

**BEST AVAILABLE  
RETROFIT TECHNOLOGY  
(BART) ANALYSIS**

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- Appendix A: EPA letter to Holcim of February 27, 2007
- Appendix B: Visibility Impacts Modeling
- Appendix C : BART Cost Analyses

# 1.0 INTRODUCTION

## 1.1. Summary

Holcim (US) Inc. (Holcim) is submitting a Best Available Retrofit Technology (BART) analysis to the U.S. Environmental Protection Agency Region VIII office (EPA). EPA submitted a letter to Holcim on February 28, 2007, regarding the preparation of a BART analysis for their cement manufacturing facility (Trident) located near Three Forks, Montana. The February letter notified Holcim that EPA had [through Western Regional Air Partnership (WRAP)] completed visibility modeling and determined that Holcim was a BART-eligible source due to the possibility that Holcim could cause visibility degradation in nearby Class I areas (Yellowstone National Park and Gates of the Mountains Wilderness Area). The notification requires Holcim to submit a BART analysis within 90 days of the February letter.<sup>1</sup> The letter also noted that if Holcim chooses not to perform an engineering analysis, then EPA will develop the analysis instead. Holcim chose to analyze the EPA modeling results and prepare a BART engineering analysis to submit to EPA.

Holcim analyzed the existing emission units for specific BART eligibility, and determined that there is one sulfur dioxide (SO<sub>2</sub>) emission source, one nitrogen oxides (NO<sub>x</sub>) emission source and twelve particulate matter with an aerodynamic diameter equal to or less than 10 microns (PM<sub>10</sub>) sources which must be addressed by a BART analysis. Table 1-1 lists those sources.

**Table 1-1: Sources Addressed by Holcim BART Analysis**

Emission Unit	PTE (Ton/year)			BART Analysis Performed (Yes or No)
	NO <sub>x</sub>	SO <sub>2</sub>	PM <sub>10</sub>	
005 – Xfer-convey-screen	Nil <sup>1</sup>	Nil <sup>1</sup>	15.89	Yes
010 – 013 Raw material silos 1-7	Nil <sup>1</sup>	Nil <sup>1</sup>	19.52	Yes
015 and 018 Coal and coke xfer, crush, store, (un)load & grinding	Nil <sup>1</sup>	Nil <sup>1</sup>	33.1	Yes
021 Kiln	6,868 <sup>2</sup>	543.1 <sup>2</sup>	163.6 <sup>3</sup>	Yes
022 Clinker cooler	Nil <sup>1</sup>	Nil <sup>1</sup>	75.09	Yes
026 Cement kiln dust silo unload	Nil <sup>1</sup>	Nil <sup>1</sup>	16.92	Yes
032a Clinker xfer to #2 finish mill	Nil <sup>1</sup>	Nil <sup>1</sup>	17.72	Yes
047 Cement load/unload at silos 14-25	Nil <sup>1</sup>	Nil <sup>1</sup>	20.12	Yes

<sup>1</sup> Nil means that emissions of this pollutant from this emitting unit are un-quantifiably small and deserve no further consideration.

<sup>2</sup> Value is from Section II.C.1.c of Permit #0982-10 (see also Page 11 of the Permit Analysis).

<sup>3</sup> Value is from Section II.C.1.a of Permit #0982-10 (0.77 lb/ton \* 425,000 tons/year \* 1 lb/2,000 tons = 163.63 tons/year).

<sup>1</sup> An extension of this deadline to June 29, 2007, was granted by an EPA letter from Cynthia Cody on May 3, 2007. A verbal extension to July 6, 2007, was granted on June 29, 2007, by Ms. Cody.

Holcim determined that the kiln is the only BART-eligible source of SO<sub>2</sub>. Holcim performed a BART analysis on the kiln for SO<sub>2</sub>, and determined that there is no add-on control or process alteration which achieves a significant visibility improvement that meets the definition of best available retrofit technology. See Section 4.3 of this report for the SO<sub>2</sub> BART analysis.

Holcim determined that the kiln is the only BART-eligible source of NO<sub>x</sub>. Holcim performed a BART analysis on the kiln for NO<sub>x</sub>, and determined that there are control and process alterations that meet the definition of best available retrofit technology which can, in total, achieve a 20% reduction in NO<sub>x</sub> and have an associated modeled 15% visibility improvement. The selected NO<sub>x</sub> technologies which will be applied to the kiln are: process alterations including a fixed inlet on the clinker cooler and a low-NO<sub>x</sub> burner. Along with the equipment changes, Holcim selected a more stringent NO<sub>x</sub> emission limitation for the kiln of 1,254 lbs/hour in a rolling 30-day period. This new emission limit represents a 20% reduction in NO<sub>x</sub> emissions from the existing permit limitation of 1,568 lbs/hour in a rolling 30-day period. See Section 4.4 of this report for the detailed NO<sub>x</sub> BART analysis. A summary of the expected visibility improvement estimated by the modeling analysis is shown in Table 1-2 below.

Holcim determined that there are twelve BART-eligible sources of PM<sub>10</sub> at the facility. The sources are the kiln, the clinker cooler and ten materials handling and processing sources. Holcim performed a BART analysis on the kiln, clinker cooler and materials handling and processing sources for PM<sub>10</sub>, and determined that there are no add-on controls or process alterations that meet the definition of best available retrofit technology. Holcim determined that add-on controls with the highest level of PM<sub>10</sub> control were already installed on these ten sources. See Section 4.5 for the kiln PM<sub>10</sub> BART analysis, Section 4.6 for the clinker cooler PM<sub>10</sub> BART analysis and Section 4.7 of this report for the ten materials handling and processing sources PM<sub>10</sub> BART analysis.

Table 1-2 below briefly summarizes the BART controls selected by Holcim, and the resulting visibility improvements modeled on the Gates of the Mountains Wilderness Area, the closest and most impacted Class I area to Holcim. See Appendix B for complete modeling results.

**Table 1-2: Summary of BART Selections and Visibility Impacts**

Pollutant	Control Technology	Approximate Control Efficiency	Modeled Emission Rate (lb/hour)	Gates of the Mountains		
				Modeled Deciviews	Modeled Deciview Improvement (above baseline)	% Improvement in Visibility (from baseline)
SO <sub>2</sub>	No Additional Controls	0%	340	1.56	0.00	0%
NO <sub>x</sub>	Process Alterations (including installation of fixed inlet on clinker cooler)	3%	1,521	1.49	0.04	3%
	Low-NO <sub>x</sub> Burner	17%	1,301	1.32	0.21	13%
	Total NO <sub>x</sub> Improvement:	20%	1,254	1.28	0.24	15%
PM <sub>10</sub>	No Additional Controls	0%	23	1.56	0.00	0%

The remainder of this report details all of the BART steps and analyses performed for the Holcim Trident facility.

## 1.2. Background and Purpose

Congress amended the Federal Clean Air Act in 1977 to include a new Section 169A and 169B for the purpose of protecting visibility in certain scenic areas. The areas afforded this visibility protection are identified as “Mandatory Class I Federal Areas.”<sup>2</sup> The rules EPA promulgated to implement these actions of the Act are generally found in 40 CFR 51, Subpart P.

Specific to this document, EPA promulgated [40 CFR 51.308\(e\)](#) which requires certain types of existing stationary sources to install best available retrofit technology (BART). The term BART is defined in §301 as follows:

*Best Available Retrofit Technology (BART) means an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by an existing stationary facility. The emission limitation must be established, on a case-by-case basis, taking into consideration the technology available, the costs of compliance, the energy and nonair quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of*

<sup>2</sup> These areas are identified in 40 CFR 81.401 *et seq.* Those areas within Montana and Wyoming are found in §417 and §436, respectively.

*improvement in visibility which may reasonably be anticipated to result from the use of such technology.*

As noted in Section 1.1 above, EPA has identified the Holcim Trident plant as a 'existing stationary source'<sup>3</sup> which is subject to the BART requirements. EPA has further identified guidelines for identifying BART-eligible sources and suggested methodologies to be employed for conducting a BART analysis. These guidelines are codified in 40 CFR 51, Appendix Y.

It is the purpose of this document to fulfill the requirements for conducting a BART analysis for the Holcim Trident facility. The remainder of this document conducts a BART analysis for each unit and pollutant subject to the regulation [40 CFR 51.308(3)]. The methodologies and guidelines found in 40 CFR 51, Appendix Y were used to develop this BART document.

### **1.3. Site Location and Description**

The Holcim Trident facility (Trident) is approximately five miles northeast of Three Forks, near the headwaters of the Missouri River. The plant site is located in Section 9, Township 2 North, Range 2 East in Gallatin County, Montana, with approximate UTM coordinates of the facility of Zone 12, Easting 464 km, and Northing 5,088 km. The elevation is approximately 4,200 feet above sea level. Maps of the Holcim facility are on file with the Montana Department of Environmental Quality (MDEQ). Site description information is also on file with MDEQ. Copies of the maps and descriptions are available upon request.

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<sup>3</sup> As defined in 40 CFR 51.301.

## **2.0 PROCESS DESCRIPTION**

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The production of Portland cement begins at the quarry. Most of the raw material used in the cement process is combined high and low-grade limestone quarried from Holcim's quarry. Limestone rock and other raw materials are blasted and loaded onto trucks and transported to the crusher or to stockpiles.

The raw materials are conveyed from the primary crusher to the storage bins. From the storage bins, the raw materials are conveyed to the ball mill where they are ground with water to form slurry, which is then sent to storage tanks. In the tanks, the slurry is blended thoroughly before entering the kiln.

The slurry is pumped to the uphill end of the kiln where it is heated. The water (H<sub>2</sub>O) evaporates from the slurry and natural minerals from the raw materials recombine to form clinker in the kiln. The plant uses a combination of natural gas, coal and/or petroleum coke as fuel sources for the clinker production.

When the clinker leaves the kiln, it is cooled, then transported to the finish mill feed bins or other storage. From the finish mill feed bins, clinker, gypsum, and other additives are transported to the "finish" ball mills, where it is ground to produce Portland cement. The final cement product is conveyed to storage silos where it is loaded into railroad cars or bulk trucks.

### **3.0 EMISSIONS INVENTORY AND BART ANALYSIS SOURCE SELECTION**

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#### **3.1 Initial BART Emission Summary**

In a series of letters MDEQ requested that Holcim submit a list of the BART-eligible sources at the Trident facility and supply sulfur dioxide (SO<sub>2</sub>), nitrogen oxides (NO<sub>x</sub>), and particulate matter less than 10 microns (PM<sub>10</sub>) emission data for the BART-eligible sources. Holcim concluded 29 emitting units (as provided in the Title V permit) from the Trident facility qualify as BART-eligible. The emission data requested was for annual potential to emit (PTE) and the highest 24-hour emission rates occurring during the three year period of 2001, 2002, and 2003. Annual emissions were based on the permitted limits in Holcim's Operating Permit #0982-10. The highest 24-hour NO<sub>x</sub> and SO<sub>2</sub> emissions for the cement kiln were determined from continuous emissions monitor (CEM) data collected during the specified 3 years. It should be noted that the highest 24-hour SO<sub>2</sub> emission rate of 340 pounds per hour (lb/hr) is significantly greater than the permitted 30-day rolling average SO<sub>2</sub> emission rate of 124 lb/hr. However, the facility did not exceed its permitted emission rate.

Table 3-1 below lists the original 29 BART-eligible emitting units and their corresponding emission rates. Table 3-1 also shows the 12 emission units selected for BART analysis due to their significant emission rates.

**Table 3-1: Potential Bart-Eligible Emitting Units**

Emission Unit	PTE (Ton/year)			Eligible for Detailed BART Analysis (Yes or No)
	NO <sub>x</sub>	SO <sub>2</sub>	PM <sub>10</sub>	
005 – Xfer-convey-screen	Nil <sup>1</sup>	Nil <sup>1</sup>	15.89	Yes
008/009 – Primary crusher/screen	Nil <sup>1</sup>	Nil <sup>1</sup>	10.96	No <sup>4</sup>
010 – 013 Raw material silos 1-7	Nil <sup>1</sup>	Nil <sup>1</sup>	19.52	Yes
014 Coal/coke unload	Nil <sup>1</sup>	Nil <sup>1</sup>	7.88	No <sup>4</sup>
015 and 018 Coal and coke xfer, crush, store, (un)load & grinding	Nil <sup>1</sup>	Nil <sup>1</sup>	33.1	Yes
016 Coal outside storage pile	Nil <sup>1</sup>	Nil <sup>1</sup>	0.28	No <sup>4</sup>
017 Coke outside storage piles	Nil <sup>1</sup>	Nil <sup>1</sup>	0.28	No <sup>4</sup>
019 Coal silo loading and unloading	Nil <sup>1</sup>	Nil <sup>1</sup>	3.00	No <sup>4</sup>
020 Coke silo loading and unloading	Nil <sup>1</sup>	Nil <sup>1</sup>	1.13	No <sup>4</sup>
021 Kiln	6,868 <sup>2</sup>	543.1 <sup>2</sup>	163.6 <sup>3</sup>	Yes
022 Clinker cooler	Nil <sup>1</sup>	Nil <sup>1</sup>	75.09	Yes
023 Inside clinker xfer from cooler	Nil <sup>1</sup>	Nil <sup>1</sup>	5.26	No <sup>4</sup>
025 Cement kiln dust silo load	Nil <sup>1</sup>	Nil <sup>1</sup>	2.25	No <sup>4</sup>
026 Cement kiln dust silo unload	Nil <sup>1</sup>	Nil <sup>1</sup>	16.92	Yes
027 Emergency clinker bins loading	Nil <sup>1</sup>	Nil <sup>1</sup>	4.13	No <sup>4</sup>
028-031 Emergency clinker storage silos 1-4	Nil <sup>1</sup>	Nil <sup>1</sup>	0.09	No <sup>4</sup>
032a Clinker xfer to #2 finish mill	Nil <sup>1</sup>	Nil <sup>1</sup>	17.72	Yes
047 Cement load/unload at silos 14-25	Nil <sup>1</sup>	Nil <sup>1</sup>	20.12	Yes
049-050 Bulk cement railcar xfer loadouts 1 & 2	Nil <sup>1</sup>	Nil <sup>1</sup>	1.80	No <sup>4</sup>
051 Bulk cement rail xfer loadout	Nil <sup>1</sup>	Nil <sup>1</sup>	0.00	No <sup>4</sup>

<sup>1</sup> Nil means that emissions of this pollutant from this emitting unit are un-quantifiably small and deserve no further consideration.

<sup>2</sup> Value is from Section II.C.1.c of Permit #0982-10 (see also Page 11 of the Permit Analysis).

<sup>3</sup> Value is from Section II.C.1.a of Permit #0982-10 (0.77 lb/ton \* 425,000 tons/year \* 1 lb/2,000 tons = 163.63 tons/year).

<sup>4</sup> Under 40 CFR 51 Appendix Y, EPA establishes *de minimis* levels of emissions under which a source is not BART-eligible.

For purposes of BART applicability determination only, EPA modeled emitting units #21 and #22, the kiln and the clinker cooler, respectively. Table 3-2 summarizes the SO<sub>2</sub> and NO<sub>x</sub> emissions and PM<sub>10</sub> speciated emissions for the two sources EPA modeled (via the University of California Riverside) in the initial BART applicability determination.

**Table 3-2: Initial EPA BART Modeled Sources and Emissions**

Emitting Unit	Total Emission Rate <sup>a</sup> (lbs/hr)								
	SO <sub>2</sub>	SO <sub>4</sub>	NO <sub>x</sub>	HNO <sub>3</sub>	NO <sub>3</sub>	SOA <sup>b</sup>	EC <sup>b</sup>	PMC <sup>b</sup>	PMF <sup>b</sup>
<b>Kiln</b>	340	7.215	784	-	-	0.01	0.01	0.093	9.31
<b>Clinker Cooler</b>	0.01	0.01	0.01	-	-	0.01	0.01	0.137	13.7

<sup>a</sup> Emissions obtained from documents on WRAP Regional Modeling Center website <http://pah.cert.ucr.edu/aqm/308/bart.shtml>.

<sup>b</sup> The abbreviations are as follows:

- SOA = Sulfur-Oxidizing Activity,
- EC = Elemental Carbon,
- PMC = Condensable Particulate Matter, and
- PMF = Filterable Particulate Matter.

Although EPA only modeled the two sources above, Holcim's analysis was conducted for all potential BART-eligible sources identified in Table 3-1 above

### 3.2 SO<sub>2</sub> Applicable Units Emissions

The kiln is the only SO<sub>2</sub> emitting unit subject to BART analysis. The PTE (federally enforceable permit limit) for SO<sub>2</sub> from the kiln is 124 lbs/hr on a rolling 30-day average (543 tons/yr). To remain consistent with the BART modeling analysis performed by EPA, Holcim has performed the BART analysis with the highest 24-hour SO<sub>2</sub> emission rate of 340 lbs/hr as recorded by Holcim's CEM during the 3-year period of 2001-2003.

### 3.3 NO<sub>x</sub> Applicable Units Emissions

The kiln is also the only NO<sub>x</sub> emitting unit subject to BART analysis. The PTE (federally enforceable permit limit) for NO<sub>x</sub> from the kiln is 1,568 lbs/hr on a rolling 30-day average (6,868 tons/yr). The BART modeling analysis performed for Holcim used the permitted NO<sub>x</sub> PTE to establish the baseline visibility impacts used in this analysis.

### 3.4 PM Applicable Units Emissions

As listed in Table 3-1, there are a total of 12 emission sources of PM<sub>10</sub> to be analyzed for BART comprising a total of 362 tons/yr of PM<sub>10</sub>. The largest (potential) emitters of PM<sub>10</sub> are the kiln (164 tons/yr) and the clinker cooler (75 tons/yr) which compose approximately 66% of the total PM<sub>10</sub> emissions.

Table 3-3 provides a summary of the 12 emitting units subject to further BART analysis. The table also shows the current emissions control associated with those units.

**Table 3-3: PM<sub>10</sub> Sources Analyzed for BART**

<b>Source</b>	<b>Current Source Control</b>
005 – Xfer-convey-screen	Baghouse
010 – 013 Raw material silos 1-7	Baghouse
015 and 018 Coal and coke xfer, crush, store, (un)load & grinding	Baghouse
021 Kiln	Electrostatic Precipitator
022 Clinker cooler	Baghouse
026 Cement kiln dust silo unload	Dustless Unloader and Baghouse
032a Clinker xfer to #2 finish mill	Baghouse
047 Cement load/unload at silos 14-25	Baghouse

## 4.0 BEST AVAILABLE RETROFIT TECHNOLOGY REVIEW

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The Clean Air Act (CAA), in section 169(a)(2), requires that State Implementation Plans (SIPs) for visibility protection must apply BART to certain large-emitting sources. BART is required for sources that meet **all** of the following criteria:

1. The source is in one of 26 specific listed source categories;<sup>4</sup>
2. The source was in existence as of August 1977, but was not in operation in August of 1962;<sup>5</sup>
3. The facility has the potential to emit 250 tons per year of any visibility-impairing pollutant; and
4. The BART-eligible source emits an air pollutant that “may reasonably be anticipated to cause or contribute to any impairment of visibility in any mandatory Class I federal area, . . .”<sup>6</sup>

The term *Best Available Retrofit Technology (BART)* is defined in 40 CFR 51.301 and means:

*“an emission limitation based on the degree of reduction achievable through the application of the best system of continuous emission reduction for each pollutant which is emitted by an existing stationary facility. The emission limitation must be established, on a case-by-case basis, taking into consideration the technology available, the costs of compliance, the energy and nonair quality environmental impacts of compliance, any pollution control equipment in use or in existence at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of such technology.”*

Appendix Y further explains how to identify sources subject to BART:

*“Once you have determined that your source or sources are subject to BART, you must conduct a visibility improvement determination for the source(s) as part of the BART determination. When making this determination, we believe you have flexibility in setting absolute thresholds, target levels of improvement, or de minimis levels since the deciview improvement must be weighed among the five factors, and you are free to determine the weight and significance to be assigned to each factor.”*

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<sup>4</sup> The 26 source categories are found in the definition of “Existing stationary facility” found in 40 CFR 51.301.

<sup>5</sup> The terms “in existence” and “in operation” are defined in 40 CFR 51.301.

<sup>6</sup> 40 CFR 51.308(e).

## 4.1 Summary

The CAA, in section 169(a)(2) requires that SIPs for visibility protection must apply BART to certain large-emitting sources. EPA identified Holcim as a possible BART-eligible source because it is a Portland cement plant, which is one of the 26 BART source categories under 40 CFR Part 51.301 under the definition of “Existing stationary source.” The Holcim facility has emitting units that meet the time frames specified in item 2 above. In addition, the entire complex has a potential to emit greater than 250 tons per year.

EPA has completed initial visibility modeling through the WRAP program. As a result of those investigations EPA has determined that Holcim is subject to a BART analysis in accordance with the BART provisions of 40 CFR 51.308. The EPA documentation of this requirement and conclusion is found in a letter from EPA Region VIII dated February 27, 2007, addressed to Mr. Ned Pettit of Holcim. A copy of that letter and conclusion is found in Appendix A of this document.

In accordance with the February 27, 2007 letter, Holcim has conducted a BART analysis using EPA-recommended methodologies and dispersion modeling recommendations found in 40 CFR 51, Appendix Y, more specifically the CALPUFF dispersion model, to assist with the proposed BART determination. The purpose of the modeling analysis is to determine the visibility improvement expected at Class I areas from the potential BART control technology applied to the source. The modeling analysis is found in Appendix B of this document.

### 4.1.1 Affected Units

There are a total of 29 emitting units at the Holcim facility that have been identified as potentially “BART-eligible.” These units have received that designation since they meet the definition of BART-eligible since they were “in existence”<sup>7</sup> as of August 1977, but not “in operation”<sup>8</sup> in August of 1962 and having (collectively) the potential to emit 250 tons per year of an air pollutant that could cause visibility degradation in a Class I area (applicable pollutants are listed in Section 4.1.2 below). See Table 3-1 for a list of potential BART-eligible emitting units.

Of the units subject to a BART engineering analysis, the kiln and clinker cooler comprise the majority of interest for BART purposes. The other ten units which are also subject to a BART engineering analysis are those units shown in Table 3-3 above.

### 4.1.2 Applicable Pollutants

The visibility impairing pollutants analyzed in this BART analysis are:

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<sup>7</sup> As defined by 40 CFR 51.301

<sup>8</sup> Ibid.

- Sulfur dioxide (SO<sub>2</sub>),
- Nitrogen oxides (NO<sub>x</sub>), and
- Particulate matter less than 10 microns (PM<sub>10</sub>).

PM<sub>10</sub> is used as an indicator for particulate matter. As emissions of PM<sub>10</sub> include the components of PM<sub>2.5</sub> as a subset, there is no need to have separate 250 ton thresholds for PM<sub>10</sub> and PM<sub>2.5</sub>; 250 tons of PM<sub>10</sub> represents at most 250 tons of PM<sub>2.5</sub>, and at most 250 tons of any individual particulate species such as elemental carbon, crustal material, etc.

## 4.2 BART Analysis Methodology

In general terms, EPA has identified a methodology for conducting a BART analysis that is similar to the Best Available Control Technology analyses conducted under the PSD permitting program (40 CFR 51.166 and elsewhere). For BART, the methodology is more refined to include pollutants related to visibility impairment and to include an analysis of the impacts the proposed technology has on the visibility directly.

The BART methodology is a case-by-case procedure. The BART methodology chosen for this analysis follows the guidelines established by EPA in 40 CFR 51, Appendix Y. Hereafter, these guidelines will be referred to as either the "Appendix Y Guideline" or simply "Appendix Y." Appendix Y suggests that the case-by-case BART analysis should follow the five steps below (Section IV.D of Appendix Y).

### *Case-by-Case Five Step BART Analysis:*

- Step 1 - Identify all<sup>9</sup> available retrofit control technologies;
- Step 2 - Eliminate technically infeasible options;
- Step 3 - Evaluate control effectiveness of remaining control technologies;
- Step 4 - Evaluate impacts and document the results; and
- Step 5 - Evaluate visibility impacts.

The following paragraphs will evaluate BART for each source or source group emitting any of the pollutants noted above as being released in significant quantities. BART for NO<sub>x</sub> and SO<sub>2</sub> emissions from the kiln, essentially the only source of these compounds, will be addressed first. BART for the various sources of particulate emissions will be addressed at the end of this section.

As suggested by Appendix Y, Holcim reviewed the New Source Performance Standards (NSPS) Subpart K for cement kilns to determine if any control technologies or emission restrictions were applicable to new facilities. This review showed that NSPS for cement kilns applies only to particulate emissions and opacity.

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<sup>9</sup> Appendix Y notes that the term "all" refers to identifying the most stringent option and a reasonable set of options for analysis that reflect a comprehensive list of options. It is not necessary (according to Appendix Y) to list all permutations of available control levels for a given technology.

To facilitate the following BART determinations, Holcim queried the EPA RACT-BACT-LAER Clearinghouse (RBLC) database for listings of pollutant emission limits and required control technologies at other cement manufacturing facilities across the country. The information generated by these queries serves as a helpful guideline to indicate expected emission rate ranges and control technologies that may have been successfully applied at facilities similar to the Holcim cement plant. When reviewing specific emission limits applied at other kilns, it is important to recognize that cement manufacturing operations and their associated emissions characteristics can vary significantly from one facility to another, and even within a single facility. Some of the inherent differences will be addressed in succeeding paragraphs. Further, the database is not always well maintained and includes some outdated information. In some cases, for instance, an owner may have accepted a stringent emission limit or an unproven control technology only to find the limit or the technology was inappropriate for the particular operation, leading to a permit change that may not be reflected in the database.

Another factor that must be kept in mind when comparing emission limits across facilities is that the averaging period associated with the limit significantly affects the source's ability to comply. A source may be able to comply with a particular emission limit over a rolling 30-day averaging period for example, but find it impossible to consistently comply with the same limit applied to a one-hour averaging period.

In following the five-step BART analysis, Holcim initially reviewed all available retrofit technologies, and then condensed this list to only include those technologies that are applicable to a long wet kiln. For example, technologies may be only available for dry or preheater/precalciner kilns, but are not appropriate to consider for a long wet kiln, such as the Trident plant.

### **4.3 SO<sub>2</sub> BART Analysis for the Kiln**

SO<sub>2</sub> forms during coal combustion as sulfur in the coal is liberated and subsequently oxidized by the oxygen present in the combustion air. Sulfur in the feed limestone can also contribute significantly to the kiln's SO<sub>2</sub> emissions. SO<sub>2</sub> emissions can be reduced by capturing and converting it once it has formed. It is possible to limit SO<sub>2</sub> formation both by limiting the amount of sulfur fed to the kiln system and by controlling the conditions necessary to oxidize sulfur. Capture and conversion of SO<sub>2</sub> in the exhaust stream through add-on controls is generally accomplished by mixing the exhaust gas stream with an alkaline reagent, facilitating the chemical conversion of SO<sub>2</sub> to a neutral salt. The salt is solid at system conditions and can be removed by physical means. The control equipment that accomplishes this is commonly referred to as a gas scrubber. Cement kiln systems inherently act as large gas scrubbers with varying degrees of effectiveness depending, in part, on the excess alkali (e.g., Na and/or K) or alkali earth (e.g., Ca) compounds available to combine with sulfur to remove SO<sub>2</sub> as described. Holcim's Trident plant has an excess of alkali compounds to sulfur input indicating a capacity to absorb much more sulfur in its kiln system.

### 4.3.1 Identify All Available SO<sub>2</sub> Retrofit Control Technologies – Step 1

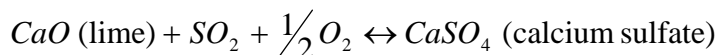
In accordance with Step 1 described in Section 4.2 above, Holcim has sought to identify all “available” retrofit technologies. To that end, EPA’s RBLC describes several permitted cement kiln installations and lists their pollutant emission limits and the control technologies approved to achieve those limits. Another source of information regarding potentially applicable SO<sub>2</sub> control technology for cement kilns is EPA’s AP-42 for Portland cement manufacturing (Chapter 11, Section 6). The following were identified as potentially applicable for controlling SO<sub>2</sub> from cement manufacturing:

- (i) Proper kiln design and operation (baseline);
- (ii) Process alterations;
- (iii) Hot meal injection;
- (iv) Spray dryer absorber;
- (v) Wet SO<sub>2</sub> scrubber.

#### Control Technology Description:

##### **(i) Proper Kiln Design and Operation**

Sulfur is present in coal and limestone as organic sulfur compounds and as minerals pyrite or iron sulfide. In these forms it is readily volatilized and then oxidized to SO<sub>2</sub> under calcining conditions. Sulfur may also be homogeneously present in limestone as calcium sulfate. This form of sulfur does not normally volatilize at calcining temperatures and tends to remain in the lime. In fact, lime reacts under dry conditions with SO<sub>2</sub> to form calcium sulfate (CaSO<sub>4</sub>) as follows:<sup>10</sup>



Similar reactions with sodium and potassium also reduce SO<sub>2</sub> in the kiln. All three of these elements are in excess supply in Trident raw materials, available for reaction. To the degree thermodynamic and kinetic factors allow the reverse reaction (i.e., conversion of sulfate to lime), a lack of oxygen, or a reducing atmosphere, will favor a desulfurization of the limestone. Conversely, increasing oxygen will cause the equilibrium to shift toward increased formation of sulfate. This is where a balance must be struck between product quality and emissions of SO<sub>2</sub>. If specifications call for low levels of sulfur, and especially if the limestone feed contains relatively high proportions of sulfur, kiln conditions must be established that inhibit SO<sub>2</sub> absorption within the kiln. Neither is the case for Holcim’s Trident Plant. If such is not the case, it may be possible to operate the kiln under conditions that favor sulfur oxidation.

##### **(ii) Process Alterations**

The process alteration that Holcim evaluated was changing their fuel to a low sulfur fuel in order to reduce their sulfur emissions. In many cases, the fuel used to fire the kiln is the primary source of sulfur, and ultimately, of SO<sub>2</sub>. One method to “control” SO<sub>2</sub>

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<sup>10</sup> “Chemistry and Technology of Lime and Limestone,” Second Edition, 1980, R.S. Boynton, pg. 181.

emissions is to “control” the sulfur in the native fuel. For example, natural gas contains very little sulfur. Coal may vary from 0.7% to over 5% sulfur. Petroleum coke typically contains 3% to 6% sulfur.

### **(iii) Hot Meal Injection**

Another possibility is the hot-meal bypass in a preheater/precalciner kiln system, where calcined hot meal is, in part, discharged in front of the kiln entrance after the precalcining process. The type of hot meal produced varies by facility. Different hot meal materials have different thermal content and pollutant emissions.

### **(iv) Spray Dryer Absorber**

The term Spray Dryer Absorber (SDA) here refers to those technologies that use a dry, semi-dry or semi-wet alkaline material to control SO<sub>2</sub> emissions from the post-combustion gases. While there are a number of injection methods and designs, it is generally understood that an SDA provides a high degree of controls (within this group) and represents a fair characterization of this class of control device.

A spray dryer absorber is an SO<sub>2</sub> scrubbing process that involves both acid gas and particulate matter control. In a typical SDA system, hot combustion gases enter a reactor where atomized hydrated lime slurry (or near slurry) is introduced at a controlled velocity. Upon injection, the water in the lime slurry quickly evaporates which cools the flue gas. The acid gas constituents (primarily SO<sub>2</sub>) quickly react with the reagent (CaOH, etc.). The result is a dried product that is removed from the exhaust stream by a particulate control device. In general, SDAs are used in combination with either electrostatic precipitators or fabric filter baghouses.

### **(v) Wet SO<sub>2</sub> Scrubber**

A wet SO<sub>2</sub> scrubber is one that uses an aqueous chemical system. These systems have been successfully employed in various industries to remove SO<sub>2</sub> from concentrated waste streams. These systems use aqueous solutions or slurries as the contact and reaction media. A typical installation uses spray tower scrubbers to introduce a reagent slurry as atomized droplets through the spray nozzles at the top of, or in stages within, the scrubber. The SO<sub>2</sub>-laden gas enters at the bottom of the column and travels upward through the tower in a countercurrent flow, though horizontal spray towers which use a crosscurrent design also exist. In most cases the sorbent is an alkaline slurry, commonly limestone, slaked lime, or a mixture of slaked lime and alkaline fly ash, though many other sorbent processes exist. Absorption of SO<sub>2</sub> is accomplished by the contact between the gas and the reagent slurry. The sulfur oxides react with the sorbent, forming a wet mixture of calcium sulfite and sulfate.

The slurry combines with the SO<sub>2</sub>-laden waste gas to form a waste slurry in the bottom of the scrubber. The sludge is removed from the scrubber and, depending upon the reagent or sorbent used to react with the SO<sub>2</sub>, the waste reacted sludge is disposed of, recycled or regenerated, or, in some cases, sold as a salable product.

### 4.3.2 Eliminate Technically Infeasible SO<sub>2</sub> Control Options – Step 2

The following discusses the feasibility or infeasibility of each technology identified in Section 4.3.1 above. The decision regarding whether a particular technology was deemed “technically feasible” was based on discussions found in 40 CFR 51, Appendix Y. Appendix Y describes guidelines for BART determinations under the regional haze rule. Hereafter, the document will be referred to as the “Appendix Y Guideline.”

The issue of feasibility is found in Section IV.2.STEP 2 of the Appendix Y Guideline. The guideline states that control technologies are technically feasible if either:

- “(1) they have been installed and operated successfully for the type of source under review under similar conditions, or*
- (2) the technology could be applied to the source under review.”*

The Appendix Y Guideline goes on to describe these circumstances further and discuss the meaning of “available” and “applicability” within the meaning of BART. As a general rule, “available” means that the owner of the facility may obtain the technology through commercial channels. In the alternative, the technology is “available” within the common-sense meaning of that term.

Commercially available is further discussed in the Appendix Y Guideline as having attained either stage (5) or (6) of the following stages of bringing a control technology to reality as a commercial product:

- (1) Concept stage;
- (2) Research and patenting;
- (3) Bench scale or laboratory testing;
- (4) Pilot scale testing;
- (5) Licensing and commercial demonstration; and
- (6) Commercial sales.

Also of note in the Appendix Y Guideline is the following statement:

*Similarly, we do not expect a source owner to conduct extended trials to learn how to apply a technology on a totally new and dissimilar source type. Consequently, you would not consider technologies in the pilot scale testing stages of development as “available” for purposes of BART review.*

The reader is referred to further discussion in the Appendix Y Guideline on this matter.

Using the Appendix Y Guidelines above, infeasible technologies are rejected where appropriate. Those technologies deemed infeasible are no longer discussed in further sections of this BART analysis.

### **(i) Proper Kiln Design and Operation**

Proper design and operation of kilns is clearly feasible and serves as the baseline case.

Conclusion: Proper kiln design and operation is considered feasible for purposes of Step 2 in this BART analysis.

### **(ii) Process Alterations**

Holcim has identified fuel selection as a process alteration which can possibly reduce SO<sub>2</sub> emissions. Fuel selection as a means to “control” SO<sub>2</sub> emissions is technically feasible. However, Holcim believes that the kiln currently has excess capacity for SO<sub>2</sub> absorption due to the alkali nature of the kiln interior. Therefore, Holcim believes that switching fuels will not significantly reduce SO<sub>2</sub> emissions because the kiln will remain an effective SO<sub>2</sub> scrubber regardless of fuel type used.

Appendix Y Guideline explicitly addresses this issue. Specifically, STEP 1: How do I identify all available retrofit emission control techniques? of the guideline contains the following statement:

*“.....note that it is not our intent to direct States to switch fuel forms, e.g. from coal to gas.”*

Given this statement, it is clear that it is not the intent of EPA to use fuel switching as a form of BART control.

Conclusion: This process alteration is considered infeasible for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

### **(iii) Hot Meal Injection**

As previously stated, hot meal is produced in a preheater/precalciner kiln. Holcim does not have a preheater/precalciner kiln design from which hot meal can be obtained; therefore, this is not a feasible option for Holcim.

Conclusion: This technology is considered infeasible for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

### **(iv) Spray Dryer Absorber**

This type of technology is not considered to be effective for large sources with relatively dilute SO<sub>2</sub> concentrations. The kiln and baghouse system acts as a large dry scrubber mixing gaseous SO<sub>2</sub> with active lime and alkali surfaces to create and capture sulfate salts. Adding a separate spray dry scrubber would only provide additional lime with which SO<sub>2</sub> can react. Supplemental scrubbing by an SDA is expected to provide no more than inefficient redundancy. The performance of a lime spray dry scrubber is sensitive to operating conditions. A “close approach” to adiabatic saturation temperature is required to maximize the removal of SO<sub>2</sub>. However, excess moisture causes the wet

solids to deposit on the absorber and downstream equipment. In spray dry systems, the flue gas must be cooled to a temperature range of 10°C to 15°C (20°F to 35°F) below saturation temperature. This temperature range avoids wet solids deposition and plugging on the downstream particulate control device. An evaporative cooler, or a heat exchanger is typically used to cool the gas, as flue gas with high temperature reduces the performance of the scrubber.

The SDA must be designed in conjunction with the particulate control device as a system. Therefore, to retrofit the existing process with an ESP will likely involve substantial modifications to the ESP.

Conclusion: Although there are serious concerns with this technology, it will be presumed that it remains technically feasible for purposes of Step 2 in this BART analysis.

#### **(v) Wet SO<sub>2</sub> Scrubber**

This type of technology is not considered to be effective for large sources with relatively dilute SO<sub>2</sub> concentrations. The kiln and baghouse system acts as a large dry scrubber mixing gaseous SO<sub>2</sub> with active lime and alkali surfaces to create and capture sulfate salts. Adding a separate wet scrubber would only provide additional alkali solution with which SO<sub>2</sub> can react. Adding a wet scrubber is expected to provide no more than inefficient redundancy. Scrubbing effectiveness is not linearly related to additional removal media concentration. At some optimal lime concentration, a point of diminishing returns is reached after which incremental effectiveness rapidly decreases. This effect is hastened by decreasing SO<sub>2</sub> concentrations. The kiln system is expected to inherently provide excess desulfurization media. Adding further excess with a supplemental scrubber cannot be expected to appreciably increase control efficiency. Aqueous chemical absorption cannot be considered applicable to the proposed project but is technically feasible.

Conclusion: Although there are serious concerns with this technology, it will be presumed that it remains technically feasible for purposes of Step 2 in this BART analysis.

#### **4.3.3 Evaluate Control Effectiveness of Remaining Control Technologies – Step 3**

Of the alternative SO<sub>2</sub> control technologies identified above, proper kiln design and operation, SDA, and wet SO<sub>2</sub> scrubbers remain as technically feasible options. Proper kiln design and operation is the baseline case for this analysis. Other control methods will be evaluated for their potential to improve upon this basis. Table 4-1 summarizes the control effectiveness of the remaining control technologies.

**Table 4-1: Summary of SO<sub>2</sub> Control Technology Efficiency**

Control Option	Efficiency (%)	SO <sub>2</sub> Emissions (lbs/hr)	SO <sub>2</sub> Emissions (tpy)	Tons Removed
Wet SO <sub>2</sub> Scrubber	95%	6.20	27	516
Spray Dry Absorber	90%	12.40	54	489
Baseline	0%	124	543	0

**4.3.4 Evaluate Impacts and Document Results – Step 4**

*(a) Spray Dry Absorbers Impacts*

Spray Dry Absorbers Economic Impacts

Holcim has calculated the cost-effectiveness for employing an SDA for SO<sub>2</sub> control, with the results presented in Table 4-2 below. Holcim has utilized the EPA’s Air Pollution Cost Control Manual to estimate costs of SDA control. The manual provides the EPA’s recommended methodology for estimating the costs for add-on control technology. To calculate the cost-effectiveness of a control technology in dollars per ton (\$/ton), the following factors are used:

**Cost-effectiveness (\$/ton)** = [(total capital investment x capital recovery factor {CRF}) + Direct Annual Cost + Indirect Annual Cost]/(tons SO<sub>2</sub> controlled)

**Capital Recovery Cost** (= total capital investment x CRF)

- Total capital investment = direct and indirect costs for purchasing and installing control equipment.
  - Capital recovery factor (CRF) = multiplier to determine the uniform end-of-year payment necessary to repay an investment in *n* years with an interest rate of *i*.
    - Control system life, *n* = 10 to 20 years, typically
    - Interest rate, *I* = 7% recommended interest rate
- For this BART analysis, CRF = 10 years @ 7% = 0.142*

**Direct Annual Cost** (utilities, labor, taxes)

**Indirect Annual Cost** (overhead, insurance, taxes)

Table 4-2 summarizes the cost-effectiveness for each of the technically feasible control options, compared against a baseline of proper kiln design and operation. Details of the SDA cost analysis can be found in Appendix C.

Spray Dry Absorbers Energy Impacts

EPA Publication EPA-542/F-03-034 states that modern spray dry absorber designs result in an energy penalty of less than 1% of the total plant energy consumption. This is a minor energy impact which is considered in the economic analysis.

*(c) Wet SO<sub>2</sub> Scrubber Impacts*

Wet SO<sub>2</sub> Scrubber Economic Impacts

Holcim has calculated the cost-effectiveness for employing a wet scrubber for SO<sub>2</sub> control, with the results presented in Table 4-2 below. The table summarizes the cost-effectiveness for each of the technically feasible control options, compared against a baseline of proper kiln design and operation. Details of the wet scrubber cost analysis can be found in Appendix C.

Wet SO<sub>2</sub> Scrubber Energy Impacts

EPA Publication EPA-542/F-03-034 states that modern wet scrubber designs result in an energy penalty of less than 1% of the total plant energy consumption. This is a minor energy impact which is only further considered in the economic analysis.

*Alternatives Analysis Summary*

For the purposes of this cost analysis, it has been assumed that the remaining life of all of the equipment is at least the 10 years used to calculate the annualized costs.

**Table 4-2: Summary of SO<sub>2</sub> Cost Analysis**

Control Option	Annualized Cost	Efficiency (%)	SO <sub>2</sub> Emissions (lbs/hr)	SO <sub>2</sub> Emissions (tpy)	Tons SO <sub>2</sub> Removed	Cost Effectiveness (\$/ton)	Incremental Cost Effectiveness (\$/ton)
Wet SO <sub>2</sub> Scrubber	\$19,607,665	95%	6.20	27	516	\$38,011	\$498,491
Spray Dry Absorber (includes baghouse)	\$6,070,650	90%	12.40	54	489	\$12,422	--
Baseline	\$0	0%	124.00	543	0	--	--

As shown in Table 4.2, the cost per ton for the wet SO<sub>2</sub> scrubber and the SDA are substantial, both higher than what is generally considered BACT in Montana. The annualized costs of both options are cost-prohibitive. In addition, the incremental cost of \$498,491 per ton SO<sub>2</sub> removed by the wet scrubber versus the SDA is enormous.

**4.3.5 Evaluate Visibility Impacts – Step 5**

Holcim has performed modeling using the CALPUFF model to predict visibility impacts of the identified potentially applicable SO<sub>2</sub> control technologies, using the 98<sup>th</sup> percentile visibility result as recommended by EPA. The results of the modeling are shown in Table 4-3 below. The results are only presented for the Gates of the Mountains Wilderness Area, as it is the closer, and more impacted Class I Area. Details of the modeling are found in Appendix B to this document.

**Table 4-3: Summary of SO<sub>2</sub> Visibility Impacts<sup>a</sup>**

Control Option	Annualized Cost	Efficiency (%)	SO <sub>2</sub> (lbs/hr)	Gates of the Mountains Wilderness Area			
				Visibility Impact (deciview)	Visibility Improvement (deciviews 24 hr)	Cost (\$/deciview)	Incremental Cost (\$/deciview)
Wet SO <sub>2</sub> Scrubber	\$19,607,665	95%	6.20	1.291	0.269	\$15,185,614	\$2,990,183,225
Spray Dry Absorber (includes baghouse)	\$6,070,650	90%	12.40	1.296	0.264	\$4,683,421	--
Baseline	\$0	0%	124	1.56	0.000	--	--

<sup>a</sup>Deciviews at each % reduction for the Gates of the Mountains are calculated using the equation:  $y = 0.001x + 1.2862$  derived from using the best fit trendline of the average 98th percentile modeling values.

### 4.3.6 Select SO<sub>2</sub> BART

Based upon the modeling results, the addition of add-on controls, in practice, will result in minimal visibility improvement. The 340 lbs/hr of SO<sub>2</sub> utilized in the models as a worst-case 24-hour value is approximately ten times higher than normal levels of SO<sub>2</sub> emissions. Even when using this larger figure in the models, the deciview change accomplished by employing the best control technology (wet scrubber) at 95% control has only a 0.269 deciview impact on visibility. Holcim believes this change is well below the human eye's ability to detect.

The costs of the add-on controls are deemed to be unjustifiable in terms of dollars spent per ton of SO<sub>2</sub> removed and per deciview of improvement. Even worse are the incremental dollar per ton and dollar per deciview values in moving up to the best control. At the lesser 90% control level, the cost per deciview of improvement is over 4.7 million dollars. Holcim believes this amount is excessive, especially considering the minimal visibility improvements achieved. A cost of over 6 million dollars per year to achieve an undetectable visibility improvement seems unjustified and outside the intention of the BART program.

Of the alternative SO<sub>2</sub> control technologies identified above, none is feasible at the Trident facility. Holcim proposes to continue to employ the baseline of proper kiln design and operation and comply with the existing SO<sub>2</sub> emission limitation (124 lbs/hour on a rolling 30-day basis). Therefore, no new requirements for SO<sub>2</sub> are proposed under the BART program.

## 4.4 NO<sub>x</sub> BART Analysis for the Kiln

Most of the NO<sub>x</sub> formed within a rotary cement kiln is classified as thermal NO<sub>x</sub>. Thermal NO<sub>x</sub> results when the heat from fuel combustion causes atmospheric nitrogen to combine with atmospheric oxygen. Virtually all thermal NO<sub>x</sub> is formed in the region of the flame at the highest temperatures, approximately 3000°F to 3600°F. A small proportion of NO<sub>x</sub> emissions results from nitrogen that is liberated from the fuel and reacts with oxygen in the air.

Theoretically, the following principles can be employed to reduce NO<sub>x</sub> formation:

- Reduce peak flame zone temperatures,
- Reduce fuel residence time in the flame zone,
- Reduce mixing of fuel and combustion air,
- Reduce oxygen concentrations in the flame zone, and
- Reduce excess air in the combustion process.

There are also post-combustion NO<sub>x</sub> control technologies which remove NO<sub>x</sub> from the flue gas after formation, using technologies that chemically convert it to nitrogen and water.

#### **4.4.1 Identify All Available NO<sub>x</sub> Retrofit Control Technologies – Step 1**

EPA's RBLC describes several permitted cement kiln installations and lists their pollutant emission limits and the control technologies approved to achieve those limits. Other sources of information regarding potentially applicable NO<sub>x</sub> control technology for cement kilns include EPA's 2000 NO<sub>x</sub> Control Technologies for Cement Kilns, and the Assessment of NO<sub>x</sub> Emissions Reduction Strategies for Cement Kilns – Ellis County, TX. First, Holcim evaluated all NO<sub>x</sub> control technologies for cement manufacturing using the documents stated above, and then identified the control technologies that were potentially applicable to long, wet kilns. The technologies that were identified as potentially applicable for controlling NO<sub>x</sub> from Holcim's cement kiln are divided into three categories: process modifications, fuel and raw material substitutions and post-combustion control technologies. These are detailed below.

- (i) Proper kiln design and operation (baseline),
- (ii) Process modifications
  - Increased thermal efficiency, and
  - Combustion system modifications including low-NO<sub>x</sub> burner (LNB)
- (iii) Fuel and raw material substitutions
  - Mid-kiln fuel injection, and
  - CemStar process,
- (iv) Post-combustion control technologies
  - Selective non-catalytic reduction (SNCR).
  - Selective catalytic reduction (SCR), and
  - LoTOx<sup>TM</sup>

The following is a brief discussion of each of the control technologies.

##### **(i) Proper Kiln Design and Operation**

Many interdependent and sometimes competing factors must be considered in the design and operation of a cement kiln. Primary among them are product quality requirements, operating costs, and pollution mitigation. Burner operation is central to all three. Product quality is critically dependent upon flame temperature and kiln

atmosphere composition. Both of these conditions are also primary factors in the production of NO<sub>x</sub>. Low temperatures reduce the production of NO<sub>x</sub>. Temperatures that are too high, besides aggravating NO<sub>x</sub> production, can result in over-burned clinker. A specific concentration of oxygen in the kiln is required to properly control combustion and oxidize the limestone and other minerals. Some of that oxygen is supplied with the combustion air and strongly affects fuel combustion characteristics such as temperature.

Fuel costs are a major portion of the cost of cement production. Consequently, every effort is made to conserve heat and thereby reduce costs. Efforts to maximize fuel efficiency also serve to reduce pollutant emissions; increasing the amount of cement produced per unit of fuel decreases the amount of combustion-related pollutants emitted per unit of product.

Fuel selection can influence NO<sub>x</sub> production in two ways: the amount of chemically bound nitrogen in the fuel helps determine the fuel's direct contribution to NO<sub>x</sub> emissions, and the fuel's combustion characteristics help determine the amount of thermal NO<sub>x</sub> created. Natural gas kilns produce approximately three times more NO<sub>x</sub> on an equivalent production basis than coal-fired kilns. Although coal contains more fuel-bound nitrogen than natural gas, it burns at lower temperatures and so produces less thermal NO<sub>x</sub>. Petroleum coke may produce less NO<sub>x</sub> than coal because it contains less nitrogen per unit of heat value and burns with a lower flame temperature.<sup>11</sup> Holcim currently uses coal and coke as the main fuel source, using natural gas only for start-up and shut-down.

In some cases, reducing emissions of a particular pollutant can cause an increase in emissions of another. This is especially true of the relationship between NO<sub>x</sub> and CO. CO is generally produced as a result of incomplete combustion of organic materials. Attempts to achieve more complete combustion typically involve increasing oxygen concentration and flame temperatures, two factors that lead to increased NO<sub>x</sub> production.

Cement kiln operation is designed to balance and optimize the above parameters for a specific set of external constraints such as feed quality, product quality requirements, pollutant emissions restrictions, and fuel availability. The design includes operational monitoring and control systems that allow the maintenance of optimum operating conditions.

## **(ii) Process Modifications**

There are many process modifications which could be made to a cement production facility in order to reduce NO<sub>x</sub> emissions. These modifications are very site-specific and must factor in existing equipment, processes, fuels and raw materials, etc. Holcim has

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<sup>11</sup> USEPA "Alternative Control Techniques Document – NO<sub>x</sub> Emissions from Cement Manufacturing," EPA-453/R-94-004, Office of Air and Radiation, Office of Air Quality Planning Standards, March 1994, page 5-4.

identified the following process modifications as feasible at the Trident facility, with potential to significantly reduce NO<sub>x</sub> emissions.

#### Increased Thermal Efficiency

One process modification Holcim has reviewed to improve the thermal efficiency of the Trident kiln is the installation of a fixed inlet at the clinker cooler. A fixed inlet modification to the clinker cooler improves the heat recovery to the kiln inlet and the overall efficiency of clinker cooler operation. With increased cooler efficiency, a greater amount of heat in the clinker is recovered, which increases the secondary air temperature of the kiln/cooler system. Consequently, the amount of fuel required in the kiln can be reduced because more heat has been captured from the cooler and does not need to be supplied by the combustion system. With the reduction in fuel usage, a proportional reduction of thermal NO<sub>x</sub> from the combustion process is achieved. A 0 to 5% reduction in NO<sub>x</sub> emissions can be expected from the installation of the fixed inlet on the clinker cooler.

#### Combustion System Modifications Including Low-NO<sub>x</sub> Burner (LNB)

Another process modification Holcim believes is applicable in reducing NO<sub>x</sub> emissions at the Trident facility is addition of a low NO<sub>x</sub> burner in conjunction with other combustion system modifications. The addition of an LNB will reduce NO<sub>x</sub> formation by controlling the mixing of fuel and air to provide low-excess-air firing or off-stoichiometric combustion. These burners are designed to reduce peak flame temperature and/or reduce the residence time at high temperature. The most common LNBs include staged air burners or staged fuel burners.

Staged air burners consist of a two-stage combustion process. Combustion initiates under fuel-rich, oxygen-deficient conditions in the primary combustion zone. These conditions allow attainment of the required flame temperature while reducing the formation of fuel and thermal NO<sub>x</sub>. They also lead to incomplete fuel combustion. In the secondary zone, relatively cool additional air (staged air) is introduced to complete the combustion process. The cooler temperatures resulting from introduction of the staged air suppress NO<sub>x</sub> formation in this stage.

Staged fuel burners mix all of the air and a portion of the fuel to create a fuel-lean environment in the primary combustion chamber. This leads to lower flame temperatures and, consequently, reduced NO<sub>x</sub> production. The remaining fuel is then injected at high pressures into the secondary combustion zone where the relative lack of oxygen inhibits NO<sub>x</sub> formation. Staged fuel burners are compatible only with gas-fired combustion units.

LNBs can also create oxygen-deficient conditions in a primary combustion zone by recycling a portion of the kiln exhaust gas to the burner, either in the primary air that accompanies the injected coal or directly into the flame. This is referred to as flue gas recirculation (FGR). This effect can also be achieved by creating a low-pressure zone at the center of the burner. The low-pressure zone tends to draw in oxygen-poor combustion gases that mix with the fuel and primary combustion air. Using an FGR

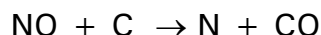
would result in unacceptable cement product quality and has not been applied at a cement kiln.

LNB control technology typically has reductions between 15 and 30% in NO<sub>x</sub> emissions.

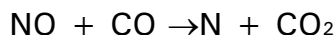
### **(iii) Fuel and Raw Material Substitutions**

#### **Mid-Kiln Fuel Injection**

During mid-kiln injection, typically, a combustible material such as tire-derived fuel (TDF) or other lump fuel, is introduced near the center of the kiln. This addition of a heat source midway through the calcining process reduces the temperature required in the primary combustion chamber, thereby reducing the formation of thermal NO<sub>x</sub>. Reductions in NO<sub>x</sub> occur as a result of the radiative transfer of heat from the primary combustion zone prior to reaching the secondary combustion zone. In addition, the entrained secondary fuel acts to reduce the temperature of the primary combustion products. NO<sub>x</sub> is reduced in the kiln combustor by following simplified reactions:



and



TDF combustion also lowers the amount of fuel-bound nitrogen introduced to the kiln and thereby lowers NO<sub>x</sub> emissions through another mechanism. Some fuels, such as TDF also introduce material to the cement clinker (such as steel) that may add beneficial qualities to the final product.

EPA, Environment Canada, and many US Regional Air Agencies documents have identified combustion of TDF, especially mid-kiln introduction of tires, as an NO<sub>x</sub> control technology.<sup>12,13</sup> This technology typically has reductions between 30 and 50% in NO<sub>x</sub> emissions.

#### **CemStar Process**

CemStar is a patented process developed by TXI industries that can reduce NO<sub>x</sub> emissions by the addition of steel slag to the feed end of the kiln. Steel slag has a low melting temperature and desirable chemical components of clinker in its material. The slag is directly added to the cement clinker manufacturing process. Due to the chemical composition of the steel slag, the material requires less fuel to convert it into cement slag, potentially resulting in lower total fuel consumption. The decreased need for limestone calcination per unit product and improved thermal efficiency of the process can lead to lower thermal NO<sub>x</sub> emissions.

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<sup>12</sup> Assessment of NO<sub>x</sub> Emission Control Technologies for Cement and Lime Kilns. April 1995.

<sup>13</sup> EPA-453/r-94-004, March 1994.

#### **(iv) Post Combustion Control Technologies**

##### **Selective Non-Catalytic Reduction (SNCR)**

SNCR is a proven technology in the cement industry for preheater/precalciner kilns to efficiently reduce NO<sub>x</sub> emissions. Like SCR technology, SNCR reduces NO<sub>x</sub> to nitrogen and water, but it does so without the use of a catalyst. It injects a nitrogenous reducing agent, typically ammonia or urea, into the upper reaches of the furnace. Because a catalyst is not used to drive the reaction, a temperature of 1600 to 2100°F is required for the reduction reaction to proceed.

NO<sub>x</sub> removal efficiency is dependent on inlet NO<sub>x</sub> concentrations, fluctuating flue gas temperatures, residence time, amount and type of nitrogenous reducing agent, mixing effectiveness, and the presence of interfering chemical substances in the gas stream.

In the past, SNCR technology was only considered feasible for preheater/precalciner type kilns and not for long wet or dry kilns. The reason is the difference in design between preheater/precalciner kilns and long wet or dry kilns. Preheater/precalciner kilns, which are shorter than long kilns, have the optimal temperature range (1600°F to 2100°F) for the necessary reaction to take place at the end of the kiln, without having to inject ammonia- or urea-based reagents into the rotating kiln itself. In long kiln designs (both wet and dry), the optimal temperature range to make an SNCR effective occurs in the middle of the kiln; therefore, mid-kiln injection of the ammonia- or urea-based reagents would have to be incorporated into the kiln design. Until recently, this has made the installation of an SNCR technically infeasible because the injection of the reagents was not continuous and not effective.

##### **Selective Catalytic Reduction (SCR)**

SCR is a post-combustion gas treatment technique that uses a catalyst to reduce NO and NO<sub>2</sub> to molecular nitrogen, water, and oxygen. Ammonia (NH<sub>3</sub>) is commonly used as the reducing agent. Ammonia is vaporized and injected into the flue gas upstream of the catalyst bed, and combines with NO<sub>x</sub> at the catalyst surface to form an ammonium salt intermediate. The ammonium salt intermediate then decomposes to produce elemental nitrogen and water. The catalyst lowers the temperature required for the chemical reaction between NO<sub>x</sub> and ammonia.

In general, the installations of SCRs are operated in clean gas circuits; i.e., dust and heavy metals are separated from the exhaust stream before the catalyst in order to prevent rapid wear and deactivation of the catalysts through catalyst poisons.

Technical factors that impact the effectiveness of this technology include the catalyst reactor design, operating temperature, type of fuel fired, sulfur content of the raw material, design of the ammonia injection system, and potential for catalyst poisoning.

An SCR characteristic common to all catalyst types is the narrow window of acceptable system inlet temperatures. Below the minimum acceptable temperature of about 575°F, the NO<sub>x</sub> reduction reaction will not proceed, while operation above the maximum

acceptable temperature of about 750°F results in shortened catalyst life and can lead to the oxidation of NH<sub>3</sub> to nitrogen oxides, thereby actually increasing the NO<sub>x</sub> emissions, or possibly generating explosive levels of ammonium nitrate in the exhaust gas.

Another critical factor affecting SCR performance, especially in an application such as coal-fired lime and cement kilns, is related to SO<sub>2</sub> in the exhaust gas. The SCR catalyst will oxidize SO<sub>2</sub> to SO<sub>3</sub>, which can form ammonium bisulfate and sulfuric acid. Ammonium bisulfate is a sticky solid that causes clogging within the catalyst, while sulfuric acid can cause corrosion within the system and result in increased visible emissions.

#### LoTOx™

LoTOx™ is a patented technology that uses ozone to selectively oxidize NO<sub>x</sub> to higher forms of oxides of nitrogen, which become soluble and can be easily removed by a wet scrubber. This technology may require reheating of the gas stream and has a high electrical energy consumption which would raise the power consumption of Holcim's facility. Furthermore, there is potential to create new waste streams like waste water or sludge that require further treatment. There are no known LoTOx installations in the cement industry.

According to TCEQ's *ASSESSMENT OF NO<sub>x</sub> EMISSIONS REDUCTION STRATEGIES FOR CEMENT KILNS – ELLIS COUNTY, FINAL REPORT* (dated 7/14/06)<sup>14</sup> Section 4.3.2, states:

*“The large gas volumes, high moisture levels and large quantities of dilution air needed to reach the operating temperature range in some systems may limit the applicability of the LoTOx™ system.”*

#### **4.4.2 Eliminate Technically Infeasible NO<sub>x</sub> Control Options – Step 2**

The methodology used to eliminate technically infeasible control technologies for NO<sub>x</sub> was described in Section 4.3.2 above. The reader is referred to that section for details of this process.

##### **(i) Proper Kiln Design and Operation**

Proper design and operation of cement kilns is clearly feasible and serves as the baseline case. Holcim's kiln design includes control systems for balancing primary and secondary combustion air flow rates and velocities. This will enable operators to optimize fuel and air mixing and ratios for minimal NO<sub>x</sub> formation.

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<sup>14</sup> The final report itself (dated on 7/14/06) may be found at:  
[http://www.tceq.state.tx.us/implementation/air/sip/BSA\\_settle.html](http://www.tceq.state.tx.us/implementation/air/sip/BSA_settle.html).

Conclusion: This technology is considered feasible for purposes of Step 2 in this BART analysis.

**(ii) Process Modifications**

Increased Thermal Efficiency

Holcim has identified a process modification that has the potential to increase thermal efficiency of the kiln and reduce NO<sub>x</sub> emissions. The process alteration involves adding a fixed inlet to the clinker cooler, which will increase thermal efficiency of the kiln, and thereby reduce fuel consumption and reduce thermal NO<sub>x</sub> formation in the kiln.

Conclusion: This technology is considered feasible for purposes of Step 2 in this BART analysis.

Combustion System Modifications Including Low-NO<sub>x</sub> Burner (LNB)

Control of NO<sub>x</sub> emissions using methods employed by LNBs such as staged air combustion, though extremely limited in practice, is technically feasible for a coal-fired rotary kiln. As noted above, cement production requires balancing many combustion parameters to optimize cement quality and energy efficiency while limiting emissions of multiple air pollutants. The cement production system must be capable of adjusting and responding quickly to changes in external conditions. Because of these requirements, some LNB technologies, such as staged fuel combustion units, may not be practical or effective when applied to Holcim's kiln.

FGR in conjunction with an LNB has not been demonstrated in kiln applications to provide better NO<sub>x</sub> reduction than can be achieved by controlling primary and secondary combustion air in a properly designed and operated kiln. Adding FGR to a burner that is already designed for optimum flame shaping and control would distort the thermal profile of the kiln such that product quality would be unacceptably compromised. Such a flame profile would also reduce kiln efficiency and potentially result in increased NO<sub>x</sub> emissions.

Holcim believes a carefully selected LNB in conjunction with proper combustion system modifications can achieve approximately a 17% NO<sub>x</sub> emission reduction.

Conclusion: This technology is considered technically feasible for purposes of Step 2 in this BART analysis.

**(iii) Fuel and Raw Material Substitutions**

Mid-kiln Fuel Injection

Holcim has previously identified mid-kiln injection of tires as a desirable process to add to the facility. In 2001, Holcim applied for an air quality permit from the Montana Department of Environmental Quality to authorize the addition of a mid-kiln tire injection system. To date, there has not been any final action taken on that application.

Conclusion: This technology is considered technically feasible for purposes of Step 2 in this BART analysis.

#### CemStar Process

Holcim is not aware of any source of steel slag for use in the CemStar Process within a reasonable distance of the Holcim facility. Therefore, there is no commercially available source of steel slag for the kiln that would be considered "available" to Holcim for purposes of BART.

Conclusion: This technology is considered technically infeasible for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

#### **(iv) Post-Combustion Control Technologies**

##### Selective Non-Catalytic Reduction (SNCR)

In the past, SNCR technology was only considered feasible for preheater/precalciner type kilns and not for long wet or dry kilns. More recently, there has been a trial installation of an SNCR system on a wet kiln in France. This installation was a trial run conducted over a four-month period.

The Holcim Trident facility believes there is very limited experience with the application of SNCR to a long, wet kiln. Therefore, the Holcim Trident facility believes it is currently an emerging technology and the application of SNCR is not an available BART technology.

Holcim has investigated the feasibility of adding urea into the existing mid-kiln injection system, the dust scoops mechanism. The dust scoops are a mechanism which recycles cement kiln dust by injecting it into the kiln as it rotates. By adding urea to the dust scoops during normal operations, the reagent would be injected into the post-combustion zone of the kiln. The downfall of this application is that the temperature profile of the kiln shows a temperature of 1400°F at the location of the dust scoop mechanism. This is below the range of temperatures (1600°F to 2100°F) necessary for the NO<sub>x</sub> reduction reaction to take place and be effective. The other drawback to this application is that the short physical distance from the dust scoops downstream to the radiative cooling section of the kiln would give the flue gas a very short residence time. Thus, the mixing of reagent and flue gas would likely be incomplete. Holcim believes these two factors combined would either substantially reduce or completely eliminate the SNCR reaction and NO<sub>x</sub> reductions would not be achieved.

Conclusion: Holcim believes SNCR is not available to the Trident facility for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

## Selective Catalytic Reduction (SCR)

SCR is not feasible for application to the Holcim cement kiln for the following reasons.

- First, SCRs are not sufficiently developed to make them commercially available in the U.S.; therefore, it should not be considered a feasible control technology. Although this technology has been used in coal-fired power plants, its commercial application to the cement industry is limited to two cement plants in the world, one in Solnhofen, Germany, and one in Di Monselice, Italy. The Solnhofen Portland cement plant located in southern Germany started operating an SCR system in 2001 and, after seven years of trials, the facility has not been able to finalize its design and resolve all its operational issues. During this period, the facility has worked on problems associated with catalyst design, sizing, and plugging. Application of SCR at Solnhofen has been a long, drawn out pilot-test, not a full-scale commercial success. Due to the operational problems, the SRC technology is no longer being used as an NO<sub>x</sub> control technology at Solnhofen. The plant in Di Monselice, Italy, installed SCR approximately a year ago, and at this time there is not enough experience and information from this installation to evaluate its performance or draw any conclusions. Consequently, its reliability and effectiveness in this application are unknown.

The Texas Commission on Environmental Quality (TCEQ) adopted new rules on May 23, 2007, to control NO<sub>x</sub> emissions from cement kilns in the Dallas-Fort Worth ozone non-attainment area. Based on TCEQ's study, in Chapter 117 – Control of Air Pollution from Nitrogen Compounds, pg 256:

*“.....however, neither SCR nor LoTOx has been applied to wet process cement kilns, and only SCR has even been attempted on dry process cement kilns with results that are in question and that cannot necessarily be transferred to the kilns in Ellis County.”*

- Second, the sulfur concentrations in the raw materials at Trident are much higher than that of the European plants. Thus, the higher concentrations of SO<sub>2</sub> in the kiln exhaust gas could cause sticky dust formation, leading to catalyst plugging, poisoning, and shortened lifespan.
- Third, the high particulate loading of the exhaust stream would require that the unit be located downstream of the ESP. Otherwise, catalyst effectiveness and longevity would be severely limited due to poisoning and plugging. Because the highest exhaust gas temperature is typically near 400°F – well below the optimum SCR inlet temperature range of approximately 575 to 800°F – the gas stream would require reheating. This would increase the cost of controls, generate additional combustion pollutant emissions, and impose substantial energy penalties.

**Conclusion:** SCRs are not sufficiently developed for cement kilns to overcome the potential problems listed above, and are not considered commercially

available for this purpose. Therefore, SCR is not considered “available” to Holcim for purposes of BART. This technology is considered technically infeasible for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

LoTOx™

To be thorough in the analysis, Holcim identified LoTOx™ technology as a potential NO<sub>x</sub> control technology; however, there are no known LoTOx™ installations in the cement industry. Therefore, LoTOx™ is not considered “available” to Holcim for purposes of BART.

Conclusion: This technology is considered technically infeasible for purposes of Step 2 in this BART analysis. No further discussion of this technology will be presented.

**4.4.3 Evaluate Control Effectiveness of Remaining NO<sub>x</sub> Control Technologies – Step 3**

Of the alternative NO<sub>x</sub> control technologies identified above, proper kiln design and operation, process alterations, combustion system modifications including a low-NO<sub>x</sub> burner and mid-kiln tire injection remain as technically feasible options. Proper kiln design and operation is the baseline case for this analysis. Table 4-4 summarizes the control effectiveness of the remaining control technologies.

**Table 4-4: Summary of Remaining NO<sub>x</sub> Control Technology Efficiency**

<b>Control Option</b>	<b>Efficiency (%)</b>	<b>NO<sub>x</sub> Emissions (lbs/hr)</b>	<b>NO<sub>x</sub> Emissions (tpy)</b>	<b>Tons NO<sub>x</sub> Removed</b>
Mid-Kiln Injection of Tires	30%	1,098	4,807	2,060
Combustion System Modifications including Low-NO <sub>x</sub> Burner	17%	1,301	5,700	1,168
Process Alterations (Install fixed inlet on clinker cooler)	3%	1,521	6,662	206
Baseline	0%	1,568	6,868	0

**4.4.4 Evaluate Impacts and Document the Results – Step 4**

*Process Alterations Impacts*

Process Alterations Economic Impacts

Holcim has calculated the cost-effectiveness for the process alterations, including a fixed inlet to the clinker cooler for NO<sub>x</sub> control, with the results presented in Table 4-5 below. The table summarizes the cost-effectiveness for each of the technically feasible NO<sub>x</sub> control options, compared against a baseline of proper kiln design and operation. Details of the process alteration cost analysis can be found in Appendix C.

### Process Alterations Energy Impacts

There are no negative energy impacts associated with installing a fixed inlet on the clinker. A fuel savings through improved kiln efficiency is expected.

### ***LNB Impacts***

#### LNB Economic Impacts

Holcim has estimated the cost of combustion system modifications, including the addition of an LNB based on EPA's NOx Control Technologies for Cement Industry (Table 6-8), which estimates an annualized cost of \$398,000 (1997 \$) for retrofit LNB installations for a 50 ton/hr long wet kiln. It is assumed this is a representative cost. The cost in 1997 dollars was adjusted to 2006 dollars using the 1.25607 CPI multiplier<sup>15</sup>. The adjusted annualized cost was calculated to be \$498,065. The results are presented in Table 4-5 below. Details of the cost analysis can be found in Appendix C.

#### LNB Environmental Impacts

There are no negative environmental impacts associated with LNB technology. There are, however, heightened safety concerns associated with the LNB fuel delivery system. Because the flow rate of air used to inject pulverized coal is reduced, there is increased risk of combustion occurring within the coal mill system.

#### LNB Energy Impacts

There are no significant negative energy impacts associated with the combustion system modifications and an LNB.

### ***Mid-Kiln Fuel Injection Impacts***

#### Mid-Kiln Fuel Injection Economic Impacts

Kiln modifications and a tire handling and injection system are required for mid-kiln introduction of TDF. The guidance document (EPA NOx Controls for Cement Industry Final Report, Sept. 19, 2000 Table 6-10) estimates an annualized cost of \$370,000 (1997 \$) for mid-kiln firing conversion for a 50 ton/hr long wet kiln. It is assumed this is a representative cost. The cost in 1997 dollars was adjusted to 2006 dollars using the 1.25607 CPI multiplier. The adjusted annualized cost was calculated to be \$473,738. The results are presented in Table 4-5 below. Details of the cost analysis can be found in Appendix C.

#### Mid-Kiln Fuel Injection Environmental Impacts

Holcim has studied the environmental impacts extensively, as reported in multiple submissions to Montana DEQ. CO emissions are expected to increase slightly. PM

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<sup>15</sup> The CPI multiplier calculator may be found at: <http://www.minneapolisfed.org/research/data/us/calc/>.

emissions are not expected to show any appreciable change. SO<sub>2</sub> emissions are expected to be unchanged. VOC emissions are expected to decrease slightly. Metal emissions are expected to decrease. Dioxin/furan (D/F) emissions are not expected to change significantly. Holcim believes combusting TDF in the kiln will have a net environmental benefit by reducing the number of tires placed in solid waste landfills, reducing the amount of coal and coke currently combusted, reducing the impacts associated with mining the coal, and reducing fossil fuel dependence.

Mid-Kiln Fuel Injection Energy Impacts

There are no significant negative energy impacts associated with the combustion of tires through mid-kiln injection.

*Alternatives Analysis Summary*

Holcim has identified several NOx reducing techniques which all have acceptable cost, energy and environmental impacts. Table 4-5 below summarizes the cost impacts of the remaining alternatives. For this analysis, it has been assumed that the remaining life of all of the equipment is at least the 10 years used to calculate the annualized costs.

**Table 4-5: Summary of NOx Cost Impacts**

Control Option	Estimated Annualized Cost	Efficiency (%)	NOx Emissions (lbs/hr)	NOx Emissions (tpy)	Tons Removed	Cost Effectiveness (\$/ton)
Mid-Kiln Injection of Tires	\$473,738	30%	1,098	4,807	2,060	\$230
Combustion System Modifications with Low-NOx Burner	\$498,065	17%	1,301	5700	1168	\$427
Process Alterations (Install fixed inlet to cooler)	\$448,250	3%	1,521	6662	206	\$2,176
Baseline	\$0	0%	1,568	6868	0	--

The costs per ton for NOx removal are all in the range of generally what would be acceptable for NOx control in a Montana BACT analysis. The annualized costs of all three options are also considered acceptable by Holcim.

**4.4.5 Evaluate NOx Visibility Impacts – Step 5**

Holcim has performed modeling using the CALPUFF model to predict visibility impacts of the identified potentially applicable NOx control technologies, using the 98<sup>th</sup> percentile visibility result as recommended by EPA. The results of the modeling are shown in Table 4-6 below. The results are only presented for the Gates of the Mountains Wilderness Area, as it is the closer and more impacted Class I area. Details of the modeling are found in Appendix B to this document.

**Table 4-6: Summary of NO<sub>x</sub> Visibility Impacts<sup>a</sup>**

Control Option	Estimated Annualized Cost	Efficiency (%)	NO <sub>x</sub> Emissions (lbs/hr)	Gates of the Mountains Wilderness Area		
				Visibility Impact (deciview)	Visibility Improvement (deciviews 24 hr)	Cost Effectiveness (\$/deciview)
Mid Kiln Injection of Tires	\$473,738	30%	1,098	0.976	0.584	\$811,195
Combustion System Modifications with Low-NO <sub>x</sub> Burner	\$498,065	17%	1,301	1.122	0.438	\$1,136,097
Process Alterations (Install fixed inlet to clinker cooler)	\$448,250	3%	1,521	1.278	0.282	\$1,591,797
Baseline	\$0	0%	1,568	1.560	0	--

<sup>a</sup>Deciviews at each % reduction for the Gates of the Mountains are calculated using the equation:  $y = 0.0112x + 0.248$  derived from using the best fit trendline of the average 98th percentile modeling values.

#### 4.4.6 Select NO<sub>x</sub> BART

SCR, SNCR, LoTOx<sup>TM</sup> and CemStar technologies have been eliminated as inappropriate for controlling NO<sub>x</sub> emissions from the facility's cement kiln. The remaining options are the baseline condition of proper design and operation of the kiln, process alterations including a fixed inlet on the clinker cooler, combustion system modifications including a Low NO<sub>x</sub> Burner, and mid-kiln injection of tires.

Holcim believes that all of the remaining NO<sub>x</sub> control technologies are effective and economically feasible. However, Holcim cannot ensure the use of mid-kiln injection of tires within the five year timeline spelled out in the BART program. Holcim cannot use tires as a fuel source until the Montana DEQ issues a final air quality permit and any legal appeals are concluded. The current permitting and EIS process has been ongoing for at least six years, and Holcim has no control over the timeline or the outcome of the process. More negotiation and litigation is expected. For these reasons, Holcim cannot propose mid-kiln injection of tires as BART.

Therefore, for the purpose of NO<sub>x</sub> control, Holcim selects a combination of process alterations, including a fixed clinker cooler inlet, and combustion system modifications, including a low NO<sub>x</sub> burner as BART. Holcim proposes to make the 20% NO<sub>x</sub> reduction federally enforceable by reducing the current permit limitation of 1,568 lbs/hour on a rolling 30-day basis to 1,254 lbs/hour on a rolling 30-day basis.

### 4.5 BART Analysis for PM<sub>10</sub> from the Kiln

#### 4.5.1 Identify Available Particulate Control Technologies – Step 1

EPA's RBLC describes several permitted cement kiln installations and lists their pollutant emission limits and the control technologies approved to achieve those limits. Another source of information regarding potentially applicable PM control technology for

cement kilns is the EPA's AP-42 for Portland cement manufacturing (Chapter 11, Section 6). The following technologies were identified as potentially applicable for controlling particulate matter from cement manufacturing using a wet process kiln:

- (i) Proper kiln design and operation with an electrostatic precipitator (ESP) (baseline),
- (ii) Fabric filter baghouse, and
- (iii) Cooling tower, multiclone, and ESP combination.

### **Control Technology Description:**

#### **(i) Proper Kiln Design and Operation**

Many interdependent and sometimes competing factors must be considered in the design and operation of a cement kiln. Primary among them are product quality requirements, operating costs, and pollution mitigation. Burner operation is central to all three. Product quality is critically dependent upon flame temperature and kiln atmosphere composition.

Holcim currently operates an ESP to control particulate emissions from the kiln. An ESP uses electrical forces to move entrained particles onto a collection surface. To remove dust cake from the collection surface, the collection surface is periodically "rapped" by a variety of means to dislodge the particulate, which drops down into a hopper. Particulate-laden air must be able to be collected and ducted to the ESP.

#### **(ii) Fabric Filter Baghouse**

Directed air flow passes through tightly woven or felted fabric, causing PM in the flow to be collected on the fabric by sieving and other mechanisms. As PM collects on the filter, collection efficiency increases while pressure drop through the system increases. Bags are intermittently cleaned by shaking the bag, pulsing air through the bag, or temporarily reversing the airflow direction. Particulate-laden air must be able to be collected and ducted to the baghouse.

#### **(iii) Cooling Tower, Multiclone, and ESP Combination**

A multiclone system is an application where many small cyclones are operating in parallel. The small cyclones remove particulate by centrifugal and inertial forces, induced by forcing particulate-laden gas to change direction. This type of technology is a part of the group of air pollution controls collectively referred to as "precleaners," because they are often used to reduce the inlet loading of particulate matter to downstream collection devices by removing larger, abrasive particles.

The cyclones are used to control PM, and primarily particulate matter greater than 10 micrometers ( $\mu\text{m}$ ). However, there are high efficiency cyclones designed to be effective for PM less than or equal to 10  $\mu\text{m}$  and less than or equal to 2.5  $\mu\text{m}$  ( $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ). Although cyclones may be used to collect particles larger than 200  $\mu\text{m}$ , gravity settling chambers or simple momentum separators are usually satisfactory and less subject to

abrasion. The combination of a multiclone and an ESP can achieve a very high collection efficiency.

#### 4.5.2 Eliminate Technically Infeasible Options – Step 2

All of the control devices listed for the kiln have been successfully applied to many cement kilns with favorable results in controlling particulate matter.

Conclusion: These technologies are considered technically feasible for purposes of Step 2 in this BART analysis.

#### 4.5.3 Evaluate Control Effectiveness of Remaining PM<sub>10</sub> Control Technologies – Step 3

Table 4-7 lists available technologies with their respective efficiencies for controlling PM/PM<sub>10</sub> emissions from a long wet kiln.

**Table 4-7: Kiln PM/PM<sub>10</sub> Control Technology Effectiveness**

Control Option	Efficiency (%)
Proper Kiln Design and Operation with ESP (baseline)	99.9%
Fabric Filter Baghouse	99.9%
Cooling Tower, Multiclone, and ESP Combination	99.9%

Emissions from the kiln are currently controlled by an electrostatic precipitator (ESP). In December of 2004, MDEQ completed an analysis titled “Air Quality Technical Analysis Report for the Review of Submittals Supporting the Holcim (US) Inc. Tires Combustion Proposal.”

In Section 4.4, paragraph 6 of the analysis, MDEQ concluded:

*“Based on the above equation, the efficiency of a single field of the Holcim ESP would be greater than 99.9%. This calculation does not account for the variable including re-entrainment and rapping. The use of two fields in series provides additional particulate removal.”*

Because the ESP has an efficiency equal to the highest control available from the other listed control technologies, Holcim proposes that the current ESP control of PM/PM<sub>10</sub> emissions from the kiln is BART, with associated emission rate limits of 0.10 gr/dscf, and 0.77 lbs/ton of clinker produced.

## **4.6 BART Analysis for PM<sub>10</sub> from the Clinker Cooler**

### **4.6.1 Identify Available Particulate Control Technologies – Step 1**

EPA's RBLC describes many clinker cooler installations and lists their pollutant emission limits and the control technologies approved to achieve those limits. Another source of information regarding potentially applicable PM control technology for cement kilns is the EPA's AP-42 for Portland cement manufacturing (Chapter 11, Section 6). The following technologies were identified as potentially applicable for controlling particulate matter from the clinker cooler at a cement production facility:

- (i) Fabric Filter Baghouse (baseline)
- (ii) Electrostatic Precipitator (ESP),
- (iii) Gravel Bed Filter.

#### **Control Technology Description:**

##### **(i) Fabric Filter Baghouse (Baseline)**

Emissions from the clinker cooler are currently controlled by a fabric filter baghouse. Directed air flow passes through tightly woven or felted fabric, causing PM in the flow to be collected on the fabric by sieving and other mechanisms. As PM collects on the filter, collection efficiency increases while pressure drop through the system increases. Bags are intermittently cleaned by shaking the bag, pulsing air through the bag, or temporarily reversing the airflow direction. Particulate-laden air must be able to be collected and ducted to the baghouse.

##### **(ii) Electrostatic Precipitator**

An ESP uses electrical forces to move entrained particles onto a collection surface. To remove dust cake from the collection surface, the collection surface is periodically "rapped" by a variety of means to dislocate the particulate, which drops down into a hopper. Particulate-laden air must be able to be collected and ducted to the ESP.

##### **(iii) Gravel Bed Filter**

Gravel bed filters are commonly used to control particulate emissions from a clinker cooler. Generally, a cyclone is used to pre-clean the exhaust stream of larger particulate. The exhaust stream is then directed through a bed of gravel, commonly crushed quartz, which captures smaller particulate through agglomeration.

#### 4.6.2 Eliminate Technically Infeasible Options – Step 2

All of the control devices listed for the clinker cooler have been successfully applied in other installations.

Conclusion: These technologies are considered technically feasible for purposes of Step 2 in this BART analysis.

#### 4.6.3 Evaluate Control Effectiveness of Remaining PM<sub>10</sub> Control Technologies – Step 3

Table 4-8 lists available technologies with their respective efficiencies for controlling PM/PM<sub>10</sub> emissions from a clinker cooler.

**Table 4-8: Clinker Cooler PM/PM<sub>10</sub> Control Technology Effectiveness**

Control Option	Efficiency (%)
Fabric Filter Baghouse (baseline)	99.9%
Electrostatic Precipitator	99.9%
Gravel Bed Filter	95% (est.)

Emissions from the clinker cooler are currently controlled by a fabric filter baghouse.

Because the fabric filter baghouse has an efficiency equal to the highest control available from the other listed control technologies, Holcim proposes that the current emission limit and baghouse control of PM/PM<sub>10</sub> emissions from the clinker cooler are BART. No further analysis is needed.

#### 4.7 BART Analysis for PM<sub>10</sub> Emissions from Material Handling Systems

The facility includes systems for transporting, transferring, and storing limestone, coal, and finished cement product. Emissions associated with these activities occur as a result of transferring the material from one system to another. These transfers, referred to as “drop transfers,” occur, for example, when material is transferred from one conveyor to another or from a chute to a load-out truck.

Table 4-9 lists the 10 material transfer emission sources that will be considered in this BART analysis.

**Table 4-9: Listing of Material Transfer Emission Points**

<b>Source</b>	<b>Current Source Control</b>
005 – Xfer-convey-screen	Baghouse
010 – 013 Raw material silos 1-7	Baghouse
015 and 018 Coal and coke xfer, crush, store, (un)load & grinding	Baghouse
026 Cement kiln dust silo unload	Dustless Unloader and Baghouse
032a Clinker xfer to #2 finish mill	Baghouse
047 Cement load/unload at silos 14-25	Baghouse

**4.7.1 Identify Available Particulate Control Technologies – Step 1**

The following technologies were identified as potentially applicable for controlling particulate matter from raw materials and product handling in the cement manufacturing process:

- (i) Fabric Filter Baghouse (baseline),
- (ii) Electrostatic Precipitator (ESP),
- (iii) Enclosures, and
- (iv) Wet Suppression.

**Control Technology Description:**

**(i) Fabric Filter Baghouse**

The Holcim Trident plant currently utilizes baghouses to control PM emissions from the sources in Table 4-9. Directed air flow passes through tightly woven or felted fabric, causing PM in the flow to be collected on the fabric by sieving and other mechanisms. As PM collects on the filter, collection efficiency increases while pressure drop through the system increases. Bags are intermittently cleaned by shaking the bag, pulsing air through the bag, or temporarily reversing the airflow direction. Particulate-laden air must be able to be collected and ducted to the baghouse.

**(ii) Electrostatic Precipitator**

An ESP uses electrical forces to move entrained particles onto a collection surface. To remove duct cake from the collection surface, the collection surface is periodically “rapped” by a variety of means to dislocate the particulate, which drops down into a hopper. Particulate-laden air must be able to be collected and ducted to the ESP.

**(iii) Enclosures**

Enclosure technology employs structures or underground placement to shelter material from wind entrainment. Enclosures can either fully or partially surround the source.

**(iv) Wet Suppression**

A fogging water spray adds water with or without surfactant to material. Emissions are prevented through agglomerate formation by combining small dust particles with larger aggregate or with liquid droplets. Water retained by sprayed material prevents emissions from storage piles and downstream transfers in a similar manner.

**4.7.2 Eliminate Technically Infeasible Options – Step 2**

All of the control methods listed for materials transfers have been successfully applied to many industries with favorable results in controlling particulate matter.

Conclusion: These technologies are considered technically feasible for purposes of Step 2 in this BART analysis.

**4.7.3 Evaluate Control Effectiveness of Remaining PM<sub>10</sub> Control Technologies – Step 3**

Table 4-10 lists available technologies with their respective efficiencies for controlling PM/PM<sub>10</sub> emissions from the BART-eligible materials transfers.

**Table 4-10: Material Transfer PM/PM<sub>10</sub> Control Technology Effectiveness**

<b>Control Option</b>	<b>Efficiency (%)</b>
Fabric Filter Baghouse (baseline)	99.9%
Electrostatic Precipitator	99.9%
Enclosures	90%
Water Suppression	50-90%

All of the listed PM/PM<sub>10</sub> emission sources from the materials handling analyzed for BART are currently controlled by fabric filter baghouses. The fabric filter baghouses are equivalent to the highest control efficiency of any of the control devices analyzed; therefore, Holcim proposes that the current baghouse control of PM/PM<sub>10</sub> emissions from the materials transfers is BART. No further analysis is needed.

**APPENDIX A: EPA LETTER TO HOLCIM**

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**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
REGION 8**

1595 Wynkoop Street  
DENVER, CO 80202-1129  
Phone 800-227-8917  
<http://www.epa.gov/region08>

**FEB 28 2007**

Ref: 8P-AR

Ned Pettit  
Holcim (US), Inc.  
4070 Trident Road  
Three Forks, MT 59752

Re: Results of "Subject to" Visibility Modeling for Best Available Retrofit Technology (BART) and Request to Conduct a BART Analysis for BART-Eligible Units at Holcim (US), Inc.

Dear Mr. Pettit:

On June 19, 2006, EPA received a letter from the Montana Department of Environmental Quality that stated it was withdrawing its efforts to meet the requirements of the Regional Haze Rule (RHR) specified at 40 CFR 51.308. On September 27, 2006, EPA Region 8 sent a letter notifying you that we would be conducting modeling to determine which sources in Montana are "subject to" the Best Available Retrofit Technology (BART) requirements in the RHR as part of our effort to address the requirements of that rule. Since it was determined that Holcim (US), Inc. (Holcim) was BART eligible, we informed you that Holcim would be included in the modeling and asked you to certify the data that would be used for this modeling.

EPA Region 8, with the assistance of the Western Regional Air Partnership (WRAP), has now completed the visibility modeling for determining those Montana sources subject to BART. Based on the modeling, EPA Region 8 has determined that your facility is subject to BART. Accordingly, we are requesting that you submit a BART Analysis for Holcim within 90 days of this letter, as explained below.

In modeling Holcim's visibility impacts, EPA Region 8 followed the approach for determining if a source is subject to BART, including the specifics on how the modeling should be performed, set out in the final RHR and EPA's "Guidelines for Best Available Retrofit Technology Determinations" (BART Guidelines). See 70 FR 39104, July 6, 2005. The BART Guidelines can be found at Appendix Y to 40 CFR Part 51. EPA Region 8's visibility modeling also generally followed the protocol outlined in the document "Draft Calpuff BART Modeling Protocol for Federal Mandatory Class 1 Areas" (Montana Department of Environmental Quality, September 2006). An electronic copy of this protocol is located on EPA Region 8's website at <http://www.epa.gov/region8/air/mtregionalhaze.html>. Where necessary, we made slight variations to the protocol, such as instances where meteorological data was not available for a certain site.

States (or EPA) have several options for determining whether a source is subject to BART, including the use of dispersion modeling to determine whether an individual source may be reasonably anticipated to cause or contribute to any visibility impairment in any Class I area. When dispersion modeling is used, part of the process of determining whether a source is subject to BART is the selection of a deciview threshold against which to measure the visibility impact of a source. For its analysis of Montana sources, EPA Region 8 has established a threshold of 0.5 deciviews as the appropriate threshold based on the number and distribution of sources impacting Class I areas in and around Montana. If dispersion modeling predicts that a source will have visibility impacts of 0.5 deciviews or more at a Class I area on the 98<sup>th</sup> percentile of values, EPA Region 8 considers that source to be subject to BART. Further information regarding this approach to determining whether a source is subject to BART can be found in section III.A of the BART Guidelines.

For Holcim, the modeling results show a maximum 98<sup>th</sup> percentile impact within a Class I area of 1.05 deciviews, which exceeds the threshold of 0.5 deciviews. Since Holcim exceeds the 0.5 deciview threshold, and thus may reasonably be anticipated to cause or contribute to visibility impairment in one or more Class I areas, EPA Region 8 has concluded that Holcim is subject to BART.

A summary of the BART modeling results is enclosed. The enclosure provides a summary of the 98<sup>th</sup> percentile predictions for the three years modeled for Holcim at all federal Class I areas in the vicinity of the plant. More detailed modeling results, including the electronic CALPUFF/CALMET files, are available on the WRAP website at <http://pah.cert.ucr.edu/aqm/308/bart.shtml>.

Because Holcim is subject to BART, EPA Region 8 is requesting that Holcim conduct a BART engineering analysis on the emission units specified on the enclosed spreadsheet and submit the analysis to our office. One of the requirements of the RHR is that each regional haze implementation plan contain enforceable emission limits for eligible stationary sources based on BART. The BART analysis will be used to identify the best system of continuous emissions reduction and corresponding emission limits for each visibility impairing pollutant that is emitted by the Holcim facility. The Clean Air Act and the RHR require that BART be established on a case-by-case basis taking into account the available retrofit control options, the costs of compliance, the energy and non-air quality impacts of compliance, any pollution control equipment in use at the source, the remaining useful life of the source, and the degree of improvement in visibility which may reasonably be anticipated to result from the use of the technology.

For purposes of the Regional Haze FIP for Montana, EPA Region 8 is intending to follow its BART Guidelines from 40 CFR Part 51, Appendix Y. The BART Guidelines are a statement of EPA's thinking on how best to meet the requirements of BART in the CAA and RHR. Thus, in conducting the Holcim BART engineering analysis, you will need to follow the five-step

BART analysis process identified in Appendix Y, section IV.D, in order to identify an appropriate BART emission limit. The five steps are:

- Identify all available retrofit control technologies
- Eliminate technically-infeasible options
- Evaluate the control effectiveness of remaining control technologies
- Evaluate impacts and document the results
- Evaluate visibility impacts

For each of these five steps, the BART Guidelines provide detailed guidance for producing an acceptable BART analysis. In addition, your BART analysis should follow other EPA guidance and policies related to BART.

Based on the above analysis, you will then identify what you believe is BART for your facility. You will need to provide a justification for adopting the technology and the emission limits that you select as the best level of control, including an explanation of how the BART factors (costs of compliance, energy impacts, non-air quality environmental impacts, remaining useful life of the facility, and visibility improvements) were considered (or weighted) in selecting one technically feasible control option over the others.

Your BART analysis should include proposed emission limits for each BART-eligible unit at your facility and for each pollutant subject to BART. For Holcim we have identified sulfur dioxide, nitrogen oxides, and particulate matter as the pollutants that need to be analyzed.

Once you submit the BART analysis and related documentation to EPA Region 8, we will review the BART analysis and will notify you of our preliminary BART determination. We will provide an opportunity for you to respond to our preliminary BART determination before making a final determination. Our final determination will be included as part of our Regional Haze FIP for Montana, which will be adopted through notice and comment rulemaking.

In order to meet regulatory schedules and coordinate with other states, EPA Region 8 is requesting that you submit your BART analysis to our offices within 90 days from the date of this letter. We understand this is a complicated endeavor, and we are available to answer any questions that you may have on the RHR, the BART Guidelines, or the BART analysis. We will assist you in any way we can and look forward to working with you.

If you choose not to perform or are unable to perform an engineering analysis for Holcim, EPA will perform the BART engineering analysis. If you will not be performing and submitting the BART analysis, we ask that you contact us within 30 days from the date of this letter so that we may begin the process of developing the analysis.

Holcim may assert a business confidentiality claim covering part or all of the information requested by this letter, in the manner described at 40 CFR 2.203(b). If no such claim

accompanies the information when it is received by EPA, EPA may make the information available to the public without further notice to Holcim. Information subject to a business confidentiality claim will be disclosed by EPA only to the extent, and by means of the procedures, set forth at 40 CFR Part 2, Subpart B.

Once again, we look forward to working with you. If you have any questions regarding the modeling results, please contact Kevin Golden of my staff at (303) 312-6442. For questions related to development of the BART analysis, please contact Laurel Dygowski at (303) 312-6144.

Sincerely,



Stephen S. Tuber  
Assistant Regional Administrator  
Office of Partnerships and Regulatory Assistance

Enclosure



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Summary of Calpuff Modeling Results for Holcim (US) Inc. Trident Plant

Class / Area	Minimum Distance (km)	98th Percentile for each Year			98 <sup>th</sup> 3 Year Average	Max Delta-dv (dv)	99 <sup>th</sup> (dv)	98 <sup>th</sup> (dv)	Days > 0.5 dv
		2001	2002	2003					
yell	100	0.33	0.55	0.55	0.48	1.91	0.67	0.52	22
gamo	101	1.05	0.55	0.70	0.77	2.77	1.01	0.61	33
anac	132	0.25	0.21	0.20	0.22	0.76	0.36	0.24	8
redr	141	0.16	0.26	0.16	0.19	1.15	0.36	0.18	6
scap	154	0.28	0.28	0.21	0.26	1.51	0.57	0.28	11
noab	157	0.22	0.29	0.45	0.32	1.76	0.45	0.30	9
boma	189	0.28	0.25	0.12	0.22	1.38	0.41	0.24	9
wash	202	0.07	0.09	0.11	0.09	0.36	0.16	0.10	0
teto	214	0.04	0.07	0.08	0.06	0.25	0.10	0.07	0
selw	217	0.10	0.18	0.15	0.14	1.72	0.24	0.15	2
mimo	230	0.12	0.12	0.08	0.11	1.54	0.20	0.12	7
glac	298	0.12	0.09	0.05	0.09	0.57	0.16	0.11	1

## **APPENDIX B: VISIBILITY IMPACTS MODELING**

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# VISIBILITY IMPACTS

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## 1.1 Introduction and Summary

Holcim has concurred with the initial EPA BART analysis that the Trident facility is a BART-eligible source. The following sections detail the modeling analysis that Bison performed on behalf of Holcim to comply with the intent of 40 CFR 51, Appendix Y. This document describes the methodologies and results of those analyses.

In conducting the BART modeling analyses, Bison closely followed the Montana Department of Environmental Quality's (MDEQ) modeling protocol for regional modeling in support of the BART program, entitled *State of Montana Draft CALPUFF BART Modeling Protocol For Federal Mandatory Class I Areas*, September 2006 Draft ("Montana BART protocol"). The analysis also relied on guidance in the *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report for Modeling Long Range Transport Impacts* (EPA, 1998), and the *Federal Land Managers' Air Quality Related Values Workgroup (FLAG) Phase I Report*, December 2000 ("FLAG document").

The BART modeling analysis specifically requires demonstrations of impacts to visibility at surrounding mandatory federal Class I areas. The mandatory federal Class I areas evaluated are:

- Yellowstone National Park, and
- Gates of the Mountains Wilderness Area.

Visibility Impacts: The visibility impacts analysis began with the permitted emissions from the cement kiln and clinker cooler located at the Trident facility. These impacts were developed to establish a visibility baseline to analyze what effects, if any, different control technologies or operating practices had on visibility at the surrounding Class I areas.

The visibility impacts analyses included the appropriate potential NO<sub>x</sub>, SO<sub>2</sub>, and PM<sub>10</sub> emissions from the sources modeled since all three pollutants contribute to visibility impairment.

## 1.2 Model Selection

Selection of the appropriate dispersion model for assessing visibility impacts in Class I areas is typically based on the distance from the emitting source to the Class I area. Appendix W in 40 CFR Part 51 recommends different models for different applications and identifies appropriate models for short- and long-range impacts.

Since EPA has already established CALPUFF for the visibility analysis, the CALPUFF model was used in the present analyses of Class I visibility impacts.

CALPUFF is a non-steady-state Lagrangian dispersion model that simulates pollutant releases as a continuous series of “puffs.” It includes algorithms for building downwash, pollutant removal due to wet scavenging and dry deposition, chemical transformation, and plume fumigation. It is supported by two primary sub-programs, CALMET and CALPOST. CALMET is used in refined analyses to create three-dimensional wind fields based on multiple sources of geophysical and meteorological data. The output of the CALPUFF model consists of binary data files with information on pollutant concentrations, wet and dry flux rates, and visibility parameters. CALPOST processes these data based on specified input parameters, and reports calculated impact values.

The present CALPUFF analysis utilized the most current version of the following primary programs and pre- and post-processors obtained from the CALPUFF developer, Atmospheric Studies Group (ASG) at:

<http://www.src.com/calpuff/calpuff1.htm>.

#### **Geophysical Data Processors**

- TERREL (Version 3.311, Level 030709)
- CTGCOMP
- CTGPROC (Version 2.42, Level 030709)
- MAKEGEO (Version 2.22, Level 030709)

#### **Meteorological Preprocessors**

- SMERGE (Version 5.31a, Level 040706)
- PTRACT
- PMERGE (Version 5.31, Level 030528)
- READ62 (Version 5.52, Level 040716)

#### **Main Models**

- CALMET (Version 6.211, Level 060414)
- CALPUFF (Version 6.112, Level 060412)

#### **Postprocessors**

- CALPOST (Version 6.131, Level 060410)
- PRTMET
- CALSUM
- POSTUTIL

The version and level identifiers for the major modules used for this project are identified above. Electronic executable files for the primary modules and the primary electronic input and output files associated with this analysis are available upon request.

### **1.3 Regional Modeling Domain**

The regional modeling domain was defined to follow the Montana Protocol. The modeling domain is defined in a Lambert Conformal Conic (LCC) system. The LCC coordinate system for this project has a projection origin at 44.25° N and 109.5° W and

matching parallels of latitude of 44.0° and 49.0° N. The coordinates of the southwest corner of the domain are 0.000 km easting and 0.000 km northing. This varies from the WRAP modeling domain which defined matching parallels of latitude of 45.0° and 49.0° N.

## **1.4 CALMET**

CALMET, the meteorological preprocessor for CALPUFF, was used to compile and process land use data, terrain data, and meteorological data for use in the CALPUFF model program. The CALMET output files defined gridded fields of wind speed, wind direction, mixing heights, stabilities, micrometeorological parameters, and precipitation – all parameters required for input to the CALPUFF dispersion model. The following sections provide a brief description of each of these data sets.

### **1.4.1 Land Use Data**

CALMET uses specific land use data developed by the U.S. Geological Survey (USGS)<sup>1</sup>. The data files used for this project were 1:250,000-scale files. Each land use cell, typically 200 meters square, is assigned a land use code. Using several data processing programs provided by ASG, the land use data were processed and combined with other geophysical data into a single data set for input to the CALMET model.

### **1.4.2 Terrain Data**

CALMET uses USGS 1:250k Digital Elevation Models (DEMs) to determine the terrain elevation in the model domain. The terrain data is preprocessed into a data set recognized by CALMET and used to help create the CALMET output file. Terrain data obtained from [www.webmet.com](http://www.webmet.com) were used to create the appropriate files for CALMET.

### **1.4.3 Meteorological Data**

CALMET output files representing meteorological data for the 2001, 2002, and 2003 calendar years were prepared for the analysis in accordance with the Montana BART protocol. Input meteorological data consisted of Mesoscale Model (MM) meteorological data, observed hourly surface data, upper air rawinsonde data, and hourly precipitation data.

#### ***Mesoscale Model Data***

The MM meteorological data for the 2001, 2002, and 2003 calendar years obtained from the Western Regional Air Partnership (WRAP) are available at the following website: <http://pah.cert.ucr.edu/aqm/308/bart.shtml>. These data are generated by Pennsylvania State University/National Center for Atmospheric Research mesoscale models. The mesoscale models are limited-area, nonhydrostatic or hydrostatic, terrain-following sigma-coordinate models designed to simulate or predict mesoscale and

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<sup>1</sup> Available for download from the USGS Earth Resources Observation and Science (EROS) web site.

regional-scale atmospheric circulation. The data are used as a basis for generating an “initial guess field” of multilayer wind vectors in CALMET. The meteorological data for all three years are in the MM5 format. They reflect a spatial resolution of 36 km.

### **Surface Data**

Hourly observed surface data for 2001, 2002, and 2003 were also obtained from the WRAP internet site. In accordance with the Montana BART protocol, National Weather Service (NWS) hourly surface data for 39 stations for 2001 and 36 stations for 2002 and 2003 were processed in CALMET. The data files were provided in the SMERGE format and were ready for input into CALMET.

Surface data from the following locations were used for the CALMET analysis:

- Badger Peak, MT (2001 only)
- Billings, MT
- Bismarck, ND
- Boise, ID
- Bozeman, MT
- Butte, MT
- Casper, WY
- Coeur d’Alene, ID
- Cut Bank, MT
- Dickinson, ND
- Dillon, MT
- Estevan, SK
- Havre, MT
- Kalispell, MT
- Garfield Peak, MT (2001 only)
- Glacier National Park, MT
- Glasgow, MT
- Great Falls, MT
- Helena, MT
- Havre, MT
- Lander, WY
- Lewistown, MT
- Livingston, MT
- Medicine Hat, AB
- Miles City, MT
- Minot, ND
- Missoula, MT
- Morningstar, MT (2001 only)
- Peabody Coal, MT
- Pocatello, ID
- Rapid City, SD

- Rexburg, ID
- Riverton, WY
- Salmon, ID
- Sheridan, WY
- Spokane, WA
- Spring Creek Coal, MT
- Theodore Roosevelt National Park, ND
- Williston, ND
- Yellowstone National Park, WY

### ***Upper Air Data***

The Montana Protocol included the use of upper air data; however, the EPA Protocol specified that upper air data would not be used, and consequently the WRAP modeling omitted this data. Bison followed the Montana modeling protocol and included the upper air station data in the BART modeling analysis.

Upper air rawinsonde data collected by seven NWS stations were obtained from the rawinsonde data repository maintained by NOAA at <http://raob.fsl.noaa.gov/>. The data were obtained in the standard FSL data format for use in the CALMET system. The seven NWS upper air rawinsonde locations used for this project are:

- Bismarck, ND
- Boise, ID
- Glasgow, MT
- Great Falls, MT
- Rapid City, SD
- Riverton, WY
- Spokane, WA

Upper air data substitution and extrapolation were accomplished as needed according to ASG's FAQ 2.3.4, which recommends temporal substitution (for example, substituting an afternoon sounding with the previous or succeeding afternoon sounding) or spatial substitution from a nearby location if soundings are missing. For in-sounding values flagged by READ62, the data values were corrected using an in-house computer program (Fix6201.exe) developed for this purpose. Nearly all of these flagged values were due to either (1) the pressure remaining constant or rising with height, or (2) the elevation remaining constant or decreasing with height. These were corrected by the in-house program by changing the flagged values by a small amount so that the pressure decreased with height or the elevation increased with height as appropriate. For spatial substitutions, another in-house program (AdjUa.exe) was used to adjust for the difference in elevation between the two locations. Temporal substitutions were accomplished manually using a text editor. All raw and processed data and data processing algorithms are available upon request.

## ***Precipitation Data***

The use of precipitation data was referenced in the Montana and EPA Modeling Protocols. The WRAP modeling omitted this precipitation data. Bison followed the modeling protocols and included the precipitation station data in the BART modeling analysis.

Hourly precipitation data in NCDC's TD-3240 format were obtained from the data set developed by MDEQ for their BART modeling analysis effort. All precipitation stations located within the CALMET modeling domain were extracted from the data set and were used in the CALMET analysis. A total of 286 stations were selected for each of the three modeled years. A complete list of precipitation stations is included as an attachment to this report.

No precipitation data interpolation or substitution was required for this project.

## **1.5 Ozone**

The ozone data provided on the WRAP website contained all the ozone sites in the United States and for the year 2002 the number of ozone sites exceeded the number of stations allowed in the CALPUFF model. Bison obtained ozone data for the following three ozone stations in the modeling domain:

- Yellowstone National Park
- Glacier National Park
- Theodore Roosevelt National Park

## **1.6 CALPUFF**

CALPUFF applies mathematical algorithms to calculate pollutant concentrations at Class I receptors. CALPUFF requires CALMET output files, source emissions, and receptor grids to model Class I impacts.

### **1.6.1 CALPUFF Parameters**

CALPUFF was run in the refined mode using the MESOPUFF III chemical transformation scheme and dry and wet deposition calculations. Model settings were based on recommendations found in the Montana BART protocol. The table below summarizes the model control file settings used for this analysis. Complete CALPUFF input files will be provided upon request.

## CALPUFF Model Control File Settings

Model Parameter/Option	Value
Number of chemical species	9
Number of chemical species emitted	7
Vertical distribution near field	Gaussian
Terrain adjustment method	Partial plume path adjustment
Subgrid-scale complex terrain	Not modeled
Slug model	Not used
Transitional plume rise	Yes
Stack tip downwash	Yes
Vertical wind shear	Yes
Puff splitting	Yes
Chemical mechanism	MESOPUFF II scheme
Wet removal	Yes
Dry deposition	Yes
Dispersion coefficient method	PG dispersion coefficients for rural areas
Partial plume penetration – elevated inversion	Yes
PDF used under convective conditions	No
CSPEC	SO <sub>2</sub> , SO <sub>4</sub> , NO <sub>x</sub> , HNO <sub>3</sub> , NO <sub>3</sub> , SOA, EC, PMC, PMF
Chemical parameters – dry gas deposition	Default
Size parameters – dry particle deposition	Default
Reference cuticle resistance (RCUTR)	30 s/cm
Reference ground resistance (RGR)	10 s/cm
Reference pollutant reactivity (REACTR)	8
Number of particle-size intervals (NINT)	9
Vegetation state in un-irrigated areas (IVEG)	1
Wet deposition parameters	Default
Ozone data input option	0
Background ozone concentration	Ozone data: Yellowstone NP, Glacier NP, Theodore Roosevelt NP
Background ammonia concentration (values specific to each Class I area analyzed)	1.22, 1.23, 1.6, 1.94, 2.29, 1.63, 1.65, 1.69, 0.98, 1.04, 1.37, 1.06 ppb
SYTDEP	550 m
MHFTSZ	0
JSUP	5
XSAMLEN	1.0 grid units
MXNEW	99
MXSAM	99
Maximum mixing height	3,000 m
Minimum mixing height	50 m
NSPLIT	2
IRESPLIT	Hour 17-22 = 1
ZISPLIT	100 m
ROLDMAX	0.25

Notes:

ppb = parts per billion

s/cm = seconds per centimeter

## 1.6.2 Receptors

The Air Resources Division (ARD) of the National Park Service (NPS) has developed a database of modeling receptors for all federal Class I areas in the United States. ARD has also developed a file conversion program to convert the data from latitude/longitude to either Lambert Conformal or UTM coordinates. Receptor grids for each federally mandated Class I area of concern were developed using the ARD data files converted to the appropriate LCC coordinate system.

## 1.6.3 Modeled Sources - General

The visibility analyses included potential emissions for the Holcim BART-eligible sources and the projected emission reductions for the applicable pollutant controls. The BART-eligible sources that were included in the analysis are:

- Cement Kiln
- Clinker Cooler

## 1.6.4 Modeled Sources - Physical Parameters

The physical parameters for each of the sources included in the models remained consistent with WRAP model inputs.

## 1.6.5 Modeled Sources – Baseline Emission Rates

Class I visibility impacts demonstrations were performed using the maximum actual emission rates for each modeled eligible source. These emission rates were obtained from Holcim's current air permits. The following table provides the emission rates used to demonstrate the BART impacts for regional haze:

**Baseline Modeled Emission Rates**

Source ID	NO <sub>x</sub> (lb/hr)	SO <sub>2</sub> (lb/hr)	PM <sub>10</sub> (lb/hr)
Kiln	1568	340	37.36
Clinker Cooler	-	-	45.82

To accurately demonstrate the changes in visibility impacts at surrounding mandatory Class I areas, potential kiln and clinker cooler emissions of NO<sub>x</sub>, SO<sub>2</sub>, and PM<sub>10</sub> emission rates were entered into the CALPUFF models to establish a baseline case for comparison. The current permit limits NO<sub>x</sub> emissions from the kiln to 1568 lb/hr on an hourly average basis. SO<sub>2</sub> permit limits are 124 lb/hr on a 30-day rolling average; however, the 340 lb/hr highest rate was used in the modeling to be consistent with the WRAP model inputs. The potential hourly kiln filterable PM<sub>10</sub> emissions of 37.36 lb/hr are based on the permit limit of 0.77 lb/ton of clinker and the annual clinker production

limit of 425,000 tons of clinker per year. The clinker cooler filterable PM<sub>10</sub> emissions of 45.82 lb/hr are limited by the process weight rule ( $E=55.0 \cdot P^{0.11-40}$ ) and 500,000 tons of clinker per year.

Including particulate matter emissions in the model is not as straightforward as including SO<sub>2</sub> or NO<sub>x</sub> emissions. Particulate matter can be present in different forms, or species, and each species can affect visibility to a different degree. The NPS has provided several spreadsheet templates that speciate PM<sub>10</sub> emissions resulting from various combustion sources.<sup>2</sup> These spreadsheets allow generalized speciation of the PM<sub>10</sub> for a specific source and as such do not necessarily accurately reflect potential speciated emissions. WRAP did not document the speciation of PM<sub>10</sub> used in the initial BART determination model. Therefore, Bison relied on the NPS speciation templates.

The following analysis was conducted to develop a source-specific PM<sub>10</sub> speciation for visibility impacts modeling. First, the following general distribution of PM<sub>10</sub> species was generated using an NPS spreadsheet for dry-bottom PC-fired boilers with flue gas desulfurization and fabric filter baghouse emissions controls.

### Guideline PM<sub>10</sub> Speciation

Species	NPS Kiln Distribution	NPS Clinker Cooler Distribution
Coarse (PMC) <sup>(a)</sup>	19.6%	39.6%
Fine Soil (PMF) <sup>(b)</sup>	57.4%	42.4%
Fine Elemental Carbon (EC)	2.2%	1.6%
CPM IOR (SO <sub>4</sub> ) <sup>(c)</sup>	18.3%	14.4%
CPM OR (SOA) <sup>(d)</sup>	2.5%	2.0%
Total:	100.0%	100.0%

(a) PMC = Particulate Matter, Coarse (filterable PM > 2.5 microns and ≤ 10 microns)

(b) PMF = Particulate Matter, Fine (filterable PM ≤ 2.5 microns)

(c) IOR = Inorganic

(d) CPM = Condensable Particulate Matter; OR = Organic; SOA = Secondary Organic Aerosols

Applying these percentages to the maximum PM<sub>10</sub> emission rate of 31.3 lb/hr, less estimated H<sub>2</sub>SO<sub>4</sub> emissions, and adding back the estimated SO<sub>4</sub> emission rate yields the following particulate species distribution.

<sup>2</sup> See web address: <http://www2.nature.nps.gov/air/Permits/ect/index.cfm>

### Final PM<sub>10</sub> Speciation

Species	Kiln Modeled PM <sub>10</sub> Speciation (lb/hr)	Clinker Cooler Modeled PM <sub>10</sub> Speciation (lb/hr)
Coarse (PMC)	9.2	21.7
Fine Soil (PMF)	27.1	23.2
Fine EC	1.0	0.9
CPM IOR (SO <sub>4</sub> )	8.6	7.9
CPM OR (SOA)	1.2	1.1
Total:	47.2	54.8

#### 1.6.6 Modeled Sources – BART Controlled Emission Rates

The BART modeling analysis required that the baseline emissions be adjusted to reflect the predicted emission reductions for each pollutant. The following table shows the proposed emissions used in this second step in the BART modeling analysis.

#### BART Controlled Modeled Emission Rates

Source ID	NO <sub>x</sub> (lb/hr)	Percent NO <sub>x</sub> Reduction	SO <sub>2</sub> (lb/hr)	Percent SO <sub>2</sub> Reduction	PM <sub>10</sub> (lb/hr)	Percent PM <sub>10</sub> Reduction
Kiln	784	50%	340	0%	37.36	0%
Clinker Cooler	-	-	-		45.82	0%

### 1.7 CALPOST

Data generated by CALPUFF was entered into the CALPOST program to summarize peak Class I visibility impacts as required. For the visibility analysis, CALPOST used modeled sulfate, nitrate, and PM<sub>10</sub> concentration data to determine the light-absorbing and light-scattering effects resulting from the project's emissions. The method recommended and used for calculating light extinction was "Method 6: Compute extinction from speciated particulate matter measurements." The background extinction coefficients were calculated based on the annual relative humidity factors and data presented in Section 6.1 and Appendices C and D of the Montana BART Protocol. Inputs to CALPOST for visibility processing are summarized in the following table. The attached CD-ROM contains the CALPOST input files.

## CALPOST Visibility Control File Settings

CALPOST Parameter/Option	Value
Maximum relative humidity (RHMAX)	95%
Included species	Sulfate, nitrate, coarse particulate (as PM <sub>10</sub> ), and fine particulate (as PM <sub>2.5</sub> )
Coarse particulate extinction efficiency	0.6 (l/Mm per µg/m <sup>3</sup> )
Fine particulate extinction efficiency	1.0 (l/Mm per µg/m <sup>3</sup> )
Ammonium sulfate extinction efficiency	3.0 (l/Mm per µg/m <sup>3</sup> )
Ammonium nitrate extinction efficiency	3.0 (l/Mm per µg/m <sup>3</sup> )
Organic carbon extinction efficiency	4.0 (l/Mm per µg/m <sup>3</sup> )
Soil extinction efficiency	1.0 (l/Mm per µg/m <sup>3</sup> )
Elemental carbon extinction efficiency	10.0 (l/Mm per µg/m <sup>3</sup> )
Method used for background light extinction	MVISBK = 6
Relative humidity	From *.VIS Files
Background extinction coefficients, SO <sub>4</sub>	0.120
Background extinction coefficients, NO <sub>3</sub>	0.100
Background extinction coefficients, PMC	3.006
Background extinction coefficients, OC	0.471
Background extinction coefficients, soil	0.501
Background extinction coefficients, EC	0.2
Extinction due to Rayleigh scattering	10.0

Notes:

NO<sub>3</sub> = Nitrate

## 1.8 Modeling Results

### 1.8.1 Regional Haze (Visibility)

Impacts to natural background visibility, expressed in terms of percentage change in 24-hour average background extinction ( $\Delta B_{ex}$ ) were calculated by CALPOST. The guidelines also reference 40 CFR §51.301(a) in asserting that determinations must be made on a "...case-by-case basis taking into account the geographic extent, intensity, duration, frequency and time of visibility impairments...." The 98<sup>th</sup> percentile impact results are summarized in the following table.

## Summary of BART Selections and Visibility Impacts

Pollutant	Control Technology	Approximate Control Efficiency	Emission Rate (lb/hour)	Gates of the Mountains		
				Modeled Deciviews	Modeled Deciview Improvement (above baseline)	% Improvement in Visibility (from baseline)
SO <sub>2</sub>	No Additional Controls	0%	340	1.56	0.00	0%
NO <sub>x</sub>	Process Alterations (install fixed inlet on clinker cooler)	3%	1,521	1.49	0.04	3%
	Low-NO <sub>x</sub> Burner	17%	1,301	1.32	0.21	14%
	Total NO <sub>x</sub> Improvement:	20%	1,254	1.28	0.24	17%
PM <sub>10</sub>	No Additional Controls	0%	23	1.56	0.00	0%

## **APPENDIX C: BART COST ANALYSES**

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## Appendix C Wet Scrubber Cost Analysis

Holcim Inc.  
Trident Facility  
BART Analysis  
Wet SO<sub>2</sub> Scrubber

Referenced: Estimating Costs of Air Pollution Control, Table 2.2, Venturi Scrubber - William M. Vatavek  
1998 \$

Cost Item	Factor	
<b>DIRECT COSTS</b>		
<b>Purchased equipment costs</b>		
Control device (Assumed)		\$14,500,000
Auxiliary equipment (Assumed)		\$3,625,000
	(A)	<b>\$18,125,000</b>
Instrumentation	0.10(A)	\$1,812,500
Sales taxes	0.03(A)	\$543,750
Freight	0.05(A)	\$906,250
	(B) =	<b>\$21,387,500</b>
<b>Purchased equipment cost, PEC</b>		
<b>DIRECT INSTALLATION COSTS</b>		
Foundations & supports	0.06(B)	\$1,283,250
Handling & erection	0.40(B)	\$8,555,000
Electrical	0.01(B)	\$213,875
Piping	0.05(B)	\$1,069,375
Insulation for ductwork	0.03(B)	\$641,625
Painting	0.01(B)	\$213,875
		<b>\$11,977,000</b>
	Retrofit Installation = DI x 1.5 =	<b>\$17,965,500</b>
Site preparation	As required, SP	
Buildings	As required, Bldg.	
	<b>Total Direct Costs, DC</b>	<b>\$39,353,000</b>
<b>INDIRECT INSTALLATION COSTS, IIC</b>		
Engineering	0.10(B)	\$2,138,750
Construction and Field Expenses	0.10(B)	\$2,138,750
Contractor fees	0.10(B)	\$2,138,750
Start-up	0.01(B)	\$213,875
Performance test	0.01(B)	\$213,875
Contingencies	0.03(B)	\$641,625
		<b>\$7,485,625</b>
	Retrofit Installation = IIC x 1.5 =	<b>\$11,228,438</b>
		<b>\$50,581,438</b>
<b>Total Capital Investment = DC + IIC</b>		

Cost Item	Wet SO <sub>2</sub> Scrubber Cost
<b>DIRECT ANNUAL COSTS</b>	
<b>Operating Labor</b>	
Operator	3285 man hrs per year <sup>a</sup> \$20.00 /hr = \$65,700
Supervisor	15% of operator = \$9,855
<b>Maintenance</b>	
Labor	1643 man hrs per year <sup>b</sup> \$20.00 /hr = \$32,850
<b>Utilities (Assumed)</b>	
Electricity & Water = 10% of Capital Cost	\$5,058,144
Waste Disposal	74 ton/yr <sup>c</sup> \$25 /ton = \$1,851
<sup>c</sup> Note: 4 gr/ft <sup>3</sup> x 1 lb/7,000 gr x 500 acfm x 60 min/hr x 8,640 hr/yr x 1 ton/2,000 lb = ton/yr	
	<b>\$5,168,400</b>
<b>Total Direct Annual Costs, DAC</b>	
<b>INDIRECT ANNUAL COSTS (IC)</b>	
Overhead (60% of total operating & maintenance costs)	\$65,043
Administrative Charges	2% of TCI = \$1,011,629
Property Taxes	1% of TCI = \$505,814
Insurance	1% of TCI = \$505,814
Capital Recovery Factor (10 yrs at 7%)	0.142 = \$7,182,564
	<b>\$50,581,438</b>
	<b>\$19,607,665</b>
<b>TOTAL ANNUAL COST</b>	

## Appendix C SDA Cost Analysis

Holcim Inc.  
Trident Facility  
BART Analysis  
Spray Dry Absorber

Referenced: Estimating Costs of Air Pollution Control, Table 2.2, Venturi Scrubber - William M. Vatawuk  
1998 \$

Cost Item	Factor	
<b>DIRECT COSTS</b>		
<b>Purchased equipment costs</b>		
FDA + Auxiliary equipment (Assumed)	(A)	\$10,000,000
Instrumentation	0.10(A)	\$1,000,000
Sales taxes	0.03(A)	\$300,000
Freight	0.05(A)	\$500,000
<b>Purchased equipment cost, PEC</b>	(B) =	<b>\$11,800,000</b>
<b>DIRECT INSTALLATION COSTS</b>		
Foundations & supports	0.08(B)	\$944,000
Handling & erection	0.14(B)	\$1,652,000
Electrical	0.04(B)	\$472,000
Piping	0.02(B)	\$236,000
Insulation for ductwork	0.01(B)	\$118,000
Painting	0.01(B)	\$118,000
<b>Direct installation costs</b>		<b>\$3,540,000</b>
	Retrofit Installation = DI x 1.5 multiplier =	<b>\$5,310,000</b>
Site preparation	As required, SP	
Buildings	As required, Bldg.	
<b>Total Direct Costs, DC</b>		<b>\$17,110,000</b>
<b>INDIRECT INSTALLATION COSTS, IIC</b>		
Engineering	0.10(B)	\$1,180,000
Construction and Field Expenses	0.05(B)	\$590,000
Contractor fees	0.10(B)	\$1,180,000
Start-up	0.02(B)	\$236,000
Performance test	0.01(B)	\$118,000
Contingencies	0.03(B)	\$354,000
<b>Total Indirect Costs, IIC</b>		<b>\$3,658,000</b>
	Retrofit Installation = IIC x 1.5 multiplier =	<b>\$5,487,000</b>
<b>Total Capital Investment = DC + IIC</b>		<b>\$22,597,000</b>

Cost Item	Spray Dry Absorber Cost
<b>DIRECT ANNUAL COSTS</b>	
<b>Operating Labor</b>	
Operator	540 man hrs per year <sup>a</sup> \$20.00 /hr \$10,800
Supervisor	<sup>a</sup> Note: 0.5 hrs/shift x 3 shifts/day x 360 days/yr 15% of operator \$1,620
<b>Maintenance</b>	
Labor	540 man hrs per year <sup>b</sup> \$20.00 /hr \$10,800
Material	<sup>b</sup> Note: 0.5 hrs/shift x 3 shifts/day x 360 days/yr 100% of maint. labor \$10,800
<b>Utilities (Assumed)</b>	
Electricity (1% of Capital Cost)	\$225,970
Waste Disposal	74 ton/yr <sup>c</sup> \$25 /ton \$1,851
	<sup>c</sup> Note: 4 gr/ft <sup>3</sup> x 1 lb/7,000 gr x 500 acfm x 60 min/hr x 8,640 hr/yr x 1 ton/2,000 lb = ton/yr
<b>Total Direct Annual Costs, DAC</b>	<b>\$261,841</b>
<b>INDIRECT ANNUAL COSTS (IC)</b>	
Overhead (60% of total operating & maintenance costs)	\$20,412
Administrative Charges	2% of TCI \$451,940
Property Taxes	1% of TCI \$225,970
Insurance	1% of TCI \$225,970
Capital Recovery Factor (10 yrs at 7%)	0.142 \$3,208,774
<b>Total Capital Cost*</b>	<b>\$22,597,000</b>
<b>TOTAL ANNUAL COST</b>	<b>\$4,656,749</b>

## Appendix C Baghouse Cost Analysis

Holcim Inc.  
Trident Facility  
BART Analysis  
Fabric Filter Baghouse

Cost Item		Factor
<b>DIRECT COSTS</b>		
<b>Purchased equipment costs</b>		
Fabric filter (EC) (Based on EPA/452/B-02-001) Baghouse + Bags + Aux Equipment Adjusted by CPI of 1.28		1756439
Bags (Assumed)		26791
Auxiliary equipment (Assumed)		89500
	(A)	<b>\$1,872,730</b>
Instrumentation	0.10(A)	\$187,273
Sales taxes	0.03(A)	\$56,182
Freight	0.05(A)	\$93,637
<b>Purchased equipment cost, PEC</b>	<b>(B) =</b>	<b>\$2,209,821</b>
<b>DIRECT INSTALLATION COSTS</b>		
Foundations & supports	0.04(B)	\$88,393
Handling & erection	0.50(B)	\$1,104,911
Electrical	0.08(B)	\$176,786
Piping	0.01(B)	\$22,098
Insulation for ductwork	0.07(B)	\$154,688
Painting	0.04(B)	\$88,393
<b>Direct installation costs, DI</b>		<b>\$1,635,268</b>
	Retrofit Insallation = DI x 1.5 =	<b>\$2,452,902</b>
Site preparation	As required, SP	
Buildings	As required, Bldg.	
<b>Total Direct Costs, DC</b>		<b>\$4,662,723</b>
<b>INDIRECT INSTALLATION COSTS, IIC</b>		
Engineering	0.10(B)	\$220,982
Construction and Field Expenses	0.20(B)	\$441,964
Contractor fees	0.10(B)	\$220,982
Start-up	0.01(B)	\$22,098
Performance test	0.01(B)	\$22,098
Contingencies	0.03(B)	\$66,295
<b>Total Indirect Costs, IIC</b>		<b>\$994,420</b>
	Retrofit Insallation = IIC x 1.5 =	<b>\$1,491,629</b>
<b>Total Capital Investment = DC + IIC</b>		<b>\$6,154,353</b>

Cost Item		Fabric Filter Baghouse Cost	
<b>DIRECT ANNUAL COSTS</b>			
<b>Operating Labor</b>			
Operator	2160 man hrs per year <sup>a</sup>	\$20.00 /hr	\$43,200
Supervisor	*Note: 2 hrs/shift x 3 shifts/day x 360 days/yr 15% of operator		\$6,480
<b>Maintenance</b>			
Labor	1 hrs/shift @	\$20.00 /hr	\$21,600
Material	100% of maint. labor		\$21,600
Replacement parts, bags			\$18,184
<b>Utilities (Assumed)</b>			
Electricity	8,054 kWh/yr <sup>b</sup>	\$0.0671 /kWh	\$540
	<sup>b</sup> Note: 0.000181 x 500 acfm x 10.3 in H2O x 8,640 hr/hr = kWh/yr		
(dried and filtered) Compressed air	518,400 scf/yr <sup>c</sup>	\$0.25 /1,000 scf	\$130
	<sup>c</sup> Note: 2 scfm/1,000 acfm x 500 acfm x 60 min/hr x 8,640 hr/yr = scf/yr		
Waste Disposal	74 ton/yr <sup>d</sup>	\$25 /ton	\$1,851
	<sup>d</sup> Note: 4 gr/ft <sup>3</sup> x 1 lb/7,000 gr x 500 acfm x 60 min/hr x 8,640 hr/yr x 1 ton/2,000 lb = ton/yr		
<b>Total Direct Annual Costs, DAC</b>			<b>\$113,585</b>
<b>INDIRECT ANNUAL COSTS (IC)</b>			
Overhead (60% of total operating & maintenance costs)			\$66,638
Administrative Charges	2% of TCI		\$123,087
Property Taxes	1% of TCI		\$61,544
Insurance	1% of TCI		\$61,544
Capital Recovery Factor (10 yrs at 7%)	0.142		\$873,918
<b>Total Capital Cost*</b>		<b>\$6,154,353</b>	
<b>TOTAL ANNUAL COST</b>			<b>\$1,413,901</b>

## Appendix C Fixed Inlet Cost Analysis

Holcim Inc.  
Trident Facility  
BART Analysis  
Installation of a Fixed Inlet

Cost Item	Factor	
<b>DIRECT COSTS</b>		
<b>Purchased equipment costs</b>		
Fixed Inlet (Assumed)	(A)	<b>\$328,922</b>
Instrumentation	0.10(A)	\$32,892
Sales taxes	0.03(A)	\$9,868
Freight	0.05(A)	\$16,446
<b>Purchased equipment cost, PEC</b>	(B) =	<b>\$388,128</b>
<b>DIRECT INSTALLATION COSTS</b>		
Foundations & supports	0.04(B)	\$15,525
Handling & erection	0.50(B)	\$194,064
Electrical	0.08(B)	\$31,050
Piping	0.01(B)	\$3,881
Insulation for ductwork	0.07(B)	\$27,169
Painting	0.04(B)	\$15,525
<b>Direct installation costs</b>		<b>\$287,215</b>
Site preparation	As required, SP	
Buildings	As required, Bldg.	
<b>Total Direct Costs, DC</b>		<b>\$675,343</b>
<b>INDIRECT INSTALLATION COSTS, IIC</b>		
Engineering	0.10(B)	\$38,813
Construction and Field Expenses	0.20(B)	\$77,626
Contractor fees	0.10(B)	\$38,813
Start-up	0.01(B)	\$3,881
Performance test	0.01(B)	\$3,881
Contingencies	0.03(B)	\$11,644
<b>Total Indirect Costs, IIC</b>		<b>\$174,658</b>
<b>Total Capital Investment = DC + IIC</b>		<b>\$850,000</b>

Cost Item	Installation of a Fixed Inlet Cost
<b>DIRECT ANNUAL COSTS</b>	
<b>Operating Labor</b>	
Operator	2160 man hrs per year <sup>a</sup> \$20.00 /hr \$43,200
Supervisor	*Note: 2 hrs/shift x 3 shifts/day x 360 days/yr 15% of operator \$6,480
<b>Maintenance</b>	
Labor	1 hrs/shift @ \$20.00 /hr \$21,600
Material	100% of maint. labor \$21,600
Replacement parts, bags	\$18,184
<b>Total Direct Annual Costs, DAC</b>	<b>\$111,064</b>
<b>INDIRECT ANNUAL COSTS (IC)</b>	
Overhead (60% of total operating & maintenance costs)	\$66,638
Administrative Charges	2% of TCI \$17,000
Property Taxes	1% of TCI \$8,500
Insurance	1% of TCI \$8,500
Capital Recovery Factor (10 yrs at 7%)	0.142 \$120,700
<b>Total Capital Cost*</b>	<b>\$850,000</b>
<b>TOTAL ANNUAL COST</b>	<b>\$443,466</b>