2021 Regional Haze Four Factor Initial Control Determination

Facility: Freeport-McMoRan, Morenci Mine

Air Quality Division
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1 ADEQ Initial Regional Haze Four Factor Control Determination

1.1 ADEQ Initial Control Determination for Freeport-McMoRan, Morenci Mine

ADEQ's initial determination is to find that it is reasonable not to require additional controls on Freeport McMoRan Morenci Mine during this planning period.

1.2 ADEQ Control Determination Finalization Timeline

In order to meet the State rulemaking process timeframe for proposed rule inclusion in the July 31st, 2021 Regional Haze state implementation plan (SIP) submittal, ADEQ must finalize all four factor analyses as expeditiously as possible. To provide an opportunity for interested stakeholders to review and comment on ADEQ's initial decision prior to finalization, the department intends to post initial decisions on the agency webpage along with the original source submitted four factor analyses. Once ADEQ has reviewed relevant stakeholder comments, the agency will revise its initial decisions if necessary and post final decisions (see Figure 1). ADEQ welcomes feedback on these initial decisions and invites any interested party to send their comments by **December 31st 2020** to:

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Please note that this review and feedback opportunity does not constitute an official state implementation plan or state rulemaking comment period. The agency intends to provide an official 30 day comment period on any proposed SIP or rulemaking action in accordance with Arizona Revised Statutes §§ 41-1023, 49-425, and 49-444.

Figure 1: Four Factor Control Determination Process Map

2 ADEQ Four Factor Analysis

2.1 Summary

ADEQ identified two processes that are subject to the four factor analysis for Freeport-McMoRan Morenci Inc.: (i) haul trucks and other vehicles travel on mine roads; and (ii) loading ore into haul trucks. Freeport completed and submitted a four factor analysis report for the two processes in December 2019. As requested by ADEQ, Freeport further provided additional information in April 2020. Following Guidance on Regional Haze State Implementation Plans for the Second Implementation Period[1], ADEQ reviewed the Freeport submittals and performed additional analyses. ADEQ's initial determination is that the emission controls Freeport is implementing for the two processes reflect current best management practices for mining industry, and that it is reasonable not to require additional controls during this planning period.

2.2 Facility Overview

2.2.1 1.1 Process Description

Freeport-McMoRan Morenci complex is located in Greenlee County, Arizona, approximately 50 miles northeast of Safford on U.S. Highway 91. The facility consists of three major operations: 1) mining operations, including the drilling and blasting of ore in open-pit copper mines, three in-pit crushers and an ore conveying system, 2) the Morenci Concentrator and Metcalf Concentrator operations for production of copper and molybdenum concentrates through conventional milling and froth flotation operations, and 3) the Metcalf Mine-for-Leach (MFL) plant and five Solution Extraction and four Electrowinning facilities (SX/EW) operations for production of high quality copper cathodes through leaching and hydrometallurgy.

Emissions from the facility consist primarily of fugitive and non-fugitive particulate matter (PM) from mining and concentration operations, nitrogen oxide and carbon monoxide from portable and stationary combustion sources and volatile organic compounds from organic liquid storage activities. The facility controls particulate matter (PM) by wet scrubbers, fabric filter dust collectors (FFDC), baghouses, and water spray systems at various emission points. Fugitive dust emissions at the facility are controlled by wet suppression methods including water trucks, water sprays, surfactant use, dust suppression fans, water jets, foggers, and inherent moisture content.

[1] https://www.epa.gov/sites/production/files/2019-08/documents/8-20-2019_-_regional_haze_guidance_final_guidance.pdf

The nearest Class I area is Gila Wilderness area, located within the Gila National Forest in Southwest New Mexico. This Class I area is located approximately 54 km from the facility.

2.2.2 1.2 Emissions Inventory

Table 1 summarizes the facility-wide emissions during 2016-2018.

Year	PM_{10} (tpy)	$PM_{2.5}$ (tpy)	NO_x (tpy)	SO_2 (tpy)	CO (tpy)	VOC (tpy)
2016	1925.02	226.24	106.51	2.11	1568.22	57.78
2017	1974.26	230.39	103.43	1.29	1500.64	60.77
2018	2631.22	340.66	135.47	1.29	1537.91	56.98

Table 1 Emission Inventory for Years 2016-2018

2.3 ADEQ Screening Methodology

ADEQ applied a screening process to determine which emission units would undergo four-factor analysis. Any processes that were identified as being effectively controlled were deferred from consideration for the current implementation period. Four-factor analysis would be conducted on the remaining processes that make up the top 80% of NO_x, SO_2, and PM_{10} emissions at the source. The detailed screening methodology is presented on the ADEQ 2021 Regional Haze SIP Planning website.[2]

In September 2019, ADEQ informed Freeport that a four-factor analysis must be performed for the following processes and pollutants:

- PM_{10} emissions from hauling trucks traveling on mine roads
- PM_{10} emissions from other vehicles traveling on mine roads
- PM_{10} emissions from loading ore into haul trucks

2.4 Existing Controls and Baseline Emissions Projections

2.4.1 Baseline Control Scenario (Projected 2028 Emissions Profile)

Baseline emissions represent a realistic depiction of anticipated annual emissions for the source. Per the EPA's Guidance on Regional Haze Implementation Plans for the Second Implementation Period, the projected 2028 emissions can be a reasonable and convenient

[2] https://static.azdeq.gov/aqd/haze/4_factor_screening_approach.pdf

choice for use as the baseline emissions. ADEQ has developed a framework for projecting the 2028 emissions for permitted facilities in Arizona.[3]

To project the 2028 emissions for Freeport Morenci mine, ADEQ used the emissions data and throughput data from 2016 – 2018. A scaling factor was determined for each pollutant and emission unit by dividing the annual emissions by the annual throughput. Then the average scaling factor and average process throughput over the three-year period (2016-2018) was calculated. The projected annual emissions for each unit process was determined by multiplying the average scaling factor by the average process throughput.

Table 2 summarizes the 2028 projected emissions for two processes that are subject to four-factor analysis.

Table 2 Emissions for Baseline Scenario (2028 Projected Emissions) for Haul Trucks and Other Vehicles Travel on Mine Roads and Loading Ores into Haul Trucks

Emission source	Miles travelled (VMT)	Loaded Ore (ton)	PM10 emissions (ton/yr)	2016-2018 Ave. Scaling Factor	2016-2018 Ave. Throughput	2028 Projected Emissions (ton/yr)
Haul Trucks Traveling on Mine Roads						
2016	6,386,540	__	220.6	2.25E-04 ton/VMT	6,894,544 miles	1,552.40
2017	6,674,956	__	439.6			
2018	7,622,136	__	799.3			
Other Vehicles Traveling on Mine Roads						
2016	32,216	__	123	2.06E-04 ton/VMT	286,723,309 miles	229.20
2017	31,200	__	78			
2018	3,281,495	__	39			

[3] https://static.azdeq.gov/aqd/haze/2028_emission_project_methodology.pdf

Loading Ores into Haul Trucks						
2016	__	293,968,661	119.91	6.35E-08 ton/ton ore	286,723,309 ton ore	120.24
2017	__	284,697,725	116.13			
2018	__	281,503,542	124.38			

2.4.2 Existing Controls and Control Efficiencies

2.4.2.1 Haul trucks traveling on mine roads

As discussed in the AP-42 Section 13.2.2, a wide variety of options exist to control emissions from unpaved roads. Options fall into the following three categories:

- Vehicle restrictions that limit the speed, weight or number of vehicles on the road;
- Surface improvement, by measures such as (i) paving or (ii) adding gravel or slag to a dirt road; and
- Surface treatment, such as watering (wet suppression) or treatment with chemical dust suppressants (chemical stabilization/treatment).

The current methodology used in Freeport's emissions inventories does not separate roads on which haul trucks travel from roads on which haul trucks do not travel. Therefore, haul trucks are the limiting factor when determining the feasibility of unpaved road controls. The remainder of this analysis will analyze haul trucks travel and other vehicle travel on mine roads as a single emission source.

According to Freeport, the speed limit for haul trucks and other vehicles at the Mission Complex is 34.5 miles per hour (mph). Although vehicle speed restriction is one of the control options, the AP-42 Section 13.2.2 does not take the vehicle speed into account for estimating the PM_{10} emissions for vehicles traveling on unpaved surfaces at industrial sites.

Paving or application of surface gravel on haul roads at the Morenci Mine is not feasible due to the weight of the haul trucks, which ranges up to 860,000 pounds. Due to the weight of the haul trucks, constant replacement of the pavement would be required, since it would quickly be degraded by the weight and movement of the trucks. In addition, the trucks will either quickly obliterate the gravel to dust or push the gravel to the side of the roads.

Watering is currently applied to the haul roads at the Morenci Mine. A control efficiency of 90% has been used in Freeport's emissions inventories. Using chemical dust suppressants is not

feasible due to the weight of the haul trucks, which ranges up to 860,000 pounds. Those can also cause a safety hazard by tire slippage during rainy days and when haul trucks make turns or travel on a slope.

2.4.2.2 Loading ore into the haul trucks

The possible controls to decrease emissions from loading ores into haul trucks are applying water on ores to increase the moisture content of ores (AP-42 13.2.4), altering loading procedures, and ceasing operations during high wind hours. According to Freeport, there is no existing controls for loading ores into haul trucks at the Morenci Mine.

2.5 Four Factor Analysis Review

2.5.1 Technical Feasibility and Emission Reductions

2.5.1.1 Control Options for PM10 Emissions from Haul Trucks Travelling on Mine Roads

Freeport has identified the following PM_{10} control technologies based on a review of the RACT/BACT/LAER Clearinghouse ("RBLC") database, technical literature, practices and engineering experience at open-pit copper mines:

- Reduce the speed limit for haul trucks;
- Apply additional water to haul roads;
- Increase freeboard in the haul trucks;
- Apply chemical dust suppressant to haul roads;
- Apply and maintain surface gravel on haul roads;
- Require haul trucks to be covered; and
- Paving the haul roads and maintain the pavement.

2.5.1.2 Reduce the speed limit for haul trucks from 34.5 mph to 25 mph

Speed reduction for haul trucks will result in reduction of haul road emissions. However, reducing the speed limit for haul trucks would significantly impact overall operations, considering that haul truck travel is critical to the ore throughput. If a stricter speed limit were to be enforced, then Freeport would deploy additional haul trucks to maintain the same level of operations. This control option is technically feasible.

As previously discussed, the AP-42 Section 13.2.2 does not take the truck speed into account for estimating the PM_{10} emissions for vehicles traveling on unpaved surfaces at industrial sites. ADEQ used a historical unpaved road emission factor equation in AP-42 to evaluate the control

efficiency resulting from the truck speed reduction. [4] As indicated in this equation, emission is linearly proportional to truck speed. Currently, the speed limit for haul trucks and other vehicles at the Mission Complex is 34.5 mph. If the speed for haul trucks reduces from 34.5 mph to 25 mph, the control efficiency would be 27.5%, resulting in an emission reduction of 427 tpy for PM_{10}.

Due to the complexity, ADEQ is unable to evaluate the changes in fuel consumption and tailpipe emissions associated with additional haul trucks. It is likely that adding more haul trucks would increase the fuel consumption and tailpipes emissions (such as $PM_{2.5}$ and NOx emissions), which could compromise the benefits from the truck speed restrictions.

2.5.1.3 Apply additional water to haul roads

Additional water spray on haul roads will result in emission reduction. Haul travel occurs inside the pit and outside the pit. However, too much watering could also lead to traction problems between the haul trucks and the roads. Additional watering for haul road travel is technically feasible. The facility will need to deploy additional water trucks.

The current control efficiency for watering at Morenci Mine 90%. Additional watering can increase the control efficiency from 90% to 95%, resulting in a reduction of 890.50 tpy for PM_{10}.

AP-42 Figure 13.2.2-2 provides a relationship between the control efficiency and the moisture ratio for unpaved travel surfaces.[5] In order to increase the control efficiency from 90% to 95%, the moisture ratio should increase from 4 to 5 (25% increase in soil moisture). ADEQ assumed that the amount of additional water needed was proportional to the increase in the moisture ratio.

2.5.1.4 Increase freeboard in the haul trucks

Increasing freeboard could potentially reduce the amount of spillage onto haul roads, which can be a source of PM_{10} emissions from vehicular traffic. This control option is technically feasible. However, increasing freeboard may reduce the capacity hauled per truck and would require additional unpaved road travel and the potential need to purchase additional haul trucks to make up for the production loss. Per email communications between ADEQ and the EPA Region 9, no data is available for the PM_{10} control efficiency for this measure.[6] Since the emissions reductions could not be quantified, this control option is not considered further in the cost of compliance analysis.

2.5.1.5 Application of additional chemical dust suppressant to haul roads

Chemical dust suppressants are not currently used on unpaved haul roads at the Morenci Mine due to the extreme weight and crushing power of the haul trucks weighing about 860,000 pounds loaded. Per Freeport, chemical dust suppressants can also cause safety hazard by tire slippage during rainy days and when haul trucks make turns or travel on a slope. In addition,

[4] https://www3.epa.gov/ttn/chief/ap42/ch13/bgdocs/b13s02-2.pdf Equation 2-1
[5] https://www3.epa.gov/ttn/chief/ap42/ch13/final/c13s0202.pdf Pg. 13.2.2-12
[6] Email communication between Ryan Templeton (ADEQ) and Panah Stauffer (EPA Region 9)

based on the several tests performed by Freeport, these chemicals can affect the recovery of copper in the floatation process. Due to safety and operation concerns, this control measure is considered technically infeasible.

2.5.1.6 Application of surface gravel on haul roads

Although it is feasible to apply gravel to the haul roads, it is infeasible to maintain it. Gravel would immediately degrade when driven on by 860,000 pounds loaded trucks. Constant application of new gravel would be needed to replace the gravel destroyed by the trucks. Large ruts would form and haul trucks would likely slip when traveling up or down a slope. Therefore, this control measure is considered technically infeasible.

2.5.1.7 Covering of haul trucks

Haul truck covers are not commercially available to accommodate the size of the haul trucks. Covers would either have to be made in-house or a new type of cover would have to be prototyped and sourced. In addition, covering and uncovering loaded haul trucks could be accomplished only with manual labor and would pose unacceptable safety risks that could not be harmonized with applicable Mine Safety and Health Act ("MSHA") rules. For these reasons, covering haul trucks would be technically infeasible.

2.5.1.8 Paving haul roads

Paving unpaved roads in an effort to reduce PM_{10} emissions from haul truck traffic would require a substantial capital investment. Moreover, paving is not feasible for industrial roads subject to very heavy vehicles and/or spillage of material in transport. Due to the weight of the haul trucks at the Morenci Mine, which ranges up to 860,000 pounds, constant replacement of the pavement would be required, since the pavement would quickly be degraded by the weight and movement of the trucks. Therefore, paving the haul roads and maintaining the pavement would be technically infeasible.

Table 3 provides a summary of the technically feasible controls for PM_{10} emissions from haul trucks traveling on mine roads.

Table 3 Technically Feasible Control Options for PM_{10} Emissions from Haul Trucks Traveling on Mine Roads

Control Options	PM_{10} Emissions Reduction (tpy)	Note
Reduce the speed limit for haul trucks from 34.5 mph to 25 mph	427	Tailpipe emissions were not estimated
Apply additional water to haul roads (increasing the control efficiency from 90% to 95%)	890.5	Apply additional water to haul roads both inside and outside the pit
Increase freeboard in the haul trucks	Emissions reductions could not be quantified	This control option is not considered further in the cost of compliance analysis

2.5.2 Control Options for PM10 Emissions from Loading Ores into Haul Trucks

Freeport identified the following PM_{10} control technologies based on a review of the RACT/BACT/LAER Clearinghouse ("RBLC") database, technical literature, practices and engineering experience at open-pit copper mines:

- Regular application of water to ores
- Altering loading procedures
- Ceasing operations during high wind hours

2.5.2.1 Apply Water to Ores

According to Freeport, the Morenci Mine can operate up to 15 loading sites at a time. To apply the amount of water needed to increase the moisture content of ores to a level that would reduce emissions on a continuous basis, Morenci would need to employ a water truck at each loading site to ensure that the moisture content in the ore during loading procedure is sufficient. This control option is technically feasible.

By using AP-42 section 13.2.4 and increasing the moisture content from 3.2% to 4.8%, a control efficiency of 43% is calculated[7]. This will result in 52.06 ton/yr PM_{10} reduction. An increase in moisture content of ores would not reduce the emissions from other downstream processes such as crushing. Per Freeport, all crushers are currently controlled with baghouses. Therefore, additional water would not provide any additional control but could actually cause reliability issues with the baghouse due to plugging with wet material. Most conveyor belt transfer points are also controlled by baghouses or water sprays. Additional water added at a truck loading point would only reduce the amount of water added at the spray bars. The PM control efficiency would be the same.

2.5.2.2 Altering Loading Procedures

Altering loading procedures such as loading trucks on the downwind side of loading equipment can be a potential control option. This technique assumes that the loading equipment itself forms a windbreak. However, per Freeport, the massive electric shovels and haul trucks used in the copper mining industry cannot be moved whenever the wind shifts directions. Therefore, this control option would be technically infeasible.

2.5.2.3 Ceasing Operations during High Wind Hour

Ceasing operations during high winds (sustained wind speed over 25 mph) is a potential control method to reduce PM_{10} emissions. This would reduce calculated emissions by assuming there

[7] https://www3.epa.gov/ttn/chief/ap42/ch13/final/c13s0204.pdf

are no emissions from loading during high winds. This control option is considered technically feasible.

A control efficiency of 0.05% was calculated for this control option based on the proportion of hours that loading and dumping would not be in operation. High wind hours are those that average more than 25 mph per the Townsite Met Station, which reported 4 hours in 2018. This would reduce PM_{10} emissions by 0.06 ton/yr.

Table 4 provides a summary of the technically feasible controls for PM_{10} emissions from loading ores into haul trucks.

Table 4 Technically Feasible Control Options for PM_{10} Emissions from Loading Ores into Haul Trucks

Control Options	PM_{10} Emissions Reduction (tpy)	Note
Apply water to ores to increase the moisture content from 3.2% to 4.8%	52.06	—
Ceasing loading operations during high wind hours	0.06	—

2.5.3 Cost of Compliance

2.5.3.1 Cost Calculation Methodology

In general, the cost calculation methodologies ADEQ employed follow the recommendations in the EPA Air Pollution Control Cost Manual, specifically the concepts and methodology as discussed in chapter 2 of section 1.[8] ADEQ recognized that the generic cost estimate information for the processes in mining industry is very limited in the EPA documentation. Therefore, ADEQ mainly relied on the source-specific estimates Freeport provided. For example, the capital costs for new haul trucks and water trucks were directly from the vendor budgetary quotes, and the Operation and Maintenance (O&M) cost of trucks were estimated based on the actual costs in the Morenci Mine during the most recent years. Interest rates and the useful life for amortization purposes are discussed as follows.

As recommended in the EPA Control Cost Manual, the bank prime rate can be an appropriate estimate for interest rates if firm-specific nominal interest rates are not available. However, Freeport provided an interest rate of 9.25%, which was based on the FMI Corporate Finance and estimated as the average of current weighted average cost of capital 11.5% and 2019 end of year weighted average cost of capital 7%.

A haul truck or water truck may last 10-12 years without a major refurbish. However, the rebuild process can significantly extend the useful life of trucks.[9] Freeport proposed a useful life

[8] https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf
[9] https://www.cat.com/en_US/campaigns/awareness/mining-truck-rebuilds.html

of 20 years for both haul trucks and water trucks, which was determined appropriate by ADEQ as well.

2.5.3.2 Evaluation Criteria for Cost-Effectiveness

ADEQ performed an analysis to determine a reasonable cost-effectiveness ($/ton) threshold for Arizona emission sources that are subject to the four factor analysis in the regional haze second planning period. ADEQ gathered data on Round 1 Regional Haze Best Available Retrofit Technology (BART) and Reasonable Progress determinations through research of previous submittals and EPA determinations and through outreach to EPA, Federal Land Managers (FLMs), Western States, and WRAP. While EPA did not explicitly state whether they used cost and visibility thresholds or not for their determinations on Round 1, EPA generally rejected cases with a cost-effectiveness of greater than 5,000 $/ton regardless of whether a visibility benefit was significant or not. ADEQ found that none of the accepted cost-effectiveness values in Round 1 exceeded 5,300 $/ton. Adjusting the cost for inflation, ADEQ determined that any controls having an average cost-effectiveness of 6,500 $/ton or higher would be cost excessive and could be rejected without further justification.

2.5.3.3 Results of Cost-Effectiveness Analysis

Table 5 provides a summary of cost effectiveness for control options for PM_{10} emissions from haul trucks travelling on The Morenci Mine roads. Table 6 provides a summary of cost effectiveness for control options for PM_{10} emissions from loading ores into haul trucks.

2.5.3.3.1 Control Options for PM10 Emissions from Haul Trucks Travelling on Mine Roads

- As shown in Table 5, the speed reduction option for haul trucks has an average cost-effectiveness of $383,018/ton, which is significantly higher than the threshold of $6,500/ton. ADEQ has determined that this control option is cost prohibitive.
- The control option of additional water spray on haul roads has an average cost-effectiveness of $10,949/ton, significantly higher than the threshold of 6,500 $/ton as discussed above. As such, ADEQ has determined that this control option is cost prohibitive.

2.5.3.3.2 Control Options for PM10 Emissions from Loading Ores into Haul Trucks

- As shown in Table 6, applying water to ores has an average cost-effectiveness of $406,990/ton, which is significantly higher than the threshold of $6,500/ton. ADEQ has determined that this control option is cost prohibitive.
- Ceasing operations during high wind hours has an average cost-effectiveness of $14,625,547/ton. ADEQ has determined that this control option is cost prohibitive.

Table 5 Cost Effectiveness of Control Options for PM10 Emissions from Haul Trucks Traveling on Mine Roads

Control option	Capital cost ($)	Annualized capital cost ($/yr)[1]	Annual operating & maintenance cost ($/yr)	Total annual cost ($/yr)	Emission reduction (tpy)	Average Cost-effectiveness ($/ton)
Reduce the speed limit for haul trucks to 25 mph	$229,500,0000	$25,590,368	$138,139,620	$163,729,988	427	$383,018
Apply additional water to haul roads	$10,000,000	$1,115,049	$8,638,517	$9,753,566	890.8	$10,949

[1] *Capital Recovery Factor = 11.15 based on an interest rate of 9.25% and a useful life of 20 years*

Table 6 Cost Effectiveness of Control Options for PM_{10} Emissions from Loading Ores into Haul Trucks

Control option	Capital cost ($)	Annualized capital cost ($/yr) [1]	Annual operating & maintenance cost ($/yr)	Total annual cost ($/yr)	Emission reduction (tpy)	Average Cost-effectiveness ($/ton)
Apply additional water to ores	$37,500,000	$4,181,433	$17,008,107	$21,189,540	52.06	$406,990
Ceasing operations during high wind hours	N/A	N/A	$878,995	$878,995	0.06	$14,625,547

[1] *Capital Recovery Factor = 11.15 based on an interest rate of 9.25% and a useful life of 20 years*

2.5.4 Time Necessary for Compliance

There is no requirement that controls determined to be necessary under 40 C.F.R. § 51.308 must be installed as expeditiously as practicable; rather, such controls should be in place by 2028, unless ADEQ concludes that the control cannot reasonably be installed and become operational until after 2028. Further evaluation of the time necessary for compliance was not evaluated given the controls identified were either currently implemented or cost prohibitive.

2.5.5 Energy and Non-Air Quality Impacts

Adding more haul trucks or water trucks will increase the consumption of fuel. Additional water spray on the haul roads/non-haul unpaved roads and ores will increase the water consumption. For other controls options, the energy and non-air quality impacts are considered negligible.

2.5.6 Remaining Useful Life of Source

The concept of remaining useful life of source is typically used in the context of a discrete emission unit. Freeport proposed a useful life of 20 years for haul trucks and water trucks. ADEQ also determined that a useful life of 20 years for trucks would be appropriate, considering the useful life of trucks could be extended through the rebuilding process.

2.5.7 Visibility Impact

Freeport performed a Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model to determine the probability that emissions from the Morenci Mine impact a Class I area when it experiences its 20% worst visibility days. The results of the HYSPLIT model indicate that the probability of emissions form the Morenci Mine impacting the Gila Wilderness Area is between 0.5% to 1%.