Resolution Copper Project and Land Exchange
Environmental Impact Statement

USDA Forest Service
Tonto National Forest
Arizona

August 6, 2018

# Process Memorandum to File

## Noise and Vibration Resource Analysis: Assumptions, Methodology Used, Relevant Regulations, Laws, and Guidance, and Key Documents

This document is deliberative and is prepared by the third-party contractor in compliance with the National Environmental Policy Act and other laws, regulations, and policies to document ongoing process and analysis steps. This document does not take the place of any Line Officer's decision space related to this project.

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# Revision History

| Date | Personnel | Revisions Made |
|---|---|---|
| 08/06/18 | Emily Newell | Process memo created |
| 10/29/18 | Emily Newell | Revisions to memorandum title, revision history table added, edits to purpose of process memorandum section, references and key documents section added |
| 11/15/18 | Emily Newell | Edits to applicability table |
| 12/26/18 | Chris Garrett | Added placeholders based on review of Draft EIS section |
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| 8/06/2019 | Donna Morey | Updated process memorandum to Draft EIS section |

# Purpose of Process Memorandum

In order to provide a concise and accessible summary of resource impacts, certain detailed information has not been included directly in the environmental impact statement (EIS). The purpose of this process memorandum is to describe additional supporting resource information in detail. The Noise and Vibration section of Chapter 3 of the EIS includes brief summaries of the information contained in this process memorandum. This process memorandum covers the following topics:

- Resource Analysis Area
- Analysis methodology
  - Noise Modeling
  - Non-Blasting Noise Modeling
  - Blasting Noise Modeling
  - Blasting Vibration Modeling
  - Noise and Vibration Metrics
- Regulations, Laws, and Guidance
- Key Documents and References Cited

# Detailed Information Supporting EIS Analysis

### Resource Analysis Area

Noise and vibration (i.e., blasting and non-blasting vibration) associated with mining activities would vary spatially and temporarily, as the location and duration of the noise- and vibration-generating project activities would change throughout the life of the project. The spatial analysis area for noise and vibration impacts consists of the extent to which future levels (i.e., noise and vibration levels generated by project activities during each mine phase plus other primary background sources) would attenuate to background levels at sensitive areas. The spatial extent of the project-level noise contours has been determined to be 2 miles. The term “project noise study area” and “project vibration study area” are used to refer to a snapshot in time at which future levels exceeds the selected thresholds or substantially increase over background levels. Mining activities that would produce the most noise and vibration extending the farthest from the project site can be divided into four distinct phases: (1) construction, (2) overlapping construction and operations, (3) operation, and (4) closure and reclamation.

- The construction phase would occur from mine year 1 through 9. The primary noise and vibration sources during this phase would result from trucking in mining equipment to each of the primary facilities (i.e., haul trucks, shovels, graders, pavers, drills, water trucks, etc.); blasting; pile driving; rock excavation; underground and at-grade conveyors construction; and material hauling associated with assembly of the processing plants such as the concentrator complex at the West Plant Site and the filter plant and loadout facility. Increased traffic noise from U.S. Route 60 (U.S. 60) and mine site access roads from personnel commuting to and from the mine sites would also occur during this phase (see Transportation in Section 3.5 of the Draft EIS).
- The overlapping construction and operations phase would occur from mine year 6 through 9. The primary noise and vibration sources during this phase would include some or all of noise and vibration sources associated with the construction phase in addition to normal operations-related noise (i.e., stationary equipment, mobile equipment, transport movement equipment, railroad activities, conveyors operation, processing operations, operations at the filter plant and loadout facility, delivery of supplies, commuter traffic, etc.).
- The operations phase would occur from mine year 10 through 46. The primary noise and vibration sources during this phase would result from stationary equipment, mobile equipment, transport movement equipment, railroad activities, conveyors operation, processing operations, operations at the filter plant and loadout facility, delivery of supplies, and commuter traffic.
- The closure and reclamation phase would occur from mine year 46 through 51 to 56 (depending on the final reclamation plan). The primary noise and vibration sources during this phase would include commuter traffic, deliveries, and decommissioning of mine facilities.

Note that although noise and vibration impacts would occur throughout all four phases of the mine life, this noise and vibration study only evaluates the operational phase and considers it a worst-case scenario. This study also evaluates noise associated with the construction of the operational facilities, estimated to require less than 2 years. The worst-case scenario for each project component is the year which has the maximum equipment use. East Plant Site noise model input uses Year -1, while West Plant Site, MARRCO corridor, and the Filter Plant and Loadout Facility use the years of operations with all equipment and mobile equipment in use.

### Analysis Methodology

Noise and vibration quantitative contours depicting background and future predicted levels at incremental distances from the project sites were developed in a supplemental noise study prepared by Tetra Tech (2018) and Amec Foster Wheeler (2017). The prediction results of these two studies set the framework for discussion of the affected environment for noise and vibration in the project noise and vibration study areas and the analysis of environmental consequences.

#### Noise Modeling

The noise analysis included determining noise impacts at existing and future planned noise-sensitive land uses. A noise-sensitive area is defined as a geographic location chosen to represent a worst-case for any land use Activity Category. Each noise-sensitive area is then defined by a discrete location known as "receptor." When background noise levels are established by field noise measurements, receptors are grouped into a Common Noise Environment (CNE), and at minimum, one measurement site is selected for each CNE. Namely those receptors are in the same land use Activity Category and expected to experience similar noise sources and topographical features. Additional background noise sampling sites at incremental distances from the project site are included to allow for determination of how far the project-related noise would reach. Because background noise levels vary during times of the day, field noise measurements included continuous long-term measurements at representative noise measurement locations for each CNE. Alternatively, field noise measurements can include a limited number of CNEs; in this case, a baseline noise model representing existing conditions is used to extrapolate background noise levels at other noise-sensitive areas.

Future non-noise levels predictions consist of creating a noise model including background environmental conditions and all project-related activities during each of the mine phases to calculate sound levels at incremental distances from sources of known emission. Alternatively, future noise levels predictions would consider a single point in time when noise and vibration-generating activities would most represent the highest levels (i.e., most or all construction equipment/activity operates concurrently with normal operations activities). Background model inputs includes all primary noise sources (i.e., adjacent major transportation network, community, rail, etc.). While project model input includes structures, fixed equipment, mobile equipment, transport movements equipment, etc. Each noise source is then assigned a sound power level, quantity, and utilization factor and entered into the noise model.

#### Non-Blasting Noise Modeling

Operations phase noise predictions included predicting impacts by modeling from all mine components, including the alternative tailings locations. Modeling assumed all mine activities are operating concurrently under favorable sound propagation weather conditions. Modeling input included structures, fixed equipment, mobile equipment, and transportation. Each noise source input included a representative sound source level, quantity, and utilization factor. Noise modeling also considered the following:

- Sound attenuation factors such as reflection from surfaces; screening by topography and obstacles; and effect of terrain features including relative elevations of noise sources.

The combined effect of multiple noise sources and source type (point, area, and/or line).

Noise modeling outputs included a cumulative hourly equivalent sound levels (measured as Leq(h), energy average hourly noise level) and 24-hour day-night average sound levels (Ldn) at the identified receptor locations. For each metric, modeling outputs included predicted project levels (i.e., noise solely from mine activities), anticipated future ranges (i.e., background ranges plus mine noise), and the incremental increase over background noise levels. Modeling outputs also included noise contours displaying sound propagation over the surrounding area of the mine site. Noise contours graphically display how the combined operations noise would be distributed over the surrounding area; they are similar to topography elevation maps (i.e., equal noise levels are represented by continuous lines around a source).

Various regulatory agencies provide published equivalent levels from documented construction sites, including the U.S. Environmental Protection Agency (Bolt Beranek and Newman 1971) and Federal Highway Administration (Knauer et al. 2006). Noise modeling for the construction phase of the operational facilities, including the West Plant Site, East Plant Site, and filter plant and loadout facility, used these published energy equivalent levels as input and calculated noise levels at incremental distances up to 1,000 feet. Modeling assumed a similar type and quantity of construction equipment at each mine facility. Modeling also assumed a point source at the center of the facility site (i.e., spherical spreading of sound waves from the source). Under spherical divergence, generally, noise levels are assumed to drop by about 6 A-weighted decibels (dBA) per doubling distance. This divergence should reasonably address non-blasting noise from typical construction power tools or mechanical equipment where noise-level propagation is not expected to exceed 1 mile. As a conservative approach, for the duration of any construction activity, modeling assumed that associated construction equipment would run simultaneously. Further, modeling excluded possible sound attenuation by shielding effects from intervening structures along the propagation path. The following describes the expected construction activities and duration:

- West Plant Site facility: construction activities assumed to occur over an 18-month period, and would include improving the main site entrance at Lone Tree Road, improving Silver King Mine Road, and constructing the administration building, warehouse, contractor laydown yard, concentrator site, and a new Salt River Project (SRP) substation.
- East Plant Site facility: construction activities assumed to occur near Shafts 9 and 10 and over a 12-month period and would include the expansion of the shaft pad and constructing surface infrastructure to support the underground development and operations. Note that shaft construction can be considered part of the blasting noise and vibration analysis.
- Filter plant and loadout facility: construction activities are assumed to occur at the facility location, along the Resolution Copper–owned Magma Arizona rail line, Skyline Road, and the Magma Arizona Railroad Company (MARRCO) corridor. Construction activities are also assumed to occur over an 18-month period; include constructing the filter plant facility, and implementing improvement on the Magma Arizona rail line, Skyline Road, pipeline, well fields, booster station sites, and access points.

### Blasting Noise Modeling

Construction activities will include the construction of an additional underground tunnel which would contain a conveyor system to transport ore from the underground production mine shafts to the concentrator at the West Plant Site. The tunnel would originate at surface level at the West Plant Site portal and continue underground to approximately 3,400 feet belowgrade at the underground mine. The tunnel construction would use underground drilling and explosives, generating ground-borne vibrations (discussed in a later section) and airblast (peak overpressure).

Airblast noise predictions used information presented in U.S. Bureau of Mines (USBM) Report of Investigations (RI) 8485 (Siskind, Stachura, et al. 1980), and in surface mining regulations (30 CFR 816.67). The predictive model input included distance between source and sensitive receptor, explosives loading per delay, and other site-specific factors. This analysis establishes an upper limit for explosive loading per delay, given airblast limit and slant distance; establishes a minimum slant distance required, given explosive per delay and airblast limit; and calculates a resulting airblast, given explosive per delay and slant distance.

### Blasting Vibration Modeling

Future blasting vibration levels prediction is based on information presented in USBM RI 8507 and Office of Surface Mining Reclamation and Enforcement 30 CFR 816.67 and methodology provided in USBM Bulletin 656. The predictive equation data inputs include “slant” distance between source and sensitive receptor, explosives loading per delay, and site constants. This predictive model can be used to do the following:

- Establish upper limit for explosive loading per delay; given vibration limit and slant distance
- Establish minimum slant distance required; given explosive per delay and vibration limit
- Calculate resulting vibration, given explosive per delay and slant distance

Airblast generates low frequency (sub-audible) and/or high frequency (audible) energies, and the resulting frequencies can be controlled by the design of the blast. There are four airblast contributors: (1) air pressure pulse (APP), (2) rock pressure pulse (RPP), (3) gas release pulse or “gas vent pulse” (GRP), and (4) stemming release pulse (SRP). In a properly designed blast, APP usually dominates the total airblast, and associated frequency range can be controlled by the delay interval. As blasting progresses underground, blasting will generate a lower APP, and will become fully absent in underground blasting environment “total confinement.” RPP is generated by the vertical component of the vibration over an area, usually associated with high-frequency energy, and has the least amplitude of the four airblast contributors. SRP is generated from the blowout when gaseous products vent through stemming. GRP is generated from the blowout when gaseous products vent through fractures in the rock. SRP and GRP are most undesirable (cause most disturbance to people), but they can be controlled by the blast design (i.e., stemming, spacing, burden, delay) and other conditions.

Airblast can sometimes be felt when they occur at acoustic frequencies or below the range of human hearing. At a high enough level, airblast can rattle loose objects or windows. At even higher energies, the potential exists for cosmetic damage, such as cracks in stucco, paint, or plaster. Airblast of

122 decibels (dB) is equivalent to a physical pressure of 0.037 pound per square inch (psi) or an approximately 13 miles per hours (mph) wind gust, which can rattle loose objects or windows. Cosmetic damage in the form of cracks in stucco, paint, or plaster can occur at peak overpressures above 134 dB, equivalent to a physical pressure of 0.0145 psi or an approximately 27 mph wind gust. Airblast above 152 dB is equivalent to a physical pressure of 0.115 psi or an approximately 75 mph wind gust, which can break poorly mounted windows.

Blasting vibrations travel away from a blast in all directions and induce vibration in buildings and other structures. Ground-borne vibrations travel much faster than airblast (first to arrive at a receiver), but also dissipate much more rapidly than airblast. Whereas geological conditions have a strong influence on the distance at which ground vibrations can be felt, it is very rare for blasting operations to produce detectable ground vibrations at distances of more than 1 to 2 miles.

This analysis establishes an upper limit for explosive loading per delay, given vibration limit and slant distance; establishes a minimum slant distance required, given explosive per delay and vibration limit; and calculates the resulting vibration, given explosive per delay and slant distance. This analysis also includes comparison between predicted ground-borne vibrations and measured background levels, in order to evaluate the significance of a possible increase in levels.

#### Non-Blasting Vibration Modeling

Non-blasting vibration describes vibration from railroad, construction activities, pile driving, stationary and mobile equipment, etc. With the exception of pile driving, non-blasting vibrations do not typically cause damage to structures. Human response and annoyance to vibration cannot always be explained by the magnitude of vibration level alone, such as individual perception sensitivity to wall and hanging objects rattling, or other resulting noises.

Blasting from mine construction and other mine activities generates airblast over-pressure and/or ground-borne vibration. Human response and annoyance are usually related to wall rattling and other resulting noises, fear of property damage or injury, and the presence of airblast.

#### Noise and Vibration Metrics

The characteristics of sound include magnitude (loudness), frequency (pitch), and time (duration). Sound-pressure levels are used to measure the intensity (magnitude) of sound and are described in terms of dB. Sound is composed of various frequencies. When measuring noise levels, frequencies to which the human ear does not respond are filtered out. Almost all environmental sound is measured in A-weighted decibels. A-weighting gives greater weight to the frequency sensitivity of the human hearing range. Noise levels developed for this analysis will be expressed in dB using an "A"-scale weighting [dB(A)]. This scale most closely approximates the response characteristic of the human hearing to typical noise levels.

In addition to noise varying in frequency, noise intensity fluctuates with time. Total accumulation metrics are called equivalent levels and represent the sound levels for either a 1-hour, symbolized as Leq(h), or a 24-hour period. The Leq(h) is defined as the equivalent steady-state sound level that, in an hourly period, contains the same acoustic energy as the time-varying sound level for the same hourly period. The hourly equivalent sound level, Leq(h), is commonly used as a descriptor of highway traffic noise. The 24-hour equivalent sound level can be expressed as Leq(24), but even more useful than Leq(24) is the day-night average sound level (Ldn). The Ldn sound level is basically 24-hour worth of Leq(h), except that nighttime hours noise levels (10 p.m. to 7 a.m.) are increased by 10 dB before averaging to include additional weighting factors for potential annoyance due to time of day (i.e., to account for people's sensitivity from nighttime noises).

Statistical descriptions (expressed as Lx, where x represents the percentage of time during which noise levels exceed the specified decibel level) are also used to characterize noise conditions over specified periods. L1, L5, and L10 descriptors can be used to characterize peak noise levels, while L90, L95, and L99 descriptors can be used to characterize background (ambient) noise levels. Note that the L50 value (the sound level is exceeded 50 percent of the time) will seldom be the same as the equivalent noise level value for the period being analyzed because the equivalent noise level value is biased toward the high-decibel contributions.

For relatively continuous noise conditions, the equivalent noise level value is often between the L30 and L40 values for the measurement period. If brief loud noises are common, the equivalent noise level value may be close to the L10 value for the measurement period.

Typical noise levels experienced by humans range from 40 dBA (equivalent to a quiet suburban area at night) to 85 dBA (the approximate noise level occurring 5 feet from a gas engine lawnmower). A change in noise level of 3 dBA may be perceptible to most listeners, whereas a change of 10 dBA may be perceived as a doubling of the noise level. Table 1 describes human loudness perception to a change in sound level. Table 2 provides a summary of the range of dBA levels typically encountered in the environment and examples of various noise sources for each range listed.

Ground-borne vibrations are measured in term of particle-velocity in inches per second (in/sec), with peak-particle-velocity (PPV) being the most critical for setting blasting vibration thresholds. Federal Transit Administration (FTA) (Quagliata et al. 2018) guidance expresses vibration levels in vibration decibels (VdB), by converting vibration levels from PPV to VdB (the decibel notation compresses the range of numbers required to describe vibration).

**Table 1. Human Perception of Sound Level Change**

| Characterization | Acoustic Energy Loss | Relative Loudness Change |
|---|---|---|
| 0 dB | 0 | Reference |
| -3 dB | 50% | Barely perceptible change |
| -5 dB | 70% | Readily perceptible change |
| -10 dB | 90% | Half as loud as original |
| -20 dB | 99% | 1/4-as loud as original |
| -30 dB | 99.9% | 1/8-as loud as original |
| +10 dB | 900% gain | Twice as load as original |

### Table 2. Typical dBA Levels

| Characterization | dBA | Example Noise Conditions |
|---|---|---|
| Threshold of pain | 130 | Surface detonation, 30 pounds of TNT at 1,000 feet.<br>Peak noise 50 feet behind firing position, M-16 and M-24 rifles. |
| Possible building damage | 125 | Mach 1.9 sonic boom under aircraft at 11,000 feet |
| Threshold of immediate noise induced permanent threshold shift (permanent hearing damage) | 120 | Air raid siren at 50 feet |
| | 115 | Commercial fireworks (5-pound charge) at 1,500 feet<br>F/A-18 aircraft takeoff with afterburners at 1,600 feet |
| | 110 | Peak noise 50 feet behind firing position, .22 caliber rifle<br>Peak crowd noise, professional football game, inside open stadium |
| | 105 | Emergency vehicle siren at 50 feet<br>Pile driver peak noise at 50 feet<br>Chainsaw (two-stroke gasoline engine) at 3 feet |
| | 100 | Jackhammer at 10 feet<br>1-mile-range foghorn at 30 feet |
| Extremely noisy | 95 | Locomotive horn at 100 feet<br>2-mile-range foghorn at 100 feet<br>Large wood chipper processing tree branches at 30 feet |
| 8-hour OSHA limit | 90 | Leaf blower at 5 feet<br>Jackhammer at 50 feet<br>Dog barking at 5 feet |
| Very noisy | 85 | Gas engine lawnmower at 5 feet<br>Bulldozer, excavator, or paver at 50 feet<br>Personal watercraft at 20 feet<br>Pneumatic wrench at 50 feet |
| | 80 | Forklift or front-end loader at 50 feet<br>Motorboat at 50 feet<br>Table saw at 25 feet<br>Vacuum cleaner at 5 feet |
| Noisy | 75 | Idling locomotive at 50 feet<br>Street sweeper at 30 feet<br>Ocean beach with medium wind and surf |
| | 70 | Leaf blower at 50 feet<br>1-mile-range foghorn at 1,000 feet<br>300 feet from busy six-lane freeway |
| Moderately noisy | 65 | Typical daytime busy downtown background conditions<br>Typical gas engine lawnmower at 50 feet<br>Ocean beach with light wind and surf |
| | 60 | Typical daytime urban mixed-use area conditions<br>Normal human speech at 5 feet<br>Typical electric lawnmower at 50 feet |

| Characterization | dBA | Example Noise Conditions |
|---|---|---|
| | 55 | Typical urban residential area away from major streets<br>Low-noise electric lawnmower at 65 feet |
| | 50 | Typical suburban daytime background conditions<br>Open field, summer night with numerous crickets |
| Quiet | 45 | Typical rural area daytime background conditions<br>Suburban backyard, summer night with several crickets |
| | 40 | Typical suburban area at night<br>Typical whispering at 1 to 2 feet |
| | 35 | Quiet suburban area at night<br>Quiet whispering at 1 to 2 feet, low background noise conditions |
| Very quiet | 30 | Quiet rural area, winter night, no wind<br>Quiet bedroom at night, no air conditioner |
| | 25 | Computer fan running |
| Barely audible | 20 | Empty recording studio<br>Remote area, no audible wind, water, insects, or animal sounds |
| | 10 | Audiometric testing booth |
| Threshold of hearing, no hearing loss | 0 | |

Note: Indicated noise levels are average dBA levels for stationary noise sources or peak noise levels for brief noises and noise sources moving past a fixed reference point. Average and peak dBA levels are not 24-hour day-night average sound level values. Decibel scales are not linear. Apparent loudness doubles with every 10-dBA increase, regardless of the initial dBA level. Most adults have accumulated some hearing loss and have a threshold of hearing above 15 dBA. In occupational hearing conservation programs, a threshold of hearing between 20 and 30 dBA is considered normal.

### Regulations, Laws, and Guidance

No single regulatory agency or threshold is applicable to non-blasting noise generated by activities at the mine sites. The following guidelines are presented to establish an approximate framework within which appropriate thresholds can be selected. Land use compatibility thresholds of significance for mine construction and operations are most appropriately established with the day-night sound level, because the duration and schedule for these activities may vary during a day. In addition, many government agencies recognize and recommend the use of Ldn metric to establish impacts, including the Federal Interagency Committee on Urban Noise, U.S. Environmental Protection Agency (EPA) for community noise exposure, Federal Aviation Administration (FAA) for aircraft noise assessment, and U.S. Department of Housing and Urban Development (HUD).

Land use compatibility standards for transportation improvements that bring increased commuter and supply truck traffic are commonly expressed in LeqA(h) or Leq(24). The Federal Highway Administration (FHWA) and Arizona Department of Transportation (ADOT) use this metric, whereas HUD applies the Ldn sound level metric to assess traffic noise impacts. Further, in transportation project with multiple noise sources (i.e., community, railroad, aircraft, and traffic), FHWA’s Analysis and Abatement Guidance methodology recommends using the noise thresholds given in Leq(h) in the noise abatement criteria (NAC) as Ldn. Again, this highlights the popularity of the Ldn metric.

Table 3 provides a summary of noise and vibration laws, regulations, policies, and plans at the Federal, State, and local level.

**Table 3. Federal, State, and Local Relevant Laws, Regulations, Policies, and Plans**

| Laws, Ordinances, Regulations and Standards | Description | Applicability |
|---|---|---|
| "Procedures for Abatement of Highway Traffic Noise and Construction Noise", Title 23 Code of Federal Regulations, Part 772 (23 CFR 772), FHWA (July 2010). | The main objectives of 23 CFR 772 are "to provide procedures for noise studies and noise abatement measures, to help protect public health and welfare, to supply noise abatement criteria, and to establish requirements for information to be given to public officials for use in the planning and design of highways approved pursuant to Title 23, United States Code." | According to FHWA regulations, a traffic noise impact occurs when the predicted future noise levels (i.e., generated by project activities plus other background sources) approaches or exceeds the Noise Abatement Criteria (NAC) for the specified land use Activity Category. In addition, an impact occurs when predicted future noise levels substantially increase (i.e., 5 to 15 dBA) over background noise levels. The FHWA/ADOT NAC are shown in Table 5 below. |
| "Highway Traffic Noise: Analysis and Abatement Guidance", FHWA (December 2011). | Provides guidance to the Federal Highway Administration for applying 23 CFR 772 in the analysis and abatement of traffic noise | If monitoring indicates non-compliance or suggests a potential non-compliance with local noise regulations at a facility, Resolution Copper will identify key contributors to the external noise and implement adequate engineering or institutional controls to ensure compliance. |
| "Use of Explosives: Control of Adverse Effects", 30 CFR 816.67, United States Department of the Interior, Office of Surface Mining Reclamation and Enforcement, OSM (Effective on January 19, 2017). | "Blasting shall be conducted to prevent injury to persons, damage to public or private property outside the blasting area, adverse impacts on any underground mine, and change in the course, channel, or availability of surface water outside the permit area." | Tables 4 and 8 present OSM standards for airblast and ground-borne vibration levels, respectively. Blasting activities shall not exceed these levels at the location of any dwelling, public building, school, church, or community or institutional building outside the permit area, except at structures owned by the mining permittee or owned and leased by the permittee to another where a written waiver has been submitted.<br>USBM RI 8485 maximum airblast levels are similar to those in Table 4, but also conclude that airblast levels exceeding 120 dBL will result some annoyance from rattling and fright. Further, airblast levels of 134 dBL, 5 to 10 percent of homes will exhibit disturbance. This suggests airblast levels at or below 120 dBL will avoid prompting structural and human response issues. USBM RI 8485 suggests airblast level measurements is best represented by 2 Hz frequency, but also recognizes that most measuring instruments setup include 5 and 6 Hz frequencies. |

| Laws, Ordinances, Regulations and Standards | Description | Applicability |
|---|---|---|
| "Use of Explosives: Control of Adverse Effects", 30 CFR 816.67, United States Department of the Interior, Office of Surface Mining Reclamation and Enforcement, OSM (Effective on January 19, 2017).<br>(continued) | | USBM RI 8507 and 8485 defines ground-borne vibration thresholds as a function of generated frequencies transmitted into structures and types of construction (Table 9). Low frequencies (≤ 40 Hz) develop with increasing distance from a blasting site (i.e., long blast to structure distance), cause the most structural response, and can result in excessive level of displacement and strain. High frequencies (> 40 Hz) are less likely to promote structural response and transmit very little energy to structures (i.e., length of wave cycle is relatively short compared to a structure dimensions). Blasting ground-borne vibration waves usually consist of both high and low frequencies, with high frequencies occurring in the beginning and low frequencies at the end. Occasionally, a high frequency peak occurs early in the wave, and with the presence of a long wave, significant low frequency components would be expected. Therefore, the safest approach would limit a blast design to low frequency thresholds (at least until blast commences, at which time site-specific data can be collected and used to refine the blast design).<br>Human response to ground-borne vibrations can also occur at levels considerably lower than those related to the effects on residential structures. Human response to vibration is dependent not only on the level of vibration, but also the event duration. USBM RI 8507 concludes that PPV at or below 0.5 in/sec occurring in 1-second event duration) should be tolerable by 95 percent of people, but complaints resulting from house rattling, fright, being startled, and activity interference can be as high as 80 percent. |
| "Arizona Department of Transportation Noise Abatement Requirements", ADOT (May 2017). | These requirements were developed in compliance to the CFR noise regulation at 23 CFR 772. | Resolution Copper must abide by the FHWA/ADOT noise abatement requirement outlined in Table 5. Current baseline studies have demonstrated that Resolution Copper currently complies with all regulations. During construction and operations, the noise level is expected to increase from current baseline levels as activities requiring the use of heavy equipment increase. |
| "The Pinal County Excessive Noise Ordinance" Pinal County, No. 05306-ENO as Amended by 031611-ENO-01 (2011). | Provides noise threshold limits for excessive noise levels at specified identified land use areas. Noise from properties may not exceed prescribed noise limits at the property boundary. | This noise ordinance is applicable to unincorporated Pinal County lands and would not apply to incorporated municipal lands such as the Town of Superior. Applicable Noise Limits can be derived from Table 6 below. |

| Laws, Ordinances, Regulations and Standards | Description | Applicability |
|---|---|---|
| U.S. Department of Housing and Urban Development Standards HUD | HUD established noise guidelines from a series of surveys compiled in 1974 by U.S. EPA (Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety). Most of the surveys indicated two breakpoints in reported interference and annoyance. Below 55 Ldn sound level, there was very little interference (for example, speech intelligibility was more than 99 percent) and very little resulting annoyance. Over 65 Ldn sound level, interference and annoyance increase rapidly. The EPA set 55 Ldn sound level as the basic goal. But other Federal agencies, including HUD, in consideration of their own program requirements and goals as well as the difficulty in achieving a goal of 55 Ldn sound level, have settled on 65 Ldn sound level as their standard. At 65 Ldn sound level, activity interference kept to a minimum, and annoyance levels are still low. Table 7 summarizes the HUD acceptability standards. | HUD's day-night average limits can appropriately assess impacts of mining activities because the duration and schedule for these activities may vary during a day. The standards could also apply to assessing impacts from commuter and supply truck traffic, although other Federal and State standards assess impacts using the equivalent noise level metric. |
| FTA 2018 Guidelines | The FTA 2018 guidelines describe ground-borne PPV in vibration velocity levels in decibels (VdB). The decibel notation is used to compress the range of numbers required to describe vibration. FTA guidelines state "PPV is generally accepted as the most appropriate descriptor for evaluating the potential for building damage. For human response, however, an average vibration amplitude is more appropriate because it takes time for the human body to respond to the excitation (the human body responds to an average vibration amplitude, not peak amplitude). Because the average particle velocity over time is zero, the root-mean-square (RMS) amplitude is typical used to assess human response." | Converting PPV to VdB usually includes a "crest factor" between 4 and 5, which is equivalent to 12 to 14 VdB. A crest factor is defined as the ratio peak amplitude (PPV) to RMS value, implying that RMS is always less than PPV. Table 10 shows that background vibration levels within residential areas are at or below 0.0013 PPV (50 VdB). While, human perceptibility usually begins at 0.007 PPV (65 VdB) and strong annoyance response begins at 0.04 PPV (80 VdB).<br><br>Non-blasting construction activities is another source of ground-borne vibrations, which usually do not reach the levels that can damage structures. Table 11 provides reasonable estimates for source levels measured under a wide variety of construction activities and soil conditions. Though a single source level (representing the average of measured data points) is reported in the table below, considerable variation may be present at each site. FTA guidelines also defines maximum ground vibration thresholds based on the type of construction (Table 12). |

| Laws, Ordinances, Regulations and Standards | Description | Applicability |
|---|---|---|
| Occupational Safety and Health Administration Standards (OSHA) guidelines | State that worker protection against the effects of noise exposure shall be provided when the sound levels exceed the A-weighted of a standard sound level meter at slow response (ranging from 90 dBA for 8 hours to 115 dBA for 15 minutes). When employees are subjected to noise levels that exceed the prescribed levels, personal protective equipment shall be provided and used to reduce sound levels to within the levels of the table. | OSHA standards are most appropriately applied in assessing the impacts of mining operation and construction on mine personnel. |
| Mine Safety and Health Administration (MSHA) Occupational Noise Exposure Standards | Delineate permissible exposure limits for A-weighted noise levels, measured at slow response, between 80 dBA for a 32-hour duration and 115 dBA at a 15-minute duration. The mine operator must establish a system of monitoring that evaluates each miner's noise exposure sufficiently to determine continuing compliance with this part (30 CFR 62) using a noise dosimeter. The noise determination must be made without adjustment for the use of a hearing protector, use a 90-dB criterion level with a 5-dB exchange rate, and use the A-weighting and slow response setting.<br>The exchange rate is a measure of how much noise level would have to change to preserve a selected measure of the risk of hearing loss (90 dB for mining activities) when the exposure duration is doubled (or halved). At no time can the noise level exceed 115 dBA; therefore, a maximum noise level metric is appropriate in such cases. | MSHA standards, as described in 30 CFR 62, are applicable specifically to miners for the duration of their workday. The standards impose reporting requirements and maintenance of records on mine operators. They are most appropriately applied in assessing the impacts of mining operations and construction on mine personnel. |

### Table 4. Peak Overpressure (Airblast) Levels

| Lower Frequency Limit of Measuring System, in Hertz (Hz), ±3 dB | Maximum level, in dB |
|---|---|
| 0.1 Hz or lower – flat response* | 134 peak |
| 2 Hz or lower – flat response | 133 peak |
| 6 Hz or lower – flat response | 129 peak |

| Lower Frequency Limit of Measuring System, in Hertz (Hz), ±3 dB | Maximum level, in dB |
|---|---|
| C-weighted – slow response* | 105 peak C weighted decibels |

* Only when approved by the regulatory (permitting) authority

### Table 5. FHWA and ADOT Noise Abatement Criteria

| Activity Category | Activity Criteria* | | Description | Applicability |
|---|---|---|---|---|
| | Leq(h) | L10(h) | | |
| A | 57 (56) | 60 | Exterior | Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential, if the area is to continue to serve its intended purpose |
| B† | 67 (66) | 70 | Exterior | Residential |
| C† | 67 (66) | 70 | Exterior | Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings |
| D | 52 (51) | 55 | Interior | Auditoriums, daycare centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios |
| E† | 72 (71) | 75 | Exterior | Hotels, motels, offices, restaurants/bars, and other developed lands, properties, or activities not included in A through D or F. |
| F | – | – | – | Agriculture, airports, bus yards, emergency services, industrial, logging, maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing |
| G | – | – | – | Undeveloped lands that are not permitted |

Source: Table 1 from 23 CFR 772, Procedures for Abatement of Highway Traffic Noise and Construction Noise, FHWA 2010, and ADOT Noise Policy

Note: Either Leq(h) or L10(h) (but not both) may be used on a project.

* The Leq(h) and L10(h) Activity Criteria values are for impact determination only and are not design standards for noise abatement measures.

† Includes undeveloped lands permitted for this activity category.

### Table 6. Noise Limits for Pinal County Land Use Zoning Classifications

| Zoning District Classifications* | Leq Limits, dBA† |
|---|---|
| Residential (CR-1A, CR-1, CR-2, CR-3, CR-4, CR-5, OS, MH, RV, MHP, PM/RVP, TR) | 60 dBA (7am-8pm)<br>55 dBA (8pm-7am) |
| Commercial or Business (CB-1, CB-2) | 65 dBA (7am-10pm)<br>60 dBA (10pm-7am) |
| Industrial (CI-B, CI-1, CI-2) | 70 dBA (7am-10pm)<br>65 dBA (10pm-7am) |
| Rural (CAR, SR, SR-1, SH, GR, GR-5, GR-10) | 65 dBA (7am-9pm)<br>60 dBA (9pm-7am) |

* Sound projected from property within one zoning district into property within another zoning district of a lesser sound level limit shall not exceed such lesser sound level limit.

Construction noise limits are not addressed in this noise ordinance, instead, it limits construction operation times to the following:

- Concrete Work can occur from 5:00 a.m. to 7:00 p.m. from April 15 to October 15, and 6:00 a.m. to 7:00 p.m. from October 16 to April 14.
- Other Types of Construction can occur from 6:00 a.m. to 7:00 p.m. from April 15 to October 15, and 7:00 a.m. to 7:00 p.m. from October 16 to April 14.
- Construction and repair work in non-residential areas (i.e., 500 feet or more from a residential property) shall not be limited to 5:00 a.m. to 7:00 p.m.
- Weekends and Holidays Excluded Construction or repair work shall be limited to 7:00 a.m. to 7:00 p.m. and concrete pouring shall be limited to 6:00 a.m. to 7:00 p.m.

† The Leq limits specified for a 2-minute time interval. Partial Leq levels may be obtained as necessary to assure an accurate indication of the representative sound environment for the site.

### Table 7. Site Acceptability Standards

| Sound Level Considered as | Ldn, dBA | Special Approvals and Requirements |
|---|---|---|
| Acceptable | Not exceeding 65* | None |
| Normally Acceptable | Above 65, but not exceeding 75 | Special Approvals†, Environmental Review†, Attenuation‡ |
| Unacceptable | Above 75 | Special Approvals†, Environmental Review†, Attenuation‡ |

*Acceptable threshold may be shifted to 70 dB in special circumstances pursuant to 24 CFR 51.105(a), HUD

† See 24 CFR 51.104(b), HUD, for requirements.

‡ 5 dB additional attenuation required for sites above 65 dB, but not exceeding 70 dB; 10 dB additional attenuation for sites above 70 dB, but not exceeding 75 dB (24 CFR 51.105(a)).

### Table 8. Maximum Ground-Borne Vibrations Based on Distance from Blast Site

| Distance between Blast Site and Structure (feet) | Maximum Allowable PPV, in/sec* |
|---|---|
| 0 to 300 | 1.25 |
| 301 to 5,000 | 1.00 |
| 5,001 and beyond | 0.75 |

* Ground-borne vibration shall be measured as the particle velocity. Particle velocity shall be recorded in the three mutually perpendicular directions. The maximum allowable PPV shall apply to each of the three measurements.

## Table 9. Maximum Ground-Borne Vibrations Based on Type of Structure and Frequency

| Type of Residential Structure | Maximum Allowable PPV, in/sec | |
|---|---|---|
| | At Low Frequency* (≤ 40 Hz) | At High Frequency (> 40 Hz) |
| Modern home, drywall interiors | 0.75 | 2.0 |
| Older homes, plaster on wood lath construction for interior walls | 0.50 | 2.0 |

* All spectral peaks with 6 dB (50 percent) amplitude of the predominant frequency must be analyzed. Further, USBM RI 8507 provides an alternate ground-borne criteria to provide a smoother set of criteria to eliminate the sharp discontinuity in the frequency range and associated PPVs thresholds (i.e., 40 Hz in Table 6). Interpreting data provided in Appendix B of USBM RI 8507 suggests a maximum "safe" vibration level of 0.1884 PPV in/sec at 1 Hz, increasing to 0.5 PPV in/sec at 2.7 to 10 Hz for a plaster type construction or 0.75 PPV in/sec at 4 to 15 Hz for a drywall type construction, then increasing to 2.0 PPV in/sec at 40 to 100 Hz.

## Table 10. Typical Levels of Ground-Borne Vibrations

| Human/Structural Response | PPV, in/sec | Typical Sources 50 feet from Source |
|---|---|---|
| Threshold, Minor Cosmetic Damage, Fragile Buildings | 0.4<br>0.15<br>0.2 | |
| Difficulty with tasks such as reading a video display terminal (VDT) screen | 0.13<br>0.07 | Commuter Rail, Upper Range |
| Residential Annoyance, Infrequent Events* | 0.04<br>0.022 | Rapid Transit, Upper Range<br>Commuter Rail, Typical |
| Residential Annoyance, Typical Events† | 0.016<br>0.013 | Bus or Truck Bump Over<br>Rapid Transit, Typical |
| Approximate Threshold of Human Perception | 0.007<br>0.005<br>0.0013 | <br>Bus or Truck, Typical<br>Typical Background Vibration Levels |

Source: FTA 2018 Guidelines (Quagliata et al. 2018) and Tetra Tech 2018.

Note: RMS Vibration Velocity in VdB reference to $10^{-6}$ in/sec and includes a crest factor of 4 (i.e., representing a difference of 12 VdB).

* Frequent events are defined as more than 70 events per day of the same source.

† Infrequent events are defined as fewer than 30 events per day of the same source.

## Table 11. Vibration Source Levels for Construction Equipment

| Equipment | | PPV, in/sec at 25 feet from source | Vibration Decibel, VdB* at 25 feet from source |
|---|---|---|---|
| Pile driver (impact) | Upper Range | 1.518 | 112 |
| | Typical | 0.644 | 104 |
| Pile driver (sonic) | Upper Range | 0.734 | 105 |
| | Typical | 0.170 | 93 |
| Clam shovel drop (slurry wall) | | 0.202 | 94 |
| Hydromill (slurry wall) | In Soil | 0.008 | 66 |
| | In Rock | 0.017 | 75 |
| Vibratory roller | | 0.210 | 94 |

| Equipment | PPV, in/sec at 25 feet from source | Vibration Decibel, VdB* at 25 feet from source |
|---|---|---|
| Hoe ram | 0.089 | 87 |
| **Large bulldozer** | **0.089** | **87** |
| Caisson drilling | 0.089 | 87 |
| Loaded trucks | 0.076 | 86 |
| Jackhammer | 0.035 | 79 |
| Small bulldozer | 0.003 | 58 |

Source: FTA 2018 Guidelines (Quagliata et al. 2018)

Note: **Bolded** cells indicate the selected worst-case vibrating source for the non-blasting vibration analysis (see subsection 3.16.3.2 in the DEIS) and Tetra Tech 2018.

* RMS Vibration Velocity in VdB reference to $10^{-6}$ in/sec and includes a crest factor of 4 (i.e., representing a difference of 12 VdB).

**Table 12. Maximum Levels of Ground-Borne Vibrations**

| Building Category | PPV, in/sec | Vibration Decibel, VdB* |
|---|---|---|
| I. Reinforced-concrete, steel or timber (no plaster) | 0.5 | 102 |
| II. Engineered concrete and masonry (no plaster) | 0.3 | 98 |
| III. Non-engineered timber and masonry buildings | 0.2 | 94 |
| IV. Buildings extremely susceptible to vibration damage | 0.12 | 90 |

Source: FTA 2018 Guidelines

* RMS Vibration Velocity in VdB reference to $10^{-6}$ in/sec and includes a crest factor of 4 (i.e., representing a difference of 12 VdB).

# Key Documents and References Cited for Noise and Vibration

The following list is meant to highlight key process or analysis documents available in the project record. It should not be considered a full list of all available documentation considered within this process memorandum or the EIS analysis.


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