

# **Moffat Collection System Project Noise and Vibration Impact Analysis Report**

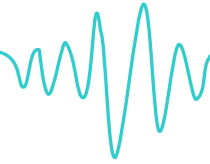
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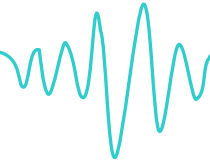
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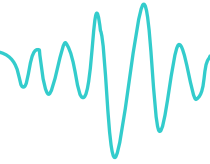


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## **1. Executive Summary**

This report evaluates the potential noise and vibration associated with the predicted haul truck traffic and the drilling and blasting activities for the onsite quarry of the proposed Moffat Collection System Project. It describes the existing noise environment in the area of study, defines thresholds of significance based on local and state ordinances, and generally recognized human response to noise criteria.

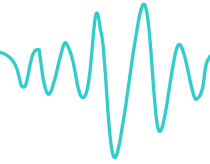
Noise and vibration levels were measured during a drilling and blasting event at the test quarry and a mock truck haul. The data was used to create computer noise models to predict the potential temporary noise in to the areas near the quarry site and haul route. The results of the measurements and the noise models were compared to the thresholds of significance to evaluate the proposed project.

### **1.1 Findings**

Considering the large project area, the planned quarry activities will not exceed significance thresholds at the nearby residences. Additionally, instantaneous noise and vibration generated by the haul trucks will not exceed significance thresholds at the residences along the haul route.

Of the six locations analyzed along the haul route shown in Figure 5-1, a significant increase in ambient noise level is not expected at Locations 1, 2, and 3 during peak haul route activity. However, Locations 4, 5, and 6 have the potential to be exposed to an increase in ambient noise level during peak haul route activity. The larger noise at Locations 4, 5, and 6 is due to the low existing number of trucks and other traffic on this section of the haul route.

The finding of potential larger noise at Locations 4, 5, and 6 was based on analysis of both the highest estimate of the number of haul trucks and low mid-morning ambient noise levels, which is a conservative scenario. The potential for larger noise at the locations may subside during non-peak haul truck activity and during periods of higher non-haul truck traffic.



## 2. Project Description

The Moffat Collection System Project proposes to raise Gross Dam by 131 feet to increase the storage volume from 41,811 acre-feet to about 119,000 acre-feet. The fine aggregate (sand), cement, and fly ash for the enlargement of the dam are planned to be imported from the Front Range of Colorado. The current plan, as described in the Final Environmental Impact Statement (FEIS), is to use common tractor trailer trucks (haul trucks) to deliver the material to the project site.

The FEIS estimates truck hauling would on average increase truck traffic by 44 trips per day (22 round-trips) using a combination of tractor trailer end dump trucks and bulk tanker trucks. During the peak of construction Denver Water estimates as many as 240 trips per day (120 round-trips) may be necessary. Figure 2-1 shows the haul route from State Highway 93 to Gross Dam.

Additionally, the project will require the development of an onsite quarry to produce coarse aggregate (gravel). Drilling and blasting are common noise producing activities related to quarry construction. Figure 5-1 shows the location of the test quarry and the main quarry.

### 2.1 Purpose of Study and Objective

The purpose of this study is to analyze noise and vibration from truck hauling and quarry development for the Moffat Collection System Project. The following is provided in this report:

- Assessment of noise and vibration levels generated by the proposed haul trucks
- Assessment of the predicted noise of the proposed haul trucks in relation to existing ambient conditions
- Assessment of the predicted noise of the proposed drilling activities associated with charge setting
- Assessment of the predicted noise and vibration of the proposed blasting activity

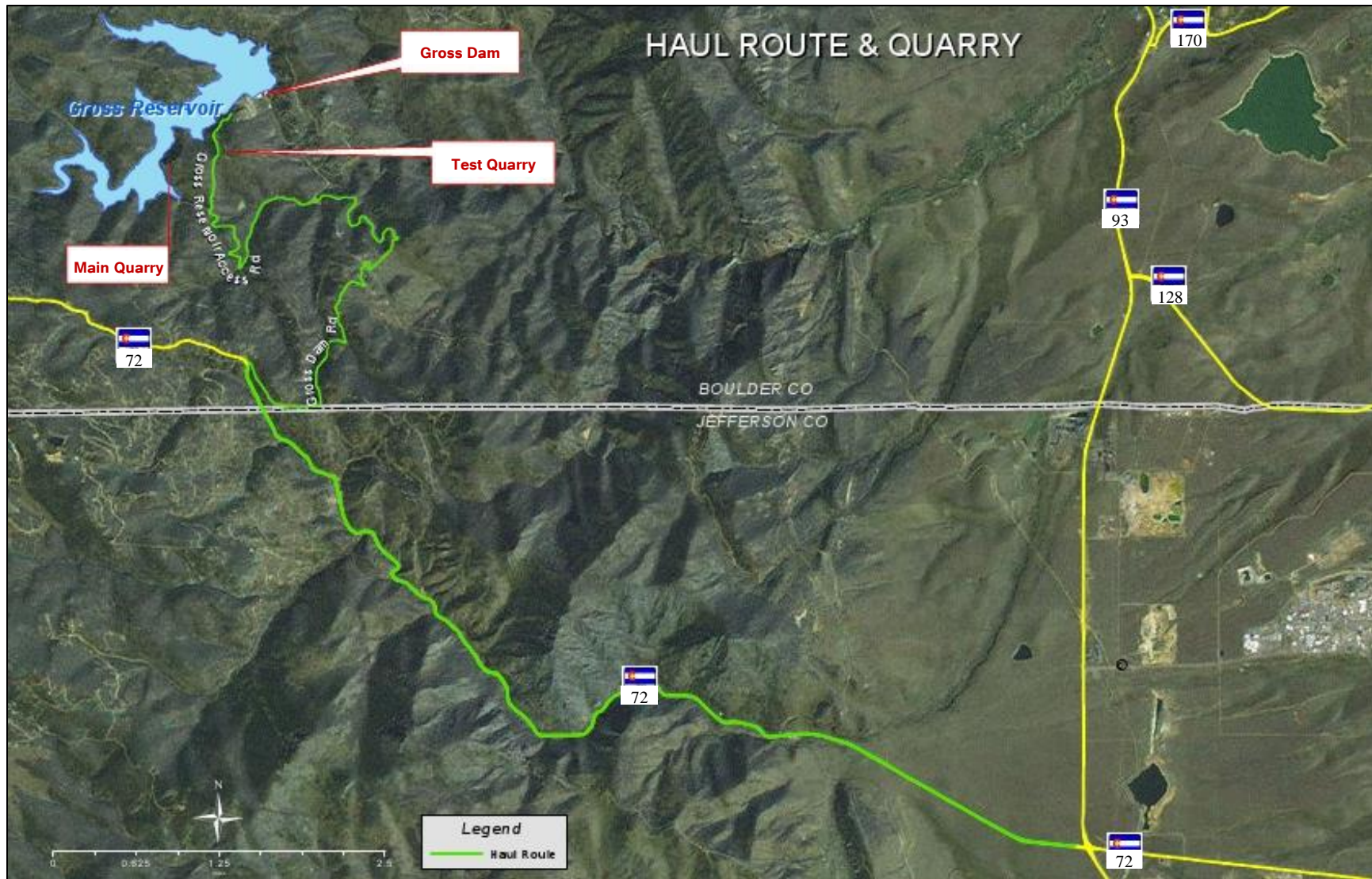
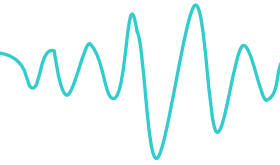
### 2.2 Project Location and Study Area

The proposed haul route discussed in this study traverses Jefferson County and Boulder County. The route includes State Highway 72 (SH 72), Gross Dam Road (Boulder County Road 77S), and Gross Reservoir Access Road. Numerous residences are located along the length of the proposed route. Six locations along the haul route were selected to analyze potential noise and vibration of the haul trucks.

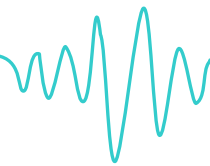
The main quarry is located at Gross Reservoir in Boulder County, Colorado (Figure 5-2). The nearest residence to the main quarry is located over a mile away on the northern shore of the reservoir. This residence was utilized as the main analysis point for the potential noise and vibration of the drilling and blasting activity.

### 2.3 Study Qualification

This report exclusively assess the predicted noise and vibration associated with the haul trucks along the haul route and the drilling and blasting activity at the main quarry as these activities have the potential to be disruptive to the local community. Other noise producing activities expected during the construction process are outside the scope of this report.



**Figure 2-1. Moffat Collection System Project Location**



## 3. Noise Fundamentals

Noise is defined as unwanted sound that may be disturbing or annoying. The character of noise is defined by its loudness and its pitch and also by the way the noise varies with time.

Sound is most commonly experienced by people as pressure waves passing through the air. These rapid fluctuations in air pressure are processed by the human auditory system to produce the sensation of sound. The rate at which sound pressure changes occur is called the frequency of the sound. Frequency is usually measured as the number of oscillations per second or Hertz (Hz). Frequencies that can be heard by a healthy human ear span the range from 20 Hz to 20,000 Hz. Towards the lower end of this range are low-pitched sounds, including those that might be described as “rumble” or “boom”. Towards the higher end of the range are high-pitched sounds such as a “screech” or “hiss”.

Environmental noise generally derives, in part, from a combination of distant noise sources. Such sources may include distant traffic, wind in trees, and distant industrial or farming activities, all part of our daily lives. These distant sources create a low-level “background noise” in which no particular individual source is identifiable. Background noise is often relatively constant from moment to moment, but varies slowly from hour to hour as natural forces change or as human activity follows its daily cycle. Superimposed on this low-level, slowly varying background noise, is a succession of identifiable noisy events of relatively brief duration. These events may include single-vehicle passbys, aircraft flyovers, screeching of brakes, and other short-term events, all causing the noise level to fluctuate.

### 3.1 Noise Descriptor

The following section describes the noise descriptors that will be used in this study.

#### Decibels

Human perception of loudness is logarithmic rather than linear. For this reason, sound level is usually measured on a logarithmic decibel (dB) scale, which is calculated from the ratio of the sound pressure to a reference pressure level. Specifically, the sound pressure level is calculated as follows:

$$SPL = 20 \log_{10} \frac{p}{p_{ref}}$$

Where:

$SPL$  = sound pressure level in decibels

$p$  = rms sound pressure

$p_{ref}$  = reference sound pressure (20 microPascals) The reference pressure for sound in the air is 20 microPascals ( $\mu\text{Pa}$ ), which is represented as zero on the decibel scale. This value is used because it approximates the lowest pressure level detectable by a healthy human ear.

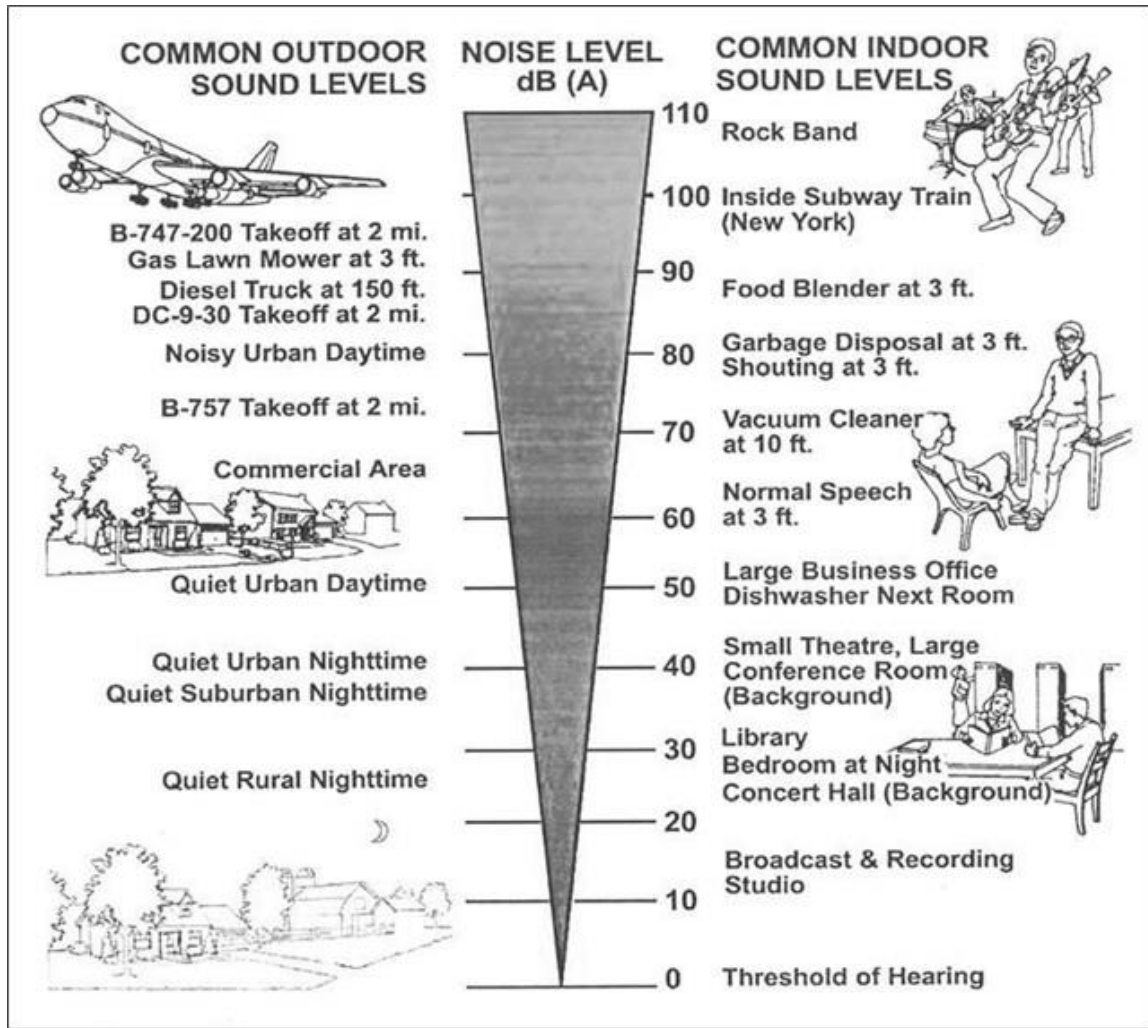
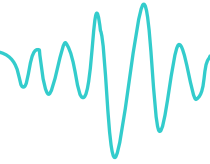


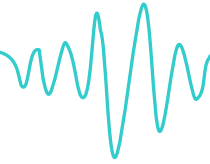
Figure 3-1. Typical Indoor and Outdoor Sound Levels

It is generally accepted that a change of 3 dBA is perceptible to the average healthy human ear. A change of 5 dBA is generally regarded as a readily perceptible increase/decrease.

## A-Weighting

Humans are more sensitive to some sound frequencies than others. It is therefore common practice to apply an audio filter to measured sound levels, to approximate the response of the human ear. This filter is called the A-weighting filter, which emphasizes sounds between 500 and 5,000 Hz and attenuates the frequencies outside of that range. The resulting measure is the A-weighted decibel, or dBA, which is used almost universally in the assessment of noise on humans. Figure 3-1 shows typical noise levels that might be found in both outdoor and indoor environments.



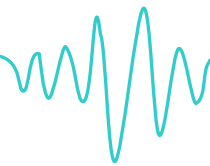


## **Equivalent Sound Level ( $L_{eq}$ )**

Some sources, such as air-conditioning equipment, produce continuous noise with a steady level that does not change with time. Other sources may be transient in nature, such as a train or aircraft passing-by. Between these two extremes are constant sources that vary gradually with time, such as distant freeway traffic, and intermittent sources that vary rapidly with time, such as traffic on a surface street. A location may receive noise contributions from a number of sources that fall into some or all of these categories, resulting in a complex time-varying noise environment. For this reason, meaningful measurement and analysis of environmental noise usually requires time-dependent noise descriptors. The equivalent sound level, or  $L_{eq}$ , is a sound energy average, calculated over a stated time period. 1-hour, A-weighted  $L_{eq}$  values are used commonly in environmental noise assessments.

## **Maximum Noise Level ( $L_{max}$ )**

The maximum noise level is defined as the highest instantaneous noise level over a specified time interval. A one-hour  $L_{max}$  level would be the highest observed noise level over the one-hour period.



## 4. Ground-Borne Vibration Fundamentals

Vibration is acoustic energy transmitted as waves through a solid medium, such as soil or concrete. Like noise, the rate at which pressure changes occur is called the frequency of the vibration, measured in Hz. Vibration may be the form of a single pulse of acoustical energy, a series of pulses, or a continuous oscillating motion.

Ground-borne vibration is the ground motion about some equilibrium position that can be described in terms of displacement, velocity, and acceleration. It can be generated by transportation systems, construction activities, and other large mechanical systems. Vibration motion moves in the X, Y and Z axes.

The way that vibration is transmitted through the ground depends on the soil type, the presence of rock formations or man-made features and the topography between the vibration source and the receptor location. As a general rule, vibration waves tend to dissipate and reduce in magnitude with distance from the source. Also, the high frequency vibrations are generally attenuated rapidly as they travel through the ground, so that the vibration received at locations distant from the source tends to be dominated by low-frequency vibration. The frequencies of ground-borne vibration most perceptible to humans are in the range from less than 1 Hz to 100 Hz.

When ground-borne vibration arrives at a building, there is usually an initial ground-to-foundation coupling loss. However, once the vibration energy is in the building structure, it can be amplified by the resonance of the walls and floors. Occupants can perceive vibration as motion of the building elements (particularly floors) and also rattling of lightweight components, such as windows, shutters or items on shelves. At very high levels, low-frequency vibration can cause damage to buildings.

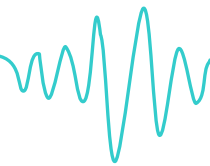
### 4.1 Vibration Descriptor

The following section describes the vibration descriptors that will be used in this study.

#### Peak Particle Velocity

The peak particle velocity (PPV) is defined as the maximum instantaneous positive or negative peak amplitude of the vibration velocity. The accepted unit for measuring PPV is inches per second (ips). PPV is appropriate for evaluating the potential for building damage and for evaluating human response to ground-borne vibration.

The ground-borne vibration criteria shown Table 4-1 is adapted from the US Bureau of Reclamation, Safety and Health Standards, Section 24.1.8 and describes typical vibration limits for different types of structures. As low-frequency vibration has a greater potential to cause damage to buildings, more stringent limits are applied to vibration with peak frequencies below 40 hertz.



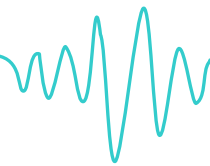
**Table 4-1. Structure Vibration Criteria**

Type of Structure <sup>1</sup>	Peak Particle Velocity (inches per second)	
	At Low Frequency <sup>2</sup> (<40 Hertz)	At High Frequency (>40 Hertz)
Modern homes, drywall interiors	0.75	2.0
Older homes, plaster on wood lath construction for interior walls	0.5	2.0

Reference: Siskind, D.E., M.S. Stagg, J.W. Kopp, and C.H. Dowding, "Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting." U.S. Department of the Interior, Bureau of Mines, Report of Investigations RI 8507, 1980.

<sup>1</sup>For precarious structures not listed in the table, use the limits for older homes; for all other structures not listed in the table, use the limits listed for modern homes.

<sup>2</sup>All spectral peaks within 50 percent amplitude of the predominant frequency must be analyzed.



## 5. Existing Environment

Noise monitoring programs were conducted to measure and document the existing ambient conditions along the haul route test quarry site near the north shore residents. The following describes the measurement procedures, locations and results.

### 5.1 Haul Route Ambient Noise and Vibration Survey

Sound level meters were deployed at six locations along the haul route on Wednesday, August 7, 2013 to continuously monitor ambient sound levels over a 24-hour period. In addition to the noise level measurements, ground-borne vibration levels were measured at three locations. The sound levels were measured with one Type 1 Brüel & Kjaer 2238 and five Type 2 Quest Technologies 2900 integrating and logging sound level meters and the vibration levels were measured with three Profound VMS systems. A summary of the survey information is included in Table 5-1 and the measurement locations are shown in Figure 5-1.

**Table 5-1. Haul Route Ambient Survey**

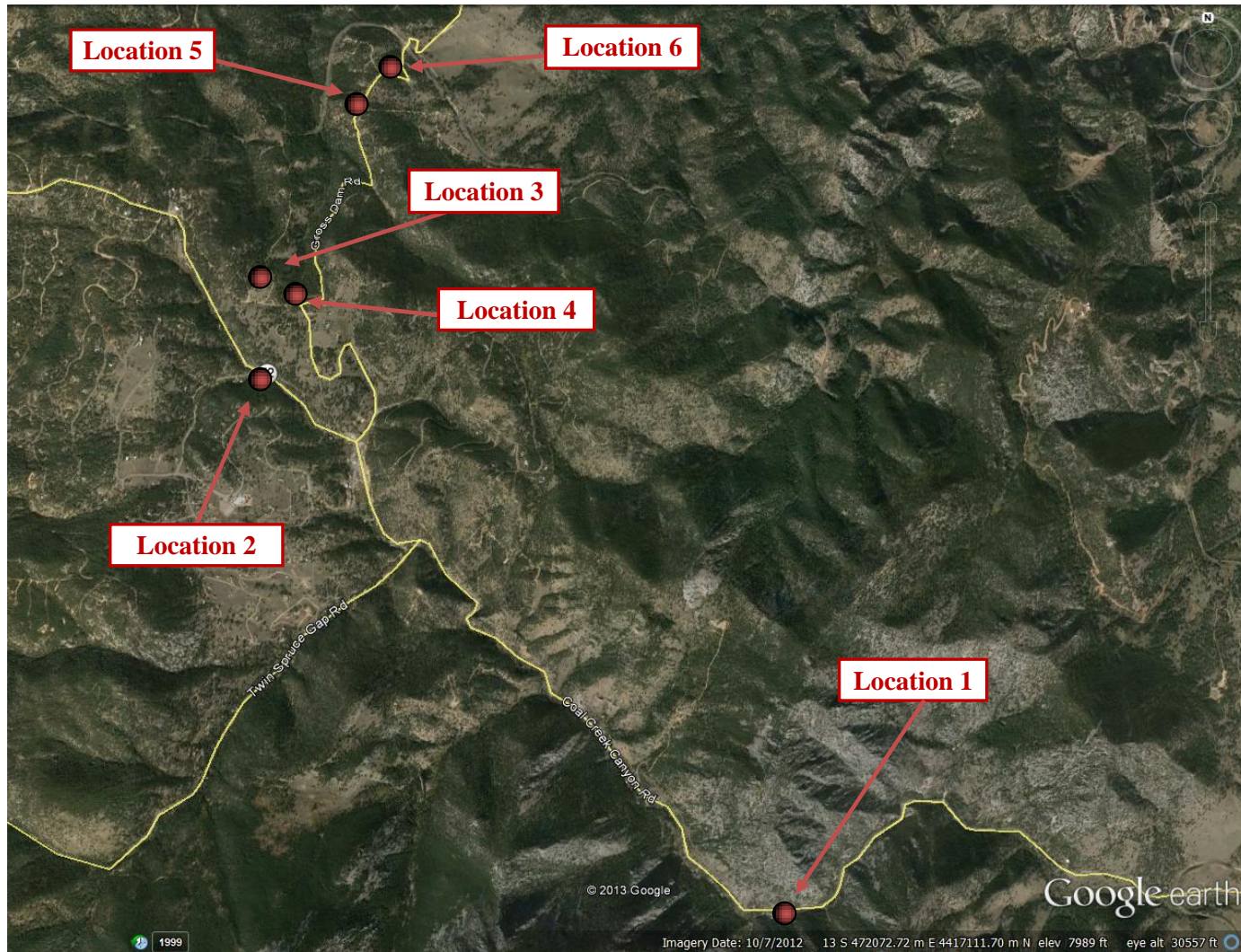
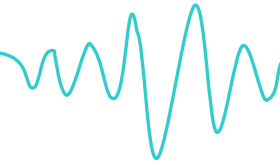
Monitoring Location	Approximate Location	Approximate Distance to Road	Vibration Meter Deployed
1	27820 Coal Creek Canyon Rd. (Hwy 72)	82 ft	no
2	30986 Coal Creek Canyon Rd. (Hwy 72)	50 ft	yes
3	3235 Lichen Lane	360 ft	no
4	Intersection of Gross Dam Rd. & Crescent Park Dr.	15 ft	yes
5	Intersection of Gross Dam Rd. & Chute Rd.	82 ft	no
6	18 Juniper Heights Rd.	15 ft	yes

The results of the ambient noise level survey are provided below in Table 5-2.

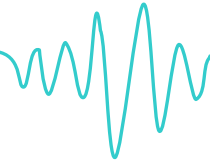
**Table 5-2. Haul Truck Measured Ambient Noise Levels**

Monitoring Location	24-Hr Ambient Noise Level (dBA)	Daytime Average Noise Level (7:00 a.m. – 7:00 p.m.)
1	57.9	59.4
2	65.4	62.9
3	46.3	48.2
4	60.6	62.3
5	56.0	58.2
6	53.9	56.6

The ambient vibration survey consisted of measuring the three-axis peak particle velocity over one-minute intervals. The ambient vibration measurement results provided in Table 5-3 are the highest peak particle velocities observed at each measurement location over the 24-hour measurement period.



**Figure 5-1. Haul Route Ambient Measurement Locations**



**Table 5-3. Haul Route Measured Ambient Vibration Levels**

<b>Monitoring Location</b>	<b>Highest Ambient Peak Particle Velocity (ips)</b>
2	.022
4	.012
6	.019

## 5.2 Quarry Ambient Noise Survey

A sound level meter was deployed adjacent to the nearest residence to the test quarry (drill and blast site) on Thursday, December 12, 2013 to continuously monitor ambient sound levels over a 24-hour period. The location of the ambient sound level survey in relation to the project site is shown in Figure 5-2. The sound levels were measured with a Type 1 Brüel & Kjaer 2250 Hand-held Analyzer sound level meter.

**Table 5-4. Quarry Measured Ambient Noise Levels**

<b>Monitoring Location</b>	<b>24-Hr Ambient Noise Level (dBA)</b>	<b>Daytime Average Noise Level (7:00 a.m. – 7:00 p.m.) (dBA)</b>
Adjacent to nearest residence to project site	51.3	44.9

An audio recording created during the monitoring period revealed temporary elevated noise levels due to wind during nighttime hours. Other noise sources recorded during the monitoring period include wildlife, road traffic, and air traffic.

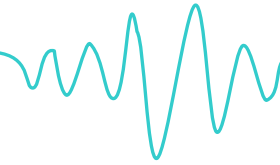
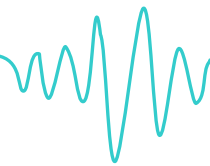


Figure 5-2. Quarry Ambient Measurement Location



## 6. Noise and Vibration Standards and Threshold of Significance

### 6.1 Boulder County

The Boulder County Noise Ordinance does not contain any limits on ground-borne vibration associated with traffic. However, Section 1.01.050(a) does contain noise limits for vehicles traveling on public roads. The following table summarizes the vehicular noise limits that apply to this project.

**Table 6-1. Boulder County Vehicle Noise Level Limits**

Type of Vehicle	Speed limit of 35 mph or less	Speed limit of more than 35 mph
Vehicle with a manufacture’s gross vehicle rating of ten thousand lbs. or more	86 dBA	88 dBA

\*Note: Noise limits apply 50 feet from center of the lane of travel

Additionally, the Boulder County Noise Ordinance does not contain regulations specifically dealing with blasting and drilling associated with charge setting for blasting. Section 1.01.050(d) does contain noise limits for construction projects, however Section 1.01.060(e) states that the provision containing the construction noise limits shall not apply to “public utilities regulated pursuant to Title 40, C.R.S.”

### 6.2 Jefferson County

The Jefferson County Noise Abatement Policy does not contain any limits on ground-borne vibration associated with traffic. It does contain noise limits for vehicles traveling on public roads. The applicable vehicular noise limits in the Jefferson County Noise Abatement Policy are identical to the limits in Boulder County shown in Table 6-1.

### 6.3 State of Colorado

The Colorado Noise Statute contains language similar to the Boulder County Ordinance associated with vehicular traffic with minor differences. Section 25-12-107(1) contains the following noise limits that apply to this project.

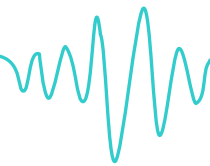
**Table 6-2. State of Colorado Vehicle Noise Level Limits**

Type of Vehicle	Speed limit of 35 mph or less	Speed limit of more than 35 mph
Vehicle with a manufacture’s gross vehicle rating of six thousand lbs. or more	86 dBA	90 dBA

\*Note: Noise limits apply 50 feet from center of the lane of travel

\*Note: Limits for vehicles manufactured after January 1, 1973





The Colorado Noise Statute also establishes maximum permissible noise levels based on property zoning. Adjustments to the maximum levels are allowed for construction activity and shorter duration noise events.

Section 25-12-103(5) states “construction projects shall be subject to the maximum permissible noise levels specified for industrial zones for the period within which construction is to be completed.” Also, Section 25-12-103(2) states “in the hours between 7:00 a.m. and the next 7:00 p.m.” the maximum noise levels “may be increased by ten db(a) for a period of not to exceed fifteen minutes in any one-hour period.” The following table summarizes the maximum noise levels with the above adjustments that may apply to this project.

**Table 6-3. State of Colorado Noise Limits**

<b>Time of Day</b>	<b>Industrial Noise Limit (for construction)</b>	<b>15-Minute per Hour Adjusted Noise Limit</b>
7:00 a.m. – 7:00 p.m. (daytime)	80 dBA	90 dBA
7:00 p.m. – 7:00 a.m. (nighttime)	75 dBA	--

\*Note: Per Section 25-12-103(1), the above noise level limits are applicable 25 feet from the property line

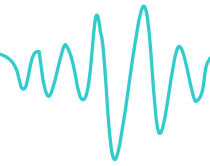
## 6.4 Threshold of Significance

Based on the standards discussed above, for the purposes of this report an exceedance would have the potential to occur if the proposed project results in the generation of noise levels in excess of the limits established in the local and state ordinances. This would occur if:

- Noise from the proposed haul trucks exceeds the allowable noise levels provided in Table 6-1 or Table 6-2.
- Noise from quarry drilling and blasting exceeds the allowable noise levels in Table 6-3, measured 25 feet from the project boundary (Denver Water Property Line).

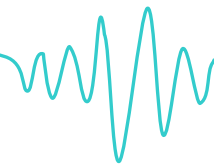
In addition to the thresholds above based on absolute noise level limits, an exceedance would have the potential to occur if the proposed project results in the generation of noise levels significantly above the existing ambient noise levels around the project site:

- The increase in noise level from haul truck generated noise results in an increase of more than 5 dB to the existing ambient noise level
- Temporary noise generated by blasting and drilling associated with charge setting for blasting results in an increase of more than 5 dB to the ambient noise level



Exposure to excessive transient ground-borne vibration also has the potential to cause an exceedance:

- Transient PPV ground-borne vibration generated by the haul trucks exceeds 0.5 ips for frequencies below 40 Hz or 2.0 ips for frequencies above 40 Hz at any structure along the haul route.
- Transient PPV ground-borne vibration generated by blasting exceeds 0.5 ips for frequencies below 40 Hz or 2.0 ips for frequencies above 40 Hz at any structure near the quarry.



## 7. Evaluation of the Proposed Project

The activities of the proposed project were assessed by collecting data during a mock truck haul and a drilling and blasting event at the test quarry. Where applicable, the results from the events were compared directly to the threshold of significance criteria. In other instances, the data collected from the events was utilized in the development of computer noise models for further analysis.

The three-dimensional noise models included in this report were created using SoundPLAN version 7.2 software. The noise models predict noise levels based on the location, noise level, and frequency spectra of the noise sources as well as the geometry and reflective properties of the local terrain, buildings and barriers. The noise models assume light downwind conditions in all directions. These models predict the noise associated with the proposed work on the local community.

### 7.1 Haul Truck Traffic

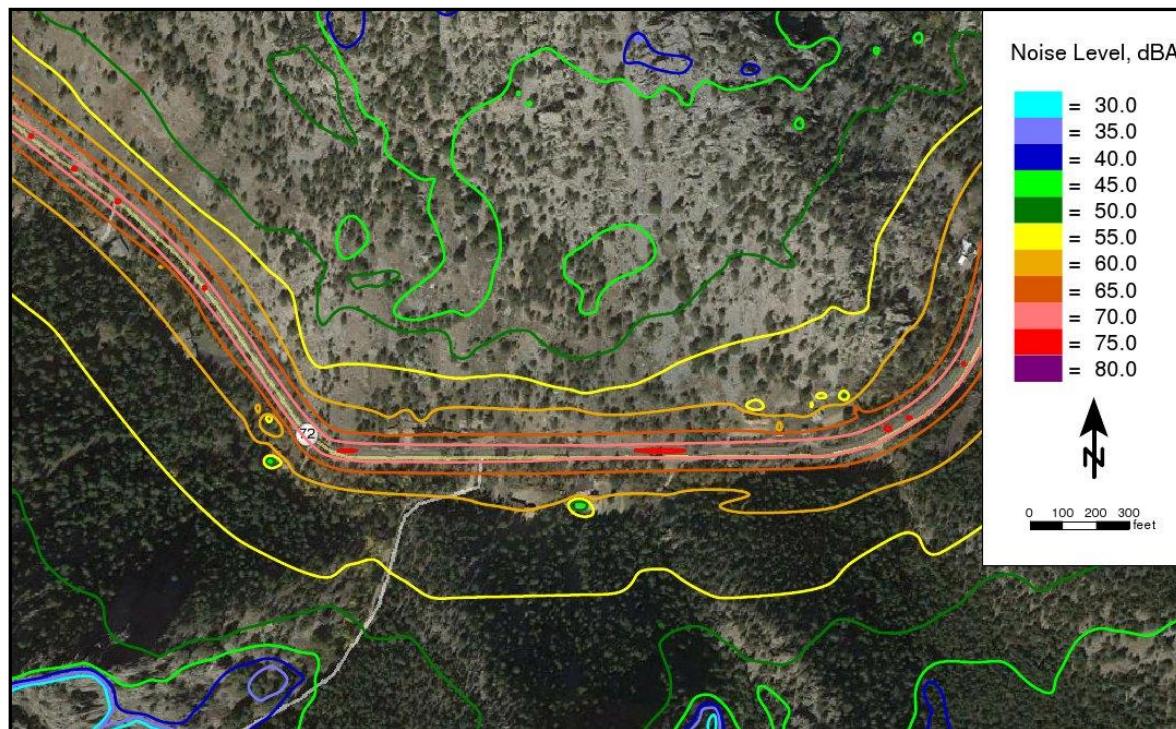
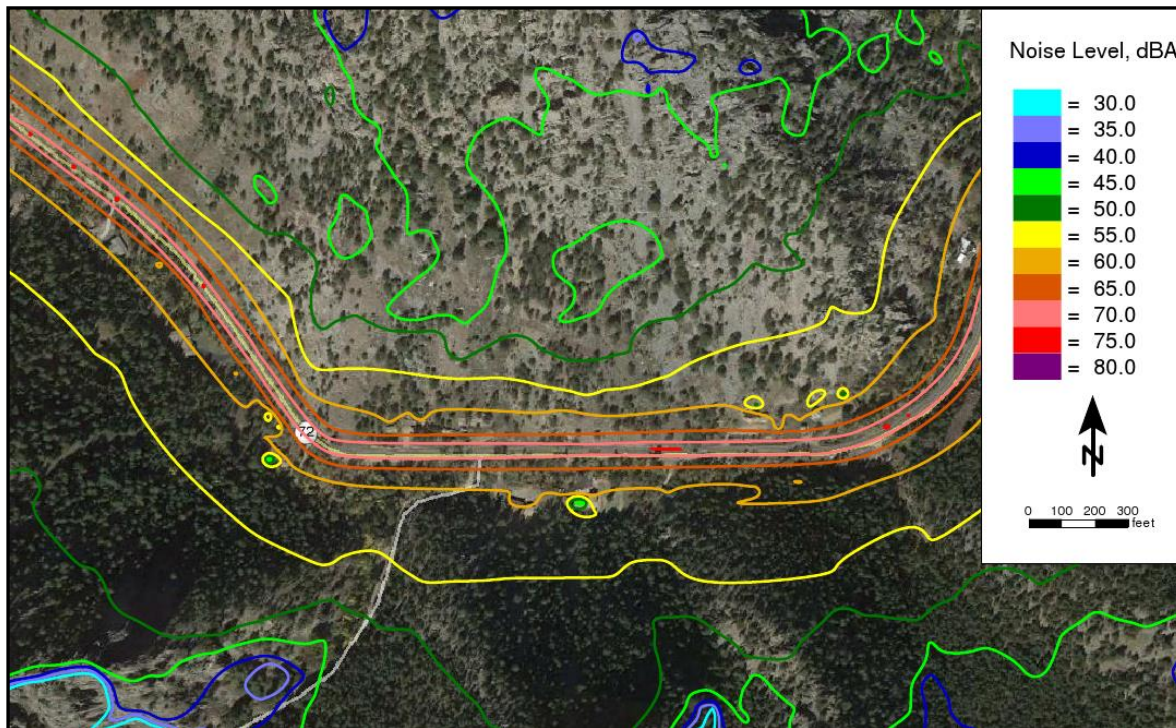
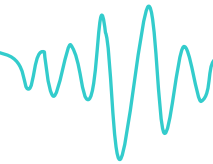
A mock haul was conducted on Thursday, August 8, 2013 to simulate the expected conditions of the proposed project. Sound and vibration meters were deployed during the mock haul in the same locations utilized in the ambient haul route survey as detailed in Table 5-1. The meters were programmed to collect maximum sound levels and peak particle vibration levels over one-minute intervals. Table 7-1 provides the maximum noise and vibration levels measured as the haul trucks passed each monitoring location.

**Table 7-1. Measured Mock Haul Noise and Vibration Levels**

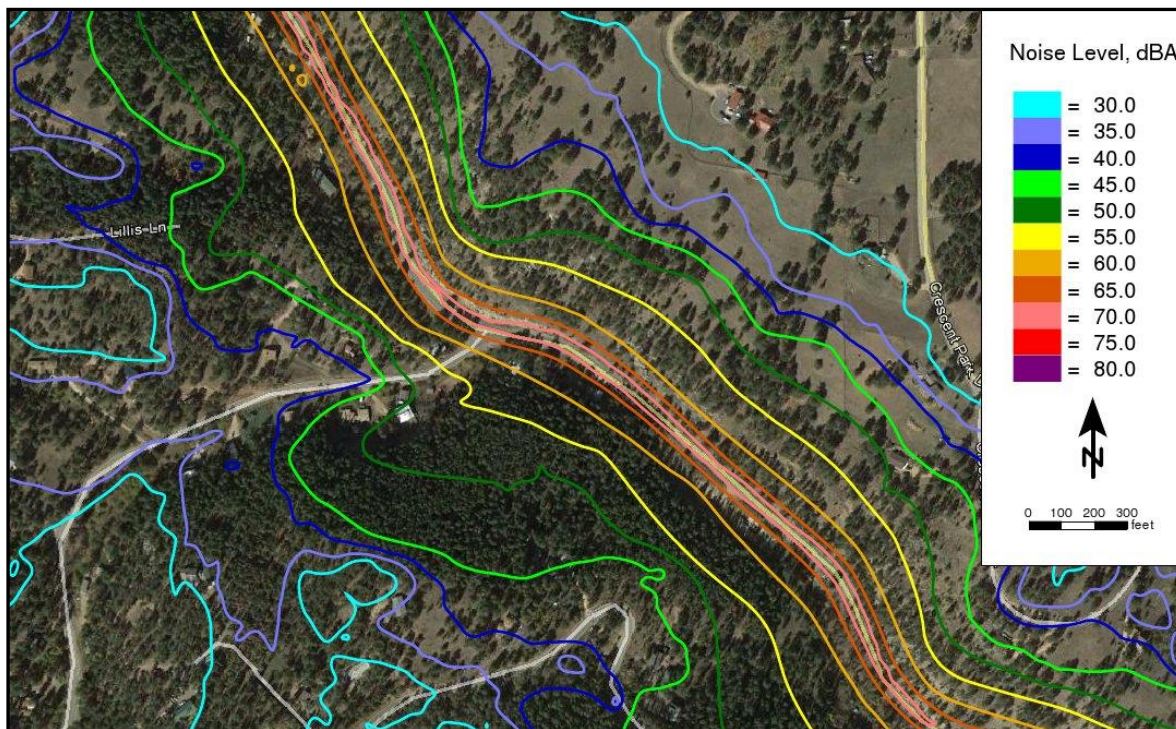
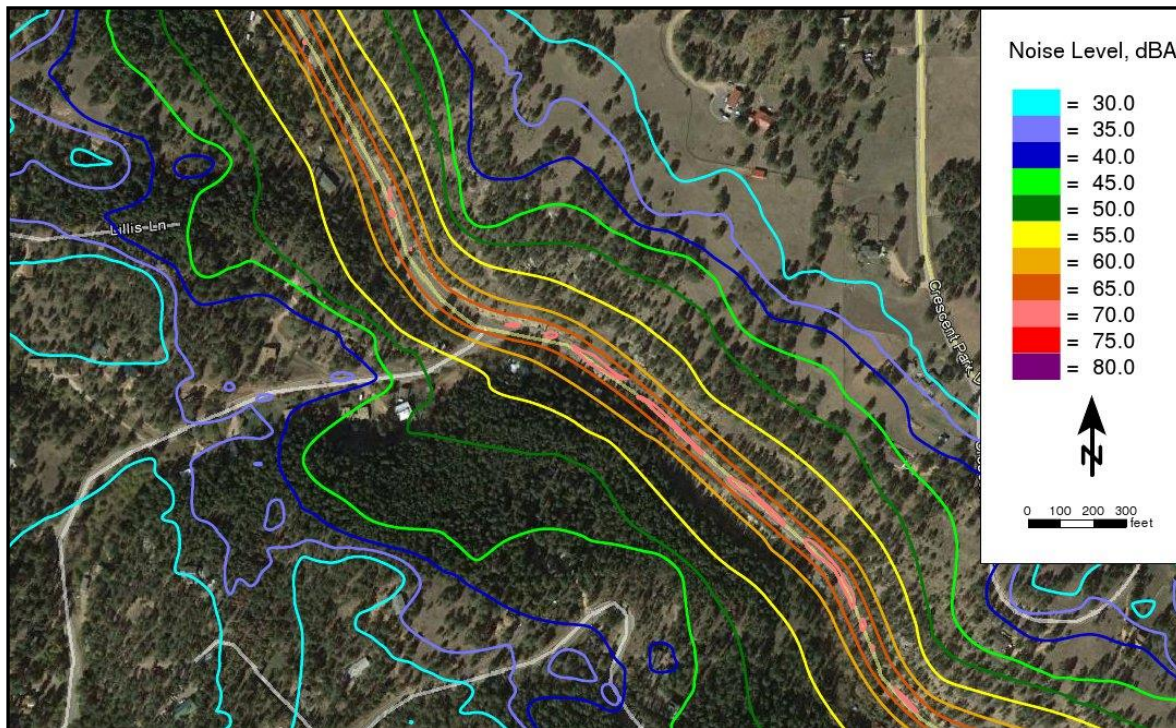
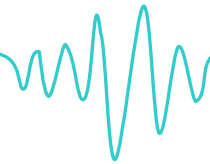
<b>Monitoring Location</b>	<b>Approximate Distance to Road</b>	<b>Maximum Measured Noise Level, <math>L_{max}</math> (dBA)</b>	<b>Maximum Allowable Noise Level at 50 ft (dBA)</b>	<b>Highest Peak Particle Velocity (ips)</b>
1	82 ft	61.6	88.0	--
2	50 ft	68.8	88.0	.008
3	360 ft	55.3	86.0	--
4	15 ft	67.4	86.0	.002
5	82 ft	64.4	86.0	--
6	15 ft	63.1	86.0	.004

The noise measurement results in Table 7-1 indicate the noise levels generated by the haul trucks will not exceed the limits detailed in Table 6-1. The  $L_{max}$  measurement of 68.8 dBA from Location 2 was conducted approximately 50 feet from the road and is below the 88 dBA limit established by Jefferson and Boulder Counties. Additionally, the measured vibration levels produced by the haul trucks were minimal and below the threshold of significance defined in Section 6.4.

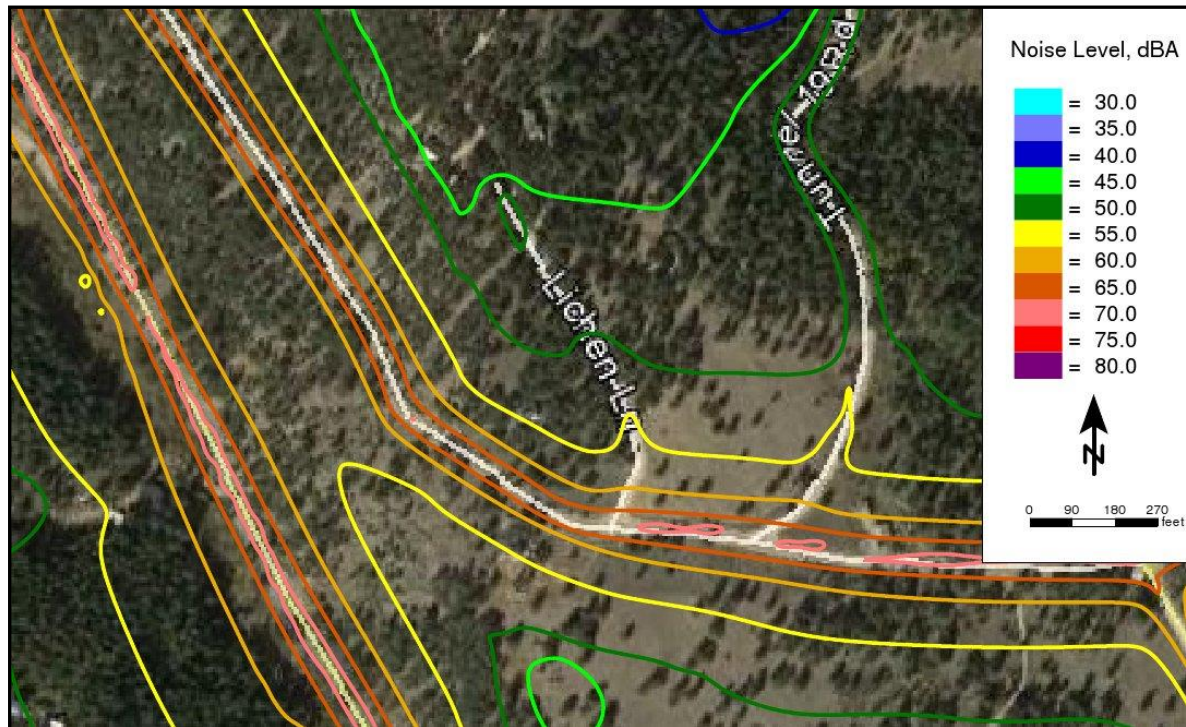
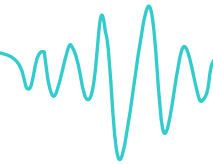
Noise models were created to compare projected average traffic noise levels with the measured average ambient noise levels at the monitoring locations. The traffic models were created with SoundPLAN version 7.2 software which calculates traffic noise levels in accordance with FHWA TNM standards. The traffic noise levels are predicted using vehicle speed, volume, and car/truck percentage of total vehicle volume. Where applicable, publicly available data was used for the vehicle speed and car/truck percentage of total vehicle volume inputs.



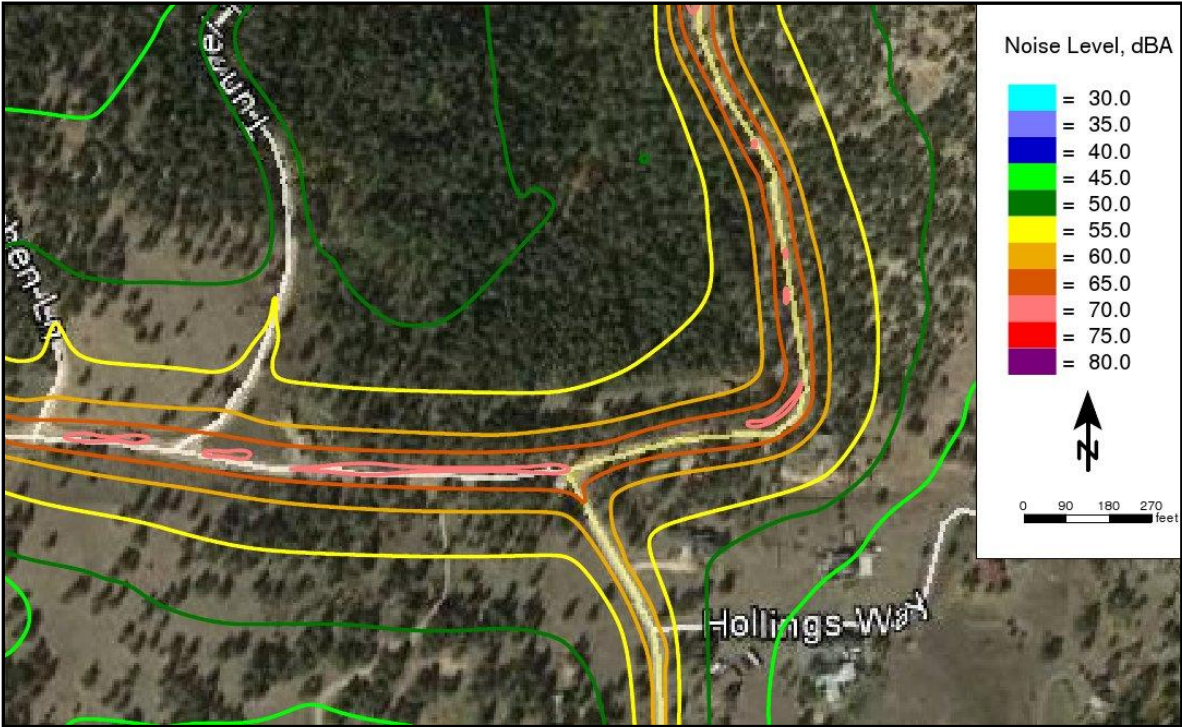
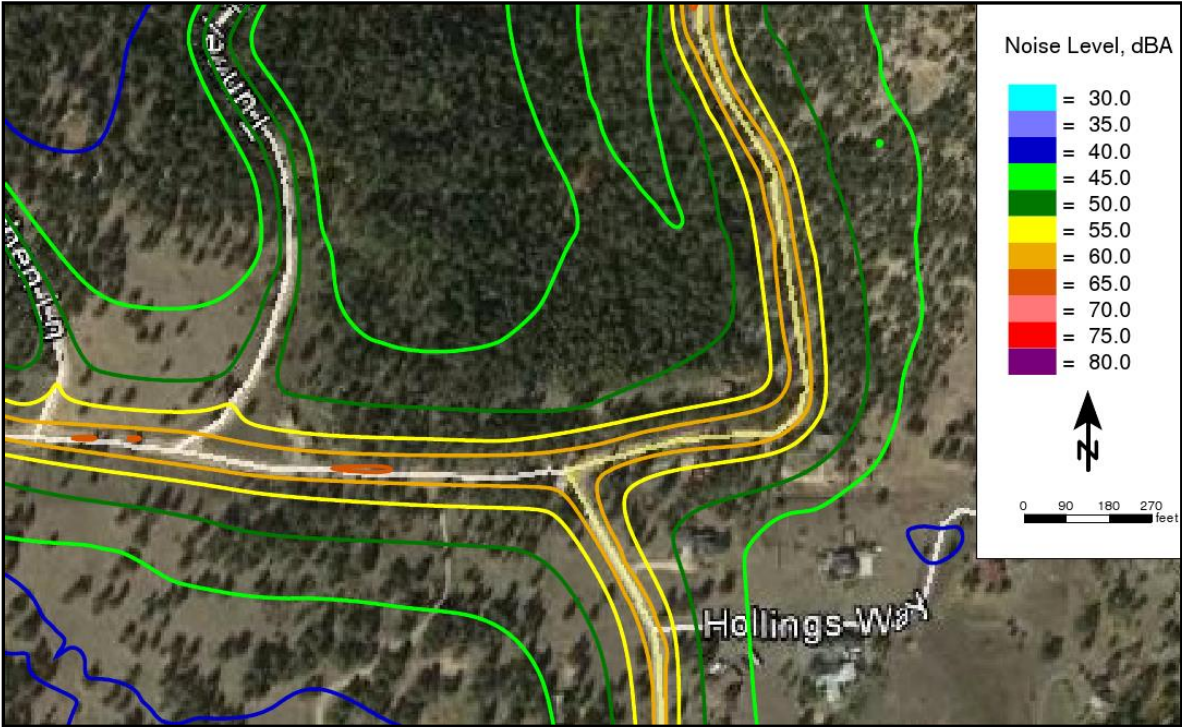
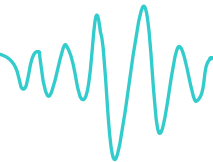
**Figure 7-1. Location 1 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
State Highway 72, Mile Marker 15**



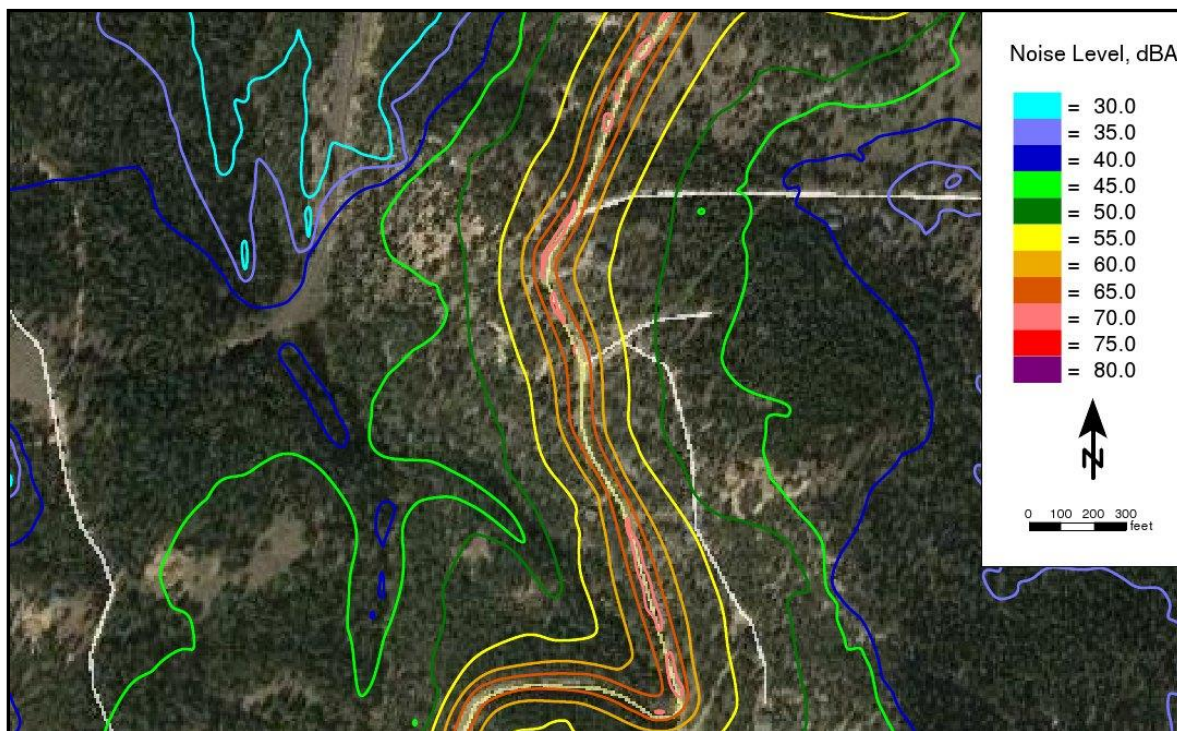
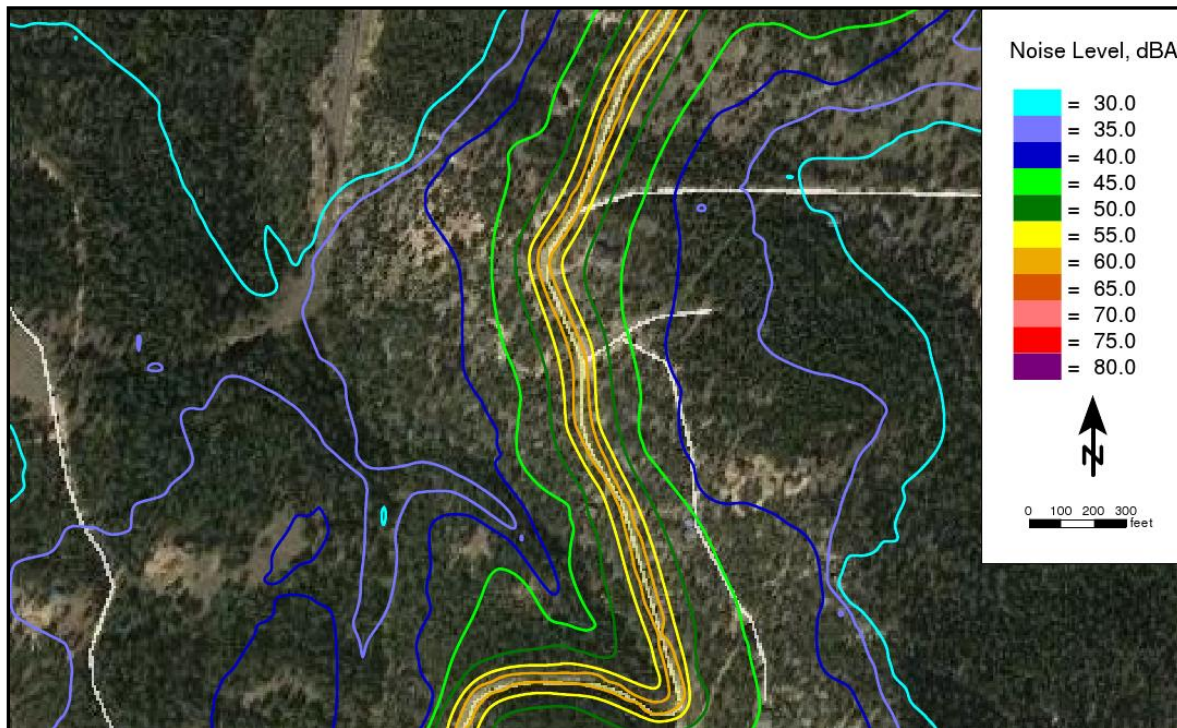
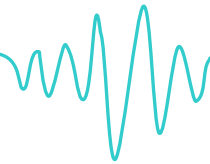
**Figure 7-2. Location 2 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
State Highway 72, Mile Marker 18.5**



**Figure 7-3. Location 3 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
Gross Dam Road & Lichen Lane**

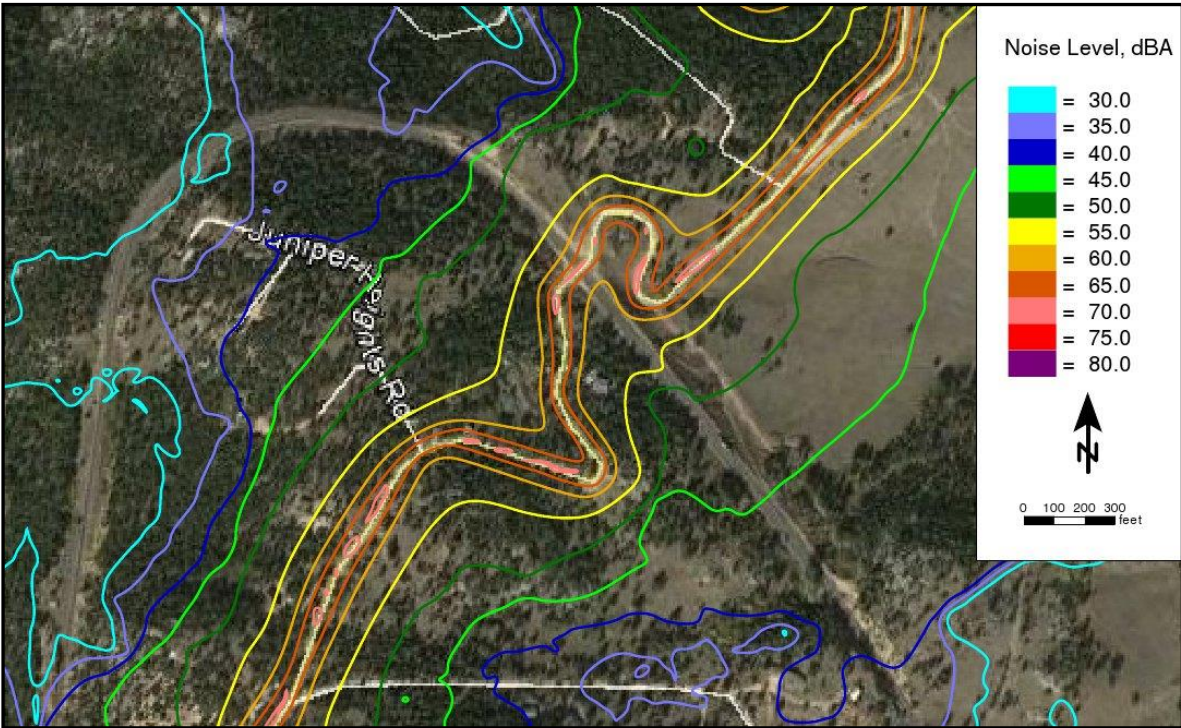
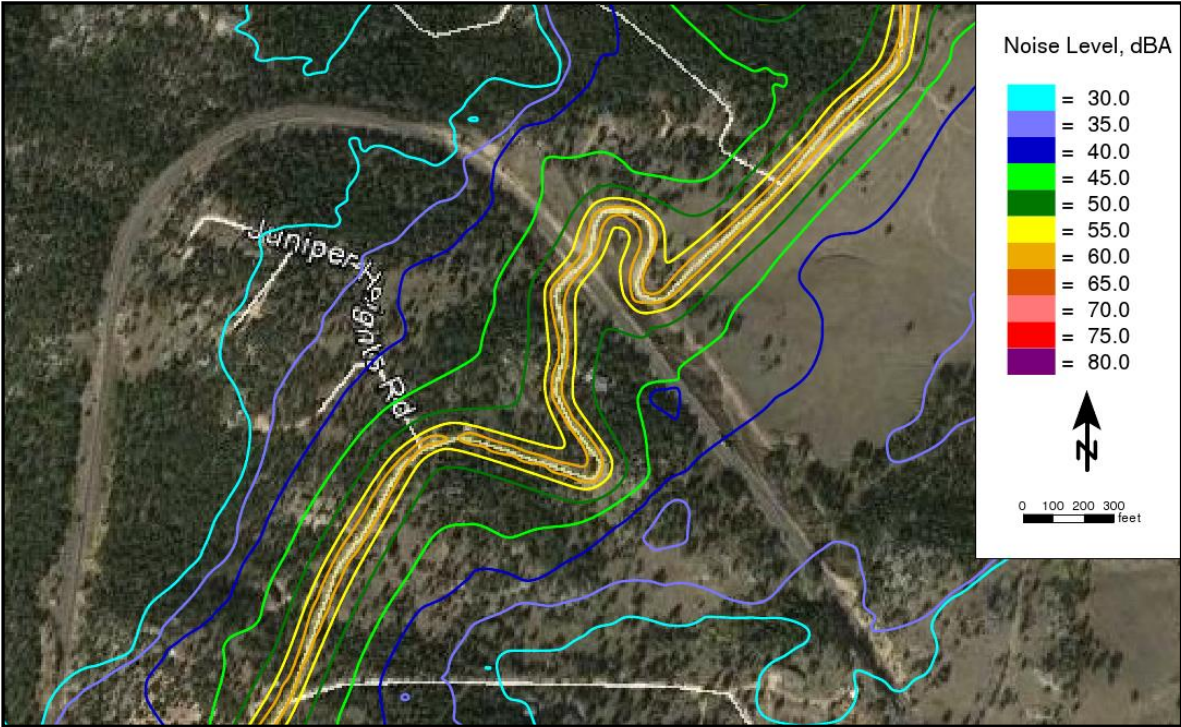
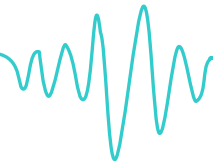


**Figure 7-4. Location 4 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
Gross Dam Road & Crescent Park Drive**

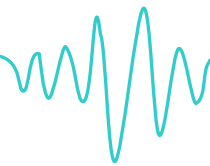


**Figure 7-5. Location 5 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
Gross Dam Road & Chute Road**





**Figure 7-6. Location 6 Ambient (top) and Haul Truck (bottom) Noise Contour Maps  
Gross Dam Road & Juniper Height Road**



Traffic noise models representing existing ambient conditions for each of the six monitoring locations were created and calibrated with the ambient noise measurements conducted at each location. Thirty haul trucks (fifteen per traffic direction) were then added to the traffic models to assess the noise of the proposed haul trucks. The number of haul trucks added to the modeling was derived from converting the highest Denver Water estimate of 240 trucks per eight-hour day to a one-hour period.

The noise contour maps in Figure 7-1 through Figure 7-6 represent the existing ambient noise levels and the predicted noise level with the proposed haul trucks. In addition to the noise contour maps, the results of the traffic modeling are summarized in Table 7-2. The reported noise values represent the projected traffic noise at the specified receiver point. Overall field sound level measurements may vary from the projected noise values due to non-traffic related noise sources or environmental factors.

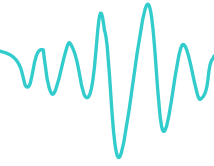
**Table 7-2. Traffic Noise Modeling Results**

Measurement Location	1-Hr Average Ambient Traffic Noise Level (1-hr Leq, dBA)	Projected 1-Hr Average Traffic Noise Level with Haul Trucks (1-hr Leq, dBA)	Projected Noise Level Increase due to Haul Trucks (dB)
1	59.2	62.7	+3.5
2	62.1	64.0	+1.9
3	46.5	50.1	+3.6
4	61.7	67.7	+6.0
5	49.9	58.1	+8.2
6	57.4	64.3	+6.9

The projected noise from the additional trucks varies at each measurement location. Locations 1, 2 and 3 are projected to increase 1.9 to 3.6 dB with the additional truck traffic while locations 4, 5, and 6 are projected to increase 6.0 to 8.2 dB. The larger noise at locations 4, 5 and 6 is due the low existing number of trucks on this section of the haul route. The larger noise at these locations is above the threshold of significance defined in Section 6.4. Generally, the haul trucks will increase the ambient noise level by an average of 5.0 dB over the six locations.

## 7.2 Quarry Drilling and Blasting

Noise measurements were conducted during test drilling and blasting events on December 11 and 12, 2013. The test quarry, which is different from the main quarry, is shown in Figure 5-2. Close-up operational sound level measurements were conducted adjacent to the drilling equipment used to set the charges. Additionally, sound level measurements were conducted during blasting activity at a location 1,900 feet southwest of the test quarry. The location of the blasting measurements is closer to the test quarry than the location of the ambient measurements conducted to the north of the site. The measured 1-second  $L_{eq}$  sound level generated by the blast at this location was 67.1 dBA.



The drilling and blasting noise levels obtained during the survey were used to calibrate the noise sources in the modeling. The drilling and blasting operations were then moved in the models to the location of the proposed project. The projected noise levels for drilling and blasting activities at the nearest residence identified in Figure 5-2 are shown in Table 7-3. The reported average drilling noise level reflects the steady-state nature of drilling noise and the reported instantaneous noise level of the blasting reflects the short duration nature of blasting noise. Figure 7-7 and Figure 7-8 show the noise contour maps for the modeled drilling and blasting activities, respectively.

**Table 7-3. Predicted Drilling and Blasting Noise Levels**

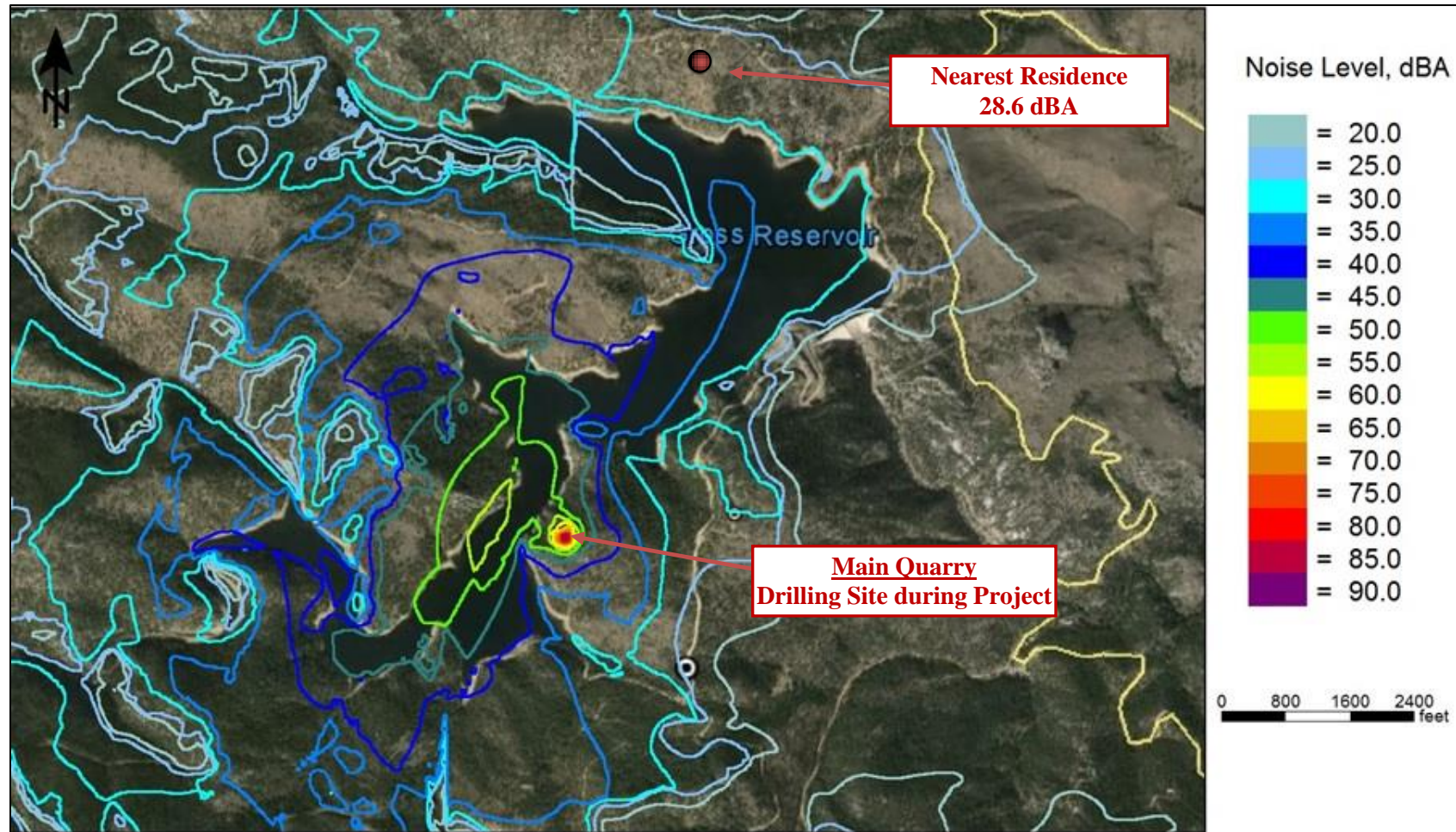
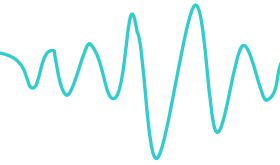
<b>Measurement Location</b>	<b>Projected Average Drilling Noise Level (dBA)</b>	<b>Projected Instantaneous 1-Second Average Blasting Noise Level (dBA)</b>
Adjacent to nearest residence to project site	28.6	53.4

The results of the drilling noise model predict a sound level of 28.6 dBA at the nearest residence. The lowest ambient hourly  $L_{eq}$  measured at this location was 41.4 dBA. Comparing the ambient measurements and drilling modeling results indicates the drilling operations will not increase the average ambient noise level at the nearest residence and as a result will not exceed the threshold of significance.

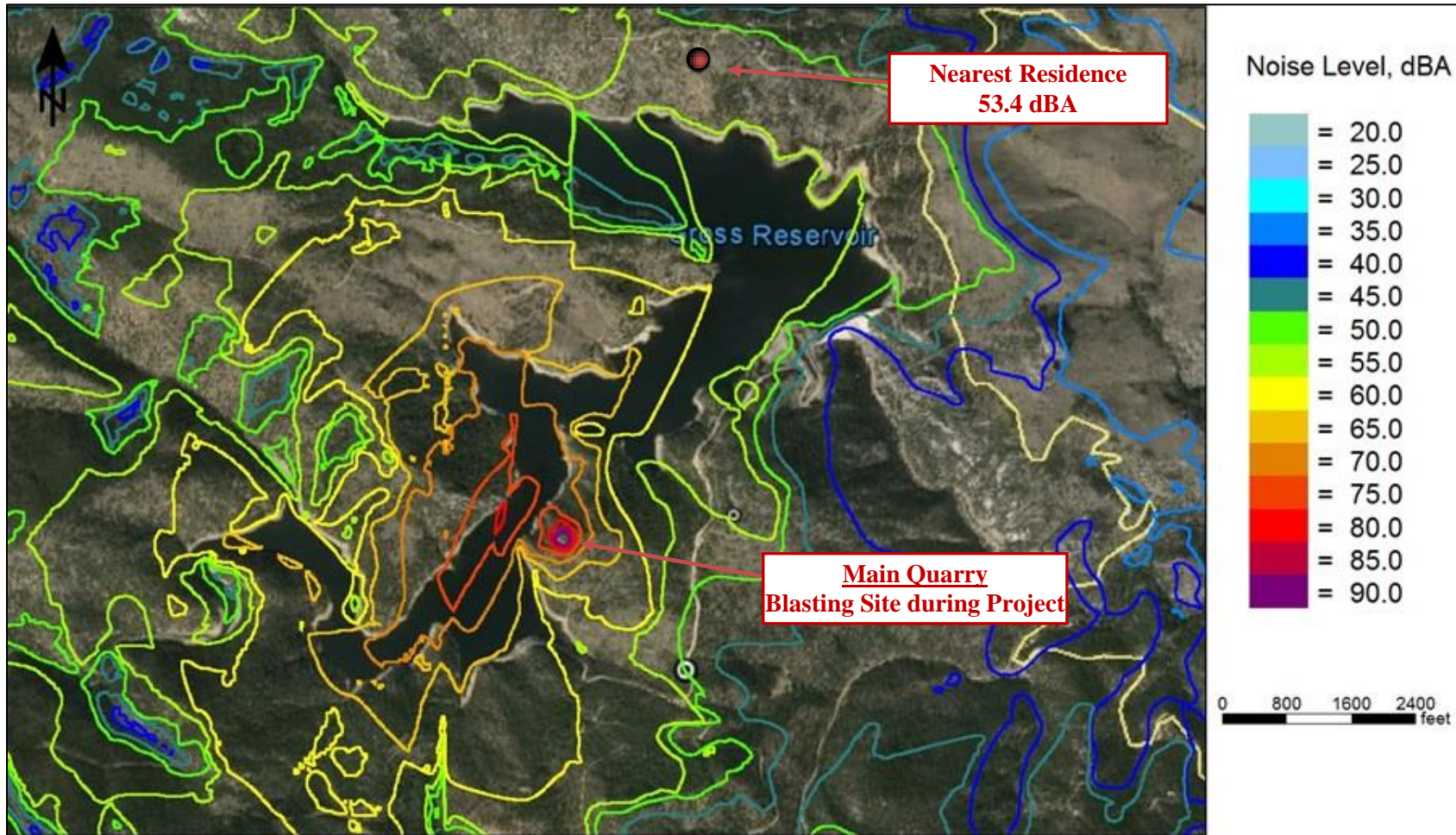
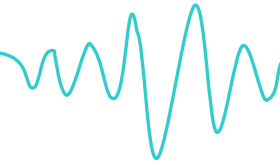
The predicted instantaneous blasting noise level is above some of the measured hourly ambient sound levels at the nearest residence and under certain conditions may be heard at the residence. However, existing ambient noise sources generate instantaneous noise levels higher than the predicted blasting noise levels at the residence. Based on the short-duration nature of the blasting noise, the blasting activities will not increase the average noise level at the nearest residence and as a result will not exceed the threshold of significance.

In addition to the noise level measurements conducted by Behrens and Associates, Inc., vibration measurements were conducted by Matheson Mining Consultants, Inc. (MMC) during the blasting event at the test quarry. As reported by MMC, three seismographs were utilized to monitor the blast. Two were placed at the right abutment and crest of the Gross Dam to the northwest and the third was placed approximately 300 feet to the southeast of the shot pattern on the access road. Both instruments placed on the dam were not triggered by the blast and the seismograph placed to the southeast recorded a PPV of 0.19 ips. The event report included in the MMC report indicates a peak frequency of 47 Hz.

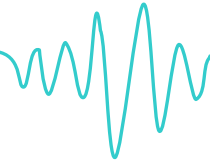
Based on the MMC report, the vibration levels measured 300 feet from the shot during blasting are under the 2.0 ips threshold of significance for frequencies above 40 Hz. Furthermore, measured vibration levels will decrease as the measurement distance from the shot increases. Considering the nearest residence is over a mile from the main quarry, the proposed blasting will not cause an exceedance at the residence.



**Figure 7-7. Predicted Drilling Noise Contour Map**



**Figure 7-8. Predicted Blasting Noise Contour Map**

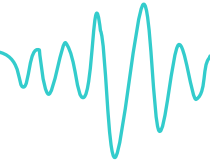


## 8. Conclusion

Considering the large project area, the planned quarry activities (drilling and blasting) of the proposed project will not exceed the threshold of significance at the nearby residences. Additionally, instantaneous noise and vibration generated by the haul trucks will not exceed the threshold of significance at the residences along the haul route.

Of the six locations analyzed along the haul route, a significant increase in ambient noise level is not expected at Locations 1, 2, and 3 during peak haul route activity. Locations 4, 5, and 6 have the potential to be exposed to a larger noise over ambient noise level during peak haul route activity. The larger noise at Locations 4, 5, and 6 is due to the low existing number of trucks and other traffic on this section of the haul route.

The finding of potential for larger noise at Locations 4, 5, and 6 was based on analysis of the highest estimate of the number of haul trucks which represents a worst-case scenario which may subside during non-peak haul truck activity. Furthermore, the mid-morning ambient noise levels used in the analysis are typically lower than morning or afternoon hours when traffic levels tend to be higher. The potential for exceedances may also subside during periods of higher non-haul truck traffic.



## 9. References

Boulder County Noise Ordinance:

<https://www.bouldercounty.org/doc/government/ordnoise.pdf>

Colorado State Noise Statute:

<https://www.noisefree.org/stateord/colorado.pdf>

Denver Water; Gross Reservoir Test Quarry Blast Report – December 12, 2013  
Rock Solid Solutions

Gross Reservoir Test Quarry; Seismograph Data Analysis – December 13, 2013  
Matheson Mining Consultants, Inc.

Jefferson County Noise Abatement Policy:

<http://jeffco.us/county-administrator/policies-and-procedures/regulations/>

US Bureau of Reclamation, Safety and Health Standards, Section 24.1.8

<http://www.usbr.gov/ssle/safety/RSHS/sec24.pdf>