2021 Regional Haze Four Factor Initial Control Determination

Nonpoint Source: Mining and Quarrying

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

1.1 ADEQ Initial Control Determination for Mining and Quarrying

Based on a review of available controls and consideration of the four statutory factors, ADEQ's initial determinations is that it is reasonable not to require additional nonpoint mining and quarrying controls 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 31, 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

Air Quality Improvement Planning (AQIP) value stream staff evaluated control strategies to mitigate PM_{10}[1] emissions from nonpoint mining and quarrying sources that are located within 50 kilometers (km) of the Chiricahua National Monument (NM) and Wilderness Area, Galiuro Wilderness Area, Saguaro National Park (NP), and Superstition Wilderness Area.

Based on a review of available controls and consideration of the four statutory factors, ADEQ's initial determinations is that it is reasonable not to require additional nonpoint mining and quarrying controls during this planning period.

2.2 ADEQ Source Screening Methodology

2.2.1 Significantly Contributing PM Species

To screen out particulate matter (PM) species that make only a small contribution to overall anthropogenic light extinction at Class I areas within the State of Arizona, ADEQ evaluated the impacts of particulate species[2] on the 20% most impaired days.[3] The results of this analysis showed that sulfate, nitrate, and coarse mass (i.e., PM_{10}) account for 72% - 89% (average 80%) of anthropogenic light extinction in these areas. ADEQ determined that these three species should be further evaluated for source controls during this planning period in order to maximize the benefit of any potential new control strategies.

2.2.2 Nonpoint Source Screening Methodology

ADEQ employed the following approach when screening nonpoint sources to determine which source sectors should be included in the four-factor analysis:[4]

1. Gather 2014 EPA NEIv2[5] county-level nonpoint datasets for the State of Arizona.

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[1] Particulate matter 10 micrometers or less in diameter (PM_{10}).
[2] Species evaluated included ammonium sulfate (sulfate), ammonium nitrate (nitrate), organic mass carbon (OMC), light absorbing carbon (LAC), [fine] soil, and coarse mass (CM).
[3] See *ADEQ 2021 Regional Haze State Implementation Plan Source Screening Methodology*, August 16, 2019.
[4] *Ibid*.
[5] National Emissions Inventory (NEI), version 2.

2. Isolate source classification code (SCC) annual emissions (tons/year) for PM_{10}-primary, nitrogen oxides, and sulfur dioxide.
3. Remove PM_{10}-primary emissions from consideration for those counties that are not located within 50 km of a Class I area since PM_{10} does not generally experience high transport distances.
4. Sum the remaining SCC-specific PM_{10} primary, nitrogen oxides, and sulfur dioxide annual emissions to calculate "Q".
5. Sort all SCCs from highest to lowest "Q".
6. Determine the "Q"-threshold which achieved inclusion of the SCCs with the largest "Q's" until >80% of total "Q" emissions across all SCCs are accounted for (i.e. "Q" >13,500 tons per year includes 6 sectors which account for 81.6% of the total statewide nonpoint "Q").
7. Isolate those sources with a "Q" value greater than 13,500 tons/year (tpy).

Based on the approach outlined above, the nonpoint source sectors that were screened into a 4-factor analysis are presented in Table 2.

Table 1 Arizona Nonpoint Source Sectors with a Q >13,500 tons/year

SCC	NO_x	PM_{10}	SO_2	Q	Sector
2285002006	18,045	541	11	18,597	Mobile - Locomotives
2294000000	0	14,501	0	14,501	Dust - Paved Road Dust
2296000000	0	107,924	0	107,924	Dust - Unpaved Road Dust
2311020000	0	15,536	0	15,536	Dust – Industrial/Commercial/Institutional Construction Dust
2325000000	0	44,753	0	44,753	Industrial Processes - Mining
2701220000	13,912	0	0	13,912	Biogenics - Vegetation and Soil

The evaluation of emissions reduction strategies for nonpoint sources during this planning cycle is focused on potential dust control measures for the paved and unpaved roads, mining and quarrying, and non-residential construction source sectors. Locomotive and Biogenic NOx emissions were not considered in this round because these sectors are generally controlled at the federal level or are mostly uncontrollable. Additionally, to make the best use of limited resources, ADEQ chose to focus on the four source sectors with the highest likelihood of presenting achievable control measures that can be implemented at the state or local levels.

2.3 Emissions Control Evaluation Areas

For the period 2013-2017 anthropogenic coarse mass emissions were found to have the highest impacts (on most impaired days) on the following IMPROVE monitoring sites and corresponding Class I areas.[6, 7]

- Chiricahua NM and Wilderness Area (IMPROVE Site: Chiricahua NM, CHIR1)
- Galiuro Wilderness Area (IMPROVE Site: Chiricahua NM, CHIR1)
- Saguaro NP (IMPROVE Site: Saguaro NP – East Unit, SAGU1)
- Superstition Wilderness Area (IMPROVE Site: Tonto NM, TONT1)

Since PM_{10} does not generally experience high transport distances, evaluation of emissions reduction strategies for paved and unpaved roads, mining and quarrying, and non-residential construction is limited to nonpoint sources within 50 km of these Class I areas.[8]

2.4 Source Sector Overview

Consideration of potential controls for the highest contributing sources is based on the location of the emitting sources (i.e., are they within 50 km of the "high impact" Class I areas)[9] and on the emitting activities used to calculate sector emissions for these areas. According to NEI documentation, emissions estimates for mining and quarrying are based on the following activities.[10]

- Earthmoving
  - Overburden removal/replacement
- Drilling and Blasting
- Material handling
  - Loading and unloading
- *Does not include material transport and storage or crushing and screening*

2.5 Analysis of Available PM_{10} Control Measures

As a first step in the evaluation of potential new PM_{10} emissions control measures for mining and quarrying, ADEQ developed a list of "available" measures from review of EPA and other agency guidance and control strategies adopted by state and local agencies. The list includes measures contained in emissions control plans for permitted mining sources and guidance developed by

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[6] See *ADEQ 2021 Regional Haze State Implementation Plan Source Screening Methodology*, August 16, 2019.
[7] Each of these sites exhibited coarse mass impacts on the most impaired days of > 10% of the total anthropogenic extinction (Mm-1) during the 2013-2017 period.
[8] See *Map of Coarse Mass Areas and 50 km Buffers*.
[9] *Ibid*.
[10] See EPA's "*Mining and Quarrying* (2014_mining_and_quarrying_2325000000_documentation_v2.3 (4).docx)."

private industry. The following are some of the reference materials used to develop the list of available measures.

- *Dust Control Handbook for Industrial Minerals Mining and Processing*, 2nd ed., U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, March 2019
- *Literature Review of Current Fugitive Dust Control Practices within the Mining Industry*, prepared by Golder Associates Ltd., submitted to The Centre for Excellence in Mining Innovation, August 11, 2010
- *Mine Site Fugitive Emission Control Plan*, prepared for Poly Met Mining, Inc. NorthMet Project, prepared by BARR Engineering Co., April 2017
- *Final Report, Bingham Canyon Mine Expansion Notice of Intent Application*, prepared for Kennecott Utah Copper LLC, prepared by CH2M Hill, submitted to Utah Division of Air Quality August 2010, Revised January 2011, App. E-3 Proposed Fugitive Dust Control Plan
- *Dust Suppression Technologies for Mining Applications*, Dust Solutions, Inc., accessed February 6, 2020
- *Dust Control in Mineral Processing Operations*, Nevada Mining Association/NIOSH Silica Dust Control Workshop for Metal/Nonmental Mining, September 28, 2010
- *Dust Production in Mining, Suppression Measures in Quarry Blasting*, Master Thesis submitted by Gonzalo Morera de La Vall Gonzalez to Escuela Tecnica Superior de Ingenieros de Minas y Energia, September 2018

Each of the listed measures were evaluated for technical feasibility and the four statutory factors required under the Regional Haze Rule.[11] The list of measures and a summary table of the technical feasibility and four-factor analysis conclusions are included in Sections VI.A through VI.E. Discussion of the reasons for including or rejecting individual measures, in whole or in part, from the Long Term Strategy (LTS) follows each summary.

[11] See *Final Rule: Protection of Visibility: Amendments to Requirements for State Plans*, 82 FR 3078, January 10, 2017.

2.6 Four-Factor Analysis Review – Mining and Quarrying (Nonpoint)

2.6.1 Four-Factor Analysis Summary and Discussion – Earthmoving and Excavating

Table 2 List of Available PM_{10} Control Measures for Earthmoving Activities

List of Available PM_{10} Control Measures for Earthmoving Activities (ACTIVITY DEFINED: overburden removal/replacement and excavation.)						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources (yr)
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
1. Additional Watering - Purchase Additional Water Truck	Yes	$157,500	$18,308	--	--	12
2. Additional Watering - Rent Additional Water Truck	Yes	--	$24,496	--	--	--
3. Implement Additional Watering with Available Trucks	N/A	--	--	--	--	--
4. Water in Operational Areas - Other Water Distribution Systems (besides trucks)	N/A	--	--	--	--	--

List of Available PM_{10} Control Measures for Earthmoving Activities (ACTIVITY DEFINED: overburden removal/replacement and excavation.)						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources (yr)
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
5. Applying dust suppressants (other than water)	No	--	--	--	--	--
6. Avoid clearing during wind gusts	N/A	--	--	--	--	--

In general, the cost calculation methodologies ADEQ employed for the feasible control methods follow the recommendations in the EPA Air Pollution Control Cost Manual, specifically the concepts and methodology as discussed in chapter 2 of section 1.[12] ADEQ recognized that the generic cost estimate information for the processes in mining and quarrying industry is very limited in the EPA documentation. Therefore, ADEQ mainly relied on the source-specific estimates provided by The Arizona Rock Products Association (ARPA).

[12] https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf

2.6.1.1 Additional Watering - Purchase Additional Water Truck

2.6.1.1.1 Technical Feasibility

Applying water to the excavated materials during earthmoving activities will result in PM10 emission reduction. A PM10 control efficiency of 82%[13] was applied to this control option, resulting in a reduction of 5.11 tpy-facility. This control option was determined technically feasible and was further considered for the Four Factor Analysis. Considering the dynamic location of the material in the pit, water trucks have been evaluated as the mechanism of applying water.

2.6.1.1.2 Cost of Compliance – Factor 1

The baseline emission rate for this activity was estimated using the bulldozing overburden removal equation in AP-42 Table 11.9-1. The emission reduction was estimated using the baseline and post control emissions with an equivalent control efficiency of 82%.

The capital cost of a 4,000-gallon water truck was determined to be $157,500 from a quote obtained from Granite Construction Company. An interest rate of 4.75% was used for the annualization of capital cost and is equivalent to the 3-year average bank prime rate at the time of cost-estimation. 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. The admin, tax, and insurance cost was assumed to be 4% of the capital cost. Operation costs included $3,100 /year for fuel, $3,100 /year for maintenance, $63,152/year operator cost, and a $361 /year water cost.

As shown in Table 4, the purchase of an additional water truck for the purpose of additional watering during earthmoving and excavation activities has an average cost-effectiveness of $18,308/ton. For comparison, ADEQ also evaluated this control for the major point source, ASARCO Ray mine. The cost of compliance for this control at that facility was estimated to be $109,742/ton.[14] The difference in truck size necessary at the major point source and the smaller truck evaluated in this analysis played a large role in the disparities between the two cost-effectiveness estimations. Regardless, ADEQ has determined that this control option is cost prohibitive.

[13] Efficiencies are based on increasing moisture content from 5% to 16.8%. Per AP-42 Table 11.9-3, the maximum moisture content range for bulldozing overburden is 16.8%. Per ADEQ Technical Review and Evaluation General Permit for Crushing and Screening Plants, a 5% initial moisture content was assumed. The control efficiency was then calculated by determining the ratio of emission rates using AP-42 Table 11.9-1, Bulldozing Overburden.

[14] ADEQ, 2021 Regional Haze Four Factor Initial Control Determination, Facility: ASARCO Ray Operations.

2.6.1.1.3 Time Necessary for Compliance – Factor 2

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.

2.6.1.1.4 Energy and Non-Air Quality Environmental Impacts of Compliance – Factor 3

Using water trucks will increase the consumption of fuel and additional water spray on the material will increase the water consumption.

2.6.1.1.5 Remaining Useful Life of Potentially Affected Sources – Factor 4

ADEQ finds that a useful life of 12 years for water trucks per replacement schedule for heavy trucks at University of Florida Administrative Services is reasonable.[15] This useful life was also referenced in the Asarco Mission Complex's initial Four Factor Analysis. ADEQ will further investigate this assumption.

2.6.1.2 Additional Watering - Rent Additional Water Truck

2.6.1.2.1 Technical Feasibility

Applying water to the excavated materials during earthmoving activities will result in PM10 emission reduction. A PM10 control efficiency of 82%[16] was applied to this control option, resulting in a reduction of 5.11 tpy-facility. This control option was determined technically feasible and was further considered for the Four Factor Analysis. Considering the dynamic location of the material in the pit, water trucks have been evaluated as the mechanism of applying water.

2.6.1.2.2 Cost of Compliance – Factor 1

The baseline emission rate for this activity was estimated using the bulldozing overburden removal equation in AP-42 Table 11.9-1. The emission reduction was estimated using the baseline and post control emissions with an equivalent control efficiency of 82%.

[15] https://www.usf.edu/administrative-services/documents/asbc-resources-field-equipment-replacement.pdf

[16] Efficiencies are based on increasing moisture content from 5% to 16.8%. Per AP-42 Table 11.9-3, the maximum moisture content range for bulldozing overburden is 16.8%. Per ADEQ Technical Review and Evaluation General Permit for Crushing and Screening Plants, a 5% initial moisture content was assumed. The control efficiency was then calculated by determining the ratio of emission rates using AP-42 Table 11.9-1, Bulldozing Overburden.

The annual rental cost and operational cost (excluding the operator cost) of a 4,000-gallon water truck was determined to be $55,432/yr. Operator costs are estimated as $63,152/year. This results in a total annual cost of $125,145.

As shown in Table 4, the rental of an additional water truck for the purpose of additional watering during earthmoving and excavation activities has an average cost-effectiveness of $24,496/ton. ADEQ has determined that this control option is cost prohibitive.

2.6.1.2.3 Time Necessary for Compliance – Factor 2

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.

2.6.1.2.4 Energy and Non-Air Quality Environmental Impacts of Compliance – Factor 3

Using water trucks will increase the consumption of fuel and additional water spray on the material will increase the water consumption.

2.6.1.2.5 Remaining Useful Life of Potentially Affected Sources – Factor 4

The useful life is dependent on the life of the facility. Since trucks are rented for the time necessary, the control equipment useful life does not apply in this scenario.

2.6.1.3 Implement Additional Watering with Available Trucks

2.6.1.3.1 Technical Feasibility

While it may be reasonable to expect certain facilities to operate a water truck at less than full capacity, it is unlikely that most or all sources would operate in this fashion. ARPA has confirmed that most operations would size the water truck to the operations needs and not purchase or rent a water truck that is oversized for the needs of the operation. This is especially true in the summer time when water demands are higher due to increased evapotranspiration and higher rates of watering are necessary. Therefore, ADEQ has determined that it is unreasonable to assume additional bandwidth is available for currently rented or owned water trucks. Further analysis of this control is not researched.

2.6.1.4 Water in Operational Areas - Other Water Distribution Systems (besides trucks)

2.6.1.4.1 Technical Feasibility

Given the dynamic locations of earthmoving and excavating on a mining and/or rock products site, a portable water source is necessary. ADEQ did not identify portable water control systems for earthmoving and excavating other than trucks. Therefore, further evaluation of this control could not occur.

2.6.1.5 Applying dust suppressants (other than water)

2.6.1.5.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector includes activity related emissions but not windblown. Given this, the controls under consideration are primarily evaluated for their ability to reduce activity related emissions. As such, while applying dust suppressants (other than water) may provide a technically feasible control for windblown dust from areas not currently under excavation and earthmoving, application of dust suppressants to active areas is not feasible. Doing so would require constant reapplication of the dust suppressants in order to meet the products normal emission reduction efficacy, as the materials under control would be undergoing constant movement. Finally, the dust suppressants can impact the quality of the product being processed by the facility.

2.6.1.6 Avoid clearing during wind gusts

2.6.1.6.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector includes activity related emissions but not windblown. Given this, the controls under consideration are primarily evaluated for their ability to reduce activity related emissions.

ADEQ was unable to estimate the increase in activity related emissions when transitioning from low to high wind scenarios. Additionally, facilities would likely increase activity during low wind periods to compensate for decreased production during high wind periods. While it is likely that decreased production during high wind would reduce the transport of emissions, it is unclear if it would reduce the total activity related emissions. For these reasons, this control could not be and was not further evaluated.

Table 3 Cost Effectiveness of Earthmoving and Excavating controls

Measure Description	Capital Cost ($)	Annualized Capital Cost ($/yr)	Annual Implementation /Maintenance Cost ($/yr)	Total Annual Cost ($)	Control Effectiveness (%)	Cost Effectiveness ($/ton)
Additional Watering - Purchase Additional Water Truck	$157,500	$17,500	$76,013	$93,533	82%	$18,308
Additional Watering – Rent Additional Water Truck	--	--	$125,145	$125,145	82%	$24,496

Table 4 Estimated Emissions Reductions for Earthmoving and Excavating controls

Measure Description	Baseline Emissions with Existing Measures (tons/year-facility)	Emissions Reductions from New Measures (tons/year-facility)
Additional Watering - Purchase Additional Water Truck	6.26	6.26
Additional Watering – Rent Additional Water Truck	5.11	5.11

2.6.2 Four-Factor Analysis Summary and Discussion – Material Handling (Bulk Loading)

Table 5 List of Available PM_{10} Control Measures for Material Handling – Bulk Loading

List of Available PM_{10} Control Measures for Material Handling – Bulk Loading (ACTIVITY DEFINED: product stream falls from the load out discharge point to the transport carrier, e.g. truck or railcar. Applies to bulk loading onto or off of conveyor systems, rail cars or trucks.)						
Available PM_{10} Control Measure for Consideration	**Technically Feasible**	**[1] Cost of Compliance**		**[2] Time Necessary for Compliance**	**[3] Energy and Non-AQ Environmental Impacts of Compliance**	**[4] Remaining Useful Life of Potentially Affected Sources (yr)**
		Capital-Implementation Costs	**Cost Effectiveness ($/ton)**			
1. Partial Closure with Hanging Curtains and the use of Water Spraying at Primary Dump	Yes	$226,782	$101,309	--	--	12
2. Regularly Apply Water Through Wetting of Material at the Pit	Yes	$157,500	$204,319	--	--	12
3. Regularly Apply Water Through Water Sprays	N/A	--	--	--	--	--
4. Reduce Falling Distance	N/A	--	--	--	--	--
5. Use of Loading Spouts	No	--	--	--	--	--

List of Available PM_{10} Control Measures for Material Handling – Bulk Loading (ACTIVITY DEFINED: product stream falls from the load out discharge point to the transport carrier, e.g. truck or railcar. Applies to bulk loading onto or off of conveyor systems, rail cars or trucks.)						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources (yr)
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
6. Use of Loading Spout Equipped with Dust Control System	No	--	--	--	--	--
7. Use of Cascading Loading Spouts	No	--	--	--	--	--
8. Use of Cascading Loading Spouts Equipped with Wind Shrouds and Discharge Skirts	No	--	--	--	--	--
9. Use of Conical Loading Hoppers (Dust Suppression Hopper)	No	--	--	--	--	--
10. Enclose Load Out	See Control #*1. Partial Closure with Hanging Curtains and the use of Water Spraying at Primary Dump*					
11. Enclose Load Out and equip with Dry Dust Collection System	See Control #*1. Partial Closure with Hanging Curtains and the use of Water Spraying at Primary Dump*					
12. Use of Dry Fog Dust Suppression System at Loading/Unloading Points	No	--	--	--	--	--

Please note that controls #10 and 11 seem to be similar to the control #1, which was found to be feasible and was analyzed for cost effectiveness. For control #1, partial closure (construction of 3-sided enclosures) with hanging curtains without additional dust controls was analyzed and found to be cost excessive. Since the partial closure without additional dust controls is highly cost excessive, ADEQ believes similar control options such as enclosing load out (#10) and enclosing load out equipped with dry dust collection system (#11) would be cost excessive as well and therefore, did not consider further analysis for those options. To address these control options, ADEQ combined them and defined one option as: “partial closure at loading in and loading out by hanging curtains”.

In general, the cost calculation methodologies ADEQ employed for the feasible control methods follow the recommendations in the EPA Air Pollution Control Cost Manual, specifically the concepts and methodology as discussed in chapter 2 of section 1.[17] ADEQ recognized that the generic cost estimate information for the processes in mining and quarrying industry is very limited in the EPA documentation. Therefore, ADEQ primarily relied on the source-specific estimates ARPA provided.

2.6.2.1 Partial closure at loading in and loading out by hanging curtains

2.6.2.1.1 Technical Feasibility

Partial closure of loading in and loading out processes by hanging curtains will result in PM_{10} emission reduction. A control efficiency of 75%[18] was applied to this control option, resulting in a reduction of 0.34 tpy for PM_{10}. This control method was determined technically feasible and was further considered for the Four Factor Analysis.

2.6.2.1.2 Cost of Compliance – Factor 1

The baseline emission rate for this activity was estimated using AP-42 Section 13.2.4 Equation (1). The emission reduction was estimated using the baseline and post control emissions and a control efficiency of 75% as explained above (see Table 8).

The capital cost for fabrication and installation of the control was estimated based on quotes obtained from vendors and an interest rate of 4.75% was used for annualization of capital cost. 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. No maintenance and operation cost was considered for this control option. The admin, tax, and insurance cost was assumed to be 4% of the capital cost.

As shown in Table 7, the partial closure of loading in and loading out processes by hanging curtains has an average cost-effectiveness of $101,309/ton. ADEQ has determined that this control option is cost prohibitive.

2.6.2.1.3 Time Necessary for Compliance – Factor 2

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.

[17] https://www.epa.gov/sites/production/files/2017-12/documents/epaccmcostestimationmethodchapter_7thedition_2017.pdf
[18] WRAP Fugitive Dust Handbook, Table 4.2

2.6.2.1.4 Energy and Non-Air Quality Environmental Impacts of Compliance – Factor 3

The energy and non-air quality impacts for this control option are considered negligible.

2.6.2.1.5 Remaining Useful Life of Potentially Affected Sources – Factor 4

The concept of remaining useful life of source is typically used in the context of a discrete emission unit. ADEQ relied on a useful life of 12 years for partial closure with hanging curtains. This is a conservative estimate. The actual useful life would be much lower because the primary dump may be moved every few years. It should be noted that the number of years corresponds to the remaining life of the unit after 2028, which is the earliest time that controls are expected to be installed. Per EPA Guidance on Regional Haze State Implementation Plans for the Second Implementation Period, typically, the remaining useful life of the source itself will be longer than the useful life of the emission control system under consideration unless there is an enforceable requirement for the source to cease operation sooner, annualized compliance costs are typically based on the useful life of the control equipment rather than the life of the source, unless the source is under an enforceable requirement to cease operation[19].

2.6.2.2 Regularly Apply Water through Wetting of Material at the Pit

2.6.2.2.1 Technical Feasibility

Applying water to the material at the pit will result in PM_{10} emission reduction. A control efficiency of 90%[20] was applied to this control option, resulting in a reduction of 0.41 tpy for PM_{10}. This control option was determined technically feasible and was further considered for the Four Factor Analysis. Considering the dynamic location of the material in the pit, due to varying blasting areas, water trucks have been evaluated as the mechanism of applying water.

2.6.2.2.2 Cost of Compliance – Factor 1

The baseline emission rate for this activity was estimated using AP-42 Section 13.2.4 Equation (1). The emission reduction was estimated using the baseline and post control emissions and a control efficiency of 90% (see Table 8).

The capital cost for a new water truck was estimated based on the average price of a 4,000 gallon water truck per quotes from vendors and CalPortland Environmental Management. An interest rate of 4.75% was used for annualization of capital cost. 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.

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

[20] WRAP Fugitive Dust Handbook, Table 4.2

The estimated cost of maintenance and operation includes water cost, fuel cost, maintenance cost, and labor cost. The cost of water was estimated based on 2020 groundwater withdrawal fees for the Phoenix Active Management Area (AMA). The cost of fuel and maintenance was estimated based on quotes obtained from Granite Construction Company Inc.'s equipment management. The cost of labor was estimated based on mean hourly pay of Arizona Industrial Truck and Tractor Operators assuming that watering will be required once a day for 8 hours. An additional cost was added for the Mine Safety and Health Administration (MSHA) training that would be required for a new hire. The admin, tax, and insurance cost was assumed to be 4% of the capital cost.

As shown in Table 7, regularly application of water to the material has an average cost-effectiveness of $204,319/ton. For comparison, ADEQ also evaluated this control for the major point sources, Freeport Sierrita mine and Freeport Morenci mine. The cost of compliance for this control at those two major point sources was estimated to be $179,501/ton and $406,990/ton, respectively.[21, 22] ADEQ has determined that this control option is cost prohibitive.

2.6.2.2.3 Time Necessary for Compliance – Factor 2

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.

2.6.2.2.4 Energy and Non-Air Quality Environmental Impacts of Compliance – Factor 3

Using water trucks will increase the consumption of fuel and additional water spray on the material will increase the water consumption.

2.6.2.2.5 Remaining Useful Life of Potentially Affected Sources – Factor 4

ADEQ relied on a useful life of 12 years for water trucks per replacement schedule for heavy trucks at University of Florida Administrative Services.[23] This useful life was also referenced in feedback from ARPA and the Asarco Mission Complex's initial Four Factor Analysis. ADEQ will further investigate this assumption.

[21] ADEQ, 2021 Regional Haze Four Factor Initial Control Determination, Facility: Freeport Sierrita.
[22] ADEQ, 2021 Regional Haze Four Factor Initial Control Determination, Facility: Freeport Morenci.
[23] https://www.usf.edu/administrative-services/documents/asbc-resources-field-equipment-replacement.pdf

2.6.2.3 Regularly Apply Water through Water Sprays

2.6.2.3.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. Additionally, there is a limit of how much water can be added to the material as to not jam up the conveyor system. This control option is not further considered for the Four Factor Analysis.

2.6.2.4 Reduce Falling Distance

2.6.2.4.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. Therefore it will not be considered for the Four Factor Analysis.

2.6.2.5 Use of Loading Spouts/ Cascading Loading Spouts/ Conical Loading Hoppers (Dust Suppression Hopper)

2.6.2.5.1 Technical Feasibility

Bulk loading at Arizona rock product facilities is typically done by front end loading. Therefore, material is not transferred in a way that would be conducive to these control methods. Typically, the material at these facilities are not stored in silos, but rather, they are stored in stockpiles. In addition, the material that is processed at these facilities consists of rocks of varying sizes. Often times, large rocks are processed through the system. The large rocks would clog loading spouts and conical loading hoppers, causing a loss in production. It is not easily quantifiable how many clogs and how much time per clog would be needed to estimate a cost of including these control methods. These control methods (items #5 to 9 of Table 6) are determined non-feasible and therefore, are not considered for the Four Factor Analysis.

2.6.2.6 Use of Dry Fog Dust Suppression System at Loading/Unloading Points

2.6.2.6.1 Technical Feasibility

Implementing a dry fog dust suppression system could cause many safety hazards. Dry fog blocks visibility, creates slippery surfaces, and mud accumulates. Also, since bulk loading is done by front end loading and changes locations, a portable dry fog dust suppression system would be required. These portable controls have been deemed ineffective. The misters clog and a significant amount of time is spent unclogging the system, which often results in spending more time towards maintenance than in operating the control. This control method also has not been implemented in practice at any ARPA facility. This control option is determined non-feasible and therefore, is not considered for the Four Factor Analysis.

Table 6 Cost Effectiveness of Material Handling (Bulk Loading) controls

Measure Description	Capital Cost ($)	Annualized Capital Cost ($/yr)	Annual Implementation /Maintenance Cost ($/yr)	Total Annual Cost ($)	Control Effectiveness (%)	Cost Effectiveness ($/ton)
partial closure at loading in and loading out by hanging curtains	226,782	25,227	__	34,299	75	101,309
Regularly apply water through wetting of material at the pit	157,500	17,520	59,187	83,008	90	204,319

Table 7 Estimated Emissions Reductions of Material Handling (Bulk Loading) controls

Measure Description	Baseline Emissions with Existing Measures (tons/year-facility)	Emissions Reductions from New Measures (tons/year-facility)
partial closure at loading in and loading out by constructing 3-sided enclosures	0.45	0.34
Regularly apply water through wetting of material at the pit	0.45	0.41

2.6.3 Four-Factor Analysis Summary and Discussion – Material Handling (Stockpiles)

Table 8 List of Available PM_{10} Control Measures for Material Handling – Stockpiles

List of Available PM_{10} Control Measures for Material Handling – Stockpiles (ACTIVITY DEFINED: loading material onto the stockpile (continuous or batch loading), moving material on the stockpile, or unloading material from the stockpile. Applies to loading onto or removal from stockpiles from conveyors, trucks, or other equipment.)						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources (yr)
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
1. Wetting Product With Plain Water And/Or Wetting Agents As It Is Loaded/Unloaded Onto Stockpile Through Use Of New Water Truck	Yes	$157,500	$204,319	--	--	12
2. Continuous Watering with New Water Truck	N/A	--	--	--	--	--
4. Wetting Product With Plain Water And/Or Wetting Agents As It Is Loaded/Unloaded Onto Stockpile Through Use Of Spray Bars	N/A	--	--	--	--	--

List of Available PM_{10} Control Measures for Material Handling – Stockpiles (ACTIVITY DEFINED: loading material onto the stockpile (continuous or batch loading), moving material on the stockpile, or unloading material from the stockpile. Applies to loading onto or removal from stockpiles from conveyors, trucks, or other equipment.)						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources (yr)
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
5. Dry Fog Dust Suppression System during Material Loading/Unloading onto Pile	N/A	--	--	--	--	--
6. Reduce Falling Distance	N/A	--	--	-	--	--

2.6.3.1 Wetting Product with Plain Water And/Or Wetting Agents As It Is Loaded/Unloaded Onto Stockpile Through Use Of New Water Truck

2.6.3.1.1 Technical Feasibility

Applying water to stockpiles will result in PM10 emission reduction. A PM10 control efficiency of 90%[24] was applied to this control option, resulting in a reduction of 0.41 tpy-facility. This control option was determined technically feasible and was further considered for the Four Factor Analysis.

2.6.3.1.2 Cost of Compliance – Factor 1

The baseline emission rate for this activity was estimated using AP-42 Section 13.2.4 Equation 1. A PM10 control efficiency of 90%[25] was applied to this control option.

The capital cost of a 4,000-gallon water truck was determined to be $157,500 from a quote obtained from Granite Construction Company. An interest rate of 4.75% was used for the annualized capital cost and is equivalent to the 3-year average bank prime rate at the time of cost-estimation. 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. The admin, tax, and insurance cost was assumed to be 4% of the capital cost. Operation costs included $3,100 /year for fuel, $3,100 /year for maintenance, $52,626/year operator cost, and a $361 /year water cost.

As shown in Table 4, the purchase of an additional water truck for the purpose of additional watering during earthmoving and excavation activities has an average cost-effectiveness of $204,319/ton-facility. ADEQ has determined that this control option is cost prohibitive.

2.6.3.1.3 Time Necessary for Compliance – Factor 2

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.

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[24] Per Table 4 of "Literature Review of Current Fugitive Dust Control Practices within the Mining Industry", 2010. It was conservatively assumed that wet suppression can attain a 90% control efficiency.

[25] Per Table 4 of "Literature Review of Current Fugitive Dust Control Practices within the Mining Industry", 2010. It was conservatively assumed that wet suppression can attain a 90% control efficiency.

2.6.3.1.4 Energy and Non-Air Quality Environmental Impacts of Compliance – Factor 3

Using water trucks will increase the consumption of fuel and additional water spray on the material will increase the water consumption.

2.6.3.1.5 Remaining Useful Life of Potentially Affected Sources – Factor 4

ADEQ incorporated a useful life of 12 years for water trucks per replacement schedule for heavy trucks at University of Florida Administrative Services.[26] This useful life was referenced in feedback from ARPA and the Asarco Mission Complex's initial Four Factor Analysis. ADEQ will further investigate this assumption.

2.6.3.2 Continuous Watering with New Water Truck

2.6.3.2.1 Technical Feasibility

Operations at mining and quarrying facilities are generally batch processes, not continuous. Hence, watering during batch operations is more appropriate. Costs calculations for this are decided in the prior control method "wetting product with plain water and/or wetting agents as it is loaded/unloaded onto stockpile through use of new water truck". As such, this control method will not be reviewed further.

2.6.3.3 Continuous Watering with Existing Water Truck

2.6.3.3.1 Technical Feasibility

While it may be reasonable to expect certain facilities to operate a water truck at less than full capacity, it is unlikely that most or all sources would operate in this fashion. ARPA has confirmed that most operations would size the water truck to the operations needs and not purchase or rent a water truck that is oversized for the needs of the operation. This is especially true in the summer time when water demands are higher due to increased evapotranspiration and higher rates of watering are necessary. Therefore, ADEQ has determined that it is unreasonable to assume additional bandwidth is available for currently rented or owned water trucks. Therefore, further analysis of this control is not researched.

2.6.3.4 Wetting Product with Plain Water And/Or Wetting Agents As It Is Loaded/Unloaded Onto Stockpile Through Use Of Spray Bars

2.6.3.4.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. As such, this control was not further researched.

[26]https://www.usf.edu/administrative-services/documents/asbc-resources-field-equipment-replacement.pdf

2.6.3.5 Dry Fog Dust Suppression System during Material Loading/Unloading onto Pile

2.6.3.5.1 Technical Feasibility

The use of dry fog dust suppression systems represents a potential safety hazard at rock product facilities as it blocks visibility, creates slippery surfaces and leads to mud accumulation. Additionally, ARPA also stated that portable dry fog dust suppression systems would be required due to the dynamic nature of material storage onsite and that the portable systems require significant maintenance due to clogging, which ultimately reduces their up-time and efficiency.

ADEQ will commit to further research of these systems to determine their technical feasibility. At this time, no additional information is available to complete a 4-factor analysis for this control.

2.6.3.6 Reduce Falling Distance

2.6.3.6.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. As such, this control was not further researched.

Table 9 Cost Effectiveness of Material Handling (Stockpiles) controls

Measure Description	Capital Cost ($)	Annualized Capital Cost ($/yr-facility)	Annual Implementation/ Maintenance Cost ($/yr-facility)	Total Annual Cost ($)	Control Effectiveness (%)	Cost Effectiveness ($/ton)
Wetting as it is loaded/unloaded onto stockpile through use of new water truck	$157,500	$17,520	$65,487	$83,008	90%	$204,319

Table 10 Estimated Emissions Reductions of Material Handling (Stockpiles) controls

Measure Description	Baseline Emissions with Existing Measures (tons/year-facility)	Emissions Reductions from New Measures (tons/year-facility)
Wetting as it is loaded/unloaded onto stockpile through use of new water truck	0.45	0.41

2.7 Four-Factor Analysis Summary and Discussion – Drilling

Table 11 List of Available PM_{10} Control Measures for Drilling

List of Available PM_{10} Control Measures for Drilling						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
1. Dry Drilling Dust Collection System	N/A	--	--	--	--	--
2. Wet Drilling	N/A	--	--	--	--	--
3. Proper Equipment Maintenance	N/A	--	--	--	--	--
4. Utilize Good Design (i.e., Drilling Fewer Holes)	N/A	--	--	--	--	--
5. Temporarily Cease Operations Until Conditions Improve	N/A	--	--	--	--	--
6. Employ BMPs	N/A	--	--	--	--	--

2.7.1 Dry Drilling Dust Collection System

2.7.1.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.7.2 Wet Drilling

2.7.2.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.7.3 Proper Equipment Maintenance

2.7.3.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.7.4 Utilize Good Design

2.7.4.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.7.5 Temporarily Cease Operations Until Conditions Improve

2.7.5.1 Technical Feasibility

Curtailing drilling during high winds would significantly impact overall operations, considering that drilling is critical to production. If drilling was to be curtailed during high winds, then the facilities would have to increase drilling at other times in order to make up for the loss in production. That said, curtailing drilling during high winds is technically feasible.

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector includes activity related emissions but not windblown. Given this, the controls under consideration are primarily evaluated for their ability to reduce activity related emissions.

ADEQ was unable to estimate the increase in activity related emissions when transitioning from low to high wind scenarios. Additionally, facilities would likely increase activity during low wind periods to compensate for decreased production during high wind periods. While it is likely that decreased production during high wind would reduce the transport of emissions, it is unclear if it would reduce the total activity related emissions. For these reasons, this control could not be and was not further evaluated.

2.7.6 Employ Best Management Practices (BMPs)

2.7.6.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.8 Four-Factor Analysis Summary and Discussion – Blasting

Table 12 List of Available PM_{10} Control Measures for Blasting

List of Available PM_{10} Control Measures for Blasting						
Available PM_{10} Control Measure for Consideration	Technically Feasible	[1] Cost of Compliance		[2] Time Necessary for Compliance	[3] Energy and Non-AQ Environmental Impacts of Compliance	[4] Remaining Useful Life of Potentially Affected Sources
		Capital-Implementation Costs	Cost Effectiveness ($/ton)			
1. Utilize Good Design (i.e., Drilling Fewer Holes)	N/A	--	--	--	--	--
2. Temporarily Cease Operations Until Conditions Improve	N/A	--	--	--	--	--
3. Employ BMPs	N/A	--	--	--	--	--
4. Wet Down Blasting Area	No	--	--	--	--	--
5. Water Cartridges (Underground Blasting)	No	--	--	--	--	--
6. Fogger Spray	No	--	--	--	--	--
7. Air Filtration System (Underground Blasting)	No	--	--	--	--	--
8. Minimize Area To Be Blasted At Any One Time	N/A	--	--	--	--	--

2.8.1 Utilize Good Design (i.e., Drilling Fewer Holes)

2.8.1.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.8.2 Temporarily Cease Operations Until Conditions Improve

2.8.2.1 Technical Feasibility

Curtailing blasting during high winds would significantly impact overall operations, considering that blasting is critical to production. If blasting was to be curtailed during high winds, then the facilities would have to increase blasting at other times in order to make up for the loss in production. That said, curtailing blasting during high winds is technically feasible.

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector includes activity related emissions but not windblown. Given this, the controls under consideration are primarily evaluated for their ability to reduce activity related emissions.

ADEQ was unable to estimate the increase in activity related emissions when transitioning from low to high wind scenarios. Additionally, facilities would likely increase activity during low wind periods to compensate for decreased production during high wind periods. While it is likely that decreased production during high wind would reduce the transport of emissions, it is unclear if it would reduce the total activity related emissions. For these reasons, this control could not be and was not further evaluated.

2.8.3 Employ BMPs

2.8.3.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

2.8.4 Wet Down Blasting Area

2.8.4.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector only estimates emissions for surface mining operations.
This control measure has been proven effective in underground mining but is less common in surface mining with solid rock and little to no overburden. Typically, the top layer of rock that is being blasted is solid and not very porous, leaving little opportunity for water to penetrate through the top layer. Also, the time interval between the watering and the blast initiation has to be minimized in order for the water to be effective. Safety considerations may also preclude wetting the blast area prior to blasting as the operators are connecting the individual hole charges. For these reasons, ADEQ does not consider this control technically feasible for surface mining operations.

2.8.5 Water Cartridges (Underground Blasting)

2.8.5.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector only estimates emissions for surface mining operations. Literature research has not indicated that water cartridges are effective in dust suppression for surface mining. Therefore, ADEQ does not consider this control technically feasible for surface mining operations.

2.8.6 Fogger Spray

2.8.6.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector only estimates emissions for surface mining operations. Literature research has not indicated that fogger spray are effective in dust suppression for surface mining blasting. Therefore, ADEQ does not consider this control technically feasible for surface mining operations.

2.8.7 Air Filtration System (Underground Blasting)

2.8.7.1 Technical Feasibility

EPA National Emission Inventory (NEI) source classification code (SCC) #2325000000 for nonpoint mining and quarrying was the source sector under evaluation. This source sector only estimates emissions for surface mining operations. Literature research has not indicated that air filtration systems are effective in dust suppression for surface mining blasting. Therefore, ADEQ does not consider this control technically feasible for surface mining operations.

2.8.8 Minimize Area To Be Blasted At Any One Time

2.8.8.1 Technical Feasibility

ADEQ was unable to identify an emission estimation methodology for this control measures and was thus unable to assess the effectiveness of this control. For this reason, this control measure was not further analyzed.

Additionally, a cost analysis of curtailing blasting at facilities could not be estimated for two reasons. First, developing an estimate would necessitate decision-making on whether each facility must: (i) accept reduced throughput at the as a result of the curtailed blasting or; (ii) increase blasting at other times in order to make up for the loss in production, and whether each facility would be able to do so as a function of its labor contracts. Second, the extents to which each facility might choose to either curtail or reschedule operations cannot be reasonably assessed as the demand of products produced at the facilities fluctuate substantially over time. For these reasons, this control was not further evaluated.