FERC guidance document recommends a continuous noise level of 49 dBA Leq as criteria for Noise Sensitive Areas (NSA) which include parklands, campgrounds, and wilderness areas. This criteria can be adopted for quarry operations in proximity to parklands, however absolute noise level limits do not apply well in this situation given the fact that the Wake Stone Triangle Quarry has been in operation since 1982, and the location is in a metropolitan area surrounded by busy state and interstate highways. The focus should be placed on how much more noise might Wake Stone be producing in the future when Pit 2 is opened for operation.

As shown in the previous section, humans can barely perceive a change in noise level of +/- 1 decibel, can likely perceive a change of +/- 3 decibels, can easily perceive a change of +/- 5 decibels, and will generally describe a change of +/- 10 decibels as a doubling or halving in level. From this commonly accepted subjective response description, acousticians and regulatory agencies have generally agreed that a 10-decibel increase would represent a *significant noise impact*.

Moreover, the State of North Carolina Department of Transportation (NCDOT) has defined the term *substantial noise increase* in their Traffic Noise Policy dated 10/6/16. In it, a receptor is considered impacted by noise if the predicted future hourly Leq equivalent noise level exceeds the existing ambient Leq noise level by 10 decibels or more.

Consequently, this acoustical study has defined a *"significantly adverse effect"* as meaning a **10 decibel or more increase in future noise levels when compared to existing noise levels**.

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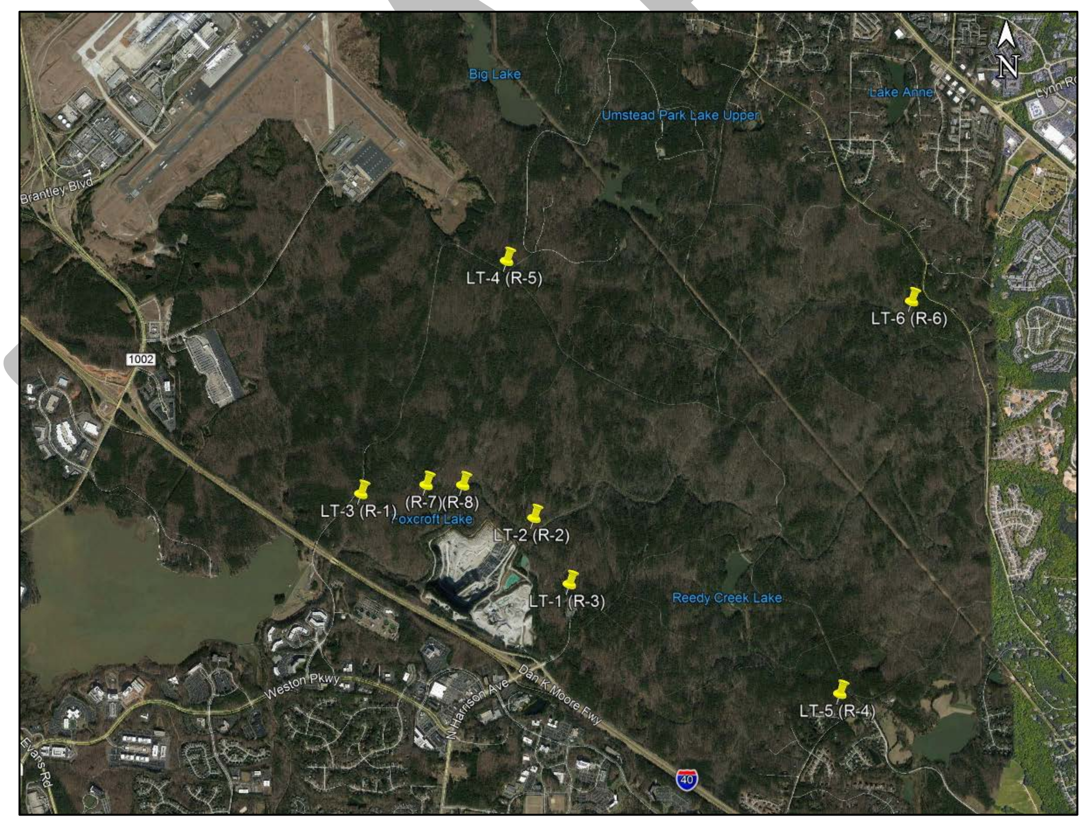
Existing Noise Measurements

Existing ambient noise measurements were performed in and around Umstead State Park from 11/16/20 to 11/23/20 and again from 12/7/20 to 12/14/20. Long-term noise measurements lasting a week were performed at the six monitoring locations (LT-#) shown in **Figure 3**. The purpose of the long-term noise measurements were two fold, (1) to document actual existing noise conditions at selected locations throughout the park, and (2) to serve as a measured noise level against which modeled existing noise levels could be compared to ensure the model was performing as expected.

Larson Davis Model 720 (LD-720) environmental noise monitors were used to measure the long-term noise data. The monitors were checked for proper calibration before and after use using a Bruel & Kjaer Model 4231 acoustical calibrator. As such, the noise monitoring system met or exceeded the accuracy requirements found in ANSI Standard S1.4 for Type 2 quality. The monitors were deployed in trees at the respective sites and the microphones were covered with windscreens. Noise data was digitally stored in hourly intervals with noise metrics including Leq, Lmax, Lmin, L1, L10, L50 and L90 sound levels. All sound levels were expressed in A-weighted decibels (dBA) using an RMS 'slow' response.

Figure 3. Long-Term Ambient Noise Monitoring Sites



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The averaged results of the long-term noise monitoring data are summarized in **Table 2** for the hours of 7:00 AM to 5:00 PM during which time Wake Stone is typically operating. Three scenarios are provided, (1) time periods when the quarry was in full production mode, (2) periods when the quarry was on a reduced work schedule performing mostly maintenance activities, and (3) Sunday periods when no work was being performed.

The results in the table indicate that noise produced by existing operations in Pit 1 may be audible throughout the park but only to a minor degree when compared to the relatively low noise produced during maintenance periods. Interpreting results relative to no work periods is difficult because all transportation and community noise sources are less noisy on Sundays.

Table 2. Measured Leq Noise Levels During Work Hours

Site No.	Location in Umstead State Park	Measured Leq (7AM - 5PM) dBA			Difference vs. Production dB	
		Production	Main-tenance	Sunday No Work	Main-tenance	Sunday No Work
LT-1	Picnic Grounds	53	51	48	-2	-5
LT-2	Company Mill Trail	50	49	46	-1	-5
LT-3	Residence Property Line	55	57	53	1	-3
LT-4	Mid Gate	52	48	45	-3	-6
LT-5	Trenton Road Gate	51	49	46	-2	-5
LT-6	Sendero Gate	47	43	43	-4	-4

Note: Sound levels rounded to the nearest full decibel.

The results of the six long-term noise monitors are shown in **Figures 4 thru 9**. The data collected over the week was reduced by averaging the results of each corresponding hour during the week. Thus the results yield typical hourly noise levels that can be expected at each monitoring location. The blue dot is the computed Ldn level and the average Lmax, Leq, and L10 and L90 percentile levels are shown for each hour. The Lmax level could have been caused by any loud event such as a nearby bird chirp, crow call, aircraft, or noise produced by Wake Stone's operations. The Leq, L10 and L90 results are more indicative of constant noise levels throughout the park. The effects of morning and evening commuter traffic (i.e. rush hour) is evident centered around 7:00 AM and 5:00 PM, respectively. More notably, the L10 levels at all sites are already well above the National Park Service's recommended noise guideline of 45 dBA L10 at all times of day and night regardless of Wake Stone's operations.

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Figure 4. Long-Term Ambient Noise Levels for Site LT-1

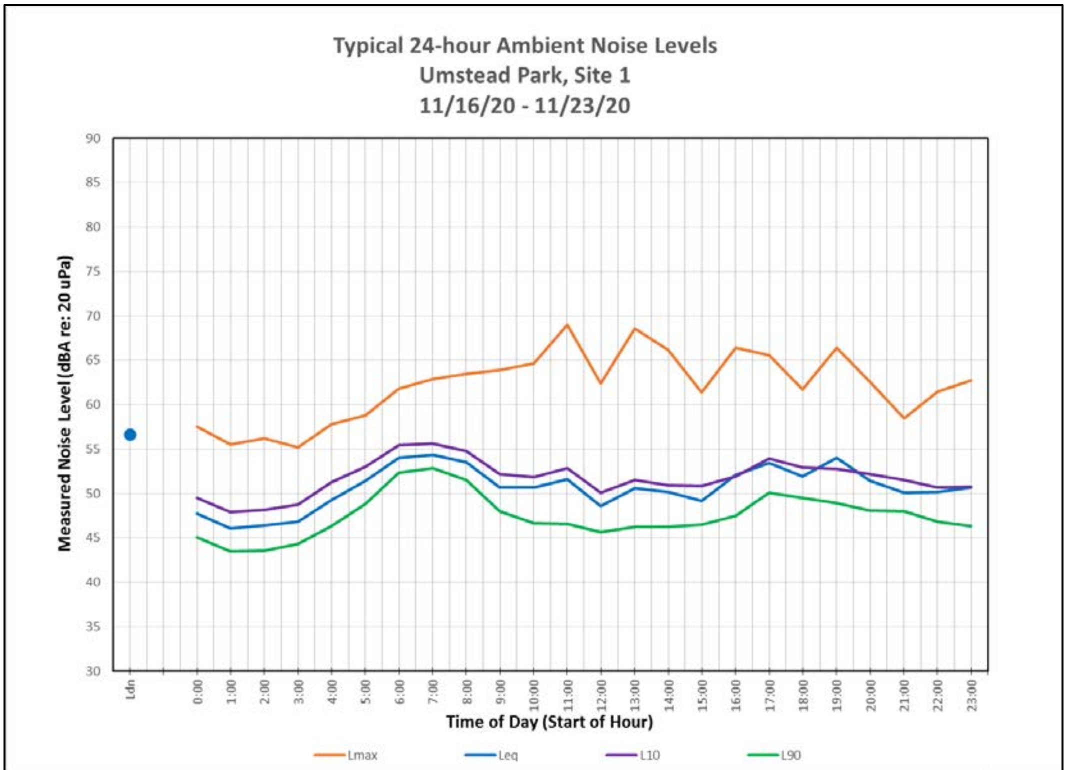


Figure 5. Long-Term Ambient Noise Levels for Site LT-2

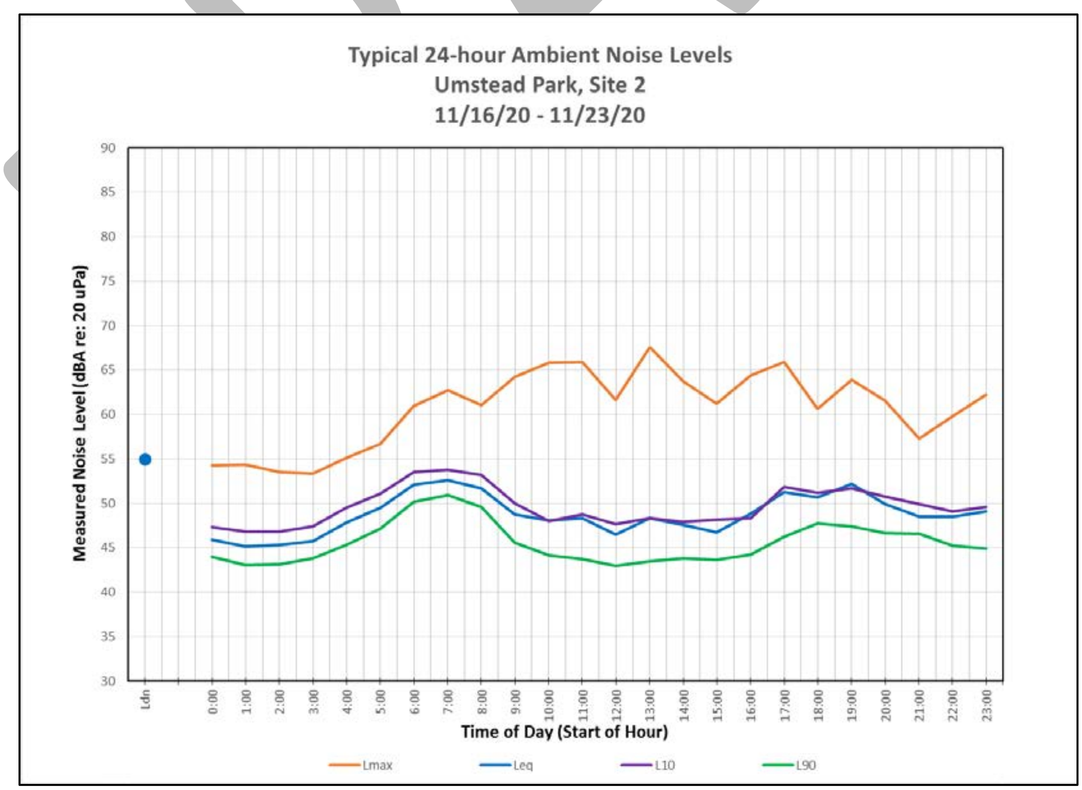


Figure 6. Long-Term Ambient Noise Levels for Site LT-3

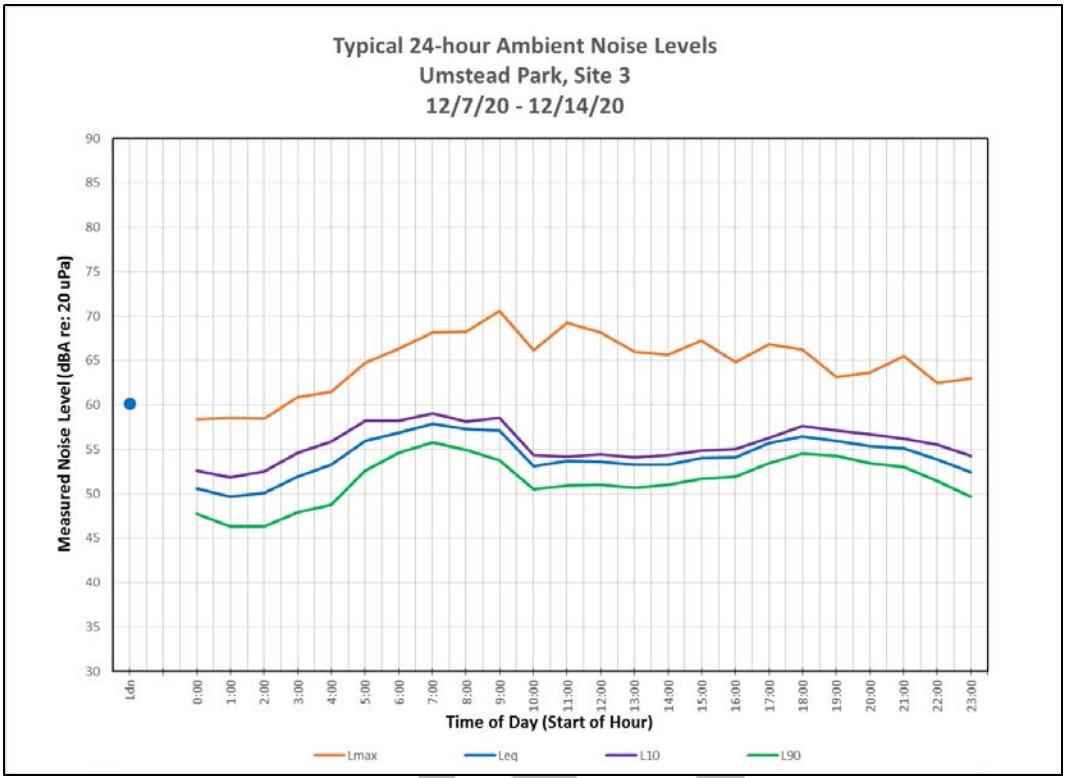


Figure 7. Long-Term Ambient Noise Levels for Site LT-4

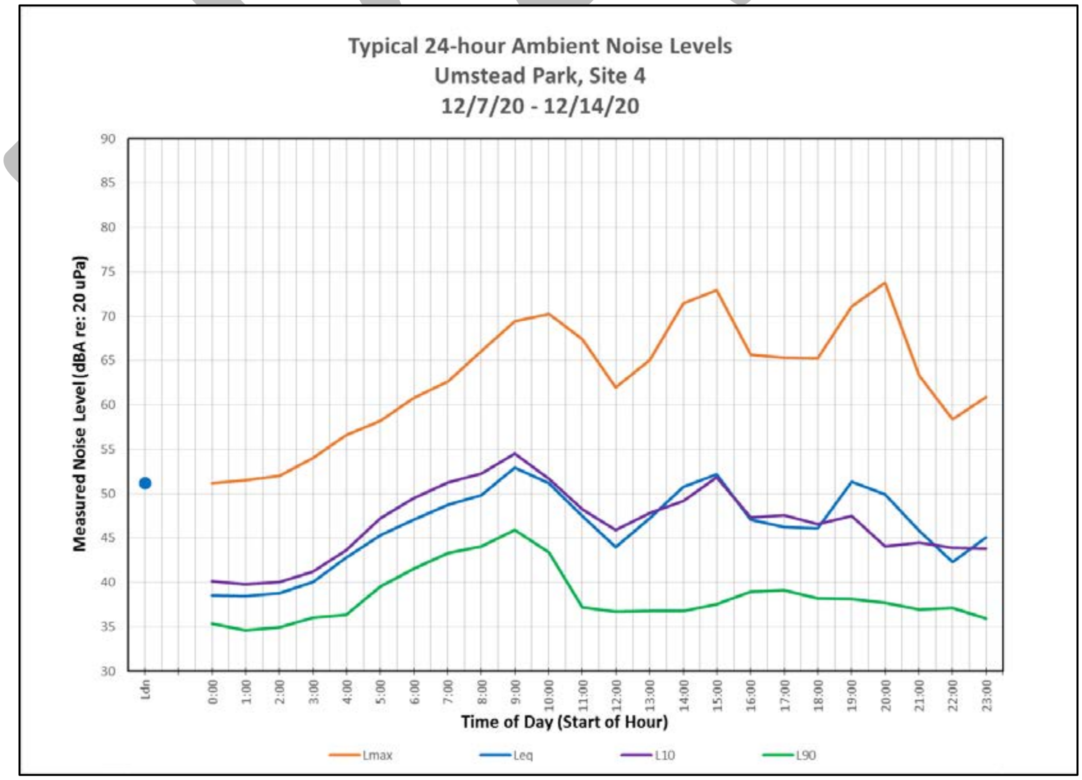


Figure 8. Long-Term Ambient Noise Levels for Site LT-5

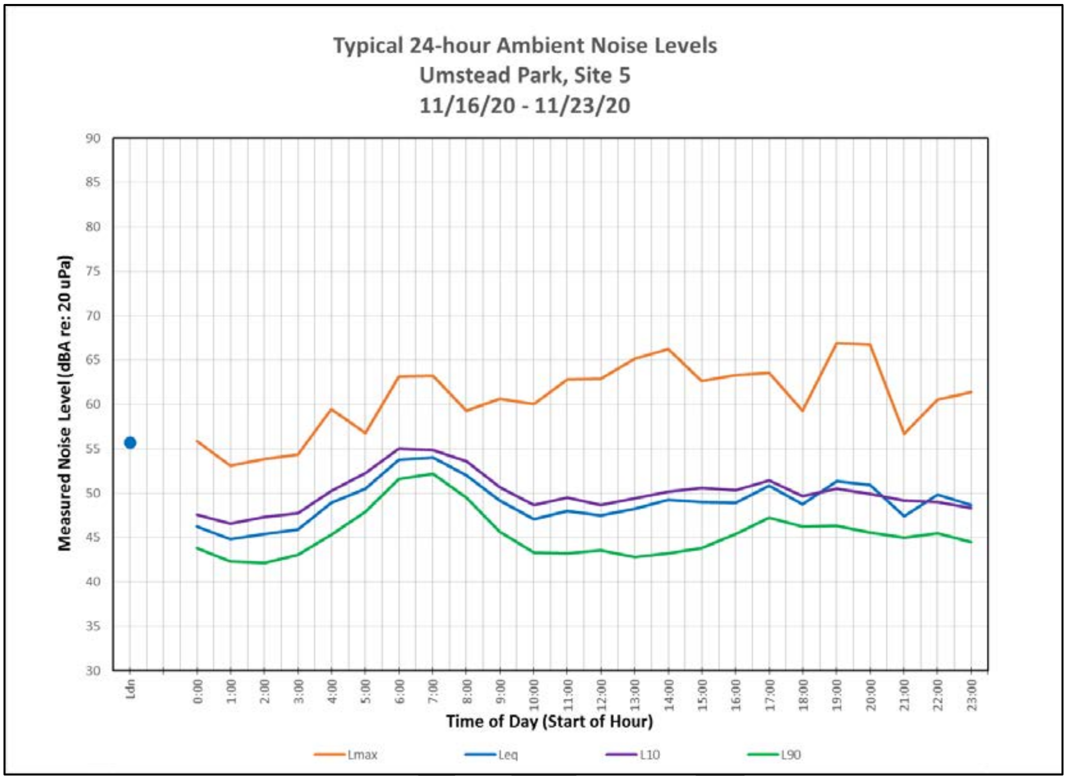
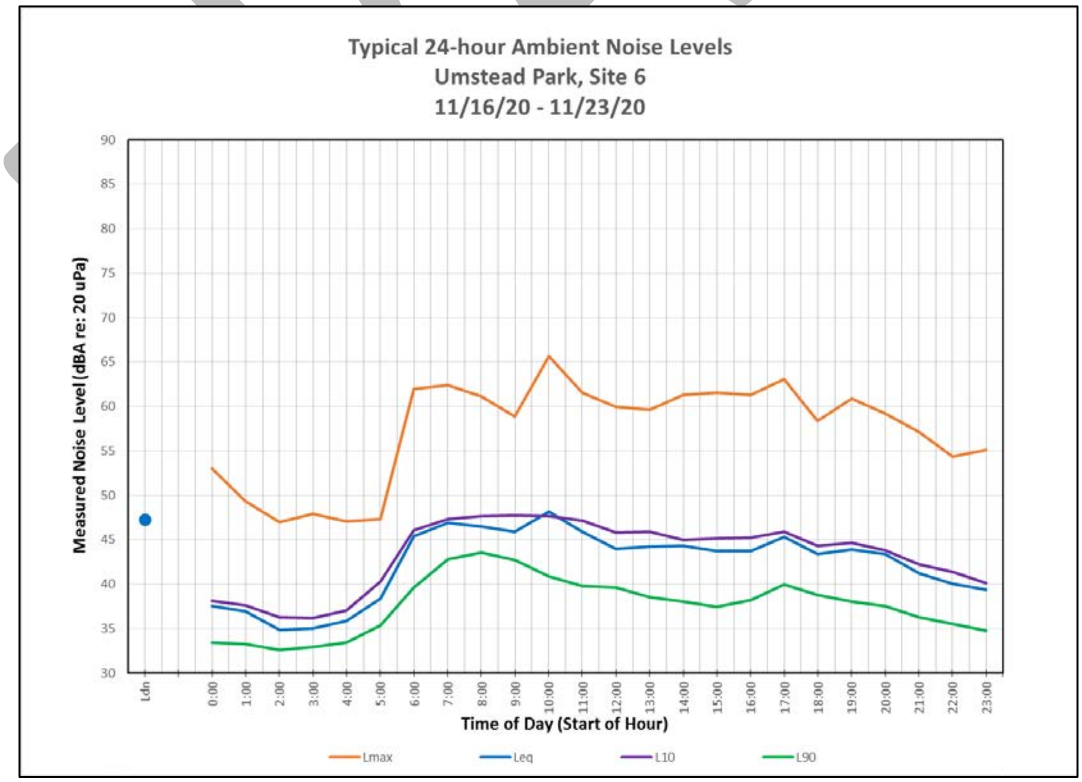


Figure 9. Long-Term Ambient Noise Levels for Site LT-6



In addition to long-term monitoring, short-term noise measurements, lasting 15 minutes, were also manually performed at four selected sites in Umstead State Park during the weeks of 11/16/20 to 11/23/20 and 12/7/20 to 12/14/20. A Svantek Model 971 (SV-971) sound level meter was used for these measurements, which meets the requirements for ANSI Standard S1.4 for Type 1 accuracy. The purpose of the short-term noise measurements was to positively identify and correlate audible noise sources with the sound levels being measured. This was particularly important to perform during the production blasts occurring during the monitoring periods.

Short-term noise data was collected during full quarry operation with blasting in the morning and the afternoon, full quarry operation with no blasting in the morning, reduced quarry operation maintenance day in the afternoon, and in the morning with the plant closed. A summary of the short-term noise data results are shown in **Table 3**.

While in Umstead State Park, noticeable noise sources included traffic noise from local roads, overhead aircraft and helicopter noise from RDU airport, and typical nature noise, such as running water, rustling leaves, birds, and insects. At monitoring locations closest to the quarry, noise levels between the quarry and I-40 were nearly indistinguishable, except for the backup alarms from equipment operating in the quarry. During blasting, warning sirens employed prior to the blast could be heard from inside Umstead State Park. The blast, which only occurs for a fraction of a second, was noticeable by ear and could be felt as well as being heard. A final siren followed the blast for about one minute.

Table 3. Short-Term Noise Measurements Results

Site No.	Site Location	Measured Short-Term Noise Level		
		L10 dBA	Leq dBA	L90 dBA
ST-7	Foxcraft Lake	47	45	42
ST-8	Entrance Gate Trail	46	44	41
ST-9	I-40 & Old Reedy Creek Road	71	70	68
ST-10	Campgrounds	43	42	38

Note: Sound levels rounded to the nearest full decibel.

The measurement data was later reviewed to identify and isolate the blast event that occurred during short-term measurements at sites ST-7 and ST-8 on 11/18/20 at 13:40. The sound level data was stored in 1-second intervals and an audio wavefile was recorded throughout the measurement. The recorded wavefiles were listened to while simultaneously viewing the measured noise data in order to audibly identify the 1-second interval where the maximum sound level from the blast occurred. The noise level during the blast was 59 dBA at Site ST-7 and 47 dBA at Site ST-8. The measured blast sound level was later also used to estimate the sound power emission of the blast for use in the noise model.

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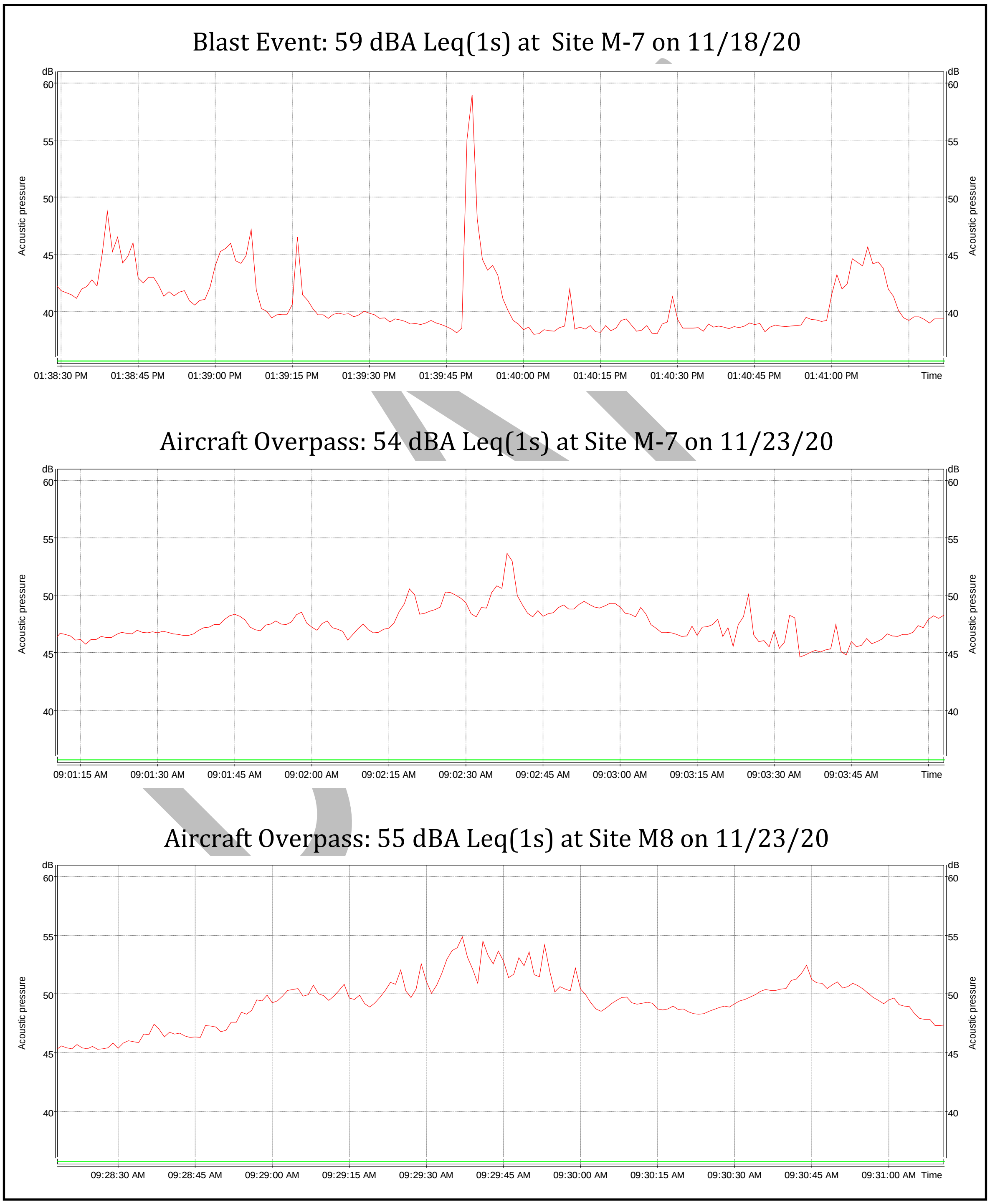
Further analysis was conducted by comparing the noise produced by the blast event to that of other common environmental sound sources of comparable loudness captured during the 15-minute short-term noise measurements. In this case, as shown in **Figure 10**, two aircraft overpasses were identified as being within 5 decibels of the blast noise level. The vertical axes of the charts are the same scale for ease in visual comparison.

Figure 10. Comparison of Blast Noise Level to Other Noise Sources



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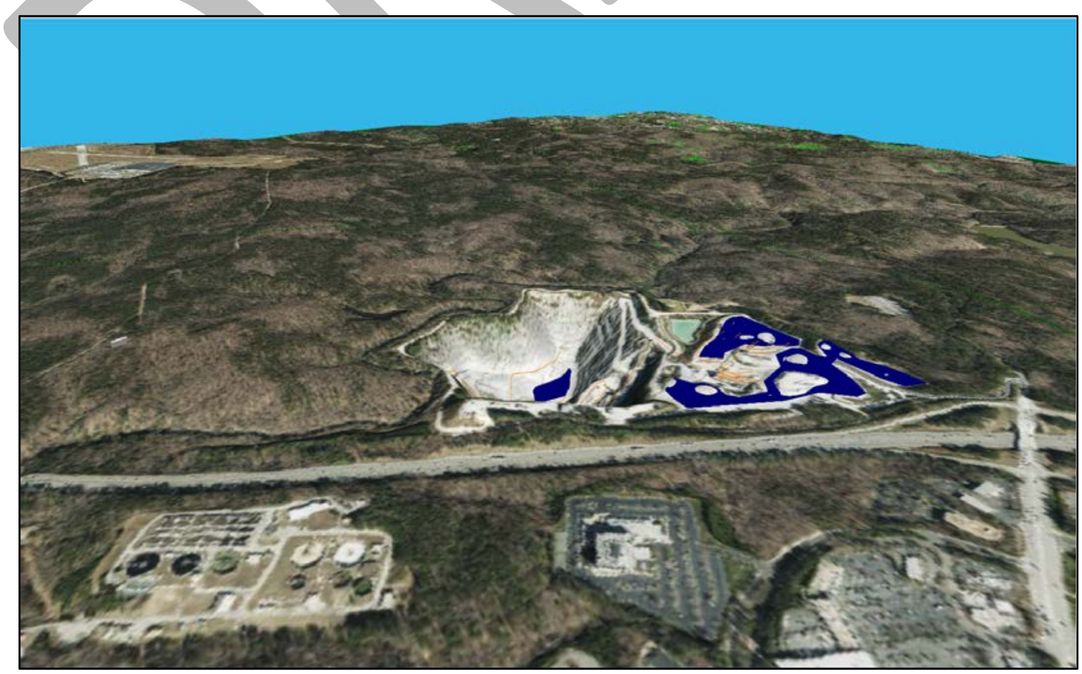
Noise Prediction Model

Noise levels associated with operation of the existing quarry (Pit 1) and future quarry (Pit 2) were predicted using the Cadna-A® noise model, developed by DataKustik, GmbH. The Cadna-A model implements ISO Standard 9613 for environmental noise sources and outdoor sound propagation. It is a comprehensive, three-dimensional, ray-tracing model in which noise sources are assembled from point, line and/or area components each emitting sound power levels (PWL) in octave bands or broadband A-weighted format. Distance losses, elevation differences, ground attenuation, wind effects, building shielding, attenuation through walls, and barrier/berm effects are computed in the Cadna-A model, and the resulting sound pressure levels (SPL) are predicted at any number of receptors of interest. As is standard practice, all receptors were modeled at a height of 5 feet above the ground.

As shown in **Figure 11**, the Cadna-A base model for the project was developed by importing geo-referenced aerial imagery along with topographic contour data in 2-foot intervals. The topographic contour data was provided by Wake Stone for the quarry areas and current North Carolina One-Map Lidar data was used for the surrounding regions of the study area.

Conservative worst-case noise assumptions were used in populating the model. For example, all noise-producing equipment was assumed to be operating simultaneously. A ground factor of G=1.0 for soft ground was set as the default for the model. Specific areas with different ground types were then defined, including the quarry site with G=0.5 for mixed hard and soft ground, and water and paved areas with G=0.0 for hard ground. To represent worst-case noise conditions during winter when leaves would be off trees, areas with foliage were not included in the Cadna-A model. And it should be noted that per ISO 9613, a "favorable wind condition" was assumed in the model in which a mild wind blows towards each receptor regardless of where the noise sources are located.

Figure 11. Perspective View of Cadna-A Noise Model (Looking Northeast)



The Cadna-A base model was then configured to estimate noise levels generated by the quarry operations for the following conditions:

- **Existing Production –** includes the current production activities in Pit 1, hauling of rock to the primary crusher, and typical crushing, plant and yard operations.

- **Future Overburden Clearing –** includes clearing of overburden at the expansion Pit 2 and hauling of overburden across the proposed Crabtree Creek Bridge to the overburden storage area on the west side of Pit 1. This condition also includes the same typical crushing, plant and yard operations as the Existing Production condition.

- **Future Production –** includes production at the expansion Pit 2 and hauling of rock across the proposed Crabtree Creek Bridge around the north side of the existing Pit 1 to the primary crusher. This condition also includes the same typical crushing, plant and yard operations as the Existing Production condition. The Future Production condition was further divided into four scenarios (280-ft, 266-ft, 210-ft and 160-ft) based on the elevation of projected working benches in the expansion Pit 2. These scenarios were modeled individually to represent how the production work will decrease in elevation over time as the new pit is excavated. It should be noted that worst-case noise producing condition occurs when equipment is operating at grade, i.e. Future Production at 280 feet.

For each of these conditions, noise levels generated by the quarry were estimated for a typical hour of operations with all equipment operating. Noise model inputs included:

- The locations of existing and future production areas where mobile equipment would be operating, haul truck routes, customer truck routes, and locations of the primary and stationary crushers, conveyors, plant and yard equipment.

- Sound power levels of mobile equipment were primarily derived from noise emission measurements taken during Wake Stone quarry operations. For stationary processing plant equipment (crushers, screens, and conveyors), sound power levels were estimated based on a review of technical literature for similar equipment. For mobile heavy equipment sound power emission levels were taken from the FHWA's Roadway Construction Noise Model (RCNM).

- The estimated number of hours per week, obtained from Wake Stone, that each piece of mobile and stationary equipment is used during a typical 50-hour work week was used to calculate a usage factor representing the percentage of time each piece of equipment is operating during a typical hour of production. The equipment-specific usage factors were then applied as an adjustment to the equipment sound power levels within the Cadna-A model.

- For the future overburden clearing and production scenarios, proposed terrain contour lines in 2-foot intervals for the expansion Pit 2, widening of haul roads, and the new bridge over Crabtree Creek were also included.

- For the future overburden clearing and production scenarios, two noise mitigation measures that Wake Stone has already committed to were included in the noise model:

    1. An approximately 15-ft tall earthen berm on the north and west sides of the expansion Pit 2.

    2. An approximately 14-ft tall noise wall to the north of the haul road along the north side of the existing Pit 1.

Noise Model Results

Once the Cadna-A model was fully populated, it was allowed to run to compute resulting sound levels for the various quarry operating conditions at eight discrete receptor locations (R-#) in Umstead State Park as shown in **Figure 3**. Six of the receptors were selected to correspond with the long-term noise monitoring sites, and another two receptors were added in response to requests from DEMLR. The results are summarized in **Table 4** and are expressed as typical hourly equivalent sound levels (Leq(1hr)) in A-weighted decibels (dBA). Again, the results shown in the table represent realistic worst-case conditions that assume all quarry equipment is running simultaneously.

As can be seen in **Table 4**, sound levels from future Pit 2 operations are expected to range from 31 to 55 dBA Leq(1hr) across all eight discrete receptor locations in Umstead State Park. Naturally, the louder sound levels will occur closer to the quarry work, and the quieter sound levels will occur farther away. This range of anticipated sound levels compares very closely with the sound levels produced by existing quarry operations in Pit 1 which range from 31 to 52 dBA Leq(1hr).

The results in **Table 4** for receptors R-2 and R-3 are of particular significance from the point of view of ensuring that the Cadna-A noise model is calculating correct noise levels. Receptors R-2 and R-3 are the closest to Wake Stone's existing work in Pit 1. As such, it would be reasonable to expect that the measured and modeled noise levels at these two receptors should match relatively closely. As can be seen, the model is nearly perfectly calibrated with the measured noise results for existing noise during production hours. Thus, the model can be relied upon to predict accurate future noise levels as well.

Table 4. Predicted Existing and Future Sound Levels for Quarry Operations

Receptor	Measured	Predicted Average Hourly Noise Level, dBA Leq(1hr)						
	Existing Production dBA Leq	Existing Quarry	Overburden Stripping	Production 280 ft	Production 266 ft	Production 210 ft	Production 160 ft	Existing I-40 Traffic
R-1: Residence Property Line	LT-3: 55	46	49	49	48	47	46	58
R-2: Company Mill Trail	LT-2: 50	50	51	52	52	52	52	38
R-3: Picnic Area	LT-1: 53	52	52	52	52	52	52	50
R-4: Residences	LT-5: 51	35	35	35	35	35	35	47
R-5: Reedy Creek Park Trail	LT-4: 52	37	38	39	39	38	38	39
R-6: North Turkey Creek Trail	LT-6: 47	31	31	31	31	31	31	29
R-7: Foxcroft Lake	N/A	50	55	53	53	52	52	45
R-8: Crabtree Creek	N/A	48	49	50	50	50	50	38

Note: Sound levels rounded to the nearest full decibel.

Table 4 also shows the predicted sound level attributable solely to traffic on I-40. These results are shown only for comparative purposes and have no bearing on the current noise analysis. The traffic noise levels were not measured; they were computed using the Cadna-A model by imputing traffic volumes, fleet mixes (i.e. trucks and cars) and speeds noted during the field measurements.

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Of more importance for the intent and goal of this study, the results in **Table 5** show the noise delta increase (+) or decrease (-) for future Pit 2 operations relative to existing sound levels produced by Pit 1 operations. As can be seen, once the overburden has been cleared, none of the receptors are expected to be exposed to a noise increase greater than 3 decibels during all phases of production for Pit 2. In fact, the majority of receptors will not experience an increase of more than 1 decibel. For perspective, such minor noise level increases are typically considered to be trivial and insignificant from an acoustical engineering perspective.

During the overburden stripping phase, future sound levels will be no louder than what is expected during the various production phases except at receptor R-7 Foxcraft Lake which might experience a temporary 4 decibel increase.

Consequently, it can be concluded that noise levels associated with Wake Stone's future operations involving Pit 2 are expected to remain well below the selected 10-decibel increase criterion, and **thus will <u>not</u> pose a *"significantly adverse [noise] effect on the purposes of a publicly owned park, forest or recreation area [in Umstead State Park]"*.**

Table 5. Expected Differences in Sound Levels for Quarry Operations

Receptor	Predicted Future re: Existing Noise Level Delta, dB					
	Overburden Stripping	Production 280 ft	Production 266 ft	Production 210 ft	Production 160 ft	Production 280 ft vs I-40 Traffic
R-1: Residence Property Line	3	3	2	1	1	-10
R-2: Company Mill Trail	0	2	2	2	2	14
R-3: Picnic Area	0	0	0	0	0	2
R-4: Residences	0	1	1	0	0	-12
R-5: Reedy Creek Park Trail	1	1	1	1	1	-1
R-6: North Turkey Creek Trail	0	1	1	1	1	2
R-7: Foxcroft Lake	4	3	3	2	2	8
R-8: Crabtree Creek	1	2	2	2	2	12

Note: Sound levels rounded to the nearest full decibel.

Blasting Noise

Concern over blasting noise affecting Umstead State Park has garnered significant attention during this process. To be clear, controlled blasting occurs now in existing Pit 1. Future blasting in expansion Pit 2 would be very similar in terms of noise event magnitude and occurrence (i.e. only a couple times per week). Warning sirens will continue to be used as they are today.

To evaluate the significance of blasting noise, the same Cadna-A model was used to predict sound levels in Umstead State Park attributable solely to a typical blast event. Sound power data to model the blast was back-calculated from the short-term noise measurements performed in the park during monitoring period blasts, as shown in **Figure 10**. The results, as summarized in **Table 6**, were then computed for the maximum sound level (Lmax) expected during a blast event expressed in A-weighted decibels (dBA) using an RMS 'slow' time response. The 'slow' time response was selected to be consistent and allow comparison with many of the other park noise criteria presented in **Table 1**.

As can be seen in **Table 6**, sound levels from blasting in future Pit 2 are expected to range from 44 to 73 dBA Lmax across all eight discrete receptor locations in Umstead State Park. Naturally, the louder sound levels will occur closer to the quarry work, and the quieter sound levels will occur farther away. This range of anticipated sound levels compares similarly with the sound levels produced by existing blasting operations in Pit 1 which range from 38 to 57 dBA Lmax. *It is important to note that sound levels on these orders of magnitude do <u>not</u> represent a concern for inducing hearing damage in anyone exposed to them.*

Table 6. Predicted Existing and Future Sound Levels from Blasting

Receptor	Predicted Blasting Noise Level, dBA Lmax slow						
	Existing Quarry	Overburden Stripping	Production 280 ft	Production 266 ft	Production 210 ft	Production 160 ft	Existing I-40 Traffic
R-1: Residence Property Line	51	N/A	73	72	69	67	58
R-2: Company Mill Trail	57	N/A	64	63	59	53	38
R-3: Picnic Area	52	N/A	60	61	60	60	50
R-4: Residences	38	N/A	47	48	47	47	47
R-5: Reedy Creek Park Trail	42	N/A	54	53	51	47	39
R-6: North Turkey Creek Trail	41	N/A	44	44	44	44	29
R-7: Foxcroft Lake	54	N/A	71	69	64	62	45
R-8: Crabtree Creek	57	N/A	64	63	59	57	38

Note: Sound levels rounded to the nearest full decibel.
Blasting is not expected to be needed during removal of overburden.
Blasting noise data shown for information only – not used for noise compliance purposes.

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The results in **Table 7** show the noise delta increase (+) or decrease (-) for future Pit 2 blasting events relative to existing sound levels produced by Pit 1 blasting events. As can be seen, blasting noise levels will remain readily audible throughout Umstead State Park but will reduce somewhat as the floor elevation of Pit 2 decreases. The loudest increase in blasting noise levels are expected near receptor R1 on the west side of the new quarry Pit 2. This is simply attributable to Pit 2 being physically much closer to receptor R1 than Pit 1 is today. There will be some noise reduction shielding provided by the 15-foot earthen berm that Wake Stone has committed to erect along the property boundary with receptor R1.

Thus, even though future blasting noise will be louder in some locations, it should not be used as a measure for compliance with the 10-decibel increase criterion due to how infrequently blasting will occur and the short impulsive nature of the blasting event.

Table 7. Expected Differences in Sound Levels for Blasting Events

Receptor	Predicted Future re: Existing Blasting Noise Level Delta, dB					
	Overburden Stripping	Production 280 ft	Production 266 ft	Production 210 ft	Production 160 ft	Production 280 ft vs I-40 Traffic
R-1: Residence Property Line	N/A	22	21	19	17	14
R-2: Company Mill Trail	N/A	6	6	2	-4	25
R-3: Picnic Area	N/A	9	9	8	8	10
R-4: Residences	N/A	9	9	9	9	0
R-5: Reedy Creek Park Trail	N/A	11	11	8	5	14
R-6: North Turkey Creek Trail	N/A	4	4	4	4	16
R-7: Foxcroft Lake	N/A	17	15	10	8	26
R-8: Crabtree Creek	N/A	7	6	2	0	25

Note: Sound levels rounded to the nearest full decibel.
Blasting is not expected to be needed during removal of overburden.
Blasting noise data shown for information only – not used for noise compliance purposes.

Backup Alarms

While not assessed as part of this study's noise modeling, loud pure-tone backup alarms are typically the number one source of noise complaints from the public at any construction site. To this end, Wake Stone will replace the standard backup alarms on their equipment with either manually-adjustable or ambient-sensitive models. These quieter backup alarms produce tone levels approximately 20 decibels quieter (i.e. about a quarter as loud) compared to a standard backup alarm.

An even more attractive backup alarm from a community noise perspective is one such as the BBS-TEK Series of backup alarms manufactured by Brigade Electronics https://brigade-electronics.com/products/reversing-and-warning-alarms/ (or equivalent). These alarms produce a much less annoying broadband "white noise" sound rather than a pure-tone.

Wake Stone will evaluate the suitability of the various quieter backup alarms based on safety, cost and effectiveness and install them as needed.

Sound Isopleth Contours

The Cadna-A model is also capable of producing sound isopleth contour lines of equal loudness. **Figure 12** illustrates the sound contour lines for the existing condition, i.e. operations occurring in Pit 1. Similarly, **Figure 13** shows the sound contour lines for the worst-case future noise condition, i.e. production occurring in Pit 2 at the surface elevation of 280 feet. The contours are drawn in 1-decibel increments with a color change occurring every 5 decibels. The purple dashed line around the outside shows the extents of Umstead State Park and the area within which the sound contours were computed.

Careful examination of the two figures shows how noise produced by Wake Stone's operations emanates from the pits, interacts with the surrounding topography, and propagates with varying efficiency in various directions. Interpolation between the contour lines allows for the estimation of quarry sound levels at any point of interest within Umstead State Park.

Lastly, **Figure 14** shows isopleth contour areas for the delta or difference between the sound levels produced in the existing versus future quarry operating conditions. As can be seen in the three shades of green, the vast majority of Umstead State Park is expected to experience a noise increase of less than 3 decibels due to Wake Stone's operations expanding from Pit 1 to Pit 2. In fact, more than half of the park will experience an increase of less than 1 decibel.

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Conclusions

A comprehensive acoustical study was performed for the Wake Stone Triangle Quarry to evaluate the potential for expanded operational noise produced in the future to impact outdoor recreation areas in the adjacent Umstead State Park. Various noise guidelines were considered, existing noise levels were measured, and existing and future noise levels were modeled. The results indicate that operating noise from the future Pit 2 will only increase noise levels throughout the vast majority of Umstead State Park by less than 3 decibels; well below the recognized definition for a substantial noise increase impact of 10 decibels. Thus, it can be concluded that expansion of Wake Stone's operations into Pit 2 will <u>not</u> pose a *"significantly adverse [noise] effect on the purposes of a publicly owned park, forest or recreation area [in Umstead State Park]"*.

Professional Certification

I hereby certify that this plan, specification, or report was prepared or reviewed by me and that I am a duly certified acoustical professional as recognized by the Institute for Noise Control Engineering (INCE).


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Figure 12. Isopleth Sound Contours for the Existing Condition

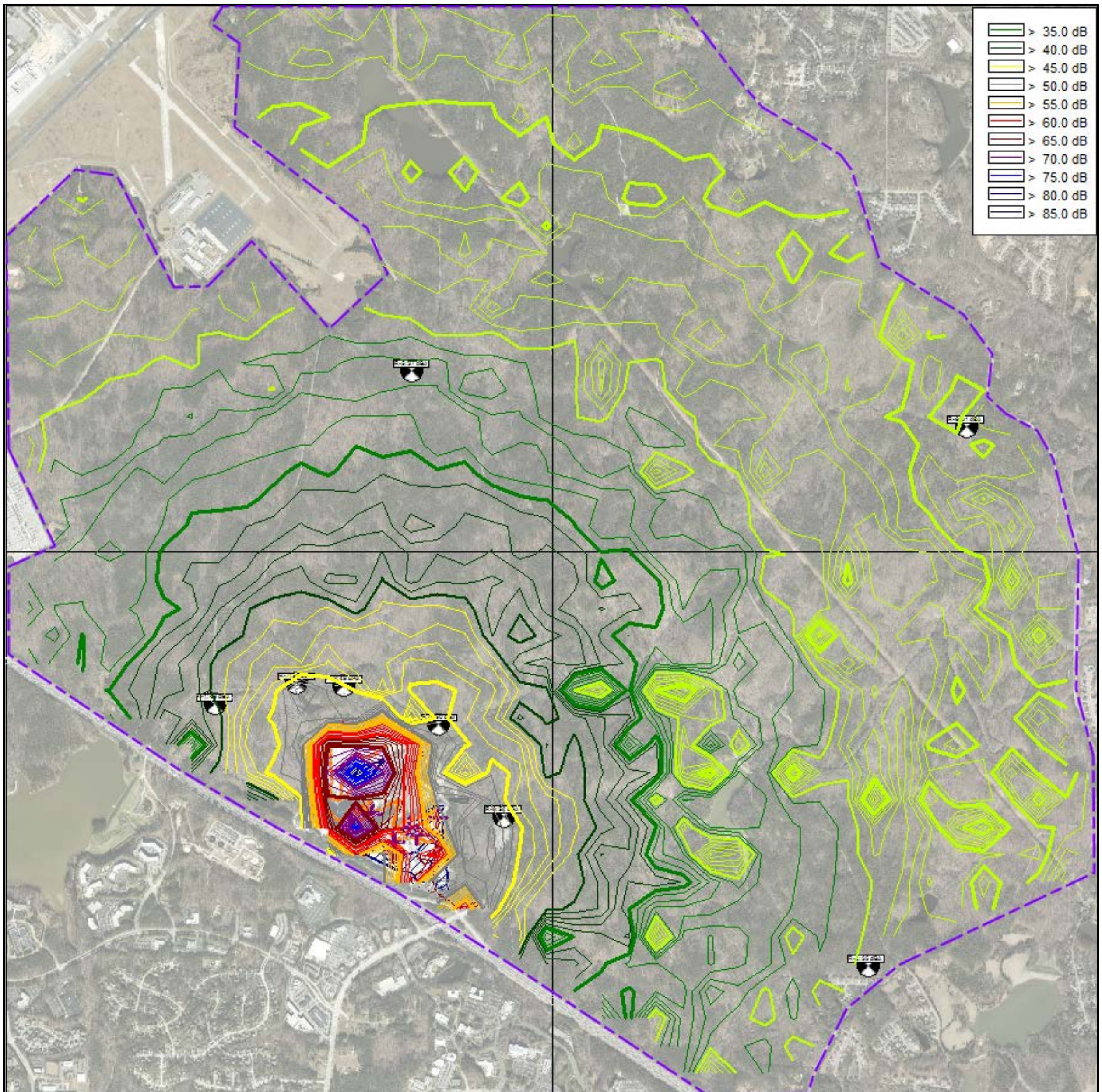

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Figure 13. Isopleth Sound Contours for the Future Condition

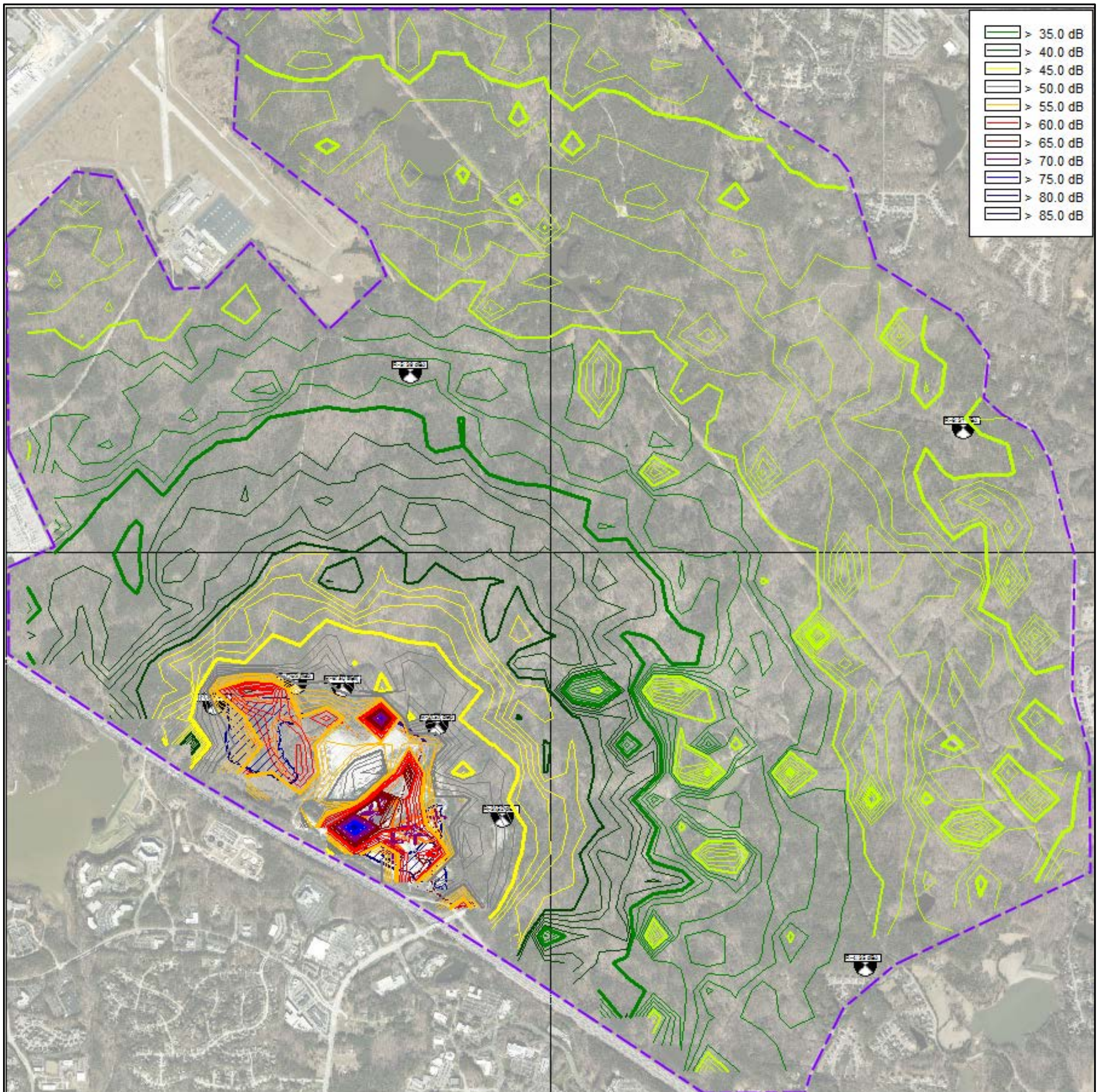

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Figure 14. Isopleth Sound Difference Contours (Future – Existing)