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Process Memorandum to File

Overview of Potential Mining Impacts on Public Health and Safety and Rationale for Analysis Approach

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Contents

Purpose of Process Memorandum 1

Summary of Scoping Concerns 1

Comments Associated with Public Health and Safety 1

Air Quality/Dust 2
Water Quality 2
Historic Contamination 3
Tailings Safety 3
Cancer Clusters 3

Issues Report 4

Air Quality 4
Water Quality 4
Historical Contamination 5
Tailings Safety 6
Cancer Clusters 6

Air Quality Hazards and Analysis Approach 6

Ozone Levels 6

Sulfur Dioxide 7

Particulate Matter 7

Particulate Matter 2.5 ($PM_{2.5}$) 8
Particulate Matter 10 (PM_{10}) 8

Carbon Monoxide 8

Nitrogen Oxide 9

Volatile Organic Compounds 9

Sulfates 10

Hazardous Air Pollutants 10

Greenhouse Gases 11

General Analysis Approach and Rationale for Air Quality Impacts 11

Health Effects 11
Other Environmental Effects 13
Greenhouse Gases and Climate Change 14

Water Quality Hazards and Analysis Approach 14

Acid Mine Drainage 14

Heavy Metal Contamination and Leaching 15

General Analysis Approach and Rationale for Water Quality Impacts 17

Hazardous Materials Analysis Approach 19

Hazardous Substance 20

Diesel Fuel 20
Explosives (Emulsion Product and Blasting Detonators) 20

Oils/Lubricants 21
Solvents 21
Antifreeze 21
Propane 22
General Analysis Approach and Rationale for Hazardous MAterials 22
Geological Hazards Analysis Approach 22
Abandoned Mine Workings 22
Mine Openings 22
Deadly Gases and Lack of Oxygen 22
Cave-ins 23
Unsafe Structures 23
Unstable Explosives 23
Waste Rock Heaps 23
Water Hazards 23
Accelerated Erosion 23
Seismic Hazard 24
Seismic Hazards near Mine Site 24
Seismic Hazards and Stability of Tailings Facility 24
Mine Subsidence 25
General Analysis Approach and Rationale for Geological Hazards 25
Hazards from Historic Contamination of Soils and Analysis Approach 26
General Analysis Approach and Rationale for Soil Contamination 26
Noise Hazards and Analysis Approach 26
General Analysis Approach and Rationale for Noise 28
Traffic Hazards and Analysis Approach 29
General Analysis Approach and Rationale for Traffic 29
Potential Need for Human Health Assessment 30
Cancer Statistics 30
Specific Studies 30
Summary of Review 31
General Analysis Approach and Rationale for Addressing Public Concerns of Cancer Prevalence 31
Literature Cited 32

Purpose of Process Memorandum

Heavy mining activity like that of the proposed Resolution Copper Project and Land Exchange (project) near Superior, Arizona, presents a range of potentially adverse effects to human health and safety, both to individuals and to the larger community. The purpose of this process memorandum is to provide an overview of these potential effects and outline approaches to assess these risks in the draft environmental impact statement (EIS).

This process memorandum covers three basic topics:

- Identification of a wide range of possible effects to public health and safety, and identification of whether these possible effects are applicable to the project. These risks include potential risks to air quality and water quality; from exposure to hazardous materials, noise, increased traffic, or previously contaminated soil; from the potential failure of tailings dams; or from geologic hazards such as cave-ins, rockslides, subsidence or earthwork collapses, and exposure to open mine shafts.
- Description of a proposed analysis approach for each potential risk along with a rationale for taking this approach; and
- An overview of past and current health studies conducted in the Superior area and greater vicinity in an effort to document any prevailing health trends.

This process memorandum is not an analysis document; analysis of impacts will be found in the environmental impact statement and supporting material. This process memorandum is a preliminary screening tool to identify topics for analysis and provide a rationale for analysis methodologies.

Summary of Scoping Concerns

When preparing an EIS, the public scoping process offers agencies, tribes and members of the public with the first formal opportunity to ask questions and provide input on the scope of the proposed project. During the 120-day scoping period, the Forest Service conducted five public meetings for interested and affected individuals, groups, and organizations, as well as local, state, and tribal governmental agencies.

Tonto National Forest officials sought specific comments to the proposed action, appropriate information that may be important to analysis of environmental effects, identification of significant issues, and identification of potential alternatives. A Scoping Summary Report recapped comments received from other agencies, tribes, and the public (Tonto National Forest 2017).

COMMENTS ASSOCIATED WITH PUBLIC HEALTH AND SAFETY

This section provides a detailed summary of public comment organized by resource topic, including air quality, water quality, historical contamination, tailings safety, and cancer clusters.

Air Quality/Dust

Some comments address the presence of airborne particles. One commenter asks, "*What are the likely air quality issues for both residents and recreational users due to PM2.5 and PM10 pollution from the tailings*?" [Letter ID 11671]

Other comments address the content of the particulate matter. One respondent notes that "*copper mining processes emit large quantities of particulate matter, trace elements, and sulfur oxides, which can have adverse effects on human health. Particulate matter emitted from smelters may include toxic metals such as arsenic, cadmium and mercury.*" [26240]

One commenter notes, "*Any air pollution will affect our health and we will no longer be able to live in Queen Valley.*" [Letter ID 19587]

"*The winds will pick up this finely ground particulate matter and fill our air and lungs with the poisonous material. This toxic matter will settle on swimming pools, open lakes and rivers and in lungs.*" [Letter ID 19553]

One respondent specifically is concerned about health impacts to nearby retirement communities, stating that that population's preexisting health conditions may make them more vulnerable to pollution impacts: "*Provide sample medical data as related to respiratory ailments that are more commonly found in residences of retirement communities. Identify the effects of inhaling tailings dust by a subject with such a condition and how they are more susceptible to problems caused by tailings dust in the home. Identify tighter dust and toxicity standards that should be used on a per-incident inspection of these homes.*" [Letter ID 25110]

Water Quality

Commenters want the EIS to include "*an environmental analysis of the expected chemical composition of water waste from mining operations, the required chemical composition of water discharged into the environment under the Clean Water Act, and the long-term legal, economic, environmental, regulatory, and compliance-related costs of ensuring that water is compliant with CWA.*" [Letter ID 15948] Similarly: "*It is critical to know the amount and composition of the 'waste' water that the mine will generate during development and operations to insure there will not be a negative impact to the underlying aquifer, surface water supplies, air quality and public health*." [Letter ID 14595]

The following commenter expresses concerns about Queen Creek and impacts to the residents of Queen Valley: "*This is extremely important to the people of Queen Valley…Queen Valley relies on the water of Queen Creek. The town would be severely affected by the loss or contaminated water from the tailing site.* [Letter ID 21285]

Commenters express concern about the potential for water contamination along the Arizona National Scenic Trail. One commenter states, "*Windblown contaminants are a major concern to [Arizona Trail] users. The GPO* [General Plan of Operations] *addresses this issue. However, it is more of a reactive solution rather than a proactive solution. How will [Arizona Trail] users be assured that* *any water they collect for drinking along the trail or allow their equine or pets to consume will be safe*?" [Letter ID 26629]

Other specific comments regarding tailings and water quality include the following:

Several existing natural springs exist in the area to be covered by the tailings pile; it seems that the seepage going right into a spring would prove toxic to the water aquifers. [Letter ID 19607]

The danger lies within the possibility of tailings contaminating regional groundwater supplies used by many throughout the region. A cessation of pumping of tailings runoff and underdrain water would result in a tremendous amount of acidic, toxic water simply discharging into the ground. [Letter ID 21793]

Historic Contamination

One commenter noted the presence of historic soil contamination at the West Plant Site: *"…where they're building this is on old tailings. So re-disturbed, I mean disturbed where they're building this is called disturbed lands, already disturbed. They're re-disturbing that land, meaning they're digging out old tailings. And that pollution is affecting Superior people drastically right now, at this time."* [Letter ID 57]

Tailings Safety

With regard to the tailings storage facility, many commenters express concern with past failures of the proposed tailings storage facility design, as seen at other mine operations. Commenters are concerned that "*there have been numerous catastrophic tailings dam failures in recent years, and new research has determined that tailings dam failures globally are increasing in severity and rate.*" [Letter ID 21793]

Cancer Clusters

During construction, operation, and post-closure, many commenters express concern with fugitive dust health impacts:

People will be exposed to tailings dust whenever high winds blow. Reports of similar wastes show that some of the material may be expected to be extremely fine, and subject to be retained in people's lungs when breathed in. Asthma and lung cancer will be promoted. COPD [Chronic Obstructive Pulmonary Disease] conditions will be promoted. It is not fair to the people of Arizona to expect them to live with this miserable hazard. [Letter ID 26619]

And what's happening in all these communities from the mining is -- it's all the chemicals they use, they're carcinogens, in the tailings that wash out with the rain and go into the ground. We have an epidemic in the north part of Superior with cancer. Hayden has one because of the smelter and the tailings. Globe has some to a certain extent. What they don't tell us is what carcinogens they use to process the ore once they get into the crushers, and it will be there forever. [Letter ID 59]

ISSUES REPORT

The issues considered relevant for detailed analysis in the EIS are listed below. Each relevant issue includes a cause-and-effect statement that relates the actions under consideration to the expected effects or unintended consequences that may occur from the proposed action and alternatives, thereby providing opportunities during the analysis to identify means to reduce adverse effects.

Air Quality

Issue 8: Impacts to Air Quality

Changes in air quality could potentially occur from the mine. Construction, mining, and reclamation activities at the mine and along transportation and utility corridors would increase dust, airborne chemicals, and transportation-related (mobile) emissions in the area. The Clean Air Act (CAA) and other laws, regulations, policies, and plans set thresholds for air quality, including Class I airsheds, and the GPO has the potential to exceed one or more of these thresholds. Long-term trends in precipitation and temperature have the potential to affect many resources.

Water Quality

Issue 6B: Groundwater Quality

Mining of the ore body and the mixing of fractured rock, water, and air underground has the potential to drive geochemical reactions (acid rock drainage) that could impact groundwater quality in the area of underground mining and the quality of dewatering water exported for use elsewhere. Other groundwater quality changes could also occur underground, including impacts from explosives residue.

Seepage would occur from the tailings facility and could impact groundwater quality and the quality of downstream surface waters fed by groundwater. Water quality concerns in tailings seepage include the potential for process chemicals, asbestiform materials, radioactive materials, and explosives residue to be entrained with the tailings, as well as the potential for sulfate and geochemical reactions (acid rock drainage) to occur in the tailings storage facility and affect seepage water quality. In addition, a tailings spill from the tailings pipeline or complete or partial failure of the tailings dam could result in impacts to downstream groundwater quality.

Creation of a pit lake in the subsidence area after closure of the mine could result in changes to groundwater quality due to geochemical reactions from the exposure of previously undisturbed rock, or due to long-term concentration of contaminants from evaporation.

The storage and use of hazardous materials throughout the project area, the storage and handling of hazardous waste, the storage and handling of process water, the transportation of concentrate by truck and as a slurry, and the transportation of tailings slurry carry a risk for inadvertent spills or release, which could impact groundwater quality. The presence of ore stockpiles on the surface could impact groundwater quality.

Effects on groundwater quality would include short-term impacts during construction and operation, as well as long-term impacts during the reclamation and post-closure phases.

Issue 6D: Surface Water Quality

Stormwater runoff could interact with hazardous materials, tailings, and ore stockpiles, which could result in contaminants moving downstream. This includes metals or other contaminants resulting from exposure to tailings, stockpiled ore, process chemicals, asbestiform materials, radioactive materials, or explosive residues entrained with the tailings, as well as the potential for sulfate, geochemical reactions (acid rock drainage), or surface salt accumulation to occur in the tailings facility and affect surface water runoff.

Disturbance of the land surface could result in increased sediment in downstream waters and cause aggradation or erosion in downstream channels leading to degradation of riparian habitat or impacts to surface water uses. In addition, a tailings spill or complete or partial failure of the tailings dam could result in impacts to downstream surface water quality, and deposition of windblown dust from the tailings storage facility could impact surface water quality.

Creation of a pit lake in the subsidence area after closure of the mine could result in new surface waters with potential surface water quality concerns due to geochemical reactions from the exposure of previously undisturbed rock, or the potential long-term concentration of contaminants from evaporation.

The storage and use of hazardous materials throughout the project area, the storage and handling of hazardous waste, the treatment and release of wastewater, the storage and handling of process water, the transportation of concentrate by truck and as a slurry, and the transportation of tailings slurry carry a risk for inadvertent spills or release, which could impact surface water quality through changes in chemical or sediment load.

Effects on surface water quality would include short-term impacts during construction and operation, as well as long-term impacts during the reclamation and post-closure phases.

Historical Contamination

Issue 9B: Impact to Existing Landscape Productivity, Stability, and Function

Ground disturbance from clearing vegetation, grading, and stockpiling soils, and waste storage (e.g., landfills, tire disposal) has the potential to compact soils, accelerate erosion, and reduce soil productivity. The tailings and waste rock facilities could be unstable over time, and reclamation may not adequately result in a stable, revegetated landscape. This could affect soil productivity and future uses of the area. The geochemical composition of tailings and waste rock facilities may not support native vegetation. Soils are nonrenewable resources. Damage, disturbance, contamination, or removal of the soil resource may result in a loss of soil productivity, physical structure, and ecological function across the proposed mine site and across downgradient lands. The mining area could potentially act as a barrier to sourcing and supporting natural downslope transportation of geological material, water, and nutrients through alluvial, eolian, and fluvial processes.

Tailings Safety

Issue 5B: Safety Concerns Related to Tailings Impoundment

The project "General Plan of Operations" (GPO) proposes a tailings dam and impoundment. Should a partial or complete dam failure occur in the future, public safety could be affected in the vicinity and downstream of the tailings facility.

Cancer Clusters

Issue 5A: Health Impacts

Concerns have been raised about whether potential dust, emissions, and/or contamination from the mine could affect public health in the local area, including increased cancer rates and impacts to people with preexisting health conditions, the elderly, and children. Specific concerns include airborne heavy metals and asbestiform materials; contamination of water from tailings seepage; operational or inadvertent release of hazardous materials, including fuels, explosives, and processing chemicals, into the environment; the potential for radioactive materials in tailings and/or processing facilities; and the potential for disturbance and mobilization by air or water of soil currently contaminated by historic mining activities.

Air Quality Hazards and Analysis Approach

Air pollutants consist of gaseous pollutants, odors, and suspended particulate matter such as dust, fumes, mist, and smoke. Fugitive dust, along with the burning of fossil fuels by stationary and mobile equipment are the largest sources of air pollutants associated with the proposed mine. Depending on their source, concentration, and interactions with other air components, airborne pollutants can have different chemical compositions
and result in a broad range of health impacts.

OZONE LEVELS

Ozone is a highly reactive gas that consists of three oxygen atoms: one with a double bond and the other with a single bond. It has the same chemical structure whether it occurs miles above the earth or at ground level. Depending on its location in the atmosphere, ozone is considered either beneficial or detrimental.

Within the troposphere—the lowest atmospheric layer extending from the earth's surface—ground-level ozone is considered harmful. Ground-level ozone pollution causes human health problems, damages crops and other vegetation, and is a key ingredient of urban smog. Ground-level ozone is created by photochemical reactions involving nitrogen oxides (NOx) and volatile organic compounds (VOCs) or hydrocarbons in the presence of sunlight (Environmental Protection Agency [EPA] 2003). These reactions usually occur during the hot summer months as ultraviolet radiation from the sun initiates a sequence of photolytic reactions. Ground-level ozone also can be transported hundreds of miles under certain meteorological conditions. Ozone levels are often higher in rural areas than in cities due to transport to regions downwind from the actual emissions of ozone-forming air pollutants (EPA 2003).

In humans, exposure to excessive levels of ozone can result in eye irritation, difficulty breathing/shortness of breath, aggravated or prolonged coughing and/or chest pain, increased aggravation of asthma, and increased susceptibility to respiratory infection. Long-term exposure could result in chronic inflammation and irreversible structural changes in the lungs, which can lead to premature aging of the lungs and illnesses such as bronchitis and emphysema (EPA 2017a).

Estimates project that the proposed mine would emit approximately 90.5 tons of NOx annually. About 62 percent of the total tonnage would result from process and underground operations at the East Plant Site; use of mobile equipment used at the tailings storage facility would account for about 18 percent of the total (Air Sciences Inc. 2018). Estimates project that the proposed mine would emit approximately 89.7 tons of VOCs annually. The largest source would be mobile equipment at the tailings storage facility, accounting for about 40 percent of the total tonnage (Resolution Copper Mining, LLC [Resolution Copper] 2016).

SULFUR DIOXIDE

Sulfur dioxide (SO_2), and the sulfates and sulfuric acid aerosols it forms in the atmosphere, can be lung irritants and aggravate asthma (Semrau 1971). Short-term exposures to SO_2 can harm the human respiratory system and make breathing difficult. Children, the elderly, and those who suffer from asthma are particularly sensitive. SO_2 emissions that lead to high concentrations of SO_2 in the air generally also lead to the formation of other sulfur oxides (SO_x) (Semrau 1971). SO_x can react with other compounds in the atmosphere to form small particles. These particles contribute to particulate matter pollution. Particles may penetrate deeply into sensitive parts of the lungs and cause additional health problems.

Estimates project the proposed mine would emit approximately 17.3 tons of SO_2 annually, almost exclusively from the molybdenum/talc dryer vent (Air Sciences Inc. 2018).

PARTICULATE MATTER

Particle pollution, also known as particulate matter (PM), contains microscopic solids or liquid droplets that are so small that they can be inhaled and cause serious health problems. The size of particles is directly linked to their potential for causing health problems.

Particulate Matter 2.5 ($PM_{2.5}$)

"Fine particles," such as those found in smoke and haze, are 2.5 microns in diameter and smaller. Fine particles are also referred to as $PM_{2.5}$. These particles can be directly emitted as solid particles from sources such as windblown dust, forest fires, and from particles emitted from power plants, industrial equipment, and automobiles. $PM_{2..5}$ material is also formed from chemical reactions in the atmosphere and through fuel combustion (e.g., motor vehicles, power generation, industrial facilities, residential fireplaces, wood stoves, and agricultural burning). Because the $PM_{2.5}$ particle sizes are so small, they remain suspended in the air and can travel extremely long distances (EPA 2017b).

Estimates project the proposed mine would emit approximately 75.5 tons of $PM_{2.5}$ annually. Process operations and fugitive sources at the East Plant Site would account for about 65 percent of the total tonnage (Resolution Copper 2016).

Particulate Matter 10 (PM_{10})

Small particles less than 10 microns in diameter (PM_{10}) can get deep into the lungs, and some may even enter the bloodstream. "Inhalable coarse particles," such as those found near roadways and dusty industries, are smaller than 10 microns in diameter. These inhalable coarse particles are referred to as PM_{10}. PM_{10} particles are directly emitted from activities that disturb the soil, including construction and mining activities, open burning, or agricultural operations (EPA 2017b). Other sources include windblown dust, pollen, salts, brake dust, and tire wear.

Estimates project the proposed mine would emit approximately 443 tons of PM_{10} particulate matter annually. Fugitive sources at the East Plant Site would account for about 48 percent of the total tonnage, while the tailings facility would account for about 27 percent (Air Sciences Inc. 2018).

CARBON MONOXIDE

Carbon monoxide (CO), when inhaled at high levels, reduces oxygen levels in the blood stream, affecting significant organs like the brain and heart. High CO levels also can result in dizziness, confusion, unconsciousness and even death (EPA 2018). These high levels are possible indoors or in other enclosed spaces. The lack of warning signs makes CO especially dangerous.

The likelihood of high levels of CO occurring outdoors is low. However, people with certain heart diseases are especially vulnerable if CO levels are elevated outdoors. Short-term exposure to high levels of CO can reduce oxygen being delivered to the heart, ultimately causing chest pain known as angina (EPA 2018).

Estimates project the proposed mine would emit approximately 411 tons of CO annually. The East Plant Site would account for about 41 percent of the total tonnage. Use of mobile equipment at the tailings storage facility would account for about 34 percent, while the West Plant Site would account for about 7 percent (Resolution Copper 2016).

NITROGEN OXIDE

Nitrogen is a constituent of both the natural atmosphere and of the biosphere. When industrial processes release nitrogen oxides (NO_X) into the environment it is considered a pollutant because of its altered chemical forms, most commonly a mix of nitrogen monoxide, nitrogen dioxide, and/or nitrous oxide. In higher concentrations nitrogen dioxide can be toxic to humans, to biota, and can adversely alter the natural chemistry of the atmosphere (EPA 1999).

The earth's atmosphere consists primarily of nitrogen (approximately 78 percent) and oxygen (approximately 21 percent). Nitrogen is also naturally present in plants and in soils. Nitrogen oxides are formed whenever combustion occurs in the presence of nitrogen and oxygen. Natural combustion occurs during lightning strikes, volcanic eruptions, or wildfires, but combustion also results from vehicle engines, industrial processes, and similar activities (EPA 1999). NOx gases contribute to smog and acid rain as well as to the formation of fine particulate matter and ground-level ozone, both of which are associated with adverse human health effects.

Estimates project the proposed mine would emit approximately 90.5 tons of NOx annually. Process operations at the East Plant Site would account for about 34 percent of the total tonnage. Use of mobile equipment at the East Plant Site and at the tailings storage facility also would account for about 34 percent (Air Sciences Inc. 2018).

VOLATILE ORGANIC COMPOUNDS

VOCs represent a diverse class of organic compounds with high vapor pressure at room temperature. VOCs are used:

- In consumer products such as hair care products, paint, degreasers, refrigerants, aerosols and furniture
- In industry as solvents
- For chemical manufacturing.

VOCs are the byproducts of the combustion of gasoline, diesel fuel, and the burning of coal. The EPA defines VOCs for outdoor air pollution as "any compound of carbon -- excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate -- that participates in atmospheric photochemical reactions" (Minnesota Department of Health 2017). VOCs are a primary contributor to photochemical smog.

In the short term, human exposure to high levels of VOCs can result in:

- Eye irritation
- Respiratory tract irritation
- Headaches
- Fatigue
- Dizziness

- Skin reactions
- Nausea
- Visual disorders
- Memory impairment.

Long-term exposure can contribute to damage to the liver and/or kidneys, the nervous system, and possibly increased risk of various cancers (Minnesota Department of Health 2017).

Estimates project the proposed mine would emit approximately 89.7 tons of VOCs annually. Process equipment at the mill facility would account for about 74 percent of the total tonnage (Resolution Copper 2016).

SULFATES

Sulfates (SO_4) are the fully oxidized ionic form of sulfur. Emissions of sulfur compounds occur primarily from the combustion of petroleum-derived fuels (e.g., gasoline and diesel fuel) that contain sulfur. This sulfur is oxidized to sulfur dioxide (SO_2) during the combustion process and a portion of the SO_2 is subsequently converted to sulfate compounds in the atmosphere (California Air Resources Board 2017).

Estimates project the proposed mine would emit approximately 17.3 tons of SO_2 annually, almost exclusively from the molybdenum/talc dryer vent at the West Plant Site (Air Sciences Inc. 2018).

HAZARDOUS AIR POLLUTANTS

Hazardous air pollutants, also known as toxic air pollutants or air toxics, are known or suspected to cause cancer or other serious health effects, such as reproductive effects, birth defects, or adverse environmental effects. Examples of toxic air pollutants include benzene, which is found in gasoline; perchloroethylene, which is emitted from some dry-cleaning facilities; and methylene chloride, which is used as a solvent and paint stripper by a number of industries. Examples of other listed air toxics include dioxin, asbestos, toluene, and metals such as cadmium, mercury, chromium, and lead compounds (EPA 2017c).

People exposed to toxic air pollutants at sufficient concentrations and durations may have an increased chance of getting cancer or experiencing other serious health effects. These health effects can include damage to the immune system, as well as neurological, reproductive (e.g., reduced fertility), developmental, respiratory, and other health problems. In addition to exposure from breathing air toxics, some toxic air pollutants such as mercury can deposit onto soils or surface waters, where they are taken up by plants and ingested by animals and are eventually magnified up through the food chain (EPA 2017c). Like humans, animals may experience health problems if exposed to sufficient quantities of air toxics over time.

Estimates project the proposed mine would emit approximately 2.7 tons of hazardous air pollutants annually. Use of diesel engines would account for about 93 percent of the total tonnage (Air Sciences

Inc. 2018). The total amount of hazardous air pollutants as trace metals in process and fugitive dust emissions, including traffic and windblown dust, is estimated at 278 pounds per year for all trace metal pollutants combined, or about 5 percent of the total hazardous air pollutant emissions.

GREENHOUSE GASES

Mining operations are energy-intensive and generate significant direct greenhouse gas (GHG) emissions, including carbon dioxide. Mining metals such as iron and copper is energy-intensive, requiring up to six times more energy to produce each ton of metal when compared to mining industrial materials such as phosphate, stone, sand, and gravel (Table 1).

Table 1. Overview of Greenhouse Gases

GHG	Description
Carbon dioxide (CO_2)	Carbon dioxide enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and wood products, and also as a result of certain chemical reactions (e.g., manufacture of cement). Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biological carbon cycle.
Methane (CH_4)	Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.
Nitrous oxide (N_2O)	Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.
Fluorinated gases	Hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for stratospheric ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). These gases are typically emitted in smaller quantities, but because they are potent greenhouse gases, they are sometimes referred to as High Global Warming Potential gases ("High GWP gases").

Source: EPA (2017d)

GENERAL ANALYSIS APPROACH AND RATIONALE FOR AIR QUALITY IMPACTS

Health Effects

Federal law has established specific air quality standards that are considered to be protective of human health and the environment. The intent of promulgating these standards is explicitly spelled out in the Clean Air Act (emphasis added):

> National primary ambient air quality standards, prescribed under subsection (a) of this section shall be ambient air quality standards the attainment and maintenance of which in the judgment of the Administrator, based on such criteria and allowing an adequate margin of safety, *are requisite to protect the public health*. (42 USC 7409(b)(1))

> Any national secondary ambient air quality standard prescribed under subsection (a) of this section shall specify a level of air quality the attainment and maintenance of which in the judgment of the Administrator, based on such criteria, is requisite to protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutant in the ambient air. (42 USC 7409(b)(2))

For the purposes of the National Environmental Policy Act (NEPA) analysis, the ability to meet these standards is considered protective of public health; therefore, a separate health-based analysis is not necessary in order to disclose impacts on human health.

A formal permitting process protects human health impacts. For a defined “minor source” such as the Proposed Action, air permitting is regulated by the Pinal County Air Quality Control District. This agency has been delegated compliance authority for air quality that is promulgated under the Clean Air Act. Pinal County reviews the proposed operations, sources, and emissions, and oversees compliance with equipment emission standards as well as ambient air quality standards in the area of the mining sites. In some cases, emissions are below a threshold that would require an extended air quality analysis.

The air quality analysis proposes to include the following components:

1) Disclose the total emissions (tonnage) of these criteria pollutants resulting from the project: carbon monoxide, nitrogen dioxide, particulate matter ($PM_{2.5}$ and PM_{10}), and sulfur dioxide.

2) Specifically assess compliance with National Ambient Air Quality Standards (NAAQS) for these criteria pollutants: carbon monoxide, nitrogen dioxide, particulate matter ($PM_{2.5}$ and PM_{10}), and sulfur dioxide, by adding the impacts from the proposed operations to a “background” air quality level for each pollutant to determine compliance with the NAAQS.

3) Specifically quantify emissions (tonnage) of Hazardous Air Pollutants.

4) Specifically quantify emissions (tonnage) of Volatile Organic Compounds.

5) Compare project emissions to regional emissions to provide context to the public.

6) Assess the potential for the ore deposit and tailings to contain asbestiform materials and radioactive materials separately as health-related concerns. The potential will be discussed qualitatively.

The air quality analysis would not include the following analyses:

1) Since ozone is not emitted directly but results from photochemical reactions in the atmosphere, analysis is usually handled separately from the other criteria pollutants if warranted. Modeling of ozone impacts requires a regional model that addresses sources and meteorological conditions for a wide region. Ozone modeling is not required under the Pinal County Air Quality Control District permitting guidelines in issuing a construction permit for this facility operation.

2) Air permitting programs do not require analysis of impacts when emissions of some compounds are below a certain threshold. Similar to ozone, in view of overall emission rates, the air quality regulations do not require analyses of lead, secondary $PM_{2.5}$ formed as sulfates and nitrates, and hazardous air pollutants. For these instances the analysis discloses the total emissions (tonnage) of these constituents.

3) The above analysis components will focus solely on exposure to the general public. While acknowledging that mine workers within the boundaries of the mine facilities have a greater potential for exposure, the Mine Safety and Health Administration (MSHA) enforces specific health and safety standards, as well as monitoring. Resolution Copper will directly address worker health and safety regulations in compliance with MSHA rules. For the purposes of the NEPA analysis this oversight is considered to be protective of mine worker health and safety. Worker health and safety regulations are not evaluated further under NEPA requirements.

Other Environmental Effects

Unlike criteria pollutants, Federal law has not established specific standards for the environmental effects of deposition of sulfur or nitrogen, or haze or visibility. However, land management agencies, including the U.S. Department of Agriculture Forest Service (Forest Service), have guidance for assessing these effects, known as "Air Quality-Related Values" (AQRVs). For the purposes of the NEPA analysis, comparison of project impacts to these standards will be used to disclose other environmental effects of emissions.

The air quality analysis is proposed to include the following components:

1) The air quality analysis will disclose impacts from emissions on both deposition and visibility, as measured at areas identified as Class 1 Federal lands under the Clean Air Act, and other specifically identified sensitive areas of concern. These areas include: Superstition Wilderness Area (near field, Class 1), White Canyon Area of Critical Environmental Concern (near field, sensitive area), Sierra Ancha Wilderness Area (far field, Class 1), Mazatzal Wilderness Area (far field, Class 1), and Galiuro Wilderness Area (far field, Class 1). Screening techniques could be applied to these areas to determine if analysis is specifically required (i.e., Q/D methodology).

2) The air quality analysis will compare emissions at these areas to Class 1 increments for Prevention of Significant Deterioration (PSD).

3) Analysis for visibility will consider NOx, SO2, and PM10 pollutants, and will assess perceptibility for multiple scenarios that consider season, time of day, and viewpoint.

4) Analysis for gaseous deposition will consider NOx and SO2 pollutants and will assess deposition of nitrogen and sulfur.

Greenhouse Gases and Climate Change

Formal guidance from the Council on Environmental Quality for handling the assessment of greenhouse gases and climate change in NEPA analyses has been rescinded,[1] leaving little certainty for how to complete these evaluations. The following approach will be used in the NEPA analysis for the Resolution Copper Project:

1) Disclose and compare greenhouse gas emissions to regional emissions. Quantitative analysis is not feasible for determining the incremental impact project-specific emissions would have on global climate change. At a global scale at which effects would need to be assessed, project-specific emissions are of such small magnitude that reasonable and feasible analytical techniques do not exist to assign specific environmental impacts to an individual project.

2) The NEPA analysis will incorporate any ongoing climatic trends as part of the Affected Environment section of the environmental impact statement.

Water Quality Hazards and Analysis Approach

Water-pollution problems typically associated with mining include acid mine drainage, metal contamination, and increased sediment levels in streams. Sources can include active or abandoned surface and underground mines, processing plants, waste-disposal areas, haulage roads, or tailings impoundments. Sediments, typically from increased soil erosion, can cause siltation that affects fisheries, swimming, domestic water supply, irrigation, and other uses of streams.

ACID MINE DRAINAGE

Acid mine drainage is a natural process that occurs when sulfides in rocks are exposed to air and water. When large quantities of rock containing sulfide minerals are excavated from an open pit or opened up in an underground mine, the minerals react with water and oxygen to create sulfuric acid (Safe Drinking Water Foundation 2017). When the water reaches a certain level of acidity, a naturally occurring type of bacteria called *Thiobacillus ferrooxidans* may become established and propagate, accelerating the oxidation and acidification processes, and leaching even more trace metals from the wastes. The acid will leach from the rock as long as its source rock is exposed to air and water and until the sulfides are leached out—a process that can last hundreds, even thousands of years. In such situations, acid is carried off the mine site by rainwater or surface drainage and can be deposited into nearby streams, rivers, lakes, and groundwater. Acid mine drainage severely degrades water quality and can kill aquatic life (First Nations Environmental Health Innovation Network 2008).

The potential for acid mine drainage has been identified as a specific issue of concern for the proposed mine, related to both in situ rock and tailings.

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[1] See Executive Order 13783, "Promoting Energy Independence and Economic Growth," March 28, 2017.

HEAVY METAL CONTAMINATION AND LEACHING

Heavy metal pollution is caused when such metals as arsenic, cobalt, copper, cadmium, lead, silver, and zinc contained in excavated rock or exposed in an underground mine come in contact with water. Metals are leached out and carried downstream as water washes over the rock surface. Although metals can become mobile in neutral pH conditions, leaching is particularly accelerated in the low pH conditions such as are created by acid mine drainage (Safe Drinking Water Foundation 2017).

Generally, humans are exposed to these metals by ingestion (drinking or eating) or inhalation of particulates or dust containing heavy metals (Table 2). Working in or living near an industrial site that uses these metals and their compounds increases one's risk of exposure, as does living near a site where these metals have been improperly disposed (Martin and Griswold 2009). Subsistence lifestyles (i.e., hunting, fishing, and/or gathering) can also result in higher risks of exposure and health impacts.

The potential for leaching of metals into groundwater, primarily from tailings seepage, and into surface water from stormwater contact has been identified as a specific issue of concern for the proposed mine.

Table 2. Common Heavy Metals and Known Public Health Effects

Common Heavy Metals	Description	Health Effects
Arsenic	Aside from occurring naturally in the environment, arsenic can be released in larger quantities through volcanic activity, erosion of rocks, forest fires, and human activity. Arsenic is found in paints, dyes, metals, drugs, soaps, and semi-conductors. Industry practices such as copper or lead smelting, mining, and coal burning can release high amounts of arsenic to the environment.	Arsenic is odorless and tasteless. Inorganic arsenic is a known carcinogen and can cause cancer of the skin, lungs, liver, and bladder. • Lower-level exposure can cause nausea and vomiting, decreased production of red and white blood cells, abnormal heart rhythm, damage to blood vessels, and a sensation of "pins and needles" in hands and feet. • Ingestion of very high levels can possibly result in death. • Long-term low-level exposure can cause a darkening of the skin and the appearance of small "corns" or "warts" on the palms, soles, and torso.
Barium	Barium is a very abundant, naturally occurring metal and is used for a variety of industrial purposes. Barium compounds are also used in drilling muds, paint, bricks, ceramics, glass, and rubber.	Barium is not known to cause cancer. • Short-term exposure can cause vomiting, abdominal cramps, diarrhea, difficulties in breathing, increased or decreased blood pressure, numbness around the face, and muscle weakness. • Large amounts of barium intake can cause high blood pressure, changes in heart rhythm, or paralysis and possibly death.

Common Heavy Metals	Description	Health Effects
Cadmium	Cadmium is a very toxic metal. All soils and rocks, including coal and mineral fertilizers, contain some cadmium. Cadmium has many uses, including batteries, pigments, metal coatings, and plastics. It is used extensively in electroplating.	Cadmium and cadmium compounds are known human carcinogens. Severe damage to the lungs may occur through breathing high levels of cadmium. • Ingesting very high levels severely irritates the stomach, leading to vomiting and diarrhea. • Long-term exposure to lower levels leads to a buildup in the kidneys and possible kidney disease, lung damage, and fragile bones.
Chromium	Chromium is found in rocks, animals, plants, and soil and can be a liquid, solid, or gas. Chromium compounds bind to soil and are not likely to migrate to groundwater, but they are very persistent in sediments in water. Chromium is used in metal alloys such as stainless steel; magnetic tapes; and pigments.	Chromium compounds are toxins and known human carcinogens. • Breathing high levels can cause irritation to the lining of the nose; nose ulcers; runny nose; and breathing problems, such as asthma, cough, shortness of breath, or wheezing. • Skin contact can cause skin ulcers. Allergic reactions consisting of severe redness and swelling of the skin have been noted. • Long-term exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation.
Lead	As a result of human activities, such as fossil fuel burning, mining, and manufacturing, lead and lead compounds can be found in all parts of our environment. This includes air, soil, and water. Lead is used in many different ways. Lead is a highly toxic metal and may result in various health concerns.	The EPA has determined that lead is a probable human carcinogen. Lead can affect every organ and system in the body. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system; weakness in fingers, wrists, or ankles; small increases in blood pressure; and anemia. • Exposure to high lead levels can severely damage the brain and kidneys and ultimately cause death. • In pregnant women, high levels of exposure may cause miscarriage. • High-level exposure in men can damage the organs responsible for sperm production.
Mercury	Mercury combines with other elements to form organic and inorganic mercury compounds. Metallic mercury is used to produce chlorine gas and caustic soda, and is also used in thermometers, dental fillings, switches, lightbulbs, and batteries. Mercury in soil and water is converted by microorganisms to methylmercury, a bio-accumulating toxin.	The EPA has determined that mercuric chloride and methylmercury are possible human carcinogens. • The nervous system is very sensitive to all forms of mercury. • Exposure to high levels can permanently damage the brain, kidneys, and developing fetuses. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. • Short-term exposure to high levels of metallic mercury vapors may cause lung damage, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation.

Common Heavy Metals	Description	Health Effects
Selenium	Selenium is a trace mineral widely distributed in most rocks and soils. Processed selenium is used in the electronics industry; as a nutritional supplement; in the glass industry; and in plastics, paints, enamels, inks, and rubber. Radioactive selenium is used in diagnostic medicine.	Selenium is toxic in large amounts, but trace amounts of it are necessary for cellular function in most, if not all, animals. For humans, selenium is an essential trace nutrient. The Tolerable Upper Intake Level is 400 micrograms of selenium per day. Consumption above that level can lead to selenosis (see below). • Short-term oral exposure to high concentrations can cause nausea, vomiting, and diarrhea. • Chronic oral exposure to high concentrations can produce selenosis. Major signs of selenosis are hair loss, nail brittleness, and neurological abnormalities. • Brief exposures to high levels in air can result in respiratory tract irritation, bronchitis, difficulty breathing, and stomach pains. Longer-term exposure can cause respiratory irritation, bronchial spasms, and coughing.
Silver	Silver usually combines with other elements such as sulfide, chloride, and nitrate. Silver is used to make jewelry, silverware, electronic equipment, and dental fillings. Silver compounds are used in photographic film. Dilute solutions of silver nitrate and other silver compounds are used as disinfectants and as an antibacterial agent. Silver iodide has been used in attempts to seed clouds to produce rain.	According to the EPA, silver is not classifiable as a human carcinogen. Stressed plants may be a sign of metal contamination. These kinds of conditions make it more likely that the plants are bioaccumulating (or uptaking) metals. Deficiencies in the plant (like a low level of zinc) can also influence a plant's likelihood to accumulate metals. Animals can accumulate metals as well by eating plants, fish, or drinking water with elevated metal concentrations. These metals are not excreted by the animals; rather, they accumulate mostly in the organs as well as the skin, hair, and bones. Fish accumulate metals from the water they live in as well as from organisms they eat. Bottom feeders are particularly susceptible to metals bioaccumulation as they can ingest sediments laced with metals.

Source: Martin and Griswold (2009)

GENERAL ANALYSIS APPROACH AND RATIONALE FOR WATER QUALITY IMPACTS

Authority over both surface water and groundwater quality is subject to Federal law but has been delegated to the State of Arizona. The State of Arizona has promulgated specific water quality standards for both groundwater (Arizona Aquifer Water Quality Standards) and surface water (Arizona Surface Water Quality Standards) that are protective of human health and the environment. The intent of promulgating these standards is explicitly spelled out in Arizona state law (Arizona Administrative Code, 49-221, emphasis added):

> C. In setting standards pursuant to subsection A or B of this section, the director shall consider, but not be limited to, the following:
>
> 1. *The protection of the public health and the environment*.

2. The uses which have been made, are being made or with reasonable probability may be made
of these waters.

3. The provisions and requirements of the Clean Water Act and Safe Drinking Water Act and the regulations adopted pursuant to those acts.

4. The degree to which standards for one category of waters could cause violations of standards
for other, hydrologically connected, water categories.

5. Guidelines, action levels, or numerical criteria adopted or recommended by the EPA or any other Federal agency.

6. Any unique physical, biological, or chemical properties of the waters.

These standards include both numeric and narrative requirements. For the purposes of the NEPA analysis, the ability to meet these standards is considered protective of public health; therefore, separate health-based analysis of individual constituents is not necessary in order to disclose impacts on human health.

The proposed NEPA analysis approach will include the following components:

1) Predictions will be made of potential water quality impacts to groundwater from exposure to materials either in situ or at the surface, and from seepage or other discharge of process water. Groundwater quality changes due to the project will be compared to numeric Arizona Aquifer Water Quality Standards. Compliance with narrative Arizona Aquifer Water Quality Standards will be assessed in a qualitative manner.

2) Predictions will be made of potential surface water quality changes from stormwater runoff from the project areas and will be compared with numeric Arizona Surface Water Quality Standards. Compliance with narrative Arizona Surface Water Quality Standards will be assessed in a qualitative manner. With respect to surface water there are numerous exposure pathways such as fish consumption, body contact, or drinking. There are different numeric Arizona surface water quality standards for each of these various exposure pathways and Arizona regulations specify which standards are pertinent to each stream or stream system. For example, the applicable standards in Devil's Canyon are for aquatic and wildlife-warmwater, full body contact, fish consumption, and agriculture and livestock (Arizona Administrative Code, Title 18, Chapter 11, Article 1, Appendix A).

3) The above comparisons against regulatory standards will be done by the NEPA team for disclosure purposes, as well as to gain a preliminary indication that the preferred alternative can be legally constructed. The Forest Service cannot approve a plan of operation that is not compliant with applicable laws and regulations. The Arizona Department of Environmental Quality (ADEQ) has the sole jurisdiction for determining whether Arizona water quality standards (aquifer and surface water) would be met; this demonstration is accomplished through the aquifer protection permitting program and through the Arizona Pollutant

Discharge Elimination System (AZPDES) permitting program, which is Arizona's delegated authority to administer and enforce Section 402 of the Clean Water Act). Resolution Copper is responsible for obtaining these permits prior to construction, and this will demonstrate compliance with water quality laws and regulations. Any comparison or analysis in the environmental impact statement is considered a disclosure step, but is not intended to override any determinations from ADEQ.

Hazardous Materials Analysis Approach

Hazardous materials can be present at all stages of processing minerals, from exploration, mining, and processing, to transport, refining, and smelting. Some materials originate from the ore body, others from chemicals used or generated during processing and degradation, and some remain in waste materials (EPA 2009). The different types of hazards can occur at different parts of the mining and mineral processing operation's life cycle (Ascent Environmental 2017). When classifying hazardous waste, the EPA defines four characteristics, as shown in Table 3 below.

Table 3. Hazardous Waste Categories and Risks to Public Health and Safety

Hazardous Waste Category	Description
Ignitability (something flammable)	Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 degrees Celsius (140 degrees Fahrenheit). Examples include waste oils and used solvents. There are three types of ignitable forms: • Liquids with a flash point—the lowest temperature at which fumes above waste ignite—of 60 degrees Celsius or 140 degrees Fahrenheit. Examples include alcohol, gasoline, and acetone. • Solids that spontaneously combust. • Oxidizers and compressed gases.
Corrosivity (something that can rust or decompose)	Corrosive substances, such as hydrochloric acid, nitric acid, and sulfuric acid, have the ability eat through containers, causing the leakage of harmful materials. A corrosive is anything liquid with a pH of less than or equal to 2 or greater than or equal to 12.5, or that has the ability to corrode steel. Everyday examples of corrosives include battery acid and rust removers.
Reactivity (something explosive)	Given their instability, reactive wastes can be very dangerous. The EPA recognizes that there are too many conditions and situations to identify all types of reactive materials. However, they use the following as guidelines to assist generators: • Unstable, and routinely experiences violent change without detonating • Potential for explosive mixture or violent reaction when combined with water • Toxic gases are released when mixed with water
Toxicity (something poisonous)	Poisonous materials pose a threat to groundwater, which can have long-term effects to human health and the environment. This is different from the first three characteristic groups, which the EPA views as containing immediate and firsthand dangers. There are 60 contaminants on the toxicity characteristics list. These contaminants are identified solely through a test method called Toxicity Characteristic Leaching Procedure or TCLP.

Source: EPA (2009)

HAZARDOUS SUBSTANCE

A poison, or toxic substance, may be defined as a chemical that, in relatively small amounts, produces injury when it comes in contact with susceptible tissue. The phrase "relatively small amounts" is less than precise, but this uncertainty is necessary because of the wide variance in the amount of each chemical needed to have an effect (Ascent Environmental 2017). A substance is generally not thought of as toxic if it is unreasonable to expect that a person would be exposed to the amount necessary to cause injury. A "susceptible" tissue is defined as that part of the body which is injured after exposure to that particular substance.

Humans can be exposed to toxic substances in either of two ways. The first is called acute exposure, which means a large exposure over a short period of time (typically less than 24 hours). The second is called a chronic exposure, which means repeated small exposures over a long period of time. Exposure to a toxic substance can produce either immediate or long-term effects. A reaction to a toxic substance can occur at the time of exposure, and might include vomiting, eye irritation, or other symptoms that often may be readily linked to a chemical exposure. These are immediate effects. Long-term effects may occur years after a single serious exposure, or as the result of chronic exposure (Agency for Toxic Substances and Disease Registry 2004). These effects are often more difficult to trace to their cause, and can include organ damage, respiratory diseases, and other illnesses. Certain toxic substances produce their long-term effects by altering the genetic code, or DNA, which tells the body's cells to perform certain activities. Below is a brief summary of common hazardous materials, high levels or chronic exposure to which is known to have health and environmental effects.

Diesel Fuel

Vapors from diesel fuel can be damaging to human kidneys, lower the blood's ability to clot, and/or increase blood pressure if breathed in for long time periods (Chilcott 2006). Diesel fuels are flammable, and vapor/air mixtures could be explosive. Health effects associated with diesel fuels can be eye, respiratory system, and skin irritation, may be a possible carcinogen, and can cause inflammation of the lungs. Diesel is not considered particularly toxic and accidental poisoning is extremely rare (Chilcott 2006).

Diesel fuel will be delivered to the project site and transferred to aboveground storage tanks. During the construction of the proposed mine, fuel cubes and fuel lines will deliver fuel to the underground mine storage tank, where it will be stored. Nearly all mobile underground and surface equipment will be powered with either diesel fuel or electricity (Resolution Copper 2016).

Explosives (Emulsion Product and Blasting Detonators)

Explosives are detonated at surface and underground mining sites routinely, but these detonations generate potentially harmful gases, e.g., carbon dioxide, carbon monoxide, oxides of nitrogen, ammonia, and sulfur dioxide. Oxygen concentrations are also reduced from blasting (MSHA 2018a). Most injuries from explosives occur due to being struck by rocks and debris, premature blasts, and misfires (Centers for Disease Control and Prevention [CDC] 2018).

Resolution Copper developed an Explosives Management Plan for proper storage, handling, transporting, use, and disposal of explosives. The proposed mine will use an emulsion of gel product, along with detonating cord, cast primers, and blasting caps during mining development (Resolution Copper 2016).

Oils/Lubricants

When oil/lubricants come into contact with the surface of the skin for long periods of time, various skin issues may appear such as itching, discoloration, dermatitis, eczema, xerodama, etc. Lubricants can emit gaseous substances upon combustion; these gases are poisonous and can cause the body harmful damage. Long-term exposure can result in constant irritation of tissues resulting in tissue damage that leads to illnesses like bronchitis, asthma, etc., and in some cases can form unnatural growths (Kumar 2017).

The proposed mine is estimated to use various oils and lubricants for equipment maintenance. These products will be delivered to the mining site and stored in the underground mine in sealed drums or totes. Used products will be collected, transported off-site, and disposed of through qualified vendors (Resolution Copper 2016).

Solvents

Solvents are liquid or gases that can dissolve or extract other substances or for cleaning. Massive amounts of solvent exposure can cause sudden death and prolonged exposure could result in blindness, irregular heartbeat, and damage to the central nervous system, kidneys, lungs, and liver (ToxTown 2017a). Regular exposure to solvents may cause hearing and memory loss, depression, fatigue, skin irritation, and nausea. Solvent vapor exposure could cause coughing, lung congestion, shortness of breath, chest tightness, and hoarseness (ToxTown 2017a).

Resolution Copper will use solvents at the East and West Plant Sites to clean parts in the trackless workshop and hoist workshop. Chlorinated solvents will be limited to specialized uses and stored in approved storage containers within or near the workshops in the underground mine. Solvent recyclers will be contracted to routinely replace the solvents in the parts cleaner (Resolution Copper 2016).

Antifreeze

Antifreeze is a colorless, odorless liquid that tastes sweet. The primary route of exposure is inhalation; however, poisoning will usually not occur unless it is heated, causing vapor (MSHA 2018b). Other effects occur with exposure to antifreeze mist and absorption through the skin. Antifreeze poisoning effects occur in three stages: central nervous system effects, cardiopulmonary failure, and renal failure (MSHA 2018b).

The proposed mine will use antifreeze for equipment. Vendors will deliver the antifreeze. It will be stored in the underground mine in storage containers within the trackless workshop (Resolution Copper 2016).

Propane

Propane is a highly flammable colorless and odorless gas or liquid. Exposure to propane is commonly from inhalation or a skin or eye irritant. Propane cuts off oxygen to the body, causing asphyxiation, and at very high concentrations it can cause death by suffocation (ToxTown 2017b). Exposure at high levels could cause incapacitation, cardiac arrest, unconsciousness, and/or seizures. If in direct contact with skin, propane may result in frostbite. Low-level exposure could damage the central nervous system, and cause fluid in the lungs, vision problems, nausea, headache, vomiting, mental illness, nosebleeds, etc. (ToxTown 2017b).

The proposed mine is expected to use propane as a source to heat water for certain facilities. It will be delivered and stored in containers near surface facilities (Resolution Copper 2016).

GENERAL ANALYSIS APPROACH AND RATIONALE FOR HAZARDOUS MATERIALS

It is never the intention to release hazardous materials or waste in an uncontrolled or unpermitted manner. By definition, such uncontrolled releases are unpredictable and undefined and individual possible releases cannot be analyzed specifically for impacts. However, the overall risk of release of hazardous materials will be disclosed. The proposed analysis approach will include:

1) The types and approximate amounts of hazardous materials used at the mine site, including petroleum products, explosives, and hazardous waste expected to be generated.

2) Storage and delivery mechanisms for hazardous materials.

Geological Hazards Analysis Approach

ABANDONED MINE WORKINGS

Mine Openings

If a person gets too close to an open edge of workings, there is the potential to fall into an open shaft, pit, or other steep opening. The weathered ground around these areas can subside or break away under vibrations from a vehicle or under a person’s weight. Vegetation and dirt can also form a false floor over underground mine openings and obscure the hazard (Government of Western Australia Department of Mines, Industry Regulation and Safety [DMIRS] 2017).

Deadly Gases and Lack of Oxygen

Lethal concentrations of methane, carbon monoxide, hydrogen sulfide, and sulfur dioxide can accumulate in underground workings. Through the process of weathering (oxidation), certain minerals can literally consume
a significant proportion of the oxygen normally present in the surrounding air (DMIRS 2017).

These processes can result in pockets of still air with little or no oxygen being encountered. By the time people feel ill, they may be unable to react appropriately to remove themselves from the hazard.

Cave-ins

Old mine workings are potentially unstable and can cave in at any time. The effects of blasting when the former mine was operating followed by the effects of weathering can weaken what was once strong rock. Work done to stabilize rock walls may also become less effective over time (DMIRS 2017).

Unsafe Structures

Old and unused underground or surface support timbers, ladders, buildings, pumps, tanks, and other mining-related structures may seem safe but can easily collapse or crumble under a person's weight (DMIRS 2017).

Unstable Explosives

Deteriorating explosives that have been left in place on abandoned operations are occasionally encountered. Unused or misfired explosives can be deadly. This is particularly true for old explosives containing nitroglycerine, which can become unstable, with a very small disturbance triggering an explosion (DMIRS 2017).

Waste Rock Heaps

Waste heaps from mining operations can become unstable when steep slopes are saturated by water from mine sources, the water table (i.e., shallow groundwater), or rainfall. In addition, landslips can engulf or injure people, damage roads and buildings, and block the paths of creeks causing upstream flooding. Waste rock heaps should never be used as recreational vantage points or jump sites (DMIRS 2017).

Water Hazards

Many abandoned mines fill with water over time. This water may be highly saline or acidic, with contact causing skin irritation, or it may contain microorganisms that can cause illness and infection. There may also be hidden hazards from abandoned equipment or structures within the body of water (DMIRS 2017).

ACCELERATED EROSION

Modifications to the natural soil and rock states due to construction activities may lead to accelerated erosion of the native soils/rock. Active engineered controls of stormwater runoff can prevent accelerated erosion due to construction modifications. Controls include, but are not limited to, silt fences surrounding active construction areas, erosion control blankets, installation of water bars or wattles, revegetation of areas disturbed during construction, and surface water diversions around project facilities.

Farming, construction, logging, and mining are the principal causes of accelerated erosion. The chances of accelerated erosion increase whenever natural vegetation or the natural contour of the ground is substantially altered without providing some sort of surface protections or mitigations. This type of erosion is reported to account for roughly 70 percent of all sediment generated in the United States each year (Hillsdale County Community Center 2016). Accelerated erosion can be minimized through careful planning and by implementing appropriate control measures.

SEISMIC HAZARD

Seismic Hazards near Mine Site

In addition to naturally occurring seismic events, it is possible for mining activities themselves to contribute to sudden and unanticipated redistributions of a rock mass. These sudden positional shifts of geological structures can be recorded on a seismograph or similar device just like a "regular" earthquake event.

Mine-induced seismicity, in general, "depends on depth, production rate, mining geometry, and geological discontinuities such as dykes, faults, etc., and on [the] ambient tectonic stress field. One or [a] combination of [these] factors may contribute significantly to mining seismicity" in any particular mine (Guha 2000:159).

Seismic Hazards and Stability of Tailings Facility

Unlike water supply dams, which are typically constructed of concrete reinforced with metal, and normally built from start to finish in a single massive effort, tailings dams are most often constructed in a series of stages, or "lifts," as mining operations continue over many years and waste storage capacity needs change. Tailings dams are usually designed along one of three basic configurations: the so-called "upstream," "downstream," or "centerline" designs. However, these basic designs may be modified in any number of ways to better suit the specific needs and specific location of a given mining project.

Unlike water supply dams, tailings impoundment dams are most often constructed using a portion of the coarser materials (larger-grained particles) of the tailings themselves or of earthen fill, which is then compacted. Tailings dams are therefore inherently less stable and somewhat more susceptible to failure than concrete water supply dams.

Arizona is widely regarded as a low-seismicity and very low precipitation area, and tailings dams in the state have therefore historically been constructed along the "upstream" design, which is both the fastest to construct and the cheapest. This design was long viewed as adequate for the relatively dry and seismically inactive local conditions. However, opinions were altered by the recent high-profile failures of upstream-design tailings dams at the Mt. Polley mine in British Columbia, and the even more destructive collapse of the Bento Rodrigues dam in southeastern Brazil, which left 17 people dead, hundreds homeless, and resulted in flows of more than 60 million cubic meters of waste material along the Doce River and into the Atlantic Ocean.

Broadly speaking, the mining industry now no longer views upstream tailings dam designs as "best practice," and has come to consider the more expensive yet more geotechnically stable and reliable centerline and downstream designs as better alternatives, even in dry environments like that of Arizona. A wide variety of dam types are considered in the alternatives analysis.

MINE SUBSIDENCE

Mine-related subsidence can be defined as the downward and/or lateral movement of upper layers of rock and soil as a result of underground mining activities creating a substantial void in the subsurface. Such voids may be caused by removal of large amounts of ore, as is the objective of block cave mining, or even through large-scale pumping and removal of groundwater, which can create numerous vacancies in the fractures and fissures in the subsurface rock and potentially contribute to a downward motion of the rock layers above.

GENERAL ANALYSIS APPROACH AND RATIONALE FOR GEOLOGICAL HAZARDS

The following analysis approach is proposed to address geological hazards:

1) Abandoned Mines. Abandoned mine workings pertinent to this NEPA analysis are those associated with the offered lands to be exchanged which would be managed by the BLM and the U.S. Forest Service. Known details of any abandoned mine workings for the Offered Lands parcels will be disclosed in the NEPA analysis.

2) Other on-site geological hazards associated with active mining within the mine facilities are assumed to be addressed by specific health and safety standards and monitoring, enforced through the Mine Safety and Health Administration; for the purposes of the NEPA analysis, these are considered to be protective of mine worker health and safety.

3) Erosion. Accelerated erosion could occur as a result of project disturbance and will be analyzed. The potential for erosion to occur due to ground disturbance will be analyzed in the NEPA analysis, including the ability of revegetation or reclamation activities to mitigate erosion. The potential for erosion to impact downstream waters will also be assessed.

4) Seismic Hazards at Mine Site and Subsidence Hazards. The substantial changes to geological units and geological stresses that would be caused by the block caving are such that the effect of the mining on seismicity would be evaluated. This would be a qualitative assessment based on professional judgment, supported by an understanding of the geological framework of the area and the types of changes imposed by the mine, but also informed by numeric modeling of subsidence.

5) Tailings Safety. The potential for failure of the tailings facility is one of great public concern. The NEPA analysis will address the issue of tailings safety from several angles, including the following:

a) a disclosure of common failure modes and design/mitigation to address those failure modes;
b) a disclosure of standards of practice for tailings storage facilities and a comparison to the proposed alternatives;
c) a comparative assessment of risks between alternative dam/facility types, including static and seismic stability, and the uncertainties that are specific to each dam/facility type; and
d) a disclosure of the general types of receptors downstream from each alternative tailings facility.

Hazards from Historic Contamination of Soils and Analysis Approach

The area of land proposed as the future West Plant Site, immediately north and adjacent to the Town of Superior, has for perhaps 140 years or more been the site of historical processing of mined minerals such as silver and copper (e.g., through milling, concentrating, and smelting). The former Magma Copper Company opened a smelter operation at this site that operated continuously from 1924 through 1972. Emissions from the smelter stack of this operation are documented to have contributed high amounts of arsenic, copper, and lead to area soils. In 2010, Resolution Copper applied to the Voluntary Remedial Program (VRP) and was accepted. Since 2015, Resolution Copper has actively worked to remove and/or remediate soils within and in the general vicinity of the proposed West Plant Site through the Arizona Department of Environmental Quality's Voluntary Remediation Program (2016). Work is expected to continue through 2019.

GENERAL ANALYSIS APPROACH AND RATIONALE FOR SOIL CONTAMINATION

Any documented soil contamination associated with the West Plant Site, or elsewhere, will be included in the NEPA analysis as part of the affected environment section of the EIS. The potential for the release of contaminated soil via air or water will be qualitatively discussed.

Based on public disclosures by Resolution Copper, completion of most or all soil remediation planned for the West Plant Site would occur by publication of the EIS and controls would be in place that would eliminate exposure pathways. This will be independently confirmed and considered in the qualitative assessment for the potential exposure.

Noise Hazards and Analysis Approach

In the context of mining, noise is an important consideration and an issue that can possibly have severe health affects across a wide range of determinants (Tables 4 and 5). Usually, noise pollution associated with mining operations frequently occurs during one of three phases:

- Access to the immediate area of the mining operation and exposure to blasting or other noise-generating activities
- Extraction of minerals using heavy machinery

- Movement of trucks and other construction equipment from the mining area to the stockpile area.

Some mining activities are located close to or within residential communities, making environmental noise pollution a serious concern for community members. Primary noise pollution sources in the area include mobile equipment, air blasts, and vibrations from blasting and other machinery. Environmental noise can have a substantial impact on people’s heath (Abdullah et al. 2016).

Potential health concerns that have been identified include hearing loss or loss of hearing sensitivity, cardiovascular and physiological effects, sleep disturbance, mental and behavioral effects, decreased cognitive performance, damage to the auditory system, stress, and discomfort (Abdullah et al. 2016). Noises can create cracks in buildings, frighten animals, delay their mating processes, and cause abortions(Yeboah 2008).

Moreover, most people are aware of the correlation between extreme noise levels and hearing damage. Violent vibrations can lead to eardrum trauma causing permanent ruptures, membrane damage around the inner ear, and collapse of the cochlear structure. Unfortunately, damage occurs from additional sources of industrial noise (Enviro Editor 2016). The middle and outer ear evolved to amplify sound, causing loud noise frequencies to affect the ears at any level, further deteriorating hearing. Common results of constant noise pollution are decreased hearing with age and abnormally loud sounds in the ear, such as buzzing or a ringing in the ears. Effects of noise pollution can be temporary but in certain cases of prolonged exposure, permanent (Enviro Editor 2016).

Studies have been published associating long-term noise exposure to hypertension. Increased noise levels throughout the night escalates the risk of heart attack, according to published research (Münzel et al. 2014). Noise pollution causes stress and stress contributes to the release of cortisol, a hormone that increases blood sugar and suppresses the immune system (Enviro Editor 2016). While sleeping, noise may not wake a person up, but the body feels the stress from the noise, releasing more cortisol into the bloodstream. Constant exposure to noise pollution at night puts increased stress on the heart and heightens the possibility of myocardial infarction. Noise pollution can, of course, also damage the actual ear but the common denominator for adverse effects to heath as a result of noise pollution is stress (Enviro Editor 2016).

Table 4. Noise Levels by Mining Equipment

Typical Noise Levels Generated by Each Piece of Mining Equipment	
Equipment Type	Sound Power Level (dBA)
Blasthole	118
Tracked bulldozers	116
Excavators	120
Face shovels	123
Front-end loaders	111
Graders	113
Water cart	116

Source: Yorke Peninsula Land Owners Group (2013)

dBA = A-weighted decibel

Table 5. Permissible Noise Exposure

Permissible Noise Exposure	
Sound Level (dBA) Slow Response	Duration per Day (hours)
90	8
92	6
95	4
97	3
100	2
102	1.5
105	1
110	0.5
115	0.25 or less

Source: Occupational Safety and Health Administration (2018)

dBA = A-weighted decibel

GENERAL ANALYSIS APPROACH AND RATIONALE FOR NOISE

The NEPA analysis will include analysis of impacts of noise from construction, operations, and transportation of materials. Analysis of transportation noise specific to the project would be limited to routes that are not major transportation routes already impacted by traffic noise. In the immediate vicinity of the project area, Highways 60 and 177 would be considered major transportation routes. The rationale for excluding these areas is the inability to assign noise impacts to project-specific trucks. The output of noise modeling associated with transportation is typically a set of noise contours parallel to the roadway; those noise contours would look similar regardless of the frequency or volume of truck traffic.

Traffic Hazards and Analysis Approach

There are various vehicular hazards at mine sites that could potentially lead to injury or death, including but not limited to:

- Heavy mobile equipment, like scrapers, loaders, haul trucks, excavators, and water trucks.
- Smaller vehicles such as vans, pickup trucks, and delivery vehicles.
- Workers on foot.
- Obstructed visibility. Mine sites have many obstacles and conditions that can obstruct a driver's visibility leading to public safety concerns. These include:
  - Heavy equipment
  - Stockpiles
  - Mine faces and contours
  - Dust
  - Night operations

Additionally, driving on roadways built for mining operations can be challenging. For example, roadways may be unpaved, narrow, elevated, have obstructions, or may be constantly changing. Additionally, roadways may have uneven surfaces due to use and/or weather, from use and/or rains; obstructed views caused by the contour of the mine and/or stockpiles, and lower speed limits. Moreover, falling rocks and mine walls create another public safety issue.

Increased traffic has been identified as a major community concern in areas with mining development. The impact of trucks on traffic flow depends on numerous characteristics including truck routes, roadways' functional classes, timing, and community population. Especially near mining access roads, traffic volumes could be significant (Maryland Department of the Environment 2017). Traffic may be heaviest during peak hours of the day, especially during the hours of 6:00–9:00 a.m. and 4:00–7:00 p.m.

There are associated cost increases from the activities, as well as inconveniences and concerns for safety. Local vehicle response and public service may need to increase their response times, including ambulances, firetrucks, and police cars. A greater need for traffic monitoring may lead to installing additional traffic signals, signage, and turn lanes.

GENERAL ANALYSIS APPROACH AND RATIONALE FOR TRAFFIC

The potential for increase in traffic volume and type will be assessed in the NEPA analysis, including transportation of materials to the mine, transportation of concentrate (molybdenum or copper) away from the mine, and traffic from employee commuting. As with the noise analysis, the transportation analysis will focus on the local roads and intersections that would be most impacted by mine traffic.

Potential Need for Human Health Assessment

Residents of Superior and Globe have expressed concern that historic and modern copper mines have increased cancer rates in the area. As noted in the *Resolution Copper Project and Land Exchange Environmental Impact Statement Scoping Report* (Tonto National Forest 2017), a number of comments received by the Forest Service during the formal scoping period for the project (March 18 to July 18, 2016) expressed concern about public health impacts that would result from air and water pollution. Specific health concerns mentioned included respiratory illnesses, neurological illnesses, and increased cancer rates.

Effects on human health will be analyzed as outlined below; however, there is still a need to define existing conditions that may factor into health effects, guided by the scoping comments. The following section of this briefing paper provides an overview of available health studies relevant to Superior, Globe-Miami, Hayden, and other communities in east-central Arizona.

CANCER STATISTICS

According to the Arizona Department of Health Services (ADHS), in 2005–2009, cancer rates by Community Health Analysis Area (CHAA) show the Globe/Hayden CHAA to have an age-adjusted incidence rate of 406.25 (rate per 100,000 people). In the same period, the Superior/Kearny CHAA had an age-adjusted incidence rate of 440.82. The state of Arizona had a rate of 412.41 (ADHS 2016a).

A query of the Arizona Cancer Registry, selecting age-adjusted cancer incidence rates from 1995–2013 for all cancer types, shows Gila County to have an incidence rate of 382.59. The Pinal County incidence rate is 371.23. The incidence rate for all counties in Arizona is 412.28 (ADHS 2016b).

When selecting only from 2013 (the latest year available to query), Gila County has an incidence rate of 313.83, Pinal County 326.21, and all counties in Arizona 371.31 (ADHS 2016b).

The State Cancer Profiles page by the CDC and National Cancer Institute provides the age-adjusted cancer incidence rate for 2008–2012. Gila County has an incidence rate of 339.2, Pinal County 330.9, and Arizona is 386.6 (ADHS 2016c).

When selecting for childhood cancer (ages <20), the incidence rate for 2008–2012 is 14.3 for Pinal County and 16.8 for Arizona (ADHS 2016c). Gila County data have been suppressed. (Counts are suppressed if fewer than 16 cases were reported in a specific area-sex-race category.)

SPECIFIC STUDIES

No studies were found indicating higher rates of cancer or other illnesses in the Globe or Superior areas.

The ADHS Arizona Cancer Registry has a Special Cancer Studies webpage (ADHS 2016d). Three location-specific studies were conducted under this program, including the Sierra Vista Childhood

Leukemia Studies and Maryvale Leukemia Study. No such studies were conducted in Gila or Pinal Counties.

The ADHS Environmental Toxicology, Public Health Assessments and Reports website (ADHS 2016e) shows that a Public Health Assessment was conducted for the ASARCO Hayden Smelter Site (ADHS 2002). The ASARCO Hayden Smelter Site Public Health Assessment discussed a 1995 study on lung cancer in six Arizona copper smelter towns, which did not find an association between living in the towns and developing lung cancer. It did, however, find a positive association between lung cancer and employment at a copper smelter.

The website WorldLifeExpectancy.com has a “Cancer Cluster Map” of the United States, using data from the CDC years 2002–2006 (World Life Expectancy 2002). It shows the cancer death rate for counties throughout the United States. Gila County was ranked moderate (death rate of 179.4), and Pinal County ranked low (147.8). Only one county in Arizona ranked high: Mohave County with a death rate of 206.6.

SUMMARY OF REVIEW

Claims have been made by residents about higher cancer rates in the Globe/Superior area attributed to the mining history of the area; for the most part, they have not cited sources of literature. No stand-alone studies have been identified that specifically investigate a higher incident rate of cancer in the Globe or Superior areas. General statistics on cancer occurrence are mixed when the cancer rate of the local region is compared to the Arizona average cancer rate. ADHS and CDC databases show that Pinal and Gila Counties have a lower cancer rate than the Arizona average. However, data from ADHS for Superior/Kearny from 2005–2009 show an elevated cancer rate compared to the Arizona average.

GENERAL ANALYSIS APPROACH AND RATIONALE FOR ADDRESSING PUBLIC CONCERNS OF CANCER PREVALENCE

The analysis approach and rationale for assessment of health effects due to exposure to contaminants from air or water is described above, through demonstrated adherence to air and water standards promulgated to protect public health. If there were evidence of an increased prevalence of cancer or other illness in the analysis area, it would be disclosed through the NEPA analysis as part of the affected environment section of the environmental impact statement.

Given the public concern and interest, the documentation described above will be disclosed. However, at this time there does not appear to be any compelling evidence that a cancer cluster exists, and as such it is not expected to be incorporated into any assessment of health effects.

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