# REVIEW OF NOISE AND VIBRATIONS FROM CR120 TRUCK TRAFFIC AND MINING OPERATIONS AT THE GCC ENERGY KING II COAL MINE

**Prepared for**

**The Board of County Commissioners of**
**La Plata County, Colorado**
**Durango, CO**

**Prepared by**

**Dr. Catherine T. Aimone-Martin**
**Aimone-Martin Associates, LLC**
**Socorro, NM**

**August 24, 2015**
**Revised September 7, 2015**

**TABLE OF CONTENTS**

## LIST OF FIGURES



## LIST OF TABLES

**BACKGROUND**

GCC Energy King II Coal Mine (GCC) has been operating since 2007 without a La Plata County Special Use Permit. A Class II land use permit for an existing mining operation (the "Project") was submitted for consideration. The permitting system, outlined in La Plata County Code of Ordinances Sec. 82-191 through 198 (the "Code"), uses a Compatibility Assessment process which sets qualitative standards the applicant must meet to mitigate any potential adverse impacts of the Project or development. The mitigation process is designed to ensure that the Project minimizes the impacts of noise and vibrations on surrounding properties and is compatible with the surrounding neighborhood. Compatibility in these areas of otherwise measurable off-site impacts is judged based on a "no disturbance" and appears as a nuisance standard.

The process allows for citizen input through a series of neighborhood compatibility meetings intended to identify the impacts using a review criteria to guide in determination of "compatibility". The applicant is given the opportunity to conduct third party studies and reviews to measure the impacts and offer mitigation to achieve compatibility evaluated by County staff and decision-makers.

The GCC permit process involves special studies to analyze potential adverse impacts of the Project within performance standards related to noise and vibrations from the mining operations and coal haul trucks traveling on CR120. Such studies should serve as guidance tools to help the applicant identify relevant and feasible mitigation as needed. The challenge with this process arises from the lack of quantitative metrics in the Code by which varying degrees of impacts might be calculated and the extent to which mitigation efforts must be effective. The design of such measurements and possible standards are left up to the third party consultant. However, with a nuisance code, such efforts may not provide acceptable results.

This review was conducted to evaluate the potential for noise and vibrations to represent adverse external effects of mining based on study data collected and analyzed by third consultants and to draw conclusions as to the need for mitigation to achieve compatibility. One important step in the review is the determination of adequacy of the studies performed to date to properly identify and measure impacts. The second step is to recommend further studies, if needed, and propose relevant criteria for compatibility determination, whether or not mitigation is required.

**Project Status**

It is the investigator's understanding that the application process is near the final stages of identifying feasible mitigation measures prior to consideration by La Plata County. A partial timeline list of documents and actions associates with the Class II Land Use Permit Application is provided on the website http://www.co.laplata.co.us/sites/default/files/departments/planning/gcc_timeline_bulleted_for_website.pdf

To date, a series of six neighborhood meetings have been conducted to identify citizen concerns of the mine expansion in line with the capability standards outlines in La Plata County Code of Ordinances Sec. 82-191 through 198. Three citizen documents resulted from these meetings and were provided to the County. One document summarized truck traffic impacts on the community along with alternatives for mitigation. The report is titled "An Alternative Approach to King Coal II Truck Traffic", dated July 13, 2015, and signed by 12 residents. A second document was submitted to the County and GCC by the Hay Gulch Citizen Advisory Panel. The report, dated July 8, 2015, described a broader range of impacts and proposed mitigation measures. The applicant has contracted with a number of consultants specializing scientific areas of concern to the citizens to perform studies. These studies summarize measurements and a limited number of performance standards chiefly in the areas of noise, vibrations, and water issues.

A third document, dated August 28, 2015 and signed by 11 residents, is titled "A Response to GCC's Compatibility Assessment and Mitigation Document" and was written to comment on CGG's plans to achieve compatibility. The document provided suggestions for mitigation in the area of truck traffic, speed, dust, and noise.

**Purpose of Report**

The purpose of this report is to

- summarize and evaluate the data collected and mitigation measures proposed to date by the citizens and applicant in the areas of noise and vibrations,
- recommend further studies and additional measurements and analyses that are needed,
- assess the feasibility of mitigation measurement currently proposed,
- identify other mitigation measures not previously considered, and
- provide a summary of noise regulations as they may apply to coal haul truck traffic traveling on CR120.

**Limitations of Review**

This report serves to organize the more important documents required in the review process of the application. This report only focuses on noise and vibrations and does not cover water quality issues or hydrological impacts.

**List of Materials used in Review**

The following outline of documents and materials were used in this review:

Websites

*LaPlata*

- http://www.co.laplata.co.us/departments_and_elected_officials/planning/gcc_energy_project

*Social Media*

- San Juan Citizens Alliance http://sanjuancitizens.org/?s=gcc
- Help Hay Gulch https://www.facebook.com/HelpHayGulch

Local newspaper coverage

*Search by Durango Herald GCC*

- "King Coal wants to grow", November 17, 2012
- "Residents need relief from busy mine operations", May 13, 2015
- "King Coal promises to control trucks", January 27, 2015

Reports submitted by Citizen's Groups

- "An Alternative Approach to King Coal II Truck Traffic", CR120N property owners, July 13, 2015
- "Recommendation for Approval of Class II Land Use Permit GCC Energy/King II Coal Mine", Hay Gulch Citizen Advisory Panel, July 8, 2015
- "A Response to GCC's Compatibility Assessment and Mitigation Document", CR120N property owners, August 28, 2015

Third-Party Studies

*Vibrations*

- "Ground Motions Studies", Matheson Mining Consultants, Inc., January 16, 2013

- "Underground Miner Ground Motion Study", Matheson Mining Consultants, Inc., December 11-31, 2014

*Noise*

- "Noise Assessment King II Coal Mine", Engineering Dynamics Inc., November 2013
  Technical Review of Studies
- "Summary of Analytical Activities in Response to Neighborhood Comments in Conjunction with Permit Expansion of GCC Energy, LLC King II Coal Mine", CDS Environmental Services LLC, May 8, 2014 rev

*Traffic*

- CR120 Traffic Impact Analysis, Roadrunner Engineering, LLC, July 31, 2015

Informal Mine Studies Conducted by GCC

*Traffic Noise*

- Initial measurements of background and loudest truck noise conducted at three locations on CR120 by GCC mine personnel and given on p. 5 of the document titled "Compatibility Assessment and Mitigation" submitted to the County July 31, 2015

Related Codes not adopted by La Plata County

- Colorado Revised Statute (CRS) 25-12-103 Colorado Noise Statute
- Colorado Oil and Gas Conservation Commission (COGCC) Regulations - Section 802
- CDOT Noise Analysis and Abatement Guidelines, March 2011
- Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, 1974

Miscellaneous Documents

*Supplied by GCC*

- Map – surface overview with cross section and geology
- Site Plan Map, July 2012
- Conceptual Plan Maps showing road construction plans and sections, July 31, 2015
- GCC King Coal Overview, December 2014
- Narrative for GCC Energy, LLC King II Coal Mines, Project 2012-0089, July 31, 2015
- Midterm Permit Review no. 7 (MT-07) Response, submitted to, Colorado Department of Natural Resources, April 2015
- Compatibility Assessment and Mitigation, submitted to the County July 31, 2015
- CR120 road alignment and grade variance application documents, July 31, 2015

**REVIEW OF CITIZEN CONCERNS**

The underlying theme of community concerns that are identified by representative citizen groups in reports focuses on road safety and health issues. Specific topics of citizen concerns are outlined in **Table 1** as summarized from documents submitted to the County. The categories and subcategories of concerns are noted along with proposed mitigation. Mitigation efforts by GCC performed to date and planned for the future are noted where applicable in the last column. Comments are also provided by Aimone-Martin.

**Road Safety**

Road safety issues focus on aspects coal haul trucks traveling to and from the mine site and include the future increase in the number of trucks planned, days and time during the day over which haul trucks operate on CR120, speed of travel, physical road conditions (pavement type, width, and grade) to accommodate both local and mine vehicles, and past truck accidents. The long-term quality of the roadway and maintenance requirements are both a safety and cost concern.

Table 1 Outline of citizen concerns and request mitigations, comments by Aimone-Martin and responses of GCC

| Group [1] | Document Date[2] | Category | Subcategory | Impacts Considered | Proposed Mitigation | AMA Comments | GCC Response |
|---|---|---|---|---|---|---|---|
| CR120N property owners "The Group" (12 residents) | 07/13/15 | Coal Haul Truck traffic and Commentary to Traffic Impact Assessment study prepared by Roadrunner Engineering, LLC July 31, 2015 | Rerouting truck traffic | 1. total number of trucks traveling on CR 120<br>2. safety and quality of life (QOL) | propose modified Option 3 in the Traffic Impact Assessment report routing outbound trucks along CR120N and rerouting inbound trucks along CR199/116 to 120 N | Current route passes by 7 residents living < 1000 ft from road. Option 3 passes by approximately 14 residents < 890 ft and the original 7 for a total of 21 residents impacted. | Option 1 of the Traffic Impact Assessment study will be used for this Project. See other impact assessments below |
| | | | | | reduce speed to 25 mph on unpaved road section and 35 mph for certain paved sections | | On gravel sections, the speed limit is 25 mph and 10 mph in front of residences. On paved sections, the speed limit is 5 mph below the posted speed limit |
| CR120N property owners "The Group" (11 residents) | 08/28/15 | Truck traffic | increased number of trucks | increased accident risk | limit truck traffic to 100 trucks per day and increase number in stages | | Has not been provided time for response as of the date of this review |
| | | | hours of operation | | Haul trucks operate 6 am to 10 pm Monday through Friday | | |
| | | | noise | detrimental effects of residents health (unspecified) | | | |
| | | | | noise levels (general) | 1. conduct noise measurements along the 8.8% grade section<br>2. addition of berms, fences, and evergreen trees in front of residents | | |
| | | | travel speed | | 1.Install GPS on truck to monitor | | |
| | | | dust | | monitor dust until road is paved | | |
| | | Roadway changes | | | 1. noise reducing pavement to be used<br>2. replace existing culverts for the Big Stick Ditch<br>3. active warning system to alert of approaching trucks<br>4. additional signage | | |
| | | Character compatibility | road alignment and quality of life | change character | none | increase in underground mining production cannot impact surface agriculture land use;<br>change in road alignment provides improved safety for all traffic | |

Table 1 cont.

| Group [1] | Document Date[2] | Category | Subcategory | Impacts Considered | Proposed Mitigation | AMA Comments | GCC Response |
|---|---|---|---|---|---|---|---|
| Hay Gulch Citizen Advisory Panel (10 residents) representing three constituencies | 07/08/15 | Coal Haul Truck traffic | Safety | travel speed | 25 mph for GVW > 20,000 lb on gravel road leaving mine; 35 mph on all other | | |
| | | | | dust | study health effects of dust suppressant chemicals | | Road dust suppression will continue with road watering until paving of CR120 is completed in 2017. reduced truck speed on gravel will suppress dust and all coal haulers will cover trailers |
| | | | | number of truck/traffic volume | reduce total no. of trucks | | There will be a reduced no. of trucks on Ct 120 on weekends; restricted haul on Sunday and reduce truck nos. on Saturdays |
| | | | | | restrict time of haul | | |
| | | | | | use a separate haul road or convey | | The current route will be used |
| | | | | exceeding safe speeds, reckless driving | call-in number to report violations of unsafe driving | | Monitoring of unsafe driving of all trucks will take place: monitoring speed with radar, post ID nos. on truck rear, maintain logs of speeding, excessive noise; provide driver training. Provide direct dial number for citizens to report safety concerns |
| | | | | | more relevant warning signs on road | | |
| | | | | size of road | widen, pave | | Pave certain gravel portions and improve CR 120, widen the 90 deg. Turn; add vehicle pull-off area, extend culvert, repaint centerline, clear vegetation for improved sighting |
| | | | Road maintenance and serviceability | wear and tear on roads from trucks | impose road use fee to pay for maintenance | | |
| | | | Noise from truck traffic | nighttime QOL and ability to sleep | restrict haul time to eliminate late night haul; no hauling on Sundays | | See above; notice from truck over 6000 lbs will be limited to 86 dBA and 90 dBA for allowable speeds of less than 35 and over 35 mph, respectively, as measure 50 ft from the road centerline [3]. Trucks will have effective mufflers. The "no jake brake" policy will be enforced for trucks traveling south on CR120 |
| | | | | noise amplitude | reduce to 80 dB or less | weighting not specified; 80 dB may be potentially annoying; this level may be in error | |
| | | | | | continuous monitoring of noise | | |
| | | Health | Air quality | | monitoring | | |

Table 1 cont.

| Group [1] | Document Date[2] | Category | Subcategory | Impacts Considered | Proposed Mitigation | AMA Comments | GCC Response |
|---|---|---|---|---|---|---|---|
| Hay Gulch Citizen Advisory Panel (10 residents) representing three constituencies | 07/08/15 | Health | Air quality | noise amplitude | monitoring | | See above; notice from truck over 6000 lbs will be limited to 86 dBA and 90 dBA for |
| | | Mine Operations | Noise | between 6 am and 10 pm | mine operations and truck noise to < 80 dB | does not state where this limit applies | Noise reduction equipment has been installed on the fan. Back-up alarms on equipment have been modified to limit detection at mine property and sound levels reduced to those required by law. GCC will limit screening to 6-10 hrs during the day |
| | | | | between 10 pm and 6 am | <50 dB at residence | assume measured at residence | |
| | | | | | no "Jake" break on CR120 | | |
| | | Vibrations | Ground vibrations from operation of continuous miner | impacts on water wells | NA | definition of constrained is needed | Vibration studies confirm absolutely no vibration impacts to surrounding residences exist fro either surface operations or underground mining |
| | | | | property damage and loss of QOL | NA | | |
| | | Surface ground subsidence | | damage to property | restriction mining to 1000 ft from residences | prediction of subsidence trough is needed along with monitoring program recommended | Subsidence is not a compatibility standard for permit and is covered elsewhere in other regulations. GCC is in compliance with these regulations |
| | | Quality of Life | Health and safety of residents | | compensation to residents | | GCC is committed to maintaining local vistas and minimizing the visual mine footprint, maintaining the historic character of the region, and promoting neighborhood privacy |
| | | Decrease in property value | | | | no evidence to substantiate | |

**(1) three names appear on both lists**
**(2) most recent revision**
**(3) CRS Section 25-12-107 most likely does not apply to this Project and this provision has not been adopted by the County**

**Health and Quality of Life (QOL) Issues**
Health and QOL issues identified by citizens include noise from coal haul trucks traveling on CR120 and from mine site operations, vibrations from underground coal excavation mine facilities and surface equipment, dust generated from truck travel that includes both unpaved road dust and coal fines from trucks. Specific health and QOL issues relate to noise as it disturbs nighttime sleep and the tranquility of rural living. Other health issues include inhalable and respirable dust. A concern that prevails throughout many of these impact areas is noise, particularly from haul truck traveling on CR120. Because this topic is of such concern, truck noise will be highlight throughout the discussions in this review.

**Other Issues**
Other issues include potential property damage from vibrations, surface subsidence from underground mine excavations, and reduced property values. While these are not compatibility standards, subsidence will be addressed as it may be perceived as a possible impact. Subsidence can change the physical and surface characteristics of the area around the mine. Nonetheless, it is easily monitored.

**THE NATURE OF SOUND AND NOISE**

**Appendix A** provides a background on sound and noise and includes a review of units used to measure noise. **Table A-1** gives a list of common sound levels and is followed by a discussion on noise characteristics and the environmental consequences of noise. Human reaction to noise and annoyance are explained.

Noise is any sound that has the potential to annoy or disturb humans, or cause an adverse psychological or physiological effect on humans. A decibel is the basic unit of sound level and denotes the ratio of intensity to a reference sound. Most sounds that humans are capable of hearing have a decibel (dB) range of 0 to 140. A whisper is about 30 dBA, conversational speech 60 dBA, and 130 dBA is the threshold of physical pain.

The human ear does not judge sound in absolute terms, but instead senses the intensity of how many times greater one sound is to another. In general, a 5 dBA change is required before most people realize there is a perceptible sound difference.

**Noise Source Characteristics**
Measurable characteristics of noise are intensity (dB), frequency (the number of cycles per second or Hertz, Hz), spectral content (intensity versus frequency over the entire time varying noise), duration (continuous or impulsive), number of noise events over a given time period, and pattern of occurrence. Stationary noise sources associated with GCC mining operations have been identified as the air intake fan and coal processing equipment. Off-site noise sources include the coal haul trucks with noise generating components such as the engine, cooling fan, air intake, exhaust, transmission, and tires.

**Receptor Characteristics**
The effects of noise on human receptors are varied and depend on the sensitivity and expectations of the person affected, and the environment in which the noise is perceived. No two people are likely to exhibit the same reaction to a noise event on two successive days. Some humans are hypersensitive to noise while others are not and what is barely perceptible to some is highly perceptible and intrusive to others. The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This makes noise impacts, and particularly annoyance, very difficult to assess.

The receptors of the GCC Project are the residents that live near the mine and, particularly those that live along the truck haul routes. Roadway noise can become objectionable and constitute of nuisance when it is unwanted or too loud, unexpected, uncontrollable, or has pure tone components (e.g. of a single frequency).

Further, noise impacts can be severe, especially during nighttime and, in many cases, simple noise mitigation strategies may not suffice.

Any assessments of noise must include comprehensive background measurements before truck noise impacts can be considered. Planning for an acceptable noise exposure must take into account added environmental noise before any mitigation strategies can be considered.

**APPLICABLE CODES AND METRICS AVAILABLE TO ASSESS NOISE COMPATIBILITY AND MITIGATION**

La Plata County currently does not have a county noise statue. Therefore, several code and guideline documents were reviewed for applicability to assess compatibility and mitigation for haul truck noise. Four codes that address impact and/or annoyance are discussed below.

- **Colorado Revised Statute (CRS) 25-12-103 or the Colorado Noise Statute**

This statute generally applies within the state but has not been adopted on the County level. Day and night noise limits are specified in **Table 2** in terms of dBA that apply 25 ft beyond the property line of a noise source. The sources are identified in four zones that include industrial for which the mine is zoned. Specifically, …"sound level radiating from a property line at a distance of 25 ft or more therefrom in excess of the dBA established for the following time periods and zones shall constitute prima facie evidence that such noise is a public nuisance"

**Table 2 CRS 25-12-103 noise limits**

| Zone | 7:00 am to 7:00 pm | 7:00 pm to 7:00 am |
|---|---|---|
| Residential | 55 | 50 |
| Commercial | 60 | 55 |
| Light industrial | 70 | 65 |
| Industrial | 80 | 75 |

It is the writers understanding this criteria has been applied in La Plata County to determine compatibility by considering that the limits are applied at the receptor rather than at the source as the statute was intended. Without considering the nature or zone of the source noise, the County has chosen to restrict noise (unspecified) at residences to 55 dBA during the day and 50 dBA at night.

Two issues of concern are noted with these limits. The limits are very conservative and not intended to apply to transient vehicle noise but rather to continuous noise sources (such as machines) directed toward a receptor. Further, background noise in neighborhoods, in the absence of unwanted noise, often can be higher than the 50 to 55 dBA criteria as will be shown.

Other noise statutes setting limits for vehicle noise (CRS Sec 25-12-106) apply in the sale of new vehicles and should not apply to this Project. However, the example ordinance, given in CRS Sec. 25-12-107, is provided by the state and intended to be a model for adoption on the city and county levels. This noise standard is intended for transient vehicle noise and given as follows:

**Table 3 CRS Sec 25-12-106 noise limits**

| | MAXIMUM MOTOR VEHICLE SOUND LEVEL (dBA) | |
|---|---|---|
| | Speed limit | Speed limit |
| Gross Vehicle Weight Rating | 35 mph or less | over 35 mph |
| less than 10,000 pounds | 81 | 85 |
| more than 10,000 pounds | 89 | 94 |

The values in this criteria are higher than those in **Table 2** because of the transient, short duration nature of roadway noise. Limits in **Table 2** are intended for continuous noise and not to transient, short duration sources. The time duration of passing vehicles is short and the overall impacts are considered, in theory, to be lower than for continuous noise courses.

- **Colorado Oil and Gas Conservation Commission (COGCC) Regulations - Section 802**

COGCC section 802 is identical to CRS 25-12-103 and applies to continuous noise source impacts associated with the exploration and production of oil and gas. Two modification to the Colorado Noise Statute include a 10 dBA allowance above the applicable criteria over a maximum 15 minutes in any one hour period during the day. For impulsive (transient) noise, this allowance is reduced to 5 dBA. A second modification applies to lower frequency noise. In the case of a resident complaint when the noise source is low frequency (a definition of "low frequency" is not provided), a 65 dBC limit is imposed 25 ft from the residence. In this case, a C-weighted measurement system is used that filter out high frequencies above 2000 Hz and low frequencies below 70 Hz. This compares with an A-weighting system that filters out low noise below 1000 Hz.

- **CDOT Noise Analysis and Abatement Guidelines (CDOT 2002, rev. March 23, 2011)**

These guidelines are used to evaluate noise impacts to sensitive receivers that include residents. Limits are based on the FHWA Noise Abatement Criteria (NAC) that considers impacts such as hearing impairment, annoyance, sleep interference, and speech communication interference and apply to certain new highways or physical changes to highways. It should be pointed out that many of the concerned citizens have noted sleep interference from haul truck traffic at night.

Measurements are reported as $L_{eq}$ dBA(T) (equivalent dBA as a function of time, T) which is the A-weighted equivalent continuous level of time-varying (fluctuating) noise averaged over a specified time period, T. The time period must be specified for the measurement results to be meaningful.

Appropriate and representative sampling intervals should be selected and justified. Normally, the typical intervals or 'averaging times' are 15 to 30 minutes during daytime, and 15 minutes during nighttime. These may need to be supplemented with shorter or longer sampling intervals in certain cases. Ideally, sampling over different days and at different times during the day will help to ensure that the survey is statistically representative to cover the variations in human sensitivities.

Noise levels for abatement consideration in the CDOT guidelines are 66 $L_{eq}$ dBA at the exterior of residences. The guidelines also state that noise abatement should be considered when noise levels "substantially exceed the existing noise levels." This criterion is defined as increases in the $L_{eq}$ of 10 dBA or more above existing noise levels.

- **EPA noise levels**

In 1974, the EPA issued a document that recommended outdoor and indoor noise levels intended to protect human health and minimize annoyance of noise to the general public. These levels are not regulatory goals or requirements and only represent a general criteria that might form the basis for state and local governments in setting standards. These have not been adopted by La Plata County.

One recommended level is given in terms of $L_{eq}$ dBA (24) where T is a 24-hour averaging time. A 24-hour exposure level, $L_{eq}(24)$ of 70 dBA was identified as the level of environmental noise which will prevent any measurable hearing loss over a lifetime.

Other levels are based on day/night sound, $L_{dn}$, which is often used for 24-hour traffic noise studies when nighttime noise is of concern. Time varying measurements are averaged over 24 hours. Usually 10 dB is added to the nighttime values in the absence of background noise. An $L_{dn}$ of 55 dBA outdoors and an $L_{dn}$ of 45 dBA indoors were identified by EPA as annoying during nighttime.

- **Federal Highway Administration**

The Federal Highway Administration recommends that exterior noise at a residence in the vicinity of a roadway not exceed 67 dBA measured as the one-hour average ($L_{eq}$).

**COMPATIBILITY DETERMINATION**

Project approval by the County requires a finding of compatibility in areas outlined in County Code section 82-191 (a) and 82-193 (c) 2. Although the suggested standards infer that the Project should not cause disturbance or unsafe conditions, words such as 'adversely' and 'significantly' imply the need for judgement and compromise in establishing acceptance. Many of the concerns listed in **Table 1** represent Project elements that can be readily quantified and mitigation efforts can be measured for public acceptance. Other concerns cannot be measured and mitigation efforts may be a challenge.

As previously stated, quantitative measures applicable to many areas of citizen concern are not specifically available in County codes. As such, compatibility must be assessed using relevant criteria either codified elsewhere or defined by best practices.

Impacts that can be reliably measured and a "no impact" determination made based on well-documented research, scientific findings, and the ability to use measurement systems to substantiate findings are listed below. These concerns can be readily monitored during operations.

- ground vibrations - no impacts have been demonstrated by two studies
- mine subsidence – impacts are being controlled by regulations
- dust – dust issues will be further addressed by the applicant and controlled
- noise as it affects hearing- no impacts have been demonstrated

Impacts associated with metrics that are complex, difficult to assess, or require predictions to judge mitigation effectiveness require input from past experiences and have been included in third party studies supported by GCC. These include

- noise as a nuisance – stationary mine operations clearly do not generate air-born noise at residences. Mitigation efforts to lower noise associated with truck operation are currently underway as shown in **Table 1.**
- increased traffic –mitigation efforts to ameliorate the impacts associated with the numbers of trucks on CR120 are underway and are expected to be completed in 2017. These include road improvements and changes in speed limits to ensure safe travel, lowered dust, and less noise.
- unsightly views and change of neighborhood character and privacy – in this terrain, the mine site is hidden from view. GCC personnel are committed to maintaining vistas and the historical value of the community around the mine.

Citizen concerns which are not possible to quantify and are not part of the compatibility standards include

- quality of life issues, and
- changes in property values as affected by the Project.

**STUDIES CONDUCTED TO ADDRESS CITIZEN CONCERNS**

Four studies by third party consultants were performed since 2013. These studies involved one noise study, one traffic study, and two ground vibration studies. These studies were contracted and managed for GCC by CDS Environmental Services LLC as stated in the summary report of findings. Additional studies of hydrology, and water quality are not addressed herein and are covered by another reviewer.

The purpose of the studies are varied. Each study provided measurements and data that can be of some use for compatibility assessment. For the most part, further studies may be needed before mitigation options can be considered.
Each study is reviewed below with respect to application, limitations and significant findings.

**Study Findings**

- Ground Motions Studies from mine site fan and screen/conveyor, January 2013

This study was performed in response to vibration complaints by two residents residing well over one mile away from the mine. The study did not represent a comprehensive impact study of stationary mine site noise. The following is a summary of the report:

- Ground motion concerns at two residents were addressed by the deployment of seismographs over a 5.5 hr period at a location between the two properties.
- Both residents indicated they perceived steady-state and not transient vibrations; neither resident complained of structure damage nor cracking associated with the vibrations.
- The source of ground motions was identified as the mine fan and screen system at a distance of over 7000 ft away while the underground mining operation was over 9700 ft away.
- The highest vibration amplitude recorded was 0.0075 in/s. However the geophone output showed a baseline shift of +0.004 in/s that was not eliminated prior to the recording. Removing the shift resulted in a peak vibration at the residence of 0.0035 in/s. This is one order of magnitude lower than the lowest threshold detection level for humans of 0.03 in/s based on scientific studies.

This reviewer finds that the peak measured value of 0.0035 in/s is 8.7 times lower than the lowest amplitude of human perception of ground vibrations while inside structures. It is also 14.3 times lower than ground vibrations required to possibly cause hairline cracking in historic structure plaster walls and 214 times lower than vibrations required to crack drywall. Normal and expected human-induced vibrations inside structures during everyday household activities can reach structure motions that are equivalent to

over 2 in/s of outside ground vibrations. It is not possible that the residents can detect mine-generated ground vibration at such small amplitudes and at these extremely long distances away.

*Findings*
This study was not intended to provide data for mitigation as it represents a complaint response to two residents. However the study does have value in that it demonstrates there is no basis for vibration impacts from mining operations.

It is the finding of this reviewer that vibration impacts of mine equipment cannot possibly exit beyond the property limits of the mine. Past vibration research by this reviewer of crusher and screening operations has shown that vibrations fall well below 0.03 in/s at distances of 25 ft and beyond from this equipment. Therefore mitigation of offsite impacts of surface facility operations is not necessary and the mine equipment is compatible with the neighborhood.

- Underground Miner Ground Motion Study from continuous miner, December, 2014

This study was conducted in response to ongoing perceptions of vibrations from mining operations on the part of residents in the Vista de Oro subdivision. Similar to the previous study, it represents measurements recorded in response to complaints. The following is a summary of the report:

- Ground motions directly overlying continuous miner operations were monitored.
- One seismograph was placed 300 ft above the continuous miner on the ground surface for 18 hrs to record vibrations.
- The trigger level was set to 0.005 in/s. No mine induced vibrations were recorded over the monitoring period because the trigger level was never exceeded. All ground vibrations on the mine site were below 0.005 in/s.

*Findings*
It is the finding of this reviewer that the residents of the Vista de Oro subdivision could not possibly detect any ground vibrations from the continuous miner at distance farther than the measurement location overlying mine operations. Ground vibration fell below the trigger amplitude of 0.005 in/s at the closest location to the operations. It is determined there is no impact of mining to residents. Mitigation is not needed for mining and the mining is found compatible with the neighborhood.

- Noise Assessment from Engineering Dynamics Inc. November 2013

This study was performed to assess noise levels and provide commentary on the levels in relation to standards. Mitigation measures were not discussed. The following is a summary of the report:

- Measurements included C-weighted noise recorded at the on-site mine fan and at 7 residences and A-weighted measurements of truck noise recorded at the intersection of CR120 and the mine entrance road
- Truck noise recorded over 22 hrs averaged 55.2 dBA as measured 50 ft from CR120 centerline
- Average noise at residences ranged from 54.2 to 67.6 dBC; high values were attributed to wind and vehicle (not specified) noise; background noise was not subtracted
- Noise levels at residents over the monitoring period did not exceed the CRS 25-12-103 criteria or COGCC Sec. 803 criteria when wind and man-made noises were factored out to isolate only truck noise
- Exact locations of measurements at structures as they relate to codes and guideline compliance were not identified

- Only daytime measurements were recorded; no nighttime measurements were made

A summary of relevant measurements is provided in **Table 4** and are the 1% or 5% exceedance level reported in the study. The sources of the peaks are unknown.

**Table 4 Measured noise levels**

| Measurement locations | $L_{eq}$ dBA | $L_{eq}$ dBC |
|---|---|---|
| Mine road/CR120 | 67 | |
| 7 Residences | | 59.8-80 |

The purpose and design of the measurements were not clearly provided in the report. The study executive summary, as presented in the CDS Environmental Services document, inferred that the mine site fan and other on-site activities were the object of noise measurements. Unfortunately, the study did not include noise associated with coal haul trucks traveling along CR120 where the impacts have been noted by the citizens. Further, nighttime measurements were not made in response to the objectionable nature of nighttime truck traffic.

Specific sources within measurement peaks, such as noise from roadway vehicles and from residential background noise were not identified. The consultant included noise peaks during instrument handling and shut-down in reporting average noise levels and these should have been filtered out prior to analysis. Background noise was reported. However these values appear to be related to the minimum values in the noise time histories captured while measuring impact noise. Background noise measurements in the absence of haul trucks and mine operations influences are needed.

The fan study provided valuable information on fan blade balance and identified a low frequency (20 Hz) noise component that may have been related to balance. Very little information on site source noise amplitude was provided. The peak noise frequency was 315 Hz which is considered to a fairly high frequency. On one hand, high frequency noise will not generate ground vibrations but may contribute to hearing perception only if the close-in amplitude of the noise is sufficient. Unfortunately the dBA or dBC peaks were not reported for the fan and only time histories were provided.

- Noise Assessments from Matheson

Fan and screen noise amplitudes were measured during the vibration study conducted by Matheson (referenced above) at the fan and can be used to provide some insight to the noise peaks at the sources. Knowing the attenuation characteristics of similar air-born noise, predictions of noise at varying distances from the mine can be estimated and the impacts at receptors known to some degree.

Seismographs used by Matheson included a microphone with L-weighting (linear often referred to as Z-weighting) capable of measuring down to 4 Hz where A-weighted systems do not accurately measure. Fan noise was less than 113 dBL 12 ft away. The range of noise amplitude and peak frequencies near the crushing and screening ranged from 104 to 113 dBL and from 5 to 47 Hz peak, respectively. The report indicated measurement distances up to 60 ft away.

These measurements appear to correlate very well with close-in quarry crushing and conveying noise attenuation data (up to 105 ft away) previously measured by Aimone-Martin Associates (AMA) and shown in **Figure 1** with the black line. Measurements were recorded in dBL and converted to dBA based on a conversion developed by AMA. The data originated from hard rock crushing 25 ft above the ground that

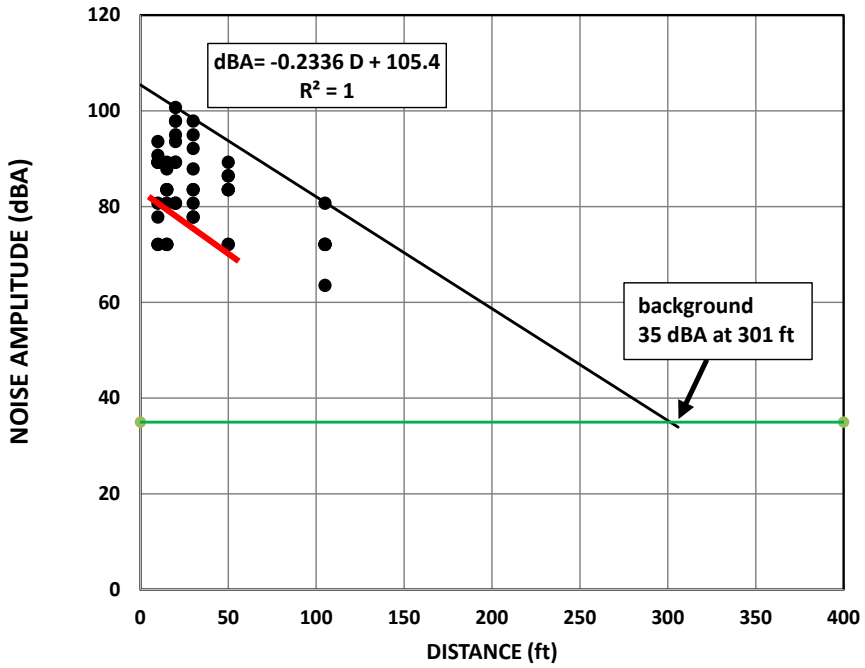



Figure 1 Quarry crusher attenuation study conducted by Aimone-Martin at another project (black symbols and line) in comparison with coal screening noise attenuation from Matheson (red line). Measurements were taken in dBL and converted to dBA

accounts for lower measured noise at 10 and 15 ft away. The quarry data exhibits far higher noise energy than the coal data (red attenuation line) while the attenuation slopes are similar as expected. The most important finding is the distance of 301 ft at which the mine-generated noise is attenuated, in theory, to the background amplitude identified by Engineering Dynamics as around 35 dBA. The coal mine data is expected to similarly attenuate to 35 dBA at less than 180 ft if the red line is extended.

*Findings*

There appears to be no impacts of mine-generated noise on the surrounding community above background levels and the mining operations should be considered compatible with respect to noise. However, the noise study does not provide critical measurements to assess haul truck noise impacts to the community nor does the study produce useful background noise at the receptors along CR120. Well-designed background and truck noise studies are needed.

- CR120 Traffic Impact Assessment

The purpose of this study was to analyze existing traffic volumes on CR120 and define roadway truck source impacts with regard to roadway safety at intersections and roadway loading. Although the study did not address noise per se, it did address truck volume and indirectly addressed the potential for noise impacts based on the numbers of trucks. Eight different haul routes were evaluated and costs to mitigate haul truck impacts to the road along these routes were computed.

Traffic surveys were conducted at three intersections. On Wednesday May 28, 2014 traffic counts took place over 3.5 hours during two shift changes. The survey was conducted at the mine entrance road on CR120 where haul trucks are not necessarily traveling at speeds indicative of the entire CR120 route and

past residences. The data shows the bulk of the vehicles being mine-associated relative to other local travel as no through traffic was noted. “Single unit” is not defined.

The second count occurred at the intersection of CR120 and State 140 on Tuesday July 15, 2014 at 1 hr intervals during peak morning and late afternoon (1 hr). This analysis may be rather confusing as the layman may not be familiar with the manner in which vehicles are accounted for. The vehicle volume counts appears to be based on the total number of axels given in terms of passenger car equivalents. Semi-trucks are broken out. However, since this is a haul truck impact study, there is no designation to indicate which semi-trucks are associated with the mine and which are not. Nonetheless, projected growth rates with planned mine expansion were used to evaluate left turning lane requirements on State 140 needed to accommodate this growth. Although the Consultant’s analysis deems this lane is not warranted, GCC plans to move forward with this turning lane in 2016 as an additional safety measure along with the flashing yellow light added in 2015.

Other counts are not discussed herein as they do not involve the truck route option currently being considered by GCC.

The Executive Summary reports 60% of the trucking hours of operation occur during the 12-hours of daytime (7:00am to 6:00pm) with the balance occurring during the evening hours (7:00pm – Midnight). There is no mention of trucks operating throughout the night.

Maintenance costs associated with haul route options show the lowest costs associated with the current route (Option 1).

Receptor impacts were inferred in a discussion on the density of residents along CR120. The report stated that residential units directly adjacent to the mine are less than 5-dwelling units per square mile (unit is not defined). However, **Figure 2** in the report shows color coding to indicate 20 to 30 residents per square mile near the end of Robert’s Ridge Dr. A careful count using Google Earth shows 4 to 6 residences at best as of June of 2014, in this area depending how the square mile is counted. There are possibly 10 houses along CR120 (not including those on State 140 near the intersection). This density map does not depict the true population in the area and should not be used to assess impact unless verified by other means. A better measure of population may be the county tax address listing along with a visual survey.

*Findings*

The study provided useful information on mine traffic impacts along proposed alternate haul truck travel routes. However there is no useful information on haul truck noise and vibration impacts to citizens and no identified impacts in these areas for the existing truck travel route.

- Informal mine studies – truck traffic noise

GCC undertook informal noise measurements at three locations along CR120. It is assumed that the noise was measured in terms of A-weighting. However this was not specified. Further, the points of measurement relative to the roadway dimensions were not noted. **Table 5** is a summary of this presented in the July 31, 2015 “Compatibility Assessment and Mitigation” document:

**Table 5 Summary of GCC noise measurements**

| | | Noise Levels (assumed to be peaks or $L_{max}$ measured as dBA) | |
|---|---|---|---|
| Location | Background | Loudest truck | Noise without background[(1)] |
| CR120 and CO140 intersection | 60.9 | 74.9 | 74.7 |
| 0.3 mi on CR120 | 61.4 | 77 (single truck) | 76.9 |
| | | 78 ( 3 trucks) | 77.9 |
| | | 83.4 (stock trailer) | 83.4 |
| Mile marker 1.8 on CR120 (1/2 way up hill) | 69.1 | 83 (w/adequate mufflers) | 82.8 |
| | | 86-88 (w/o adequate mufflers) | 87.9 |

(1) calculated by Aimone-Martin

The loudest truck measurement is not out of line with measurements for large trucks driving uphill which is similar to noise during acceleration (Sandberg, 2001).

This informal noise study shows a very important aspect of measuring traffic noise. Background noise was measured and shows the potential to have intensities in excess of the 55 dBA daytime criteria under consideration by the County to limit truck noise for residents living close to the roadway. More importantly, other types of vehicles, such as a stock trailer, generated higher noise levels compared with noise from haul trucks. In addition, the trailer noise exceeded the 55 dBA limit under consideration by the County. Since the measurement distance from the roadway is not known, this data cannot be used for further analysis.

*Findings*

This informal noise study demonstrates an attempt to provide relative measures of background, mine truck and other vehicle noise. Such studies need to continue to ensure background noise amplitudes are fully characterized and other types of vehicles are measured and compared to haul trucks.

## RECOMMENDATIONS FOR ADDITIONAL STUDIES

It is clear that mine truck noise impacts on the community have not been adequately studied. Criteria and methods for mitigation cannot be considered without accurate and comprehensive studies of background noise and truck noise relative to other vehicle noise on CR120. Such studies must include the nature and characteristics of source and receptor noise level as well as noise generated at residents under varying conditions, time of the day and day of the week. Imperative to such studies is the identification of all noise sources.

The outcome of such studies must identify sources of non-mine impacts, a relevant impact criteria or threshold above which mitigation is needed for mine- and truck-generated noise, and the degree to which feasible mitigation methods might reduce the impacts to acceptable levels for compatibility determination.

Therefore it is recommended to conduct a background noise study in the absence of heavy haul trucks and a haul truck noise study. The following sections present a brief overview of similar studies and noise descriptors relevant to such sources.

**Background Noise Studies**

*Metrics - ANSI Standards*

The American National Standards Institute (ANSI) S12.9 provides guidance for environmental noise descriptors and acceptable levels of background residential noise. The A-weighing scale is recommended and ambient noise is reported as $L_{90}$ dBA (T), or the noise level which was exceeded 90% of the measurement time, T. A 5 dBA increase over background is considered as "noise" although no guidance is given for a mitigation threshold or noise tonal qualities (e.g., frequency components).

*Ceres, CA Pre-Project Noise Study*

An example of a comprehensive background noise study in conjunction with a draft EIS is given by Bollard Acoustical Consultants, Inc. (2009) for a project in Ceres, CA and included ambient road noise. This is not background *per se*, but rather existing traffic prior to the start of a construction project. Two days of measurements were conducted. Hourly measurements were averaged over daytime (7 am to 10 pm) and nighttime (10 pm to 7 am) periods in terms of hourly $L_{eq}$ (average) and $L_{max}$ (the absolute peak maximum). $L_{dn}$ was provided for the entire 24 hour period. All measurements were given in terms of dBA. These values serve to demonstrate traffic noise levels at residences. The range in noise values measured at three residential locations were as follows:

| | **Average measured hourly noise (dBA)** | | | |
|---|---|---|---|---|
| | **Daytime** | | **Nighttime** | |
| $L_{dn}$ | $L_{eq}$ | $L_{max}$ | $L_{eq}$ | $L_{max}$ |
| 59-71 | 57-68 | 64-95 | 51-63 | 62-84 |

**Brief Literature Review of Large Truck Noise Sources**

A review of large truck noise sources and methods used to reduce noise is presented herein. Such a review is important to identify relative measurements of noise generated from various parts of trucks prior to considerations of traffic noise mitigation. A limited number of studies identifying sources of stationary and traveling truck noises has been published. The distribution of noise from various components of trucks and the predominant frequencies associated with the noise widely vary in the literature and depend on measurement technique and attributes of the trucks and roadways. Unfortunately, little data is available on the effects of modifications to truck noise on community annoyance.

The most comprehensive truck study by Donavan, et al., (2009), sponsored by the Transportation Research Board (TRB), addresses the sources and levels of heavy truck noises on highways to more successfully mitigate traffic noise impacts. Although the focus of the publication highlights research on noise mapping techniques, referred to as beamforming using arrays of measurement devices, the study is invaluable in pinpointing individual noise sources from test trucks in actual road conditions. It was found that noise near the roads fell in a frequency range between 250 and 2000 Hz with the bulk of the noise above 1500 Hz which is considered in the high frequency range. Plotkin, et al. (2008) provides a description of source mapping for truck noise.

Noise from heavy trucks in the TRB study originated from a variety of sources including exhaust stack outlet, muffler shell, exhaust pipes, engine block, air intake, cooling fan, tires, and aerodynamics. The relative contributions of these sources varied with vehicle type, operating condition, and (for tire noise) the type of pavement. It was determined that 50% of the truck noise came from a source height of 12 ft (at the stack) and 50% came from the ground level and did not depend on truck speed or pavement type. It is the case that mine haul trucks may not have emission stacks but rather mufflers at road level.

Recent European studies have found that tire–pavement noise contributed 63% to 84% of the total truck noise at typical highway speeds. A few studies have shown that noise is strongly dependent on truck tire type. This emphasis on tire noise is perhaps a reflection of engine noise controls put in place over recent years.

The effects of low frequency noise components on structure inhabitants living near roads in Europe and Australia during passage of heavy trucks were reviewed by Roberts (2010). A clear definition of low frequency was not provided while reference to a range less than 200 to 400 Hz appeared to constitute "low to medium frequency". The thrust of this article was nighttime health effects and a low frequency weighting approach used for noise capture of truck engines. It is unclear that studies in the US have provided useful information on low frequency noise and the inclusion of a C-weighted measurements system is needed.

Sandberg (2001) provided a global view of the effects of the vehicle noise regulations on road traffic noise, strides taken to modify noise sources, and long-term community reactions to these modifications, citing numerous studies and measurements. Sandberg verified the 50/50 emission source divided between power unit (engine, exhaust, air intake, and transmission) and tire noise supporting the TRB findings. Limited data on improvements in community annoyance complaints in recent years suggest that annoyance from road noise has reduced in the last 10 to 15 years, despite increasing traffic throughout the world. Recommendations for mitigation from cited studies include reducing tire noise, checking tire wear, assessing the role of the road surface in tire/road noise, and creating better measurement standards.

**Suggested Design of Additional Noise Studies**

Two additional noise studies are recommended before final mitigation considerations and predicting the reductions in impacts. These studies are briefly discussed below.

*Background Noise Study in the Absence of Haul Truck Noise*

A properly designed noise study is required to obtain background measurements at receptors locations (e.g. residents) along CR120. Two sources of noise should be studied and include roadway noise and residential property noise both in the absence of haul truck passage. The residential noise is noise generated on any off-road property. Both A- and C-weighted noise monitoring systems are recommended and the descriptor can be selected appropriate for the environment and time of study ($L_{90}$, $L_{eq}$ and $L_{dn}$ as dBA and dBA; $L_{dn}$ if the study is to be conducted over a 24-hour period and trucks will travel after 10 pm).

Roadway noise should be measured at a "standard" distance of 50 ft from the center of the roadway as well as 25 ft from the closest residential structure in the direction of the road at a sound meter height of 5 ft from the ground. The remainder of measurement locations should be selected to provide a statistically significant attenuation model of noise. All vehicle types separate from haul trucks (not to include haul truck noise) must be identified. Both gravel and paved road sections should be included. All residential background noise generated at or near properties must be identified by source. The study should include one day during the week, over the time period of planned haul truck travel, and on Saturday.

*Haul Truck Noise Attenuation*

A mine haul truck study that focuses on the attenuation or decrease of noise with perpendicular distance away from the road alignment under different roadway conditions is recommended. The study should be performed on the same days and over the same hours as the background study. Measurement location distances of 35, 50, 80 and 140 ft from the center of CR120 are suggested. The $L_{90}$ dBA values for selected time periods over each day should be plotted to establish a series of regression best-fit lines such that the noise levels at or near the closest structures may be predicted anywhere along CR120. The measurement location at 50 ft, common to the both background and truck noise studies, can be compared for the same day and relative time periods to determine a measure of impact. In addition, the non-mine truck background traffic noise can be compared with the interpolated truck noise at inhabited structures.

At a minimum, the haul truck noise study conditions should include various combinations of the following:

- different road surfaces (gravel versus pavement)
- varying haul truck travel speed (e.g. 20, 25, 30, and 35 mph)
- road grade effects, ascent and descent sections versus a flat road
- gear
- travel direction at the 8.8% grade section (ascent and descent)

The outcome should be a series of attenuation plots similar to Figure 1 with 50-percentile linear regression and upper bound lines identified. Analysis includes various combinations of truck driving conditions to determine if mitigation is needed or if acceptable levels of noise at predefined distances from the roadway can be achieved with mitigation.

**Reporting**

Noise measurement reports should contain the

- manufacturer, model type and serial number of the sound level meter, calibrator, and microphone used,
- frequency weighting and meter responses used,
- verification of on-site calibration before and after the measurements using a calibrated acoustic calibrator with a recent (annual) traceable calibration,
- type of windshield and other microphone attachments used,
- a description of the meteorological conditions (wind speed and direction),
- a scaled map of the measurement site showing the locations of measurement point and alignment of CR120,
- the latitude and longitude of each measurement location,
- date and time duration (start and end times) of the measurement, and
- names of the person/s that undertook the survey and drafted the survey report.

For the background study, include

- the source of all non-haul truck traffic to include vehicle type and travel speed, and
- sources of all residential noise, time started and stopped, and if short duration or continuous.

For haul truck study at any one location on CR120, include

- time of truck passage, direction of travel, and travel speed.

Tabulated and plotted measurements for both studies to include, as examples for illustrative purposes only,

- attenuation plots of $L_{90}$ dBA measurements averaged over 1-hour windows (others may include $L_{eq}$, $L_{max}$, and C-weighted measurements if low frequency noise is present); these are plots of noise versus four distances recommended above as shown in **Figure 2** for background and truck noise on a weekday,
- plots similar to **Figure 3** for variation in gear and travel direction (as simplified examples),
- in **Figure 4a** for noise as a function of haul truck speed 50 ft from road centerline (unspecified source)
- In **Figure 4b** for two sensor heights to capture relative noise as a function of frequency for exhaust and tire noise (idealized here and may not be possible),
- other plots to include variations in speed with road surface type, road grade, and travel direction,
- dominate frequencies of all sources identified by plotting frequency spectrums for typical events (passage of vehicles and trucks) each for the varying conditions of study noted above (similar to **Figure 4b**), and
- for residential background noise, tabulated values of $L_{90}$ dBA for measurements taken at structures for various noise sources identified and include $L_{dn}$ if measurements are taken over 24 hours.

**Use of Additional Noise Studies**

These example plots, and other plots to be identified as data is collected and analyzed, will be useful to establish relevant criteria for noise and possible mitigation technologies. It may be the case that the 55 dBA (day) and 50 dBA (night) noise criteria under consideration by the County is below background noise levels and a revised criteria for haul truck noise should be considered.

An essential component of analysis is the dominate frequency associated with various noise sources. In particular, the frequencies of all vehicular traffic must be reported to include passenger and small pickup vehicles, vehicles with trailers, large non-mine trucks and mine haul trucks. This is very important as noise measurements should be analyzed according to frequency range and certain mitigation techniques can only remove specific frequency components.

The increase in dBA noise above background to be considered as a threshold for mitigation is recommended to range from 5 to 15 dBA, depending on the duration and tone of noise impact. This will be assessed after future studies are completed.

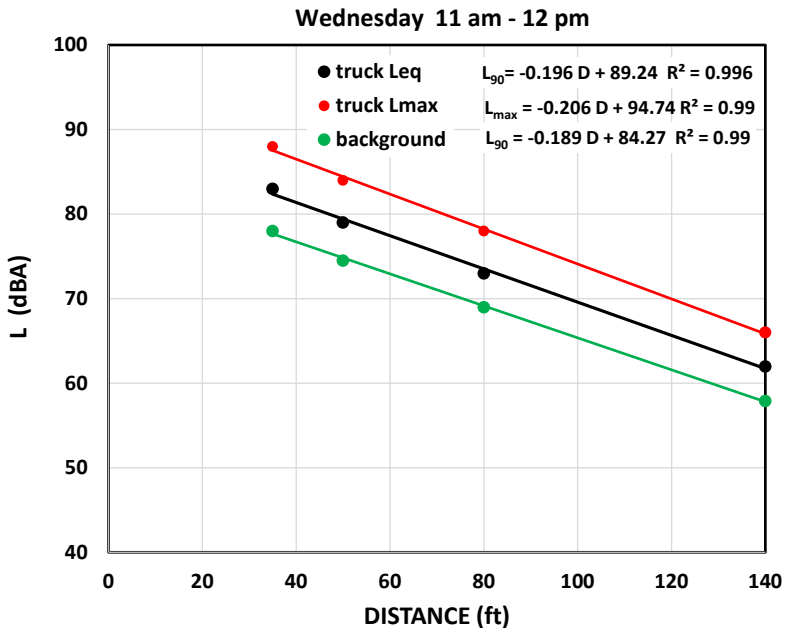



Figure 2 Example attenuation plots for one-hour measurements of background noise as a function of distance from road centerline in comparison with haul truck roadway travel noise for illustration purpose only

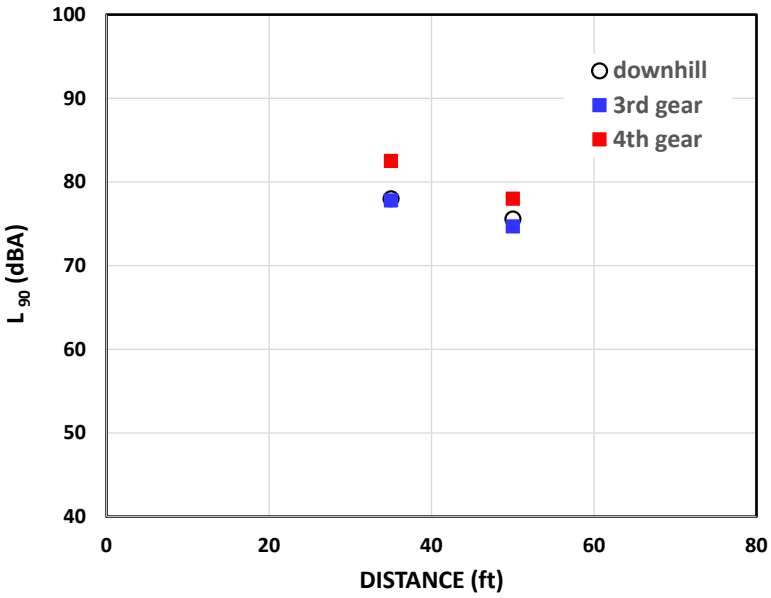
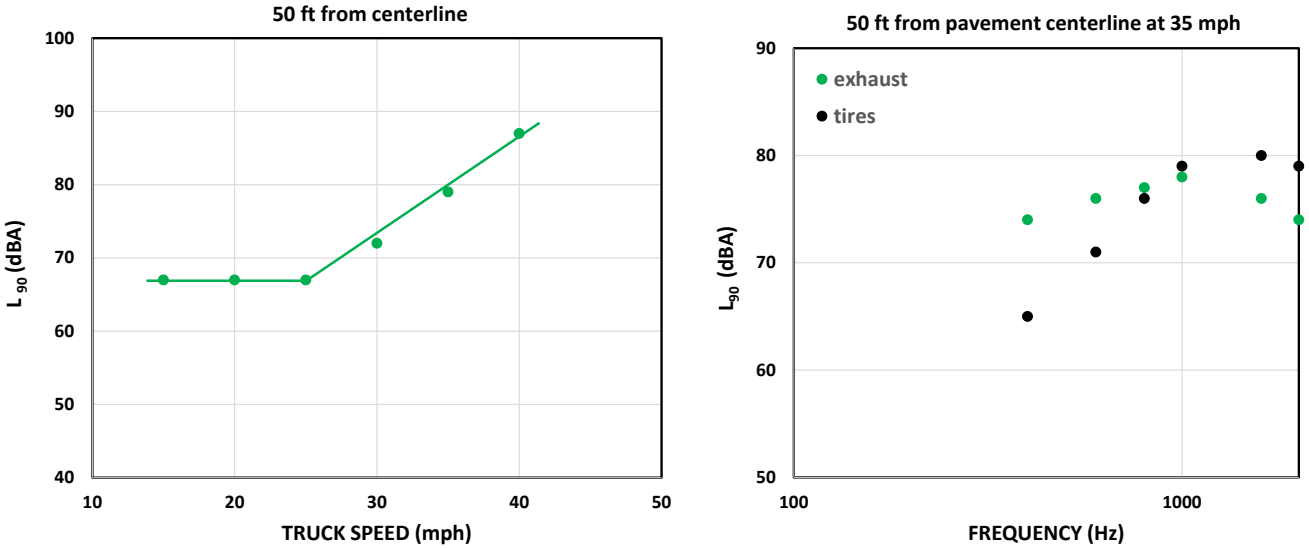



Figure 3 Example one-hour measurements of noise as a function of distance from road centerline for haul truck travel downhill and uphill in 3rd and 4th gears for illustration purpose only




(a) (b)

Figure 4 Noise levels as a function of truck speed (a) and source at truck speed of 35 mph (b) 50 ft from centerline, for illustration purpose only

## POSSIBLE MITIGATION MEASURES TO ADDRESS TRUCK NOISE

The following is an outline of possible mitigation measures available to reduce the impacts of truck noise in terms of source (truck and road) and receptor (residential) generated noises. It should be noted that many of

these measures are currently being considered by GCC regardless of additional noise study results as they represent best manage practices to mitigate truck noise in rural areas.

In some cases, the estimated reduction in noise levels normally gained with these measures are given below. However these reductions are site-specific to past studies and are tempered by many truck-specific and travel conditions. As such, noise reduction numbers are offered only as relative measures.

**Measures to Control Noise at the Source**

- Exhaust silencers/mufflers required on all exhaust systems – (3 dBA reduction)
  This is included in mitigation measures submitted by GCC as outline in Table1.

- Encapsulating or insulating entire engine while improving combustion chamber efficiency (4 dBA reduction)
  Use of acoustical foams or barriers of flexible vinyl, metal foils, or cotton materials to reduce noise outside the audible range and improving the fuel pump.

  Li et al., 2008, studied engine noise for a stationary heavy truck and found that noise energy frequencies were distributed from 800 Hz to 3150 Hz when the truck was accelerated. By selectively monitoring various engine components (engine block, oil pan, turbo charger, injectors, and air compressor contributing between 86.7 to 96.8 dBA) it was determined that oil pan vibrations (96.5 dBA), the engine block (96.8 dBA), and fuel injection pump (90.3 dBA) contributed the most to overall noise directly at the source. The overall noise near the engine was 90.3 dBA.

  A reduction in overall noise during acceleration was achieved by improving the engine performance and adding acoustic absorbing materials to the inside of the engine compartment with gaps to allow for heat to escape. Engine improvements included dynamic balancing the crank shaft and flywheel, replacing the common in-line fuel pump with a VE ("Verteiler", a German word for distributor or divider) diesel injection pump that has comparatively few moving parts, and adding support to the oil pan to suppress vibrations. Acoustic enclosure materials included a micro perforated aluminum panel wrapped beneath the oil pan (providing good acoustic absorption between 500 and 2000 Hz) and the use of superfine fiber glass cotton under the hood and wrapped partially down the sides over the flywheel housing. The results were a 7.5 to 8.3 dBA reduction in overall engine noise during acceleration.

- Use low-noise tire tread to change the tonal qualities from the road base (4 to 5 dbA reduction above 1000 Hz)
  Replace bias ply tires with radial tires and use randomized tread patterns to avoid tonal noise (noise of one tone) from tires especially during extreme acceleration conditions.

- Replace older trucks
  It is well known that noise emission of vehicles increases with age and wear.

- Restrict the use of exhaust brakes
  “Jake brakes” (Jacobs engine brakes) are often perceived as very noisy and when this type of brake is applied, a sudden and extremely loud, sharp sound with a very special temporal pattern may occur. The noise can be especially annoying in poorly muffled or unmuffled exhaust systems, systems that have been illegally modified or poorly maintained, and/or truckers who simply enjoy making noise.

- GCC-stipulated noise standards for trucks as a condition of contract to haul coal

It is recommended that GCC require a reasonable minimum noise output of trucks at a given distance from the roadway for uphill and downhill travel at various speed as a compliance stipulation for contract, require a traffic control plan from contractor, specify tire type and design, and restrict maximum truck age, and so forth.

*Combination of efforts*

- Using combinations of electronic combustion. exhaust silencer, transmission improvements, tire selection, and engine shields (can provide 5 dBA reduction)

- Using combination of combustion optimization and engine speed (rpm) reduction (can provide 4 to 5 dBA reduction)

**Road Noise Control outside the Truck**

- Noise reducing asphalt road overlays have been effective in reducing road noise for heavy trucks; a number of these design mixes include the following:
    - Porous asphalt (3 to 5 dBA reduction)
      1-3 in thick, elastic, porous surface, with 16 to 20% porosity and elastomeric binder to keep water out
    - Stone Mastics Asphalt (SMA) (2 to 3 dBA reduction)
      2 in thick coarse stone skeleton filled with a mastic of bitumen and filler to which fibers are added. Texture resemble porous asphalt but has no porosity

  Research regarding pavement influence on noise levels has been an ongoing process. In general, the use of certain types of asphalt surfaces have been shown to provide noise reduction benefits to properties up to 200 to 300 feet from highways. Long-term benefits are still being evaluated.

  Noise reduction claims state overlays have resulted in 3 to 10 dBA reductions in road noise with an average reduction of 7 to 9 dBA. These studies include trucks on interstate systems traveling at speeds higher than those expected on CR120. It is most likely that an overlay may reduce noise on CR120 by 3 dB or more, particularly when accelerating uphill.

- References for western states that have used overlays include Arizona and Colorado:
  ARIZONA
  Rubberized Asphalt Concrete (RAC) – state of Arizona
  http://www.azdot.gov/business/environmental-planning/programs/quiet-pavement-program/what_is_rubberized_asphalt.asp
  COLORADO
  Rubblization plus Asphalt Overlay (http://co-asphalt.com/resources/media/),

- Cost comparisons are discussed in the following documents:
  CALTRANS
  http://www.dot.ca.gov/hq/maint/Pavement/Offices/Planning_Programming/PDF/2011_CrumbRubberReport.pdf

  ARIZONA – long term cost comparisons
  http://www.csgwest.org/programs/documents/DRAFTExecutiveSummaryonArizonasUseofRubberizedAsphalt.pdf

**Noise Control between Source and Receptor**

- Soil berms and deflection barriers (3 dBA reduction)
  Such berms and barriers are of limited benefit and the pros and cons are outlined below.
  - are aesthetically pleasing
  - where houses are close to the road, berms will take up a larger footprint than walls (a 3:1 slope is needed for stability)
  - houses higher in elevation than the roadway above receive deflected noise enhancement
  - Barriers must have wide openings for visual safety for access that will diminish the effectiveness of a barrier
  - noise barriers are not typically constructed for isolated homes
  - the benefit-cost ratio is the reduction in noise level divided by the cost distributed among the number of residents. The benefit-cost to isolate one home over long distances may become excessive
  - if trucks have elevated exhaust outlets, noise barriers may be less effective

- Vegetation - adding trees, dense tall bushes along the roadway
  Vegetative cover and tree do little good to reduce vehicle noise and are not recommended for consideration for this Project.

- Simply eliminate truck hauling after 10 pm at night to reduce the annoyance factor during community nighttime sleep times

**LONG-TERM MONITORING OF IMPACTS**

Suggestions for long-term monitoring to ensure impacts stay as low as practical include the following:

- Employing a site weather station for real-time reporting of wind speed and direction

- Dust collection systems with weekly analysis

- Real-time noise monitoring stations along the roadway
  Future monitoring must address the need for standardized measurements and reporting units

- GCC employ random noise checks of contactor trucks for the following test conditions at standardized distances: stationary engine, constant speed tire, and acceleration power unit

- Vibrations
  Although vibrations are not an issue and no mitigation is needed, it may be of some use to keep a seismograph deployed above the active coal extraction heading to verify “no impact”

- Travel speed controlled with real-time radar and cameras

- Surface subsidence
  Subsidence in not a compatibility standard although it is a citizen concern. Subsidence is easily measured and cost-effective techniques can be employed with existing mine personnel and survey equipment. The following is a list of possible equipment and methods:
  *Total Station*
  Provides x, y, z ground surface positioning, and requires measurements on regular intervals.

*Monitoring Wells*

Using an existing water well is a useful monitoring technique for subsidence; a sudden drop in water level may indicate subsidence.

**COUNTY NOISE REGULATIONS RELATED TO TRAFFIC**

It is the understanding of this reviewer that the County plans to restrict residential noise from mining operations using the limits given in Colorado Noise Statute Section 25-12-103. These limits are 55 dBA daytime and 50 dBA nighttime and planned to be applied at the residents. These limits may also apply to noise from haul trucks.

The applicability of this Statue, as written, may not apply to the Project for haul truck noise for the following reasons:

- it specifies noise limits 25 ft from the source and not at the receptor (resident); in this case it may have applicability to houses closer than 25 ft from the roadway where a haul truck is considered as a source,

- the day and night residential noise levels are intended for a residential noise source in a residential neighborhood where one resident may affected a neighbor with annoyance noise levels, and

- the code is not specific to road traffic and does not specify the appropriate unit of measure for traffic.

Section CRS 25-12-107 refers to noise from traffic based on ANSI standards for gross vehicle weight and road speed limits. Both codes give limits based on A-weighted measurement systems yet fail to designate the appropriate traffic reporting metric in terms of $L_{eq}$ and $L_{DN}$ to address nighttime traffic impacts. Further, time, T, over which measurements should be taken is not provided.

Lastly, and of greatest concern, is the real possibility that background noise in the absence of haul truck passage may exceed the daytime level of 55 dBA at residents closest to CR120. Informal measurements recorded to date have shown that a private vehicle and trailer exceeded the noise of a haul truck. This raises concerns over the applicability of any noise statute without a proper background study.

**SUMMARY**

A review of noise and vibration impacts that are important to the community members near the GCC Energy King II Coal Mine (GCC) operations has been conducted. Scientific studies of noise and vibrations from third party consultants were evaluated to determine levels of impacts from the mine operations as well as from haul trucks traveling on CR120.

From this review is has been determined that vibrations from mining operations do not impact citizens living in the area. Therefore no mitigation is needed for vibrations.

Noise from mining operations were also demonstrated to provide no impact. Mitigation of mine-site noise is not required.

Noise form haul trucks traveling on CR120 pose a potential increase in noise levels that can be construed as annoying under certain circumstance. Various noise standards for truck traffic were reviewed for applicability to the Project to assess truck impacts. However, before noise standards can be addressed, additional noise studies along CR120 should immediately be undertaken. These studies include the following:

- Background study – to establish the background noise as a function of distance away from CR120 and at selected residents in the absence of any haul truck travel, and

- Haul truck study – to determine the impacts of haul trucks noise above background noise.

Ideally A- and C-weighted noise measurements should be recorded for a 24 hour period, on one weekday and on a Saturday, along gravel and pavement portions of CR120, for different travel directions and on varying road slopes. Noise should be evaluated as $L_{eq}$, $L_{max,}$ and $L_{DN}$ and include frequency components associated with amplitudes. The studies will provide valuable guidance in setting noise limits to be applied at residents along CR120.

The report outlined possible mitigation measure to lessen the impacts of truck noise and provided options for long-term monitoring to ensure citizen concerns are addressed and compatibility is achieved.

**REFERENCES**

ANSI S12.9-2005/Part 4
http://archive.leg.state.mn.us/docs/2015/other/150681/PFEISref_1/ANSI%202005.pdf

Bollard Acoustical Consultants, Inc. (BAC), 2009, Environmental Noise Assessment, Section 4.1 Noise, Draft Environmental Impact Report (Draft EIR) for the proposed Mitchell Ranch Center, City of Ceres, CA
http://staffrep.ci.ceres.ca.us/planning/Mitchell%20Ranch%20DEIR/Draft%20EIR/4.10Noise.pdf

Clarion Associates and Alan Richman Planning Services, and Four Corners Planning and Design Group, Diagnosis of the La Plata County Land Use System (Subpart B of the La Plata County Code), October 2002

Colorado Department of Transportation Noise Analysis and Abatement Guidelines, Department of Transportation Development (DTD) Environmental Programs Branch, Denver, March 23, 2011

Donavan, P., Gurovich, Y. A., Plotkin, K. J., Robinson, D. H., and Blake W. K., 2009, National Cooperative Highway Research Program (NCHRP) Report 635: Acoustic Beamforming: Mapping Sources of Truck Noise, Transportation Research Board, National Academy of Sciences.
Roberts, C., 2010, Low Frequency Noise from Transportation Sources, Proceedings of 20th International Congress on Acoustics, ICA 2010, Sydney, Australia

Environmental Protection Agency, Noise Control Act of 1972, P.L. 92-574, 86 Stat. 1234, 42 U.S.C.

Environmental Protection Agency, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, 1974

Li, H., Lui, H., Yuan, W., and Shannguan, Y., 2008, Study on Identification of Noise Resources and Truck's Noise Reduction, School of Mechanical and Vehicular Engineering Beijing Institute of Technology, Beijing, Chengdu Yunnei Power Co., Ltd., Sichuan, and R&D Center, Beijing AUMAN Heavy Motor Plant, Beijing, *proceedings*, 26th IMAC: Conference and Exposition on Structural Dynamics 2008: IMAC XXVI, Society for Experimental Mechanics ( SEM ), Florida.

Plotkin, K. J., Gurovich, Y., Blake, W. and Donavan, P., 2008, Noise Source Mapping for Trucks, Part 1: Development and Design, *proceedings*, Acoustics 08, Paris, pp 1009-1014.

Sandberg, U, 2001, Noise Emissions of Road Vehicles Effect of Regulations, Final Report 01-1
I-INCE Working Party on Noise Emissions of Road Vehicles (WP–NERV), International Institute of Noise Control Engineering, 2001 July.

**RESOURCES**

Asphalt Pavement Alliance www.asphaltroads.org

Bernhard, R., and Wayson, R.L., An Introduction to Tire/Pavement Noise of Asphalt Pavement.

http://www.asphaltroads.org/assets/_control/content/files/anintroductiontotire-pavementnoiseofasphaltpavement.pdf

# APPENDIX

## Noise Terminology and Units of Measure

**UNITS OF MEASURE**

- A-weighted sound

Traffic noise is most commonly measured in A-weighted decibels (dBA). The dBA scale corresponds to the way in which the human ear perceives, and is sensitive to, the intensity of sounds at different frequencies. The A-weighted sound measurement system filters out noise below 1000 Hz frequency and above 10,000 Hz. Table A-1 provide a list of typical A-weighted noise levels of common sources at or below 90 dBA.

- C-weighted sound

C-weighted measurement system is used to filter out high frequencies above 5000 Hz and low frequencies below 50-60 Hz, preserving much of the low frequency noise.

- $L_{eq}$

The unit of measure commonly used for traffic is an "equivalent" noise energy. This is because traffic noise is constantly fluctuating over time. Therefore, an "equivalent" noise energy is computed that gives the same level of continuous noise as the time-varying noise of intermittent traffic. This is usually measured over a one-hour period for traffic studies and reported as $L_{eq}$ dBA (or equivalent noise in dBA weighting).

- $L_{dn}$

The day/night sound level $L_{dn}$ is often used for 24-hour traffic noise studies when nighttime noise is of concern. It is the average noise level over a 24-hour period. Usually 10 dB is added to the nighttime values in the absence of background noise. The Federal Aviation Administration (FAA) indicated $L_{dn}$ of 65 dB is incompatible with residential communities and requires mitigation such as new fan and exhaust engine technologies.

- Sound Frequency

Frequency is the number of oscillations per second of a periodic sound wave given as Hertz (Hz), or cycles per second. The human ears can perceive or detect sound only at 20 or more Hz. As such, the human ear is more sensitive to high frequency sounds as opposed to low frequency sounds below 20 Hz.

**MEASUREMENTS OF COMMON SOUNDS**

**Table A-1 Comparison of Common Sound Levels[1,2]**

| | | |
|---|---|---|
| Heavy truck (at 50 ft.)<br>Motorcycle (operator)<br>Power lawnmower<br>Jet ski<br>Pleasure motorboat<br>Shouted conversation | 90 | Very annoying |
| Heavy traffic<br>Many industrial workplaces<br>Electric razor | 85 | Level at which hearing damage begins with 8 hour exposure. |
| Ringing telephone<br>Average city noise<br>Freight train (at 50 ft.) | 80 | Annoying; interferes with conversation |
| Freeway traffic (at 50 ft.)<br>Urban housing on major avenue (Ldn)<br>Inside a car<br>TV audio | 70 | Interferes with telephone conversation.<br>EPA Ldn for lifetime exposure without hearing loss. |
| Normal conversation<br>Sewing machine | 60 | Intrusive<br>Interference with human speech begins at about 60 dBA |
| Rainfall<br>Refrigerator<br>Wooded residential (Ldn)<br>Light auto traffic (at 100 ft.) | 50 | Quiet<br>Comfortable<br>Sleep disturbance may occur at less than 50 dBA. |
| Quiet office, library<br>Quiet residential area<br>Rural Residential (Ldn) | 40 | |
| Soft whisper (at 15 ft.) | 30 | Very Quiet |
| Normal breathing | 10 | Just audible |
| | 0 | Threshold of hearing |

[1] Adapted from several web sites, including: League for the Hard of Hearing, www.lhh.org; The Canadian Hearing Society, www.chs.ca

[2] These are typical levels and some may be approximate averages of ranges; actual levels may depend on several factors, including distance from the sound source.

**NOISE CHARACTERISTICS**

Sound is characterized by its intensity, frequency, and duration. Intensity is the physical measurement of sound in decibels, which is perceived as loudness. Frequency is a physical measurement of sound in cycles per second (Hertz), which is perceived as pitch (high and low sounds). Duration is the length of time that a sound continues and is characterized as short-duration, transient or continuous, long-duration. Unfortunately, the element of time is not specified in such cases and the transition between the two durations is often a grey area.

Noise is a variety of sound. The subject of sound and human response is extremely complex. The same noise that would be highly intrusive to someone in a quiet park might be barely perceptible in the middle of the freeway at rush hour. Therefore, planning for an acceptable noise exposure must take into account the types of activities and corresponding noise sensitivity in a specified location for each particular set of land uses.

Noise can be perceived either physiologically or psychologically. Physiological noise can be measured and is related to hearing when sound waves impact the ear drum. Human health effects of physiological noise on hearing are well established. Noise that affects human hearing loss can be quantified and forms the basis of hearing protection for occupational noise.

Psychological noise is sound that is noticed; rather than filtering sound through the subconscious, the sound shifts to conscience awareness and becomes noticeable. Psychological noise is difficult to quantify and is often described as unwanted, disturbing, or annoying. The adverse effects of constant noise can, in some cases, lead to negative health conditions when it is perceived as stressful.

**Health Effects of Noise**

Sudden, short-term and infrequent high-pitched and/or high-intensity sounds can be startling and stressful, even fearful, particularly when not expected. Long-term and frequent periods of high pitch and/or high intensity noise can cause a variety of health issues such as:

- Permanent or temporary loss of hearing
- Permanent ringing or buzzing in the ears
- Stress and stress related illness/disease
- Increase blood pressure, hypertension
- Rest disturbance, sleep deprivation, fatigue
- Absenteeism
- Communication difficulties
- Learning/education difficulties

**Annoyance**

Human reaction to unwanted noise is extremely complex as it is subjective and depends on human sensitivity. A person who finds any loudness and duration of noise disturbing can suffer some of the health effects listed above. No two persons react to noise in the same manner. Whether or not a noise is annoying depends on many sound quality factors. High intensity, short duration noise can be far more disturbing than low intensity long duration noise for some persons whereas the opposite is true for others. Some loud noises may be acceptable when they are expected, such as a sudden crack of thunder. However, thunder may be unexpected to others and the startling effect can be disturbing and make people fearful.

Between a noise source and a receptor, the perceived loudness or intensity may change as a result of distance, topography, vegetation, water bodies, and structures. These changes may increase or decrease the perceived loudness. The closer a receptor is to a noise source the louder the noise seems; for every doubling of distance from a source the intensity drops by about 6 dB over land and about 5 dB over water. Topography, vegetation, and structures can change noise intensity through reflection, absorption, or deflection; reflection tends to increase the intensity, while absorption and deflection tend to decrease the intensity.

**Traffic noise**

Traffic noise from highways and other roads is never constant and depends on the volume of traffic, the speed of the traffic, and the number of vehicles in traffic flow. Traffic noise generally increases with heavier traffic volume, higher speeds and greater numbers of trucks. Vehicle noise is a combination of noise produced by the engine, exhaust, and tires, and can be increased by faulty equipment.

Highway noise is usually described as a single number; most commonly reported as $L_{eq}$. Peak sound levels for freeway traffic at 50 feet may be about 70 dBA, while light auto traffic may be about 53 dBA. The $L_{eq}$ would generally be less. Since traffic noise is a linear noise source, its loudness generally drops about 3 dBA for every doubling of distance from the highway or road, so 70 dBA at 50 feet would be only 67 dBA at 100 feet.

Intermittent traffic noise is a source of psychological noise that can be disturbing depending on human sensitivity. The higher the pitch or more pronounced the intermittency of the noise, the greater the chance of annoyance. Such noise will produce different human reactions within the various environments in which the noise is heard. As such, actual noise level itself is not a good indicator of human annoyance as this level may not be dependent on traffic volume. Regulating noise when growth generates increased traffic makes land use planning a challenge.