

**Technical Support Document for the Soda Ash  
Manufacturing Sector: Proposed Rule for  
Mandatory Reporting of Greenhouse Gases**

Office of Air and Radiation  
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## 1. Industry Description

Soda ash (sodium carbonate,  $\text{Na}_2\text{CO}_3$ ) is a raw material utilized in numerous industries including glass manufacturing, pulp and paper production, and soap manufacturing. Soda ash production in 2006 amounted to 11 million metric tons (MMT), an amount consistent with 2005 and 500,000 MT more than was produced in 2002. Owing to a glut of soda ash on the market in 2006 approximately 17 percent of the soda ash industry's nameplate capacity was idled (USGS 2007).

The majority of the 11 MMT of soda ash produced is used for glass manufacturing (USGS 2007). In the United States, trona ore, the raw material from which most American soda ash is produced, is mined exclusively in Wyoming. Wyoming is home to five of the seven United States soda ash manufacturing facilities (Table 1). Nameplate capacity at the five Wyoming facilities analyzed in this document is included in Table 1. The nameplate capacity of the Wyoming units totals 12.3 MMT of soda ash per year.

The facility located in California extracts soda ash from sodium carbonate-bearing brines that are carbonated. The  $\text{CO}_2$  utilized in the carbonating process is recycled and only results in small fugitive emissions. Therefore, the  $\text{CO}_2$  emissions are assumed to be zero, and thus, the California facility is not accounted for in the threshold analysis.

The facility located in Parachute, Colorado, was closed in September 2004 and no plans to restart soda ash manufacturing have been reported. USGS reports that previously closed facilities are being brought back online (USGS 2007). No confirmation that the Parachute, Colorado facility will be brought back on-line in the near future has been received. Therefore, the plant is not accounted for in the threshold analysis.

**Table 1. U.S. Producers of Soda Ash**

Company	Plant Location	Nameplate Capacity (MMT per year)	Source of Sodium Carbonate
FMC Wyoming Corp.	Granger, WY	1.18	Underground Trona Ore
FMC Wyoming Corp.	Green River, WY	3.22	Underground Trona Ore
General Chemical Partners	Green River, WY	2.54	Underground Trona Ore
OCI Chemical Corp.	Green River, WY	2.81	Underground Trona Ore
Solvay Chemicals, Inc.	Green River, WY	2.54	Underground Trona Ore
<b>Total</b>		12.3	

Source: USGS Minerals Yearbook 2006 ([http://minerals.usgs.gov/minerals/pubs/commodity/soda\\_ash/myb1-2006-sodaa.pdf](http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/myb1-2006-sodaa.pdf))

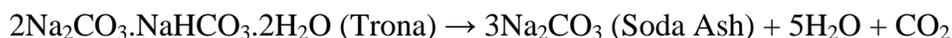
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## 2. Total Emissions

Emissions from natural soda ash facilities for 2006 were approximately 3,121,438 MTCO<sub>2</sub>e. These emissions were closely divided between process emissions of approximately 1.6 MMTCO<sub>2</sub>e and stationary combustion emissions of approximately 1.5 MMTCO<sub>2</sub>e.

### 2.1 Process Emissions

As discussed above, the production of soda ash from mined trona ore emits CO<sub>2</sub>. Trona-based production methods are collectively referred to as “natural production” methods. “Natural production” emits CO<sub>2</sub> by calcining trona ore based on the following reaction:



Calcining involves placing crushed trona ore into a kiln to convert sodium bicarbonate into crude sodium carbonate that will later be filtered into pure soda ash. Following the formula, 1 MTCO<sub>2</sub> process emissions is produced for every 10.27 MT of trona consumed (IPCC 2006).

### 2.2 Stationary Combustion

Stationary combustion emissions of greenhouse gases from the production of soda ash are limited to the fuel inputs used to fire ore crushers, coal crushers, trona ore driers, industrial boilers and other necessary equipment of the manufacturing process. Coal, natural gas, distillate fuel oil, and residual fuel oil are all possible fuel inputs though the actual mix of fuels will be site-specific.

## 3. Review of Existing Programs and Methodologies

Emissions monitoring from the soda ash manufacturing sector are addressed in numerous protocols and reporting programs. Many programs and guidance documents, such as the *U.S. Greenhouse Gas Inventory* (EPA 2008) and DOE’s 1605(b) Reporting Program, contain specific monitoring methods rather than use generic emissions factors and stoichiometric calculations. The *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006) presents three methods (tiers) for addressing GHG emissions at soda ash manufacturing facilities classified according to the extent of plant-level data that are available. Tier 1 methodology is based on default values and national statistics, Tier 2 methodology is a facility-specific method that utilizes either trona ore input or soda ash output as well as a facility-specific emissions factor, and Tier 3 uses monitoring and direct measurement of CO<sub>2</sub> emissions. The IPCC guidelines, Australian Government’s National Mandatory Greenhouse and Energy Reporting System, Government of Canada’s Greenhouse Gas Reporting program, *U.S. Greenhouse Gas Inventory*, and DOE’s 1605(b) Reporting Program are discussed in more detail below.

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### **3.1 2006 IPCC Guidelines**

The IPCC considers two different methods for calculating process-related emissions from soda ash manufacturing (IPCC 2006). The fractional purity of trona or soda ash is defined as the level of inorganic carbon present in trona or soda ash. The Tier 1 method uses a default emission factor per unit of output (either 0.0974 tons of CO<sub>2</sub>/ton of trona ore consumed or 0.138 tons of CO<sub>2</sub>/ton soda ash produced) multiplied by production activity data (i.e., trona ore used in production, or amount of natural soda ash produced). The default emission factor assumes that the fractional purity of each material is 100%. The Tier 2 method calculates process emissions through facility-level data collection (i.e., site-specific CO<sub>2</sub> emission factor, site-specific trona ore usage or soda ash production data, and measured fractional purity of the trona or soda ash). The Tier 3 method uses CO<sub>2</sub> data obtained through direct measurement (i.e., CEMS).

The IPCC Tier 1 method (utilizing the 0.0974 tons of CO<sub>2</sub>/ton of trona ore consumed emission factor) was used to determine process-related CO<sub>2</sub> emissions from the facilities presented in Table 2.

### **3.2 2008 U.S. Inventory of Greenhouse Gas Emissions and Sinks**

The U.S. Greenhouse Gas Inventory system requires reporting of CO<sub>2</sub> emissions from soda ash manufacturing. This program is not an industry reporting program but instead utilizes a stoichiometric CO<sub>2</sub> emission factor (0.0974 tons of CO<sub>2</sub>/ton of trona ore consumed) and annual activity data (trona ore consumption) at the national level. The input data source used to calculate emissions are stoichiometric CO<sub>2</sub> emission factor and trona ore consumed (both taken from USGS 2006).

### **3.3 Government of Canada's Greenhouse Gas Reporting program**

The Government of Canada's Greenhouse Gas Reporting Program uses a similar approach to the 2006 IPCC guidelines.

### **3.4 Australian National Greenhouse and Energy Reporting System**

The Australian Government's National Greenhouse and Energy Reporting System requires reporting of CO<sub>2</sub> emissions from soda ash manufacturing. Registration and reporting under this system is required for corporations if: they control facilities that emit at least 25,000 MTCO<sub>2</sub>e, or produce or consume at least 100 terajoules of energy; or their corporate group emits at least 125,000 MTCO<sub>2</sub>e, or it produces or consumes at least 500 terajoules of energy (Australian DCC 2007). The methods for estimating emissions from soda ash manufacturing follow the IPCC procedures.

### **3.5 Technical Guidelines Voluntary Reporting of Greenhouse Gases (1605(b)) Program**

The DOE's 1605(b) Reporting Program is a voluntary inventory and emission reduction program reporting of CO<sub>2</sub> emissions from soda ash manufacturing. The DOE's 1605(b) program considers two different approaches for calculating process-related emissions from soda ash manufacturing. The first approach uses a default emission factor per unit of output (either 0.0974 tons of CO<sub>2</sub>/ton of trona ore consumed multiplied by activity data (trona ore used in production)). The second approach calculates process emissions through facility-level data collection (i.e., direct emissions measurement).

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## 4. Options Considered for Reporting Threshold

### 4.1 Emissions Thresholds

For the reporting of process CO<sub>2</sub> emissions from soda ash manufacturing, threshold options considered included emissions-based thresholds of 100,000, 25,000, 10,000, and 1,000 MTCO<sub>2</sub>e for combined combustion and process emissions. The results of the threshold analysis are summarized in Table 2.

All production-based emission threshold levels were found to incorporate the entire soda ash manufacturing sector. Table 2 provides the production-based emissions threshold analysis for the soda ash manufacturing sector.

**Table 2. Production-Based Threshold Analysis for Soda Ash Manufacturing**

Threshold Level (MTCO <sub>2</sub> e/yr)	Process Emissions (MTCO <sub>2</sub> e/yr)	Combustion CO <sub>2</sub> Emissions (MTCO <sub>2</sub> e/yr)	Total National Emissions (MTCO <sub>2</sub> e/yr)	Number of Entities	Emissions Covered		Entities Covered	
					MTCO <sub>2</sub> e/yr	Percent	Number	Percent
100,000	1,626,095	1,495,343	3,121,438	5	3,121,438	100%	5	100%
25,000	1,626,095	1,495,343	3,121,438	5	3,121,438	100%	5	100%
10,000	1,626,095	1,495,343	3,121,438	5	3,121,438	100%	5	100%
1,000	1,626,095	1,495,343	3,121,438	5	3,121,438	100%	5	100%

This analysis estimated total emissions for the soda ash manufacturing sector of 3.1 MMTCO<sub>2</sub>e. This total was the sum of process emissions of 1.6 MMTCO<sub>2</sub>e and combustion emissions that totaled ~1.5 MMTCO<sub>2</sub>e. All five facilities that have been identified surpass the 100,000 MTCO<sub>2</sub>e reporting threshold. The option of regulating all soda ash manufacturing facilities regardless of their emissions profile is similar to the emissions threshold option because at each threshold level all soda ash facilities would be regulated.

Process emissions for this document were calculated using a stoichiometric emissions factor of 0.0974 tons of CO<sub>2</sub> per ton of trona ore consumed (U.S. EPA 2008). The 16.7 MMT of trona ore mined in Wyoming in 2006 (USGS 2007) were estimated to produce approximately 1,626,095 MTCO<sub>2</sub>e based on the following formula:

$$\text{CO}_2 \text{ Emissions} = \text{EF} \times \text{AD}$$

Where:

$$\text{CO}_2 \text{ Emissions} = \text{Emissions of CO}_2 \text{ (MT)}$$

EF = Emissions factor of 0.0974 tons of CO<sub>2</sub> per ton trona ore consumed

AD = Amount of trona ore consumed (MT)

Stationary combustion CO<sub>2</sub> emissions for this document were calculated using fuel input data from the National Renewable Energy Laboratory (NREL) Life-Cycle Analysis database (NREL 2007). Each fuel input estimate was multiplied by the amount of soda ash produced using the trona-based method. Trona-based soda ash manufacturing was apportioned from total soda ash production using nameplate capacity as a surrogate for facility production. By dividing the nameplate capacity of non-trona-based production facilities (2.45 million short tons) by the total nameplate capacity (16 million short tons) it was determined that 15 percent of total U.S. soda ash production was non-trona-based. Therefore 85 percent (9.35 MMT) of total U.S. soda ash production was trona-based. NREL Life-Cycle Analysis fuel input estimates for bituminous coal, distillate fuel oil, residual fuel oil, and natural gas are listed in Table 4 (i.e., the quantity of fuel required for providing one short ton of soda ash).

Based on this stationary combustion CO<sub>2</sub> emissions were estimated to produce approximately 1,495,343 MT or 1.5 MMTCO<sub>2</sub>e.

**Table 3. NREL Life-Cycle Analysis Fuel Input Estimates**

<b>Input</b>	<b>Fuels Consumed per Short Ton of Soda Ash Production</b>
Coal	107.6 pounds
Distillate fuel oil	0.067 gallons
Residual fuel oil	0.185 gallons
Natural gas	797.5 cubic feet

Source: NREL Life-Cycle Analysis (<http://www.nrel.gov/lci/database/>)

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## 4.2 Capacity Thresholds

Three capacity threshold levels were considered for the soda ash manufacturing sector. Capacity is the largest amount of soda ash that a facility can produce on an annual basis. These thresholds were 3, 2, and 1 MMT of soda ash produced per year. The results of the capacity threshold analysis are shown in Table 4.

**Table 4. Capacity Threshold Analysis for Soda Ash Manufacturing**

Capacity Threshold Level (MT soda ash/yr)	Process Emissions (MTCO <sub>2</sub> e/yr)	Number of Entities	Emissions Covered		Entities Covered	
			MTCO <sub>2</sub> e/yr	Percent	Number	Percent
3,000,000	1,696,373	5	444,437	27%	1	20%
2,000,000	1,696,373	5	1,533,622	94%	4	80%
1,000,000	1,696,373	5	1,696,373	100%	5	100%

A threshold of 1,000,000 MT captures all facilities in the inventory. A threshold of 2,000,000 MT captures 94 percent of emissions, 80 percent of the facilities. A threshold of 3,000,000 MT captures 27 percent of emissions, 20 percent of the facilities. Process emissions for this document were calculated using a stoichiometric emissions factor of 0.138 metric tons CO<sub>2</sub> per ton of soda ash produced (IPCC). The 12.3 MMT of soda ash production capacity in Wyoming in 2006 (USGS 2007) were estimated to produce approximately 1,696,373 MTCO<sub>2</sub>e based on the following formula:

$$\text{CO}_2 \text{ Emissions} = \text{EF} \times \text{AD}$$

Where:

$$\text{CO}_2 \text{ Emissions} = \text{Emissions of CO}_2 \text{ (MT)}$$

$$\text{EF} = \text{Emissions factor of 0.138 MT CO}_2 \text{ per ton of soda ash produced}$$

$$\text{AD} = \text{Total nameplate capacity of soda ash produced (MT)}$$

Combustion emissions for this analysis were considered to be the same as those used in the production-based threshold analysis.

## 4.3 No Emissions Threshold

The no emissions threshold includes all soda ash manufacturing facilities regardless of their emissions or capacity.

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## 5. Options for Monitoring Methods

Three separate monitoring methods were considered for this technical support document: a default emission calculation (Option 1), and direct measurement (Option 3 and Option 4). All of these options require annual reporting.

Options 3 and 4 would measure both process and combustion related CO<sub>2</sub> emissions from soda ash production.

### 5.1 Option 1: Default Emission Calculation

Option 1 follows the IPCC's Tier 2 protocol. The Tier 2 monitoring method offers the choice of two options. The emissions can be determined through knowledge of the trona ore input or the soda ash output. To use either method, the quantity of material, the fractional purity of the material and the default emission factor must be known. The equation for calculating emissions is:

$$\text{CO}_2 \text{ Emissions} = \text{AD} \times \text{FP} \times \text{EF}$$

Where:

CO<sub>2</sub> Emissions = process emissions of CO<sub>2</sub> (MT)

AD = Quantity of either trona ore input or soda ash output

FP = Fractional purity of either trona ore input or soda ash output (as determined by the inorganic carbon content)

EF = Default emission factor per unit of trona ore input or soda ash output

The default emission factor per unit of trona ore input is 0.0974 tons of CO<sub>2</sub>/ton of trona ore consumed. The default emission factor per unit of soda ash output is 0.138 ton of CO<sub>2</sub>/ton of soda ash produced (IPCC 2006).

The IPCC Tier 2 protocol is the foundation for numerous other programs and guidance documents around the world; both Canada's Greenhouse Gas Reporting program and Australia's National Greenhouse Gas Energy Reporting System refer to the IPCC's guidance.

The default stoichiometric emission factors for trona consumed or for soda ash produced are applied either to the quantity of trona consumed or the amount of soda ash produced and the fractional purity of the trona or soda ash. The fractional purity of trona or soda ash would be determined by the level of the inorganic carbon present in trona using in-house total organic carbon (TOC) analyzers or in soda ash using applicable test methods. Soda ash facilities are conducting daily tests of fractional purity (Cole 2008).

### 5.2 Option 2: Stack Testing

For direct measurement using stack testing, sampling equipment would be periodically brought to the site and installed temporarily in the stack to withdraw a sample of the stack gas and

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measure the flow rate of the stack gas. Similar to CEMS, for stack testing the emissions are calculated from the concentration of GHGs in the stack gas and the flow rate of the stack gas. The difference between stack testing and continuous monitoring is that the CEMS data provide a continuous measurement of the emissions while a stack test provides a periodic measurement of the emissions.

Performing a stack test requires additional cost and time to implement the method compared to Option 1. However, the method may not be appropriate for all soda ash production facilities depending on the site-specific operations at the facility. A method using periodic, short-term stack testing would be appropriate for those facilities where process inputs (e.g., trona composition and fuel types) and process operating parameters remain relatively consistent over time. In cases where significant variations in the process inputs characteristics or operating conditions could occur, continuous measurements would be needed to accurately record changes in the actual GHG emissions from the sources resulting from any process variations.

### **5.3 Option 3: Direct Measurement**

Option 3 follows the IPCC's Tier 3 protocol. For industrial source categories for which the process emissions and/or combustion GHG emissions are contained within a stack or vent, direct measurement constitutes either measurements of the GHG concentration in the stack gas and the flow rate of the stack gas using a Continuous Emissions Monitoring System (CEMS), or periodic measurement of the GHG concentration in the stack gas and the flow rate of the stack gas using periodic stack testing. Under either a CEMS approach or a stack testing approach, the emissions measurement data would be reported annually.

Elements of a CEMS include a platform and sample probe within the stack to withdraw a sample of the stack gas, an analyzer to measure the concentration of the GHG (e.g., CO<sub>2</sub>) in the stack gas, and a flow meter within the stack to measure the flow rate of the stack gas. The emissions are calculated from the concentration of GHGs in the stack gas and the flow rate of the stack gas. A CEMS continuously withdraws and analyzes a sample of the stack gas and continuously measures the GHG concentration and flow rate of the stack gas.

## **6. Procedures for Estimating Missing Data**

Options and considerations for missing data under Option 2 would require a complete record of all measured parameters as well as parameters determined from company records that are used in the GHG emissions calculations (i.e., trona ore input, soda ash output, fractional purity analyses, etc.). Therefore, whenever a quality-assured value of a required parameter is unavailable (e.g., if a monitor or CEMS malfunctions during unit operation or if a required fuel input parameter is not obtained), a substitute data value for the missing parameter must be used in the calculations.

### **6.1 Procedures for Option 1: Default Emission Calculation**

For process sources that use a facility specific calculation no missing data procedures would apply because the emission calculation is derived from default emission factors and activity data. Activity data such as production or consumption are readily available. Therefore, 100 percent data availability would be required.

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## **6.2 Procedures for Option 2: Stack Testing**

This monitoring method was not the chosen option under this rule and therefore no procedures for estimating missing data are provided.

## **6.3 Procedures for Option 3: Direct Measurement**

This monitoring method was not the chosen option under this rule and therefore no procedures for estimating missing data are provided.

## **7. QA/QC Requirements**

Facilities should conduct quality assurance and quality control of the production and consumption data, on-site fractional purity analyses, and emission estimates reported. Facilities are encouraged to prepare an in-depth Quality Assurance Project Plan (QAPP) which would include checks on production data, the carbon content information received from the supplier and from the lab analysis, and calculations performed to estimate GHG emissions. Several examples of QA/QC procedures that can be included in the QAPP are listed below.

### **7.1 Stationary Emissions**

For QA/QC options for stationary combustion refer to EPA-HQ-OAR-2008-0508-004.

### **7.2 Process Emissions**

Options and considerations for QA/QC will vary depending on the monitoring method. Each option would require unique QA/QC measures appropriate to the particular methodology employed to ensure proper emission monitoring and reporting.

#### **7.2.1 Continuous Emission Monitoring System (CEMS)**

For units using CEMS to measure CO<sub>2</sub> emissions, the equipment should be tested for accuracy and calibrated as necessary by a certified third party vendor. These procedures should be consistent in stringency and data reporting and documentation adequacy with the QA/QC procedures for CEMS described in Part 75 of the Acid Rain Program.

#### **7.2.2 Stack Test Data**

U.S. EPA regulations for performance testing under 40 CFR § 63.7(c)(2)(i) state that before conducting a required performance test, the owner/operator is required to develop a site-specific test plan and, if required, submit the test plan for approval. The test plan is required to include “a test program summary, the test schedule, data quality objectives, and both an internal and external quality assurance (QA) program” to be applied to the stack test. Data quality objectives are defined under 40 CFR § 63.7(c)(2)(i) as “the pre-test expectations of precision, accuracy, and completeness of data.” Under 40 CFR § 63.7(c)(2)(ii), the internal QA program is required to include, “at a minimum, the activities planned by routine operators and analysts to provide an assessment of test data precision; an example of internal QA is the sampling and analysis of replicate samples.” Under 40 CFR § 63.7(c)(2)(iii) the external QA program is required to include, “at a minimum, application of plans for a test method performance audit (PA) during the performance test.” In addition, according to the 2005 Guidance Document, a site-specific test plan should generally include chain of custody documentation from sample collection through

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laboratory analysis including transport, and should recognize special sample transport, handling, and analysis instructions necessary for each set of field samples (US EPA 2005).

### **7.3 Data Management**

Data management procedures should be included in the QAPP. Elements of the data management procedures plan are as follows:

- For measurements of carbon content, assess representativeness of the carbon content measurement by comparing values received from supplier and/or laboratory analysis with IPCC default values.
- Conduct third party (off-site) or on-site sampling and analysis of material carbon contents to verify information provided by suppliers.
- Check for temporal consistency in production data, carbon content data, and emission estimate. If outliers exist, they should be explained by changes in the facility's operations, or other factors. A monitoring error is probable if differences between annual data cannot be explained by:
  - Changes in activity levels,
  - Changes concerning fuels or input material,
  - Changes concerning the emitting process (e.g. energy efficiency improvements) (EU 2007).
- Determine the "reasonableness" of the emission estimate by comparing it to previous year's estimates and relative to national emission estimate for the industry:
  - Comparison of data on fuel or input material consumed by specific sources with fuel or input material purchasing data and data on stock changes,
  - Comparison of fuel or input material consumption data with fuel or input material purchasing data and data on stock changes,
  - Comparison of emission factors that have been calculated or obtained from the fuel or input material supplier, to national or international reference emission factors of comparable fuels or input materials,
  - Comparison of emission factors based on fuel analyses to national or international reference emission factors of comparable fuels, or input materials,
  - Comparison of measured and calculated emissions (EU 2007).
- Maintain data documentation, including comprehensive documentation of data received through personal communication:
  - Check that changes in data or methodology are documented.

## **8. Types of Emission Information to be Reported**

Based on the existing programs and the emission sources at soda ash manufacturing facilities, GHG reporting for these facilities is limited to CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O. Soda ash facilities should report both process (CO<sub>2</sub>) and combustion related (CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O) greenhouse gas emissions. The data to be reported may vary depending on monitoring options selected. However, a soda ash manufacturing facility should report its annual trona consumption, number of soda ash manufacturing lines, fractional purity of trona consumed or soda ash produced, annual soda ash manufacturing, annual soda ash production capacity, electricity usage (kilowatt-

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hours), and annual operating hours. For reporting options for stationary combustion refer to EPA-HQ-OAR-2008-0508-004.

### **8.1 Other Information to be Reported**

Each soda ash manufacturing facility should report the following:

- Total annual CO<sub>2</sub> process emissions from all soda ash manufacturing lines (MT);
- Number of soda ash manufacturing lines;
- Annual soda ash production (MT) and annual soda ash production capacity;
- Annual consumption of trona ore from monthly measurements (MT);
- Fractional purity (i.e., inorganic carbon content) of trona or soda ash (by daily measurements and by monthly average);
- Electricity usage (kWh/yr); and
- Number of operating hours in calendar year.

### **8.2 Additional Data to be Retained Onsite**

Facilities should be required to retain data concerning monitoring of GHG emissions onsite for a period of at least five years from the reporting year. EPA could use such data to conduct trend analyses and potentially to develop process or activity-specific emission factors for the process. Facilities should retain the following information:

- Monthly production of soda ash (MT);
- Monthly consumption of trona (MT);
- Daily analyses for inorganic carbon content of trona or soda ash (as fractional purity);
- QAPP and related QA/QC records;
- Electricity usage, kWh/yr; and
- Operating hours in calendar year

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