DRAFT QUANTIFICATION PROTOCOL FOR THE USE OF FLY ASH IN CONCRETE AND OTHER CEMENT BASED PRODUCTS

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1.0 Project and Methodology Scope and Description

This quantification protocol is written for those familiar with the production and use of fly ash, a coal combustion product recovered from air pollution control devices at coal power plants or other coal combustion facilities, as a partial substitute for cement (e.g. Portland Cements) used to produce concrete and other cement based products (e.g. pre-cast pipe, oil well slurries, paving stones, soil cement, etc.).

The opportunity for generating carbon offsets with this protocol arises from the avoidance of process emissions associated with the production of clinker from carbonate materials such as limestone and from the avoidance of fossil fuel combustion normally required to process raw materials and to operate cement kilns and other equipment during the production of clinker and other cement products. The baseline practice would be the production of an equivalent quantity of cement at the average GHG emissions intensity of cement production plants operating in Alberta to match the quantity of fly ash used at mixing sites in the project condition. The baseline emissions would be defined based on the GHG emissions intensity of cement production in Alberta, which is expressed as the combined GHG emissions from fossil fuel combustion and from process (CO_2) emissions per unit of cement produced at all cement production plants in the province. Therefore the GHG savings are quantified on the basis of the tonnes of cement displaced by the use of fly ash.

1.1 Protocol Scope and Description

This protocol is applicable to projects that involve the mixing of fly ash with cement to decrease the quantity of cement required in concrete or other cement based products and therefore reduce GHG emissions associated with the production of cement from raw materials. GHG emissions from cement production are primarily process CO_2 emissions that occur during the calcination of carbonate materials as well as emissions from the consumption of fossil fuels to provide heat and power for the operation of cement kilns and other material processing equipment.

In the project condition the fly ash may enter the cement product supply chain at a variety of points, which may include transportation to cement production plants, product mixing facilities, intermediate distribution centres or transported directly to the site of concrete pouring or other end use. The fly ash may ultimately be used in many different applications as a replacement for cement and therefore the quantification of GHG emissions is focussed on the tonnes of cement displaced by fly ash.

This protocol is NOT applicable to fly ash that is directly used at cement plants subject to the Alberta Specified Gas Emitters Regulation or other applicable provincial or federal climate change regulations, where the GHG intensity (tonnes of CO_2 equivalent from direct emissions per unit of cement product output from the plant) of the cement plant is calculated on an intensity basis that includes the tonnes of fly ash used in the denominator. The project proponent would be responsible for tracking fly ash distribution to ensure that fly ash used at regulated cement plants is not included, to avoid double counting of GHG emission reductions.

Recognizing that there may be many different uses of fly ash which may have relatively complicated supply chains, the protocol is generic in nature to account for possible distribution and mixing facilities included in the project boundary, as illustrated in FIGURE 1.1. The project boundary is built around the fly ash distribution chain as the cement production processes will not be impacted by the project activity, although these processes constitute most of the upstream sources GHG emissions displaced by the project activity. It is therefore the responsibility of the project proponent to define their specific fly ash supply/distribution chain to fully account for all incremental GHG emissions associated with the distribution and mixing of fly ash. The project proponent may be from one of many positions in the fly ash supply chain (e.g. fly ash user, marketer, blender, etc.). The one commonality among all project proponents is the likely need for co-operation between fly ash producers, distributers, and users to share information.

For consistency with other Alberta Offset System protocols this protocol does not explicitly assign ownership, but instead states the minimum data collection requirements in order to adequately quantify the net GHG benefit of the project activity. It is therefore up to each project proponent to provide proof of ownership of all offsets claimed at the time of third party verification or upon request by Alberta Environment (e.g. through contracts with other participants in the fly ash distribution chain).

The scope of the protocol does not fully account for GHG emissions associated with raw material processing or other activities in the baseline that occur upstream of cement production plants (ie at quarries), which represents a conservative approach to quantification. The project proponent may choose to add in these additional sources and sinks related to upstream material processing and transportation provided that they can justify the selection of appropriate emission factors under the protocol flexibility mechanisms.

FIGURE 1.1 offers a process flow diagram for a typical project. The dashed line around SS's P17, P18 and P19 represents the typical points within the fly ash supply chain at which information may need to be collected by the project proponent.

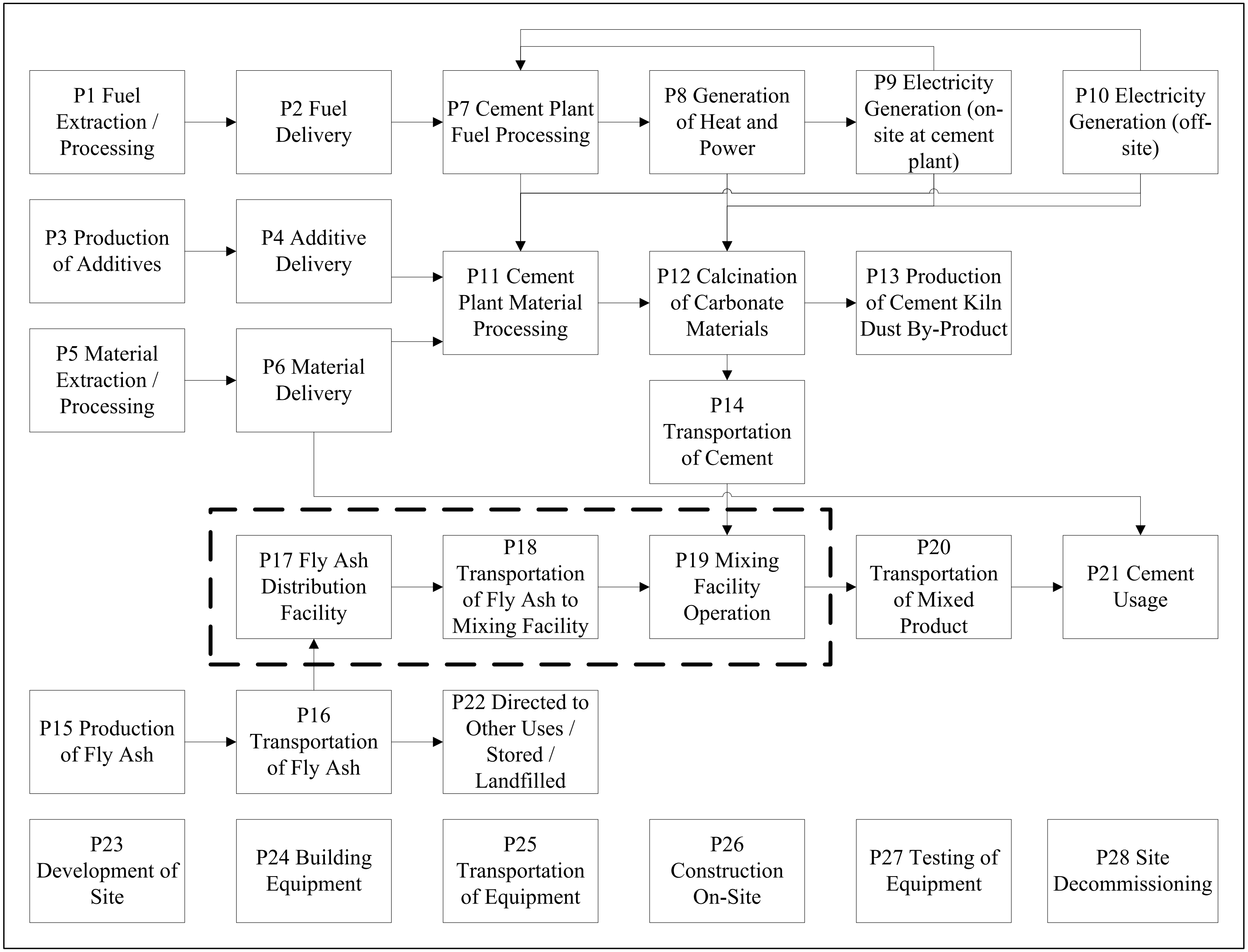
Protocol Approach

The protocol quantification approach is based on the tonnes of fly ash used that result in the substitution of cement used in the production of cement blends, concrete or other cement based products. The baseline approach utilizes aggregated GHG emission intensity data from cement production facilities in Alberta to determine the baseline emissions that would have occurred had fly ash not been used as a substitute for cement based products.

To demonstrate that a project is covered by the scope of the protocol, the project proponent must demonstrate that his/her activities (e.g. the implementation or expansion of a marketing/ distribution system for fly ash, changes in mixing facility operating practices, construction of a fly ash storage silo or increased purchase or use of fly ash in place of cement products) have resulted in the incremental use of fly ash in place of conventional cement products and/or that the fly ash would normally have been managed differently. As evidence, the project proponent must provide historical records of fly ash sales and/or utilization/mixing to demonstrate that this baseline condition, illustrated in Figure 1.2, was either the previous practice or most likely practice based on conventional industry practices. Further, they must show that under the project activity the tonnes of fly ash diverted to productive use as a cement substitute has increased relative to a baseline period from 1999 to 2001, which is consistent with the Alberta Offset System eligibility criteria requiring offset project start dates to be after January 1, 2002.

The process flow diagrams for the project and baseline scenarios were simplified in FIGURE 1.3 and FIGURE 1.4, respectively, by aggregating the activities that would occur at cement production plants under a single GHG lifecycle element, herein referred to as a source or sink (SS) of GHG emissions, to be consistent with the expected format of the data related to fuel consumption and process emissions at cement plants.

FIGURE 1.1: Process Flow Diagram for Project Condition



1 **FIGURE 1.2: Process Flow Diagram for Baseline Condition**

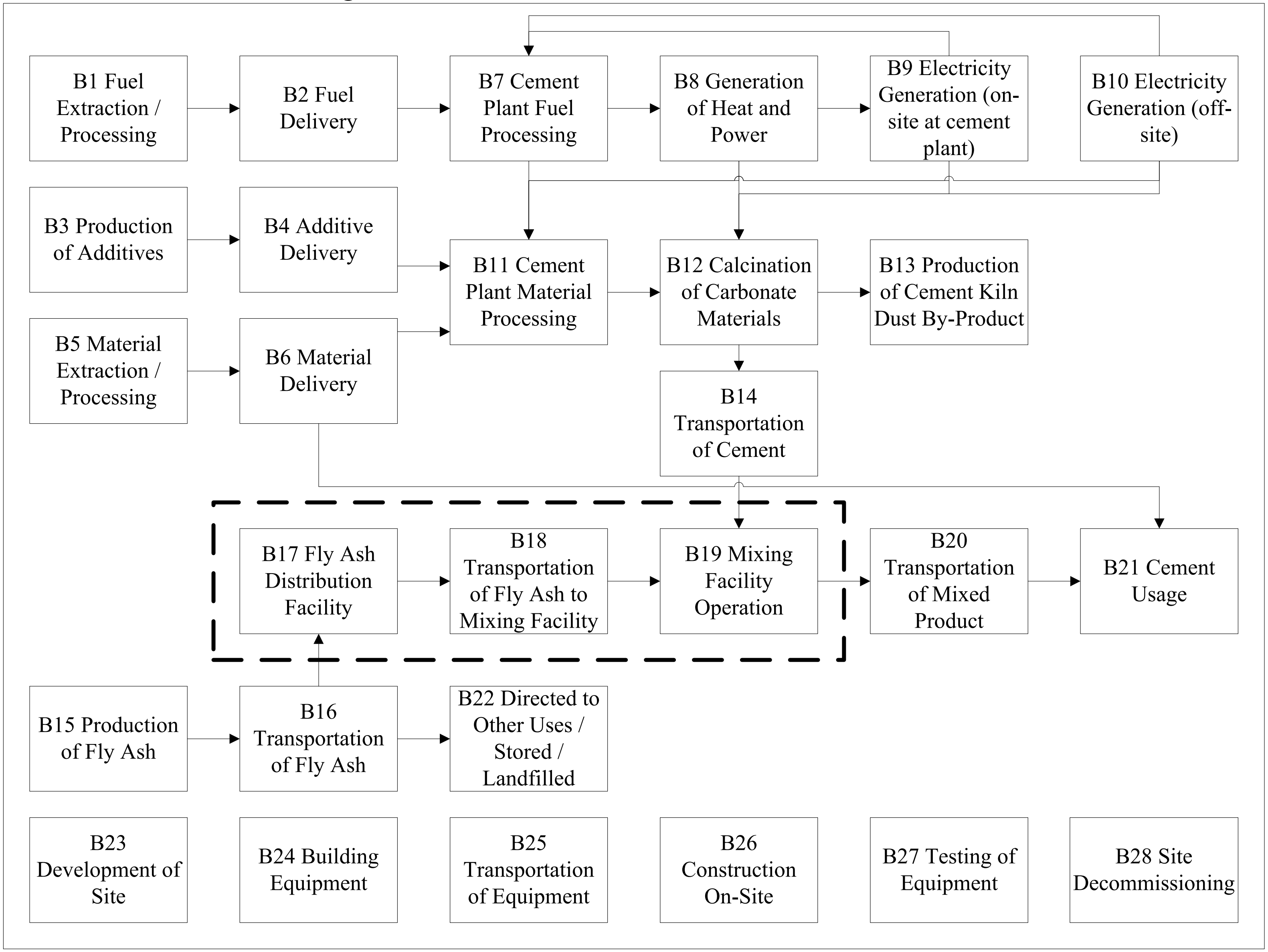


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FIGURE 1.3: Simplified Process Flow Diagram for Project Condition

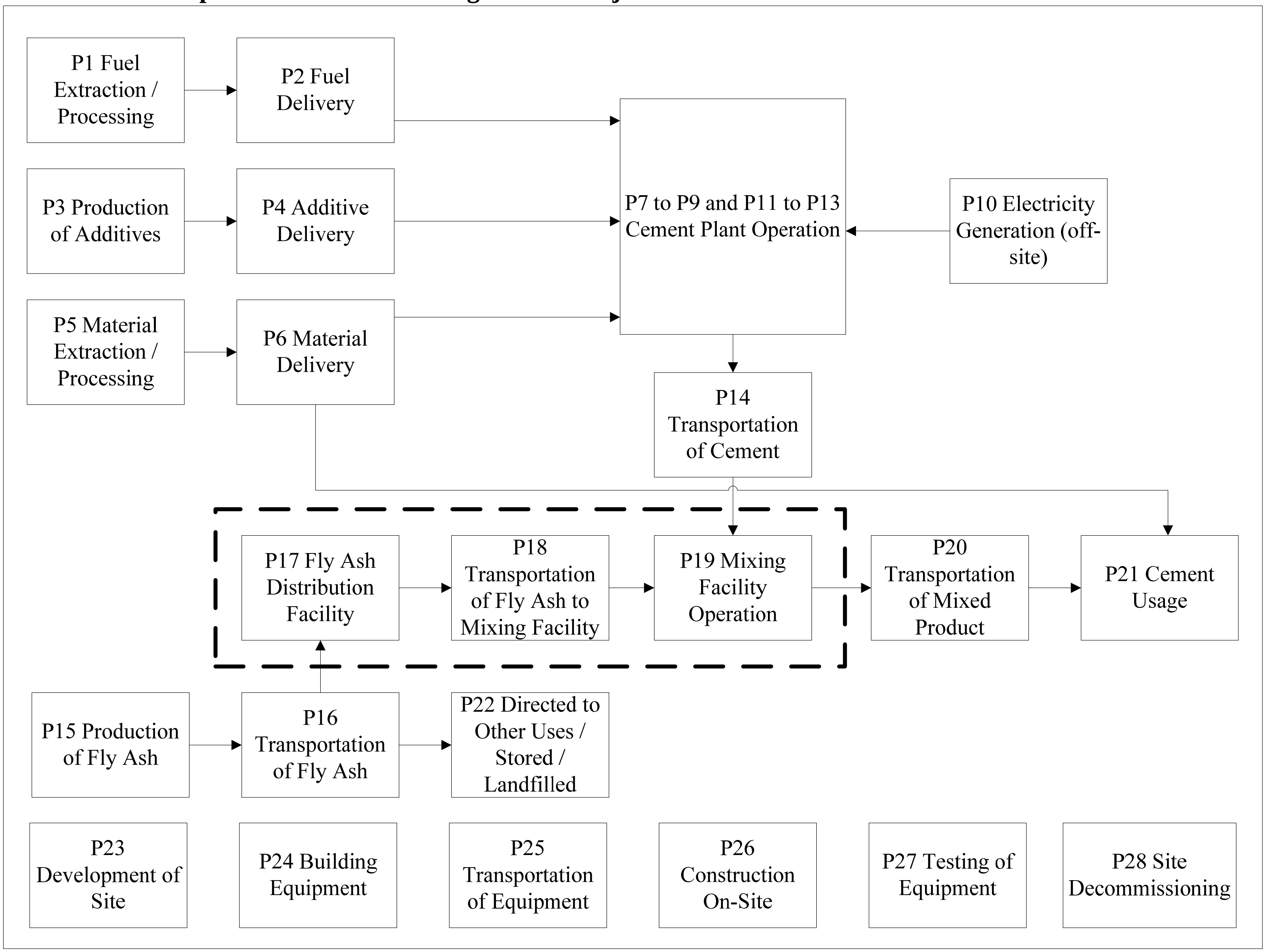
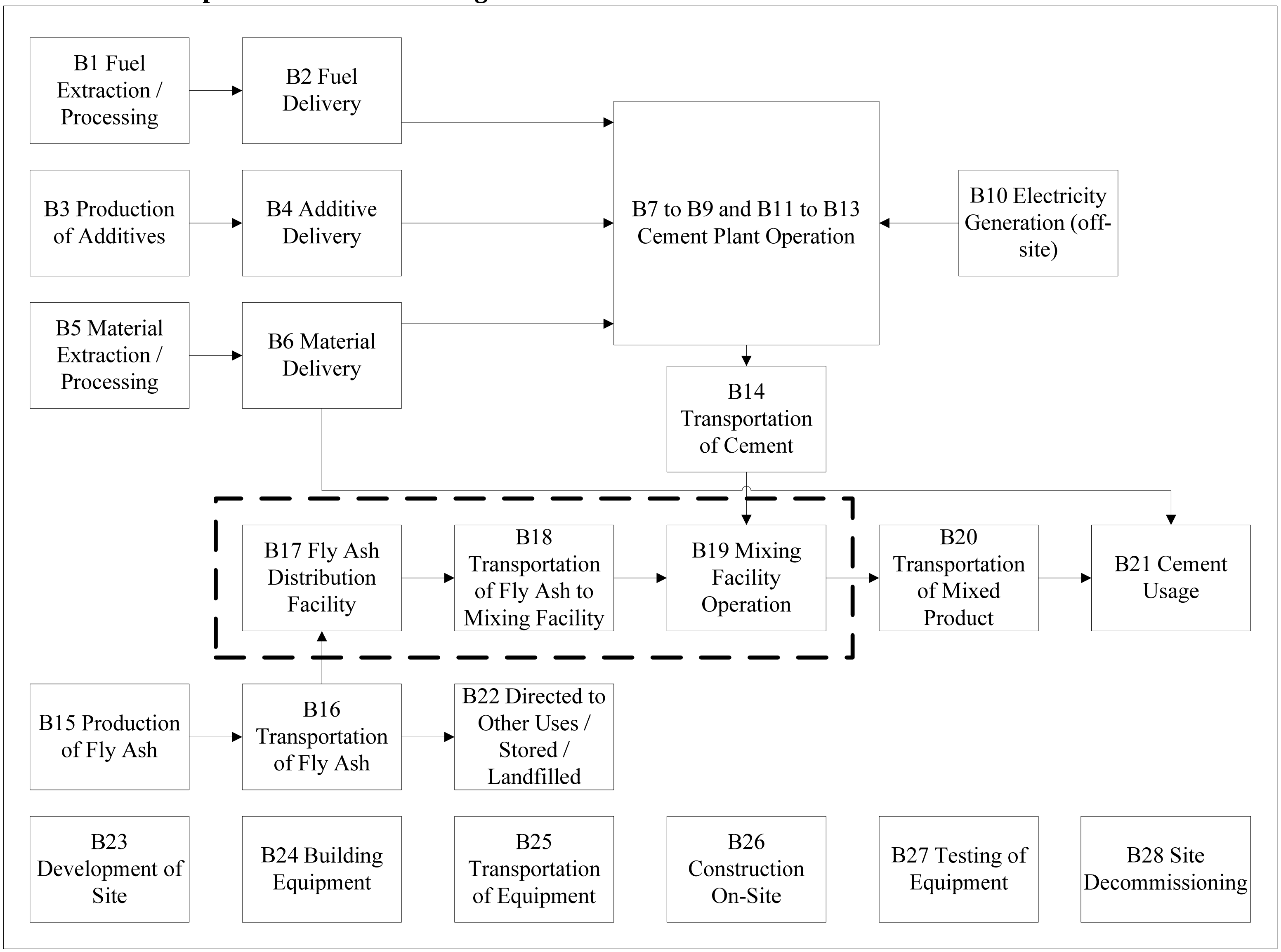


FIGURE 1.4: Simplified Process Flow Diagram for Baseline Condition



Protocol Applicability

To demonstrate that a project meets the requirements under this protocol, the project proponent must provide evidence that:

1. The project proponent must define a project specific baseline based on historical fly ash usage or sales during the years 1999-2001. The baseline can be defined as the 3 year average of fly ash tonnes sold/mixed or as the highest value during that period if less than 3 years worth of data are available. Fly ash usage or sales prior to January 1, 2002, would not be considered eligible under the Alberta Offset System and therefore only the incremental quantity of fly ash sold and used in the project condition would be considered eligible for offset crediting;
2. Project proponents should track the distribution of fly ash up to the point where the fly ash is added to other materials to produce concrete or other cement based products in order to demonstrate that the fly ash is actually displacing cement and is being mixed at non-regulated facilities. Any fly ash distributed and blended at cement production plants subject to the Alberta Specified Gas Emitters Regulation (SGER) (or other relevant provincial/federal climate change regulation) and included in the intensity calculation for that facility is ineligible for offsets. The GHG intensity of cement production plants is expressed as the tonnes of greenhouse gas emissions per unit of product output. The product output would include clinker, blended cement, and/or additives that are added to the primary facility outputs within the cement production facility fence line as defined by the Alberta SGER. Fly ash included in the total production output from the cement plants defined as Large Final Emitter Sites under the SGER would be ineligible to generate offsets because the overall GHG intensity for the cement production plant would have been decreased by having a larger value for the total facility output. Project proponents must exercise reasonable diligence to ensure that the double counting of GHG emission reductions from fly ash mixing is avoided. If fly ash is handled at a regulated facility but not included in annual SGER reporting, records must be available to verify this;
3. The quantification of reductions achieved by the project is based on actual measurement and monitoring (except where indicated in this protocol) as indicated by the proper application of this protocol; and,
4. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System. [Of particular note:
    a. [The date of equipment installation, operating parameter changes or process reconfiguration are initiated or have effect on the project on or after January 1, 2002 as indicated by facility records;]
    b. [The project may generate emission reduction offsets for a period of 8 years unless an extension is granted by Alberta Environment, as indicated by facility and offset system records. Additional credit duration periods require a reassessment of the baseline condition; and,]

c. [Ownership of the emission reduction offsets must be established as indicated by facility records.]

Protocol Flexibility

Flexibility in applying the quantification protocol is provided to project proponents in three ways:

1. The project proponent may choose to develop a baseline GHG emissions intensity factor for cement production using project specific fuel consumption and process emissions data from one or more cement production plants in place of the aggregated values provided in this protocol. The development of the baseline GHG intensity should follow Good Practice Guidance from Alberta Environment and account for all direct GHG emissions at the facility per unit of cement product output from the plant consistent with the quantification approaches outlined in the Alberta SGER Technical Guidance Document for Baseline Emission Intensity Applications. There exists a wide range of other good practice guidance related to the quantification of GHG emissions from cement production including, but not limited to, the World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD) GHG Protocol Initiative, California Climate Action Registry (CCAR) Cement Reporting Protocol and the Clean Development Mechanism (CDM) Methodology ACM0005. Refer to Appendix A for the detailed quantification approach for this flexibility mechanism;
2. The project proponent may define and justify a project specific cement to fly ash replacement ratio based on measured fly ash and cement usage data from at least one year of operations for the specific application of fly ash. This factor may be substituted for the conservative replacement ratio (referred to as an equivalence factor) used in Table 2.4. The methodology for generation of this factor must ensure accuracy; and be robust enough to provide an uncertainty range;
3. Site specific emission factors may be substituted for the generic emission factors indicated in this protocol document in Appendix B. Some cement plants may employ Continuous Emissions Monitoring Systems (CEMS) or conduct frequent fuel analyses (energy content and carbon content) which can effectively be used to determine site-specific emission factors that may be more appropriate than the default emission factors in this protocol. The methodology for generation of these emission factors must ensure accuracy; and be robust enough to provide uncertainty ranges in the factors;
4. Measurement and data management procedures may be modified by the project proponent to account for the available equipment as long as the specified minimum standards for data quantity, frequency and quality are met. Where these standards cannot be met, the project proponent must justify why the method used represents a reasonable deviation from the protocol methodology.

The project proponent will have to justify their approach in detail to apply any of these flexibility mechanisms.

1.2 Glossary of New Terms

Blended Cement: Blended cement is cement that contains supplementary cementing materials such as fly ash, blast furnace slag, and silica fume.

Cement: Cement is used as an ingredient in concrete, mortar, stucco, and grout. The most common type of cement used is called Portland cement, which is made from clay, limestone, sand, and iron. Portland cement does not contain any supplementary cementing materials.

Cement Plant: A facility that produces clinker and blended cement products. The main components of a cement plant are a high temperature kiln used to remove CO2 from carbonate materials to produce clinker and a mill used to grind materials to the appropriate size.

Clinker: Raw materials including minerals containing calcium oxide, silicon oxide, aluminium oxide, ferric oxide, and magnesium oxide are mined and mixed to the proper proportions. This mixture is fed by either wet or dry process into large, heated kilns to drive off unwanted elements. The remaining materials are called clinker.

Fly Ash: Fly ash is generated during the combustion of ground or powdered coal at power generation facilities and is collected from the exhaust gas stream. Fly ash is generally finer than cement and is pozzolanic in nature, which means it exhibits cementitious properties. It consists mostly of silicon dioxide, aluminium oxide, calcium oxide, and iron oxide. CSA A3001 identifies three types of fly ash on the basis of calcium content. Two of these types are produced in Canada, Type F (<8% CaO) and Type CI (8 – 20% CaO). A maximum of 5% SO_3 for all types is permitted for use in cement.

Functional Equivalence The Project and the Baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement (such as the mass of cement product produced or blended) for comparison between the Project and Baseline activities.

2.0 Quantification Development and Justification

The following sections outline the quantification development and justification.

2.1 Identification of Sources and Sinks (SS's) for the Project

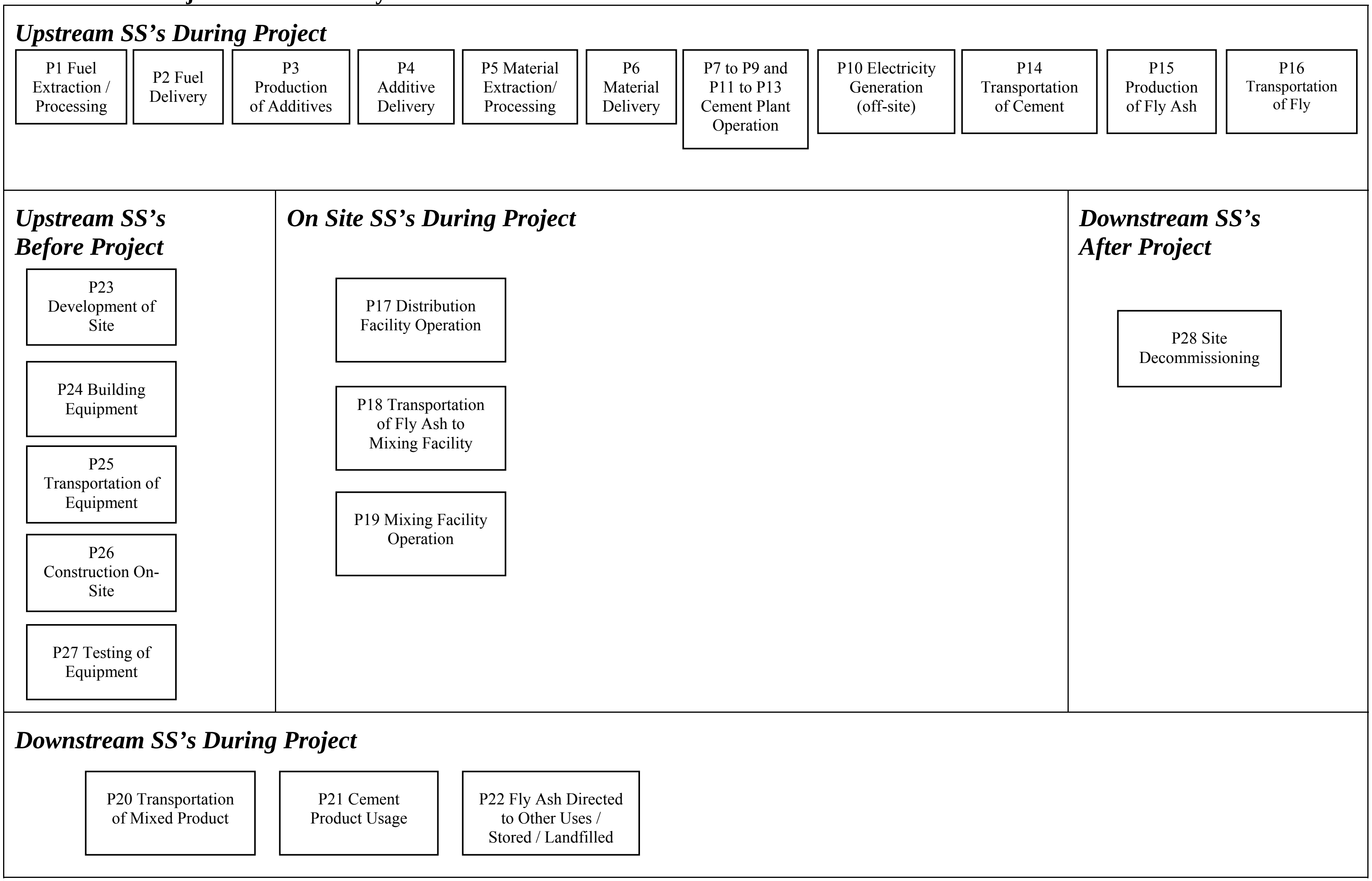
SS's were identified for the project by reviewing the relevant process flow diagrams, consulting with stakeholders (i.e. project proponents) and reviewing good practice guidance and other relevant greenhouse gas quantification protocols. This iterative process confirmed that the SS's in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagrams provided in FIGURE 1.1 and, the project SS's were organized into life cycle categories in FIGURE 2.1. Descriptions of each of the SS's and their classification as controlled, related or affected are provided in TABLE 2.1**.**

The criteria for classifying SS's, based on Guidance provided by Environment Canada, are as follows:

Controlled:	The behaviour or operation of a controlled SS is under the direction and influence of a Project Proponent through financial, policy, management, or other instruments.
Related:	A related SS has material and / or energy flows into, out of, or within a project but is not under the reasonable control of the project proponent.
Affected:	An affected SS is influenced by the project activity through changes in market demand or supply for projects or services associated with the project.

FIGURE 2.1: Project Element Life Cycle Chart



1 **TABLE 2.1: Project SS's**

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Project Operation		
P1 Fuel Extraction / Processing	Each of the fuels used throughout the project will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are aggregated under this SS to account for GHG emissions associated with their extraction and processing at upstream oil and gas facilities. Volumes and types of fuels are the important characteristics to be tracked.	Related
P2 Fuel Delivery	Each of the fuels used throughout the on-site component of the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
P3 Production of Additives	The additives used in the cement production process of the project will need to be produced off-site. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production of additives. Volumes and types of additives are the important characteristics to be tracked.	Related
P4 Additive Delivery	The additives used in the cement production process of the project will need to be transported to the site. This may include shipment by truck or rail, resulting in the emissions of greenhouse gases. Distance and means of additive delivery as well as the tonnes of additives delivered are the important characteristics to be tracked.	Related
P5 Material Extraction / Processing	The materials used in the cement production process of the project such as limestone and gypsum will need to be produced off-site. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production of materials. The tonnes of each material are the important characteristic to be tracked.	Related
P6 Material Delivery	The materials used in the cement production process of the project will need to be transported to the site. This may include shipment by truck or rail, resulting in the emissions of greenhouse gases. Distance and means of material delivery as well as the volumes of materials delivered are the important characteristics to be tracked.	Related
P7 to P9 and P11 to P13 Cement Plant Operation	The fuels used at the cement plant to operate a variety of equipment to produce cement may require additional processing prior to combustion. This is particularly true when alternative fuels such as biomass, refuse or tire derived fuels are used. The processing of these fuels may require the operation of grinding equipment and dryers which would require additional energy inputs that may not be covered by the primary heat and power generation systems at the cement plant, resulting in the emission of greenhouse gases. The types and quantities of fossil fuels consumed are the important characteristics to be tracked.	Related
	The generation of heat and/or power at the cement production plant site would be required to operate the mill and kiln as well as other cement production process. This will require combustion of fossil fuels such as coal, petroleum coke, natural gas or alternative fuels, resulting in the emission of greenhouse gases. The quantities, heating values and (fossil) carbon contents of each type of fuel are the important quantities to track.	Related
	The cement plant may generate electricity on-site to provide power for the cement production processes and will result in the combustion of various conventional and possibly alternative fuels, resulting in the emission of	Related

	greenhouse gases. The type, quantity and (fossil) carbon content of each fuel should be tracked in addition to the total MWh of electricity generated.	
	The cement plant will require a variety of on-site material processing units such as a mill to grind the raw materials into the appropriate sizes. This equipment may require the consumption of fossil fuels, resulting in greenhouse gas emissions. The type, quantities and (fossil) carbon contents of all fuels not already accounted for under the SS for Heat and Power Generation should be accounted for here.	Related
	The calcination of limestone and other carbonate materials to produce clinker involves heating the materials in a kiln at very high temperatures. The chemical decomposition reaction (called calcination) results in the release of CO2 for every unit of carbonate contained in the kiln feedstock (mainly limestone) based on the stoichiometry of the reaction. These emissions from calcination are referred to as Industrial Process Emissions and they represent a major source of anthropogenic GHG emissions in the cement industry. Additionally the combustion of fossil fuel is required to operate the kiln. The tonnes of clinker produced as well as the types, quantities and carbon contents of each fuel consumed to operate the kiln are the important characteristics to be tracked.	Related
	Cement kiln dust (CKD) may be produced in appreciable quantities as a by-product from the kiln particulate matter control units (baghouses, electrostatic precipitators and cyclones). The CKD may represent the leakage of GHG emissions if it isn't recycled at the plant and blended into the final products. The industrial process emissions from the cement plant may be quantified based on the clinker output of facility (rather than the raw material composition and input to the facility) and therefore if large amounts of CKD are sent to disposal then the process emissions may be somewhat under estimated due to this discrepancy. The important items to track are the total tonnes of CKD produced, the quantity recycled/blended and the tonnes sent for disposal.	Related
P10 Electricity Generation (off-site)	Electricity may be required for operating a variety of equipment at the cement production facility in the project. The site may have on-site generation electricity, but may also source electricity from other generators or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. This electricity would have been produced at an emissions intensity as deemed appropriate by the Program Authority. Quantity and source of power are the important characteristics that may need to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
P14 Transportation of Cement	The cement produced at the cement plant will need to be transported to the blending facility or directly to the end site where the concrete will be poured. This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of transportation as well as tonnes of cement transported are the important characteristics to be tracked.	Related
P15 Production of Fly Ash	Fly ash is produced from the combustion of coal. The facility that generates the fly ash (typically a coal fired power plant) would have the primary function of producing electricity and would have any number of processes that would require energy inputs and therefore consume fossil fuels as part of those processes. GHG emissions from coal fired electricity generation facilities are not included under the scope of this protocol as they are independent of the project activity (GHG emissions from fly ash blending/usage are not dependent on the operations of the power generation facility) and are already subject to regulation under the Specified Gas Emitters Regulation.	Related

P16 Transportation of Fly Ash	The fly ash produced at coal combustion facilities would need to be transported to distribution facilities before it is delivered to mixing facilities or to the end user in the project condition in order to be used in cement products. Any fly ash that is not used in cement products would have to be transported to other end uses, to storage or to a disposal site (e.g. landfill). This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of fly ash transportation as well as volumes of fly ash transported are the important characteristics to be tracked.	Related
Onsite SS's during Project Operation		
P17 Distribution Facility Operation	The operation of a distribution facility will require the consumption of fossil fuels to operate material handling equipment such as dump trucks and loaders, resulting in the emission of greenhouse gases. Types and quantities of fuels should be tracked to establish functional equivalence between the project and baseline.	Controlled
P18 Transportation of Fly Ash to Mixing Facility	The fly ash may need to be transported from any distribution facilities to one or more mixing or blending facilities. This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of fly ash transportation as well as volumes of fly ash transported are the important characteristics to be tracked.	Controlled
P19 Mixing Facility Operation	In the project condition there may exist blending or mixing facilities (often referred to as concrete plants) that add fly ash to cement to meet product specifications (e.g. for Ready Mix applications). These facilities, herein referred to as mixing facilities, are assumed not to have mills that grind the fly ash. The operations of the mixing facilities may require fossil fuels for material processing, mixing and for operation of other mobile equipment requiring diesel, gasoline or other fuels, resulting in the emission of greenhouse gases. In the majority of cases the mixing of fly ash in the project is functionally equivalent to the baseline.	Controlled
Downstream SS's during Project Operation		
P20 Transportation of Mixed Product	The mixed product (fly ash and cement) will need to be transported from the mixing facility to the end user (e.g. the concrete pour site). The transportation of this product will require the consumption of fossil fuels. The distance should be evaluated to account for functional equivalence between the baseline and project condition.	Related
P21 Cement Product Usage	The final blended product will be used for any number of uses in the project condition such as in Ready-Mix applications, concrete, grout, or oil and gas well development. This SS includes any further distribution of concrete or other cement based products. All of the product end uses will require the combustion of fossil fuels to operate equipment which will result in greenhouse gas emissions. Product usage, material properties, durability and performance should be assessed to evaluate functional equivalence between the baseline and project conditions. It is noted that the use of fly ash may extend the service life of the concrete or cement based product in which it is used.	Related
P22 Fly Ash Directed to Other Uses / Stored / Landfilled	In the project condition some fly ash will not be used in cement based products and will be directed to other end uses or to disposal. Other end uses for fly ash may include use in the manufacture or paints, plastics, ceramics, synthetic wood and soil remediation. The remaining fly ash would either be stored indefinitely or sent to a disposal site, such as a landfill. Depending in the type of end uses and disposal methods, there may be resulting greenhouse gas emissions. The tonnes of fly ash disposed and type of disposal method are important characteristics to be tracked.	Related
Other		

P23 Development of Site	Additional development may be required for the addition of a distribution facility in the project condition. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, etc. There will also need to be some construction of structures for the facility such as storage areas, offices, etc. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P24 Building Equipment	Additional equipment may need to be built either on-site or off-site to accommodate the blending of fly ash at the blending facility. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
P25 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by truck, barge and/or train. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P26 Construction On-Site	The process of construction at the site may require a variety of construction equipment such as heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
P27 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment in order to ensure that it is operational. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P28 Site Decommissioning	Once a distribution facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

1

2.2 Identification of Baseline

The baseline condition for this protocol is defined as the GHG emissions from the production of an equivalent mass of cement from raw materials that has been displaced by fly ash in the project condition due to the activities of the project proponent, which could include the establishment or expansion of a marketing and distribution system for fly ash that was previously underutilized, the increase in fly ash mixing with cement products or the increased use of fly ash in cement products at end-use sites. The baseline GHG emissions are quantified based on three main elements: the baseline GHG intensity of cement production in Alberta, the current (project) level of fly ash utilization and the historic level of fly ash utilization.

The baseline condition uses a historic benchmark approach to account for the GHG emissions intensity of cement production in the baseline. Baseline emission factors were developed using aggregated GHG emissions from fossil fuel consumption and industrial process emissions at all cement production plants in Alberta during 2003 to 2006. The total GHG emissions from these plants were divided by the total production output from the cement plants to arrive at a kg CO_2e/tonne of product baseline emission intensity factor. The use of three years of historical GHG emissions data collected after the Alberta Offset System project eligibility start date of January 1, 2002 provides for reasonable certainty as to the actual GHG emissions avoided by projects initiated post 2002. The use of a static baseline emission factor was therefore reasonable at the time of protocol writing and practical given the challenges related to the transfer of potentially sensitive information between proponents in the cement industry and the project proponent(s) distributing and using the fly ash. However, it is expected that as additional Federal GHG regulations come into force in Canada in 2010, there will be opportunities to refine these baseline emission factors with more up to date data at that time.

The baseline emissions from the production of a functionally equivalent quantity of cement are calculated based on the measured tonnes of fly ash mixed with cement in the project condition times the emissions intensity factor for cement production in Alberta. The baseline emissions are quantified on the basis that one tonne of fly ash displaces 0.88 tonnes of cement product as per the Natural Resources Canada (NRCAN) October 2006 report titled *Estimating GHG Savings from Use of Fly Ash* (N. Bouzoubaa, A. Bilodeau, and B. Fournier). This cement to fly ash replacement ratio factor (tonnes of cement displaced per tonne of fly ash used) is based on the assumption that concretes containing some fly ash and those that only contain cement have similar 28 day compressive strengths and workability. It is based on laboratory data on concrete using fly ashes from eastern and mid-western Canada, and validated by field data provided by ready mixed concrete companies from western Canada. This factor represents a conservative approach to determining the quantity of cement displaced by fly ash for the majority of applications. Where higher replacement rates or different performance specifications are used, the project proponent should refer to the section on Flexibility Mechanisms in this protocol.
Additional research from the US Department of Energy, through the Utility Solid Waste Activities Group, confirms the magnitude of the value presented by the NRCAN report. In

the June 2005 report *Revised General Guidelines and Draft Technical Guideline for EPACT Section 1605(b) Voluntary GHG Reporting* (J. Roewer) an average of 0.91 tonnes of cement was displaced by 1 tonne of fly ash in most construction, manufacturing and grout applications.
The use of the cement to fly ash replacement factor ensures functional equivalence between the baseline and project conditions. It should also be noted that the use of fly ash can extend the service life of concrete or cement based products through improved durability.

In order to ensure that the project activity's use of fly ash exceeds business as usual practices, the baseline scenario requires the project proponent to collect historic fly ash sales or usage data to establish the average tonnes of fly ash blended with cement products during the years 1999-2001. By quantifying a project-specific business as usual activity level in the baseline, only the incremental tonnes of fly ash blended in the project condition are credited for offsets.

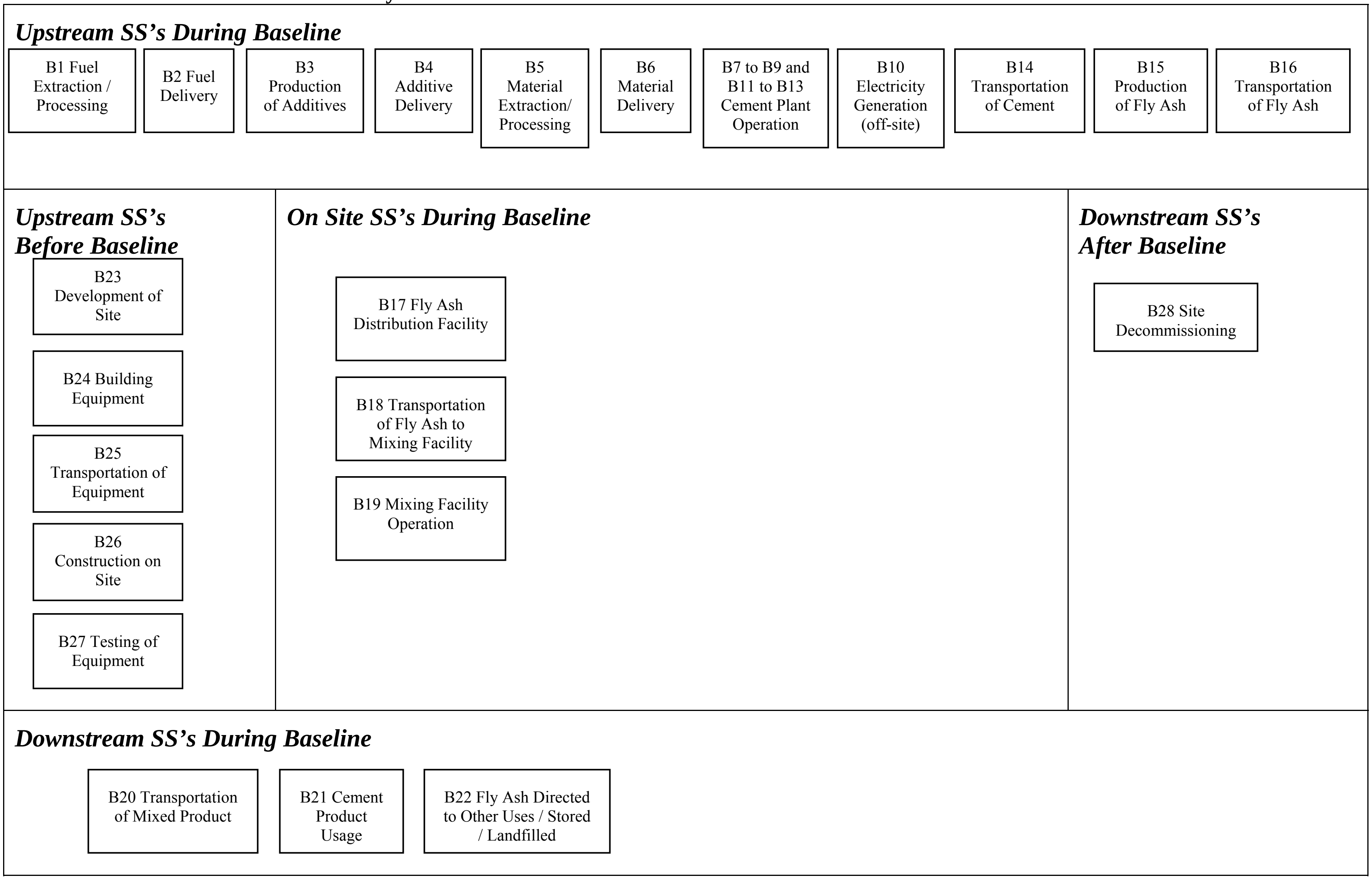
The use of measured fly ash tonnages and historical GHG emission intensities for cement production in Alberta provides reasonable certainty in the quantification of baseline emissions. The baseline condition is dynamic in approach as the use of ex post fly ash data accounts for the market forces and other factors in the supply chain that may impact the quantity of cement displaced from year to year.

The baseline condition is defined including the relevant SS's and processes as shown in FIGURE 1.2. More detail on each of these SS's is provided in Section 2.3, below.

2.3 Identification of SS's for the Baseline

Based on the process flow diagrams provided in FIGURE 1.2, the project SS's were organized into life cycle categories in FIGURE 2.2. Descriptions of each of the SS's and their classification as either 'controlled', 'related' or 'affected' is provided in TABLE 2.2**.**

FIGURE 2.2: Baseline Element Life Cycle Chart



1 **TABLE 2.2: Baseline SS's**

1. SS	2. Description	3. Controlled, Related or Affected
Upstream SS's during Baseline Operation		
B1 Fuel Extraction / Processing	Each of the fuels used at the facility in the baseline will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site SS's are aggregated under this SS to account for GHG emissions associated with their extraction and processing at upstream oil and gas facilities. Volumes and types of fuels are the important characteristics to be tracked.	Related
B2 Fuel Delivery	Each of the fuels used at the facility in the baseline will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gases. Distance and means of fuel delivery as well as the volumes of fuel delivered are the important characteristics to be tracked.	Related
B3 Production of Additives	The additives used in the cement production process of the baseline will need to be produced offsite. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production of additives. Volumes and types of additives are the important characteristics to be tracked.	Related
B4 Additive Delivery	The additives used in the cement production process of the baseline will need to be transported to the site. This may include shipment by truck or rail, resulting in the emissions of greenhouse gases. Distance and means of additive delivery as well as the volumes of additives delivered are the important characteristics to be tracked.	Related
B5 Material Extraction / Processing	The materials used in the cement production process of the baseline (including limestone) will need to be produced offsite. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production of materials. Volumes of materials are the important characteristics to be tracked.	Related
B6 Material Delivery	Each of the materials used at the cement plant will need to be transported to the site. This may include shipments by truck or rail, resulting in the emissions of greenhouse gases. Distance and means of material delivery as well as the volumes of materials delivered are the important characteristics to be tracked.	Related
B7 to B9 and B11 to B 13 Cement Plant Operation	The fuels used at the cement plant to operate a variety of equipment to produce cement may require additional processing prior to combustion. This is particularly true when alternative fuels such as biomass, refuse or tire derived fuels are used. The processing of these fuels may require the operation of grinding equipment and dryers which would require additional energy inputs that may not be covered by the primary heat and power generation systems at the cement plant, resulting in the emission of greenhouse gases. The types and quantities of fossil fuels consumed are the important characteristics to be tracked.	Related
	The generation of heat and/or power at the cement production plant site would be required to operate the mill and kiln as well as other cement production process. This will require	Related

	combustion of fossil fuels such as coal, petroleum coke, natural gas or alternative fuels, resulting in the emission of greenhouse gases. The quantities and (fossil) carbon contents of each type of fuel are the important quantities to track.	
	The cement plant may generate electricity on-site to provide power for the cement production processes and will result in the combustion of various conventional and possibly alternative fuels, resulting in the emission of greenhouse gases. The type, quantity and (fossil) carbon content of each fuel should be tracked in addition to the total MWh of electricity generated.	Related
	The cement plant will require a variety of on-site material processing units such as a mill to grind the raw materials into the appropriate sizes. This equipment may require the consumption of fossil fuels, resulting in greenhouse gas emissions. The type, quantities and (fossil) carbon contents of all fuels not already accounted for under the SS for Heat and Power Generation should be accounted for here.	Related
	The calcination of limestone and other carbonate materials to produce clinker involves heating the materials in a kiln at very high temperatures. The chemical decomposition reaction (called calcination) results in the release of CO2 for every unit of carbonate contained in the kiln feedstock (mainly limestone) based on the stoichiometry of the reaction. These emissions from calcination are referred to as Industrial Process Emissions and they represent a major source of anthropogenic GHG emissions in the cement industry. Additionally the combustion of fossil fuel is required to operate the kiln. The tonnes of clinker produced as well as the types, quantities and carbon contents of each fuel consumed to operate the kiln are the important characteristics to be tracked.	Related
	Cement kiln dust (CKD) may be produced in appreciable quantities as a by-product from the kiln particulate matter control units (baghouses, electrostatic precipitators and cyclones). The CKD may represent the leakage of GHG emissions if it isn't recycled at the plant and blended into the final products. The industrial process emissions from the cement plant may be quantified based on the clinker output of facility (rather than the raw material composition and input to the facility) and therefore if large amounts of CKD are sent to disposal then the process emissions may be somewhat under estimated due to this discrepancy. The important items to track are the total tonnes of CKD produced and the quantity recycled/blended.	Related
B10 Electricity Generation (off-site)	Electricity may be required for operating a variety of equipment at the cement production facility in the baseline. The site may have on-site generation electricity, but may also source electricity from other generators or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. This electricity would have been produced at an emissions intensity as deemed appropriate by the Program Authority. Quantity and source of power are the important characteristics that may need to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
B14 Transportation of Cement	The cement produced at the cement plant will need to be transported to the mixing facility site. This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of transportation as well as volumes of cement transported are the important	Related

	characteristics to be tracked.	
B15 Production of Fly Ash	Fly ash is produced from the combustion of coal. The facility that generates the fly ash (typically a coal fired power plant) would have the primary function of producing electricity and would have any number of processes that would require energy inputs and therefore consume fossil fuels as part of those processes. GHG emissions from coal fired electricity generation facilities are not included under the scope of this protocol as they are independent of the project activity (GHG emissions from fly ash mixing/usage are not dependent on the operations of the power generation facility) and are already subject to regulation under the Specified Gas Emitters Regulation.	Related
B16 Transportation of Fly Ash	The fly ash produced at the coal combustion facilities will need to be transported to distribution centers if a marketing system is already in place in the baseline for fly ash usage in cement products, otherwise the fly ash may need to be transported to non-cement product end uses, storage or to a disposal site (e.g. landfill). This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of fly ash transportation as well as volumes of fly ash transported are the important characteristics to be tracked in order to evaluate functional equivalence between the baseline and project scenarios.	Related
Onsite SS's during Project Operation		
B17 Fly Ash Distribution Facility	In some cases the project proponent may have already been transporting and handling fly ash and operating a distribution facility. The operation of a distribution facility will require the consumption of fossil fuels to operate material handling equipment such as dump trucks and loaders, resulting in the emission of greenhouse gases. Types and quantities of fuels should be tracked to establish functional equivalence between the project and baseline.	Controlled
B18 Transportation of Fly Ash to Mixing Facility	The fly ash may need to be transported from any distribution facilities to one or more blending facilities. This may include shipment by truck or rail, resulting in the emission of greenhouse gases. Distance and means of fly ash transportation as well as volumes of fly ash transported are the important characteristics to be tracked to establish functional equivalence between the project and baseline.	Controlled
B19 Mixing Facility Operation	In the baseline there may exist blending or mixing facilities (often referred to as concrete plants) that add fly ash to cement to meet product specifications (e.g. for Ready Mix applications). These facilities, herein referred to as mixing facilities, are assumed not to have mills that grind the fly ash. The operations of the mixing facilities may require fossil fuels for material processing, mixing and for operation of other mobile equipment requiring diesel, gasoline or other fuels, resulting in the emission of greenhouse gases. Types and quantities of fuels should be tracked to establish functional equivalence between the project and baseline.	Controlled
Downstream SS's during Baseline Operation		
B20 Transportation of Mixed Product	The mixed cement product will need to be transported from the mixing facility to the final site pouring concrete or producing other cement based products. The transportation of this product will require the consumption of fossil fuels. The distance should be evaluated to account for functional equivalence between the baseline and project condition.	Related

B21 Cement Product Usage	The final blended product will be used for any number of uses in the project condition such as in Ready-Mix applications, concrete, grout, or oil and gas well development. This SS includes any further distribution of concrete or other cement based products. All of the product end uses will require the combustion of fossil fuels to operate equipment which will result in greenhouse gas emissions. Product usage, material properties, durability and performance should be assessed to evaluate functional equivalence between the baseline and project conditions. It is noted that the use of fly ash may extend the service life of the concrete or cement based product in which it is used.	Related
B22 Fly Ash Directed to Other Uses / Stored / Landfilled	In the baseline condition some fly ash will not be used in cement based products and will be directed to other end uses or to a disposal site (e.g. landfill). Other end uses for fly ash may include use in the manufacture or paints, plastics, ceramics, synthetic wood and soil remediation. The remaining fly ash would either be stored indefinitely or sent to a disposal site. Depending in the type of end uses and disposal methods, there may be resulting greenhouse gas emissions. The tonnes of fly ash disposed and type of disposal method are important characteristics to be tracked.	Related
Others		
B23 Development of Site	The mixing site may need to be developed under the baseline condition. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer etc. This may also include clearing, grading, etc. There will also need to be some construction of buildings for the facility such as storage areas, offices, etc. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
B24 Building Equipment	Equipment may need to be built either on-site or off-site. This can include the baseline components for the storage, handling and processing of the cement and mixing materials. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabricating and assembly.	Related
B25 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by truck, barge and/or rail. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B26 Construction on Site	The process of construction at the site will require a variety of heavy equipment, smaller power tools, cranes and generators. The operation of this equipment will have associated greenhouse gas emission from the use of fossil fuels and electricity.	Related
B27 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment in order to ensure that it is operational. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related

B28 Site Decommissioning	Once a mixing facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related

2.4 Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline conditions were compared and evaluated as to their relevancy using the guidance provided in Annex D of the "Guide for Protocol Developers: Draft for Consultation", dated August 2008 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in TABLE 2.3 below. All other SS's listed previously are included.

TABLE 2.3: Comparison of SS's

1. Baseline Options	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
Upstream SS's				
P1 Fuel Extraction / Processing	N/A	Related	Exclude	Excluded since the emissions from fuel extraction and processing would have been higher in the baseline due to a greater amount of cement being produced that would have required a greater amount of fossil fuels to be extracted and processed.
B1 Fuel Extraction / Processing	Related	N/A	Exclude	Excluded as the data needed to quantify this SS are not directly controlled by the project proponent and therefore it is unlikely that the project proponent would have access to fuel consumption records from the cement production plant. Since the protocol approach relies on aggregated emissions intensity data per unit of cement production, it would likely not be possible for the project proponent to disaggregate specific fuel consumption data per unit of cement displaced by his/her project activity. Additionally it would be conservative to exclude these emissions in the baseline scenario.
P2 Fuel Delivery	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce the quantity of fuel delivered to the cement plant and therefore it is conservative to exclude these SS's.
B2 Fuel Delivery	Related	N/A	Exclude	
P3 Production of Additives	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce the amount of additives produced for the cement plant and therefore it is conservative to exclude them.
B3 Production of Additives	Related	N/A	Exclude	
P4 Additive Delivery	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce the amount of additives delivered to the cement plant and therefore it is conservative to exclude them.
B4 Additive Delivery	Related	N/A	Exclude	
P5 Material Extraction / Processing	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce the amount of materials extracted and processed for use at the cement plant and therefore it is conservative to exclude them.
B5 Material Extraction / Processing	Related	N/A	Exclude	
P6 Material Delivery	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce the amount of materials delivered to the cement plant and therefore it is conservative to exclude them.
B6 Material Delivery	Related	N/A	Exclude	
P7 to P9 and P11 to P13 Cement Plant Operation	N/A	Related	Include	N/A

B7 to B9 and B11 to B13 Cement Plant Operation	Related	N/A	Include	
P10 Electricity Generation (Off-Site)	N/A	Related	Exclude	Excluded as these SS's are likely lower in the project condition because the replacement of cement with fly ash would indirectly reduce electricity usage for material processing at cement plants as less material would be required to produce cement products and therefore it is conservative to exclude them.
B10 Electricity Generation (Off-Site)	Related	N/A	Exclude	
P14 Transportation of Cement	N/A	Related	Exclude	Excluded as the replacement of cement with fly ash in the project would reduce transportation requirements for cement compared to the baseline and it is therefore conservative to exclude these SS's.
B14 Transportation of Cement	Related	N/A	Exclude	
P15 Production of Fly Ash	N/A	Related	Exclude	Excluded as the fly ash is a by-product from coal power plants and all GHG emissions from these facilities are already regulated under the Specific Gas Emitters Regulation.
B15 Production of Fly Ash	Related	N/A		
P16 Transportation of Fly Ash	N/A	Related	Exclude	Refer to P18/B18 for justification
B16 Transportation of Fly Ash	Related	N/A		
Onsite SS's				
P17 Distribution Facility Operation	N/A	Controlled	Include	N/A
B17 Distribution Facility Operation	Controlled	N/A	Exclude	Excluded as these emissions are likely immaterial in the baseline and it is conservative to exclude them.
P18 Transportation of Fly Ash to Mixing	N/A	Controlled	Exclude	Excluded as for the majority of project configurations the total transportation distance included in the project fly ash distribution chain (P16, P18 and P20) would be equivalent to the total distance required to transport an equivalent amount of cement and fly ash in the baseline from production facilities to each respective end use via distribution facilities, mixing facilities, end users or disposal sites (B14, B16, B18 and B20) had fly ash not been utilized in the project activity. This assumption is supported by the November 2003 US EPA study titled "Background Document for Life-Cycle Greenhouse Gas Emission Factors for Fly Ash Used as a Cement Replacement in Concrete" demonstrated that the transportation of fly ash to end users did not materially impact overall lifecycle GHG emissions even when the distance required to transport the fly ash significantly farther than the distance required to transport cement. A sensitivity analysis indicated that when the fly ash transportation distance was 3.33 times that of cement only a 2% difference in lifecycle GHG emissions were obtained.
B18 Transportation of Fly Ash to Mixing	Controlled	N/A		
P19 Mixing Facilities Operation	N/A	Controlled	Exclude	Excluded as the mixing facilities will continue to process the same volume of materials (cement plus fly ash) using the same types of equipment and mixing

B19 Mixing Facilities Operation	Controlled	N/A		operations will likely not be impacted by the project activity and will therefore be functionally equivalent in the baseline and project conditions.
Downstream SS's				
P20 Transportation of Mixed Product	N/A	Related	Exclude	Excluded as in the majority of project configurations there will be no change in product transportation practices and therefore no change in fossil fuel consumption for mixed product transportation, making the baseline and project scenarios functionally equivalent.
B20Transportation of Mixed Product	Related	N/A		
P21 Cement Product Usage	N/A	Related	Exclude	Excluded as in the majority of project configurations there will be no change in downstream cement product usage due to the pozzolanic properties of fly ash that make it an ideal replacement for cement in many applications. In many cases the cement products containing fly ash may be more durable than the conventional cement products they replace and as such the design life of the end use application may be increased, which could further improve the lifecycle GHG emission profile of a particular project. Due to the long life times of concrete and cement product uses, there is considerable uncertainty around the magnitude of this GHG benefit. It is therefore conservative to exclude these SSRs as the baseline emissions are likely higher than in the project condition.
B21 Cement Product Usage	Related	N/A		
P22 Fly Ash Directed to Other Uses / Stored / Landfilled	N/A	Related	Exclude	Excluded as by definition these GHG emissions would be higher in the baseline as a greater volume of fly ash would have been directed to other uses, storage or landfill. Therefore the GHG emissions associated with these activities would have been higher in the baseline and it is conservative to exclude these SS's.
B22 Fly Ash Directed to Other Uses / Stored / Landfilled	Related	N/A		
Other				
P23 Development of Site	N/A	Related	Exclude	Emissions from the distribution and blending facilities site development are not material given the long project life, and the minimal site development typically required.
B20 Development of Site	Related	N/A	Exclude	Emissions from blending facility site development are not material for the baseline condition given the minimal site development typically required.
P24 Building Equipment	N/A	Related	Exclude	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B21 Building Equipment	Related	N/A	Exclude	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.
P25 Transportation of Equipment	N/A	Related	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B22 Transportation of Equipment	Related	N/A	Exclude	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
P26 Construction on Site	N/A	Related	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.

B23 Construction on Site	Related	N/A	Exclude	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P27 Testing of Equipment	N/A	Related	Exclude	Emissions from testing of equipment are not material given the long project life and the minimal testing of equipment typically required.
B24 Testing of Equipment	Related	N/A	Exclude	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.
P28 Site Decommissioning	N/A	Related	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B25 Site Decommissioning	Related	N/A	Exclude	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

2.5 Quantification of Reductions, Removals and Reversals of Relevant SS's

2.5.1 Quantification Approaches

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in TABLE 2.4, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Cement Plant Operation}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Cement Plant Operation}} + \text{Emissions}_{\text{Distribution Facility Operation}}$$

Where:

$\text{Emissions}_{\text{Baseline}}$ = sum of the emissions under the baseline condition.

$\text{Emissions}_{\text{Cement Plant Operation (SS B7 to B9 and B11 to B13)}}$

$\text{Emissions}_{\text{Project}}$ = sum of the emissions under the project condition.

$\text{Emissions}_{\text{Cement Plant Operation (SS P7 to P9 and P11 to P13)}}$

$\text{Emissions}_{\text{Distribution Facility Operation (SS P17)}}$

TABLE 2.4: Quantification Procedures

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P7 to P9 and P11 to P13 Cement Plant Operation	This SS is accounted for under the baseline scenario as only the incremental change in tonnes of cement displaced by fly ash are quantified. Refer to the SS's for B7 to B9 and B11 to B13, collectively referred to under 'Cement Plant Operation.'					
P17 Distribution Facility Operation	$Emissions_{Distribution\ Facility\ Operation} = \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CO2})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ CH4})\ ;\ \sum (Vol.\ Fuel_i * EF\ Fuel_{i\ N2O})$					
	Emissions $_{Distribution\ Facility\ Operation}$	kg of CO_2; kg of CH_4; kg of N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Fuel Consumed for the operation of the Distribution Facility / Vol. Fuel $_i$	L / m^3 / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO_2 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CO2}$	kg CO_2 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ CH4}$	kg CH_4 per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF Fuel $_{i\ N2O}$	kg N_2O per L / m^3 / other	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
Baseline SS's						
B7 to B9 and B11 to B13 Cement Plant Operation	$Emissions_{Cement\ Plant\ Operation} = (Mass\ of\ Cement_{Displaced\ Project} - Mass\ of\ Cement_{Displaced\ Business\ as\ Usual}) * EF_{Cement\ Production\ Intensity}$ $Mass\ of\ Cement_{Displaced\ Project} = Mass\ of\ Fly\ Ash\ Mixed_{Project} * Equivalence\ Factor$ $Mass\ of\ Cement_{Displaced\ Business\ as\ Usual} = Average\ Mass\ of\ Fly\ Ash\ Mixed_{1999-2001} * Equivalence\ Factor$					

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Emissions $_{Cement\ Plant\ Operation}$	kg of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Incremental Mass of Cement Product Displaced by Fly Ash / Mass of Cement $_{Displaced\ Project}$	Tonnes	Calculated	Calculated based on the mass of fly ash mixed at eligible (non-regulated) facilities in the project condition times the equivalence factor to determine the mass of cement displaced per mass of fly ash mixed.	Reconciliation of Monthly Totals	It is reasonable to determine the equivalent amount of cement displaced on a monthly basis as this value is calculated from fly ash data that is measured on a per load basis.
	Average Mass of Cement Product Displaced by Fly Ash in the Baseline/ Mass of Cement $_{Displaced\ Business\ as\ Usual}$	Tonnes	Calculated	Calculated based on the average mass of fly ash mixed at eligible (non-regulated) facilities from 1999-2001 times the equivalence factor to determine the mass of cement displaced per mass of fly ash mixed.	Reconciliation of Monthly Totals	It is reasonable to determine the equivalent amount of cement displaced on a monthly basis as this value is calculated from fly ash data that is measured on a per load basis.
	Mass of Fly Ash Mixed With Cement Products in the Project Condition/ Average Mass of Fly Ash Mixed $_{Project}$	Tonnes	Measured	The mass of fly ash mixed is the weight of fly ash received by eligible mixing facilities or end users as measured using conventional truck scales or other applicable weigh scales that are regularly maintained and calibrated.	Each load	Measurement on a per load basis represents the highest level of diligence to account for variations in moisture content and bulk density.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Average Mass of Fly Ash Mixed With Cement Products Over the 3 years Preceding 2002 / Average Mass of Fly Ash Mixed $_{1999\text{-}2001}$	Tonnes	Estimated	Average mass of fly ash used or delivered to mixing facilities or end users during the years 1999 – 2001 (the 3 years preceding the Alberta Offset System project start date eligibility criteria). This quantity represents the business as usual rate of fly ash substitution.	N/A	Measurement will be based on historical fly ash utilization or delivery records available to the project proponent. The use of three years of historical data provides sufficient diligence to establish business as usual fly ash usage and determine the incremental fly ash usage that has occurred as a result of the project activity.
	Equivalence Factor to Convert from Mass of Fly Ash Used to Mass of Cement Displaced/ Equivalence Factor	Tonnes cement displaced/ tonne fly ash used	Estimated	The equivalence factor represents the ratio in which cement is displaced by fly ash and is used to account for the fact that one tonne of fly ash does not displace exactly one tonne of cement. The default equivalence factor is 0.88 as per *Materials Technology Laboratory, Estimating GHG Savings from Use of Fly Ash* (N. Bouzoubaa, A. Bilodeau, and B. Fournier).	Once	The use of an equivalence factor represents a conservative method to determine the actual displacement of cement per unit of fly ash used based on the physical properties of the two materials (compressive strength, pozzolanic properties etc.).

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Emissions Intensity Factor for Cement Production / Cement Production Intensity	800 kg of CO_2e per tonne of cement displaced	Estimated	This represents an aggregate emission factor for fossil fuel consumption (stationary combustion and on-site transportation) and industrial process (CO_2) emissions per unit of cement product output at all relevant Alberta cement production plants. GHG emissions intensities have been averaged from 3 years of data at the relevant cement production plants that was submitted to Alberta Environment under the Specified Gas Emitters Regulation (SGER) during 2003-2006.	Annual	The Alberta SGER submissions represent best available cement industry data that has been verified by a 3rd party auditor and reviewed by Alberta Environment. The facility GHG emission intensity data has been collected for all cement production plants in Alberta. In the event that SGER data is unavailable to the project proponent, guidance is given in Appendix A on the required data needed to establish a baseline GHG intensity per unit of cement displaced by fly ash.

2.5.2. Contingent Data Approaches

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in TABLE 2.5, below.

2.6 Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements in Table 2.4 and be substantiated by company records for the purpose of verification.

Since this protocol relies on existing audited GHG intensity data from cement production plants in Alberta, the main data management requirements are focussed on the tonnes of fly ash utilized in the project condition as well as in the business as usual case, defined to be the three years preceding the Alberta Offset System start date eligibility requirement (2002). The fly ash distribution chain from the coal combustion facility through to the end user may involve a number of different parties and diligent record keeping is important to ensure accurate determination of the mass of fly ash that has displaced cement. The project proponent would be expected to retain hard copies of measured data from weigh scales and/or soft copies from databases or spreadsheets tracking sales and distribution records.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigour of the management system for the data, the more easily a third party will be able to conduct an audit for the project.

Due to the broad nature of this protocol it is possible that project proponents could be from one of many different positions in the fly ash supply chain (e.g. fly ash producer, marketer, blender, user etc.). Each project proponent will have access to select information and data based on that position. It is recognized that many fly ash utilization projects will employ different marketing and supply chains from producer to end user and as such the project proponent should analyze the information flow available to them to ensure that data quality is high.

For projects applying the flexibility mechanism in Appendix A, instead of relying on data that has been audited by a third party for completeness and accuracy and reviewed by Alberta Environment, a higher level of data management is expected in order to substantiate the accuracy of records related to fossil fuel consumption and process emissions required to develop the baseline GHG intensity per unit of cement output from a relevant cement plant. Rigorous data management systems at the cement plant would be important to track the required three years of fuel consumption records, process CO_2 emissions data and production output from the cement plant to establish the baseline GHG intensity.

2.6.1 Record Keeping

Record keeping practises should include:

a. Electronic recording of values of logged primary parameters for each measurement interval;
b. Printing of monthly back-up hard copies of all logged data;
c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
d. Retention of copies of logs and all logged data for a period of 7 years; and
e. Keeping all records available for review by a verification body.

2.6.1 Quality Assurance/Quality Control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

a Protecting monitoring equipment (sealed meters and data loggers);
b Protecting records of monitored data (hard copy and electronic storage);
c Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
d Comparing current estimates with previous estimates as a 'reality check';
e Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
f Establish minimum experience and requirements for operators in charge of project and monitoring; and
g Performing recalculations to make sure no mathematical errors have been made.

TABLE 2.5: Contingent Data Collection Procedures

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Contingency Method	6. Frequency	7. Justify measurement or estimation and frequency
Project SS's						
P17 Distribution Facility Operation	Volume of Each Type of Fuel / Volume of $Fuel_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased by the distribution facility operator within a given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used
Baseline SS's						
B7 to B9 and B11 to B13 Cement Plant Operation	Mass of Fly Ash Mixed With Cement Products in the Project Condition/ Average Mass of Fly Ash $Mixed_{Project}$	Tonnes	Estimated	Reconciliation of mass of fly ash sold each month in the project condition. The project proponent must demonstrate that the tonnes of fly ash sold do not include any fly ash sold to facilities regulated under the SGER or equivalent GHG regulation as specified in the protocol applicability criteria.	Reconciliation of Monthly Totals	Records of sales to eligible facilities provides a reasonable estimate of the parameter when the more accurate and precise method cannot be used.
	Average Mass of Fly Ash Mixed With Cement Products Over the 3 years Preceding 2002 / Average Mass of Fly Ash $Mixed_{1999-2001}$	Tonnes	Estimated	Reconciliation of mass of fly ash sold during the years 1999-2001.	Reconciliation of Monthly Totals	Frequency of reconciliation provides for reasonable diligence. Use of historic sales data is reasonable given the wide range of potential end users of fly ash.

APPENDIX A

Quantification of Flexibility Mechanisms

Flexibility Mechanism

Introduction: This flexibility mechanism is intended to allow the project proponent to quantify GHG emissions from individual SSRs that, when combined, represent the entire operations within the boundary of one or more cement production plants, in the event that aggregated GHG emissions data per unit of cement product output from the plant(s) is not available through other reporting systems (e.g. Alberta SGER). The project proponent must define which activities are considered to be part of the "Cement Plant Site" as each site will differ in its configuration. Project proponents may refer to the Alberta Specified Gas Emitters Regulation Guidance Document, Environment Canada Section 71 and the World Resources Institute Cement Protocol, Clean Development Mechanism protocol, or California Climate Action Registry protocol for further guidance.

The main activities that result in GHG emissions at the Cement Plant Site can be separated into direct emissions from fuel consumption and from process CO2 emissions, as discussed below. Indirect emissions from the consumption of electricity produced off-site (e.g. grid electricity) are not included in the quantification approach as these emissions would occur upstream of the cement plant. Since this flexibility mechanism is used for the determination of baseline emissions, it is conservative to exclude the indirect emissions from electricity generation (imported from the grid or other direct connected facilities) as the resulting baseline GHG emission intensity per unit output will be lower.

Fuel Consumption:

Fossil fuel consumption is broken down into two streams: The fossil fuels, alternative fuels or biomass fuels consumed to generate high temperatures in the cement kiln and pre-calciner (kiln fuels) and the fossil fuels consumed to operate various other equipment at the cement plant (non-kiln fuels). Non-kiln fossil fuels may be consumed to operate thermal process equipment (e.g. dryers), power generation systems, on-site and quarry vehicles, and for room heating. The SSRs in Figure 1.2 that represent the operations of the cement plant (B7, B8, B9 and B11) are aggregated in terms of non-kiln fuels and kiln fuels, however project proponents may account for fuel consumption based on individual site activities or aggregated activities as appropriate. The project proponent should justify the boundary of the cement plant to account for fossil fuel consumption for material handling and on-site transportation as individual cement plants may differ in their configuration. It is assumed for simplicity that any alternative or biomass fuels are consumed as kiln fuels.

Process CO2 Emissions:

Process CO2 emissions result from the calcination of carbonate materials (e.g. calcium carbonate and magnesium carbonate) and can be quantified based on a material balance into and out of the cement kiln. The SS's B12 Calcination of Carbonate Materials and B13 Production of Cement Kiln Dust By-Product represent the potential sources of process emissions from cement plant operations. Quantification of process emissions can be done on a raw material input basis that considers the carbonate materials input into the kiln and their compositions (IPCC) or on a product output basis considering the tonnes of clinker and cement kiln dust produced (WRI and CCAR). The approach used in this flexibility mechanism is consistent with the WRI and CCAR approaches that rely primarily on facility clinker production. Additionally, for conservativeness, GHG emissions from cement kiln dust were not included in the baseline GHG intensity.

Unit of Production:
The GHG emission quantification approach used in this protocol requires that all emissions are quantified on an intensity basis, per unit of cement produced in order to determine the GHG benefit from the replacement of cement with fly ash. The denominator of the GHG intensity term must therefore account for the total product output from the cement plant, which would include total clinker production at the plant and all mineral components added either as clinker substitutes (gypsum, fly ash, puzzolana, limestone, slag, CKD) or as direct cement substitutes (mineral additives that are mixed on-site and shipped as blended cement products). The total production should be representative of the end products shipped from the cement plant site and be inclusive of additives, including any fly ash that has been mixed at the cement plant or input into the kiln with raw materials.

Flexibility Quantification Approach

The quantification approach for the development of a baseline GHG intensity for cement production includes an aggregation of the relevant baseline SS's defined in Figure 1.2 for cement plant operation. These calculation methodologies serve to complete the following three equations for calculating the baseline GHG intensity per tonne of output from a cement plant.

Annual GHG Emissions Intensity = Emissions $_{\text{Cement Plant Operation}}$ / Total Production

GHG Emissions $_{\text{Cement Plant Operation}}$ = Emissions $_{\text{Fuel Consumption for Kiln Operation}}$ + Emissions $_{\text{Fuel Consumption for Other}}$ + Emissions $_{\text{Industrial Process}}$

Total Production = Tonnes $_{\text{Clinker}}$ + Tonnes $_{\text{Mineral Components Added as Clinker Substitutes}}$ + Tonnes $_{\text{Mineral Components Used On-Site as Cement Substitutes}}$

Where:
Emissions $_{\text{Cement Plant Operation}}$ = sum of the direct GHG emissions at the cement plant site.

Emissions $_{\text{Fuel Consumption for Kiln Operation}}$ = Sum of emissions from fossil fuels, alternative fuels and biomass fuels consumed to generate heat and/or power to operate the cement kiln (F1)

Emissions $_{\text{Fuel Consumption for Other}}$ = Sum of emissions from fossil fuels consumed for non-kiln activities including other on-site heat, power generation and the operation of on-site mobile equipment (F2)

Emissions $_{\text{Industrial Process}}$ = Sum of industrial process CO_2 emissions from calcination of carbonate materials (F3)

Total Production = sum of the total annual product output from the cement plant. (P)
Tonnes $_{\text{Clinker}}$ = Total facility clinker output in tonnes

Tonnes $_{\text{Mineral Components Added as Clinker Substitutes}}$ = Tonnes of mineral components consumed in clinker and cement production, including gypsum, limestone, slag, fly ash, puzzolana, cement kiln dust and other materials

Tonnes $_{\text{Mineral Components Used On-Site as Cement Substitutes}}$ = tonnes of pure mineral components added as direct cement substitutes at the cement plant site before shipment of cement products off-site

TABLE A. 1: Flexibility Mechanism

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Aggregated SS's for Cement Plant Operation						
Baseline Cement Plant GHG Intensity	Cement Plant GHG Intensity = ∑ (Emissions $_{F1, F2 \text{ and } F3}$) / (Total Production)					
	Emissions $_{F1, F2 \text{ and } F3}$	kg of CO_2; kg of CH_4; kg of N_2O	N/A	N/A	N/A	Quantity being calculated. The baseline cement plant intensity should be calculated as the average from 3 years worth of data. The use of 3 years of data provides consistent representation of facility fuel mix and production levels.
	Total Cement Plant Output Including Additives/ Total Production	Tonnes	Measured	Reconciliation of facility clinker production records and facility cement production records. Total production includes all mineral additives that are blended into cement	Monthly Reconciliation	Monthly reconciliation is reasonable since facilities keep detailed production and accounting records.
F1 Fuel Consumption for Kiln Operation	Emissions F1 $_{\text{Fuel Consumption for Kiln Operation}}$ = ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ CO2}$); ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ CH4}$); ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ N2O}$); ∑ (Mass Alt. Fuel * HHV $_{AF}$ * EF Alt. Fuel $_{i\ CO2}$); ∑ (Mass Alt. Fuel * HHV $_{AF}$ * EF Alt. Fuel $_{i\ CH4}$); ∑ (Mass Alt. Fuel * HHV $_{AF}$ * EF Alternative Fuel $_{i\ N2O}$) ∑ (Mass Biomass * HHV $_{Biomass}$ * EF Biomass $_{CH4}$); ∑ (Mass Biomass * HHV $_{Biomass}$ * EF Biomass $_{N2O}$)					
	Emissions $_{\text{Fuel Consumption for Kiln Operation}}$	kg of CO_2; kg of CH_4; kg of N_2O	N/A	N/A	N/A	Quantity being calculated.
	Quantity of Fossil Fuel Consumed for Kiln Operation / Vol. Fuel $_i$	m^3 , tonne or other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Higher Heating Value of Fossil Fuel / HHV_{FF}	GJ/ m3 or GJ/tonne	Measured	Annual fuel analysis or use of reference values from Environment Canada or WRI/WBCSD GHG Protocol Initiative.	Annual	The use of higher heating values is consistent with Environment Canada's National GHG Inventory. Annual fuel analysis or the use of reference values is reasonable since most fossil fuels used will have consistent heating values.
	CO_2 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\,CO2}$	kg CO_2 per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems or fuel carbon content analyses) should be used where available, otherwise Environment Canada default values may be used.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\,CH4}$	kg CH_4 per GJ	Estimated	From Environment Canada reference documents. Project proponents may also choose to ignore methane emissions due to the high temperatures in the kiln or for conservativeness.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\,N2O}$	kg N_2O per GJ	Estimated	From Environment Canada reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Quantity of Alternative Fuel Consumed for Kiln Operation / Mass Alt. Fuel	Tonne / other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	Higher Heating Value of Alternative Fuel / HHV_{AF}	GJ/tonne or GJ/ m^3	Measured	Annual fuel testing or use of reference values from Environment Canada.	Annual	The use of higher heating values is consistent with Environment Canada's National GHG Inventory. Annual fuel analysis or the use of reference values is reasonable since most fossil fuels used will have consistent heating values.
	CO_2 Emissions Factor for Each Type of Alternative Fuel / $EF_{Alt. Fuel\ i\ CO2}$	kg CO_2 per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems or fuel carbon content analyses) should be used where available, otherwise default values from the WRI/ WBCSD GHG Protocol Initiative may be used.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted periodically as part of the GHG Protocol Initiative.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	CH_4 Emissions Factor for Each Type of Alternative Fuel / EF Alt. Fuel $_{i\ CH4}$	kg CH_4 per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems) should if available, otherwise default values from the WRI/ WBCSD GHG Protocol Initiative may be used. Project proponents may also choose to ignore methane emissions due to the high temperatures in the kiln or for conservativeness.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted periodically as part of the GHG Protocol Initiative.
	N_20 Emissions Factor for Each Type of Alternative Fuel / EF Alt. Fuel $_{i\ N2O}$	kg N_2O per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems) should be used where available, otherwise default values from the WRI/ WBCSD GHG Protocol Initiative may be used.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted periodically as part of the GHG Protocol Initiative.
	Quantity of Biomass Consumed for Kiln Operation / Mass Alt. Fuel	Tonnes	Measured	Reconciliation of masses purchased and in storage.	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	CH_4 Emissions Factor Biomass / EF Biomass $_{CH4}$	kg CH_4 per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems) should be used where available, otherwise default values from the WRI/ WBCSD GHG Protocol Initiative may be used.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted periodically as part of the GHG Protocol Initiative.
	N_20 Emissions Factor for Biomass / EF Biomass $_{N2O}$	kg N_2O per GJ	Estimated	Site specific emission factors (e.g. from continuous emissions monitoring systems) should be used where available, otherwise default values from the WRI/ WBCSD GHG Protocol Initiative may be used.	Annual	Site specific emission factors represent best available data for the fuels consumed to operate the kiln. Reference values adjusted periodically as part of the GHG Protocol Initiative.
F2 Fossil Fuel Consumption for Other	Emissions F2 $_{\text{Fuel Consumption for Other}}$ = ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ CO2}$); ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ CH4}$); ∑ (Vol. Fossil Fuel *HHV $_{FF}$ * EF Fossil Fuel $_{i\ N2O}$);					
	Emissions $_{\text{Distribution Facility Operation}}$	kg of CO_2; kg of CH_4; kg of N_2O	N/A	N/A	N/A	Quantity being calculated.
	Volume of Fuel Consumed for Other Non-Kiln Operations at Cement Plant Site/ Vol. Fuel $_i$	L , m^3, tonne, other	Measured	Direct metering or reconciliation of volume in storage (including volumes received).	Continuous metering or monthly reconciliation.	Both methods are standard practise. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Higher Heating Value of Fossil Fuel / HHV_{FF}	GJ/ m3, GJ/ L or GJ/tonne	Measured	Annual fuel analysis or use of reference values from Environment Canada or WRI/ WBCSD GHG Protocol Initiative.	Annual	The use of higher heating values is consistent with Environment Canada's National GHG Inventory. Annual fuel analysis or the use of reference values is reasonable since most fossil fuels used will have consistent heating values.
	CO_2 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CO2}$	kg CO_2 per GJ	Estimated	From Environment Canada or WRI/ WBCSD GHG Protocol Initiative reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH_4 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ CH4}$	kg CH_4 per GJ	Estimated	From Environment Canada or WRI/ WBCSD GHG Protocol Initiative reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N_20 Emissions Factor for Each Type of Fuel / EF $Fuel_{i\ N2O}$	kg N_2O per GJ	Estimated	From Environment Canada or WRI/ WBCSD GHG Protocol Initiative reference documents.	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
F3 Industrial Process	$\text{Emissions F3}_{\text{Industrial Process}} = \sum (\text{Mass Clinker} * \text{EF Clinker}_{CO2})$ $\text{EF Clinker}_{CO2} = [(\%\text{CaO}_{\text{clinker}} - \text{CaO}_{\text{imported}})*(44/56) + \%\text{MgO}_{\text{clinker}} *(44/40)]$					
	$\text{Emissions}_{\text{Industrial Process}}$	kg of CO_2	N/A	N/A	N/A	Quantity being calculated.
	Mass of Clinker produced in Each Month / Mass Clinker	tonnes	Measured	Reconciliation of historical facility clinker output records based on facility weigh scales.	Monthly Reconciliation	Frequency of reconciliation provides for reasonable diligence given that these records will be historical.

1.0 Baseline SS	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justify measurement or estimation and frequency**
	CO_2 Emissions Factor for Industrial Process Emissions from Clinker Production / EF Clinker $_{CO2}$	kg of CO_2 / tonne clinker	N/A	N/A	N/A	Quantity being calculated.
	Mass Percent Calcium Oxide in Clinker Produced/ %CaO $_{clinker}$	Tonne CaO / tonne clinker	Measured	Reconciliation of clinker compositions from testing or material specifications.	Quarterly	Frequency of testing provides for reasonable diligence as clinker compositions will likely remain fairly constant for most operations.
	Tonnes of Non-Carbon Bound Calcium Oxide Contained in Raw Materials Fed to the Kiln per Unit of Clinker Output/ CaO $_{imported}$	Tonne CaO / tonne clinker	Measured	Reconciliation of composition of raw material mix input into the kiln based on material testing or product/kiln operating specifications.	Quarterly	Frequency of testing provides for reasonable diligence as raw material compositions will likely be consistent for most operations.
	Stoichiometric Conversion Factor from mass of CaO to mass of CO2 / 44/56	-	N/A	Reference value based on molecular weights of carbon dioxide and calcium oxide, which are 44 g/mol and 56 g/mol, respectively.	N/A	Molecular weights are standard values.
	Mass Percent Magnesium Oxide in Clinker Produced / %MgO $_{clinker}$	Tonne CaO / tonne clinker	Measured	Reconciliation of clinker compositions from testing or material specifications.	Quarterly	Frequency of testing provides for reasonable diligence as clinker compositions will likely remain fairly constant for most operations.
	Stoichiometric Conversion Factor from mass of MgO to mass of CO2 / 44/40	-	N/A	Reference value based on molecular weights of carbon dioxide and magnesium oxide, which are 44 g/mol and 40 g/mol, respectively.	N/A	Molecular weights are standard values.

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TABLE A. 2: Flexibility Mechanism - Contingency

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
Aggregated SS's for Cement Plant Operation						
F1 Fuel Consumption for Kiln Operation	Quantity of Fossil Fuel Consumed for Kiln Operation / Vol. Fuel $_i$	m^3, tonne or other	Estimated	Reconciliation of volume of fuel purchased by the cement plant facility operator within a given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Quantity of Alternative Fuel Consumed for Kiln Operation / Mass Alt. Fuel	Tonne / other	Estimated	Reconciliation of mass of fuel purchased by the cement production plant operator within a given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Quantity of Biomass Consumed for Kiln Operation / Mass Alt. Fuel	Tonnes	Estimated	Reconciliation of masses purchased and in storage.	Monthly Reconciliation.	Frequency of reconciliation provides for reasonable diligence.
F2 Fossil Fuel Consumption for Other	Volume of Fuel Consumed for Other Non-Kiln Operations at Cement Plant Site/ Vol. Fuel $_i$	L / m^3 / other	Estimated	Reconciliation of volume of fuel purchased by the cement plant facility operator within a given time period.	Monthly	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
F3 Industrial Process	Mass of Clinker produced in Each Month / Mass Clinker	tonnes	Estimated	Reconciliation of historical facility clinker sales and input records (into other processes) based on facility weigh scales.	Monthly Reconciliation	Frequency of reconciliation provides for reasonable diligence given that these records will be historical.
	Mass Percent Calcium Oxide in Clinker Produced/ %CaO $_{clinker}$	Tonne CaO / tonne clinker	Estimated	Reconciliation of clinker compositions from previous years data.	Annual	Frequency of reconciliation provides for reasonable diligence as clinker compositions will likely remain fairly constant for most operations.

1.0 Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Tonnes of Non-Carbon Bound Calcium Oxide Contained in Raw Materials Fed to the Kiln per Unit of Clinker Output/ $CaO_{imported}$	Tonne CaO / tonne clinker	Estimated	Use of industry standard composition of raw material mix in the relevant geographic region.	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.
	Mass Percent Magnesium Oxide in Clinker Produced / $\%MgO_{clinker}$	Tonne CaO / tonne clinker	Estimated	Use of industry standard composition of raw material mix in the relevant geographic region	Annual	Provides reasonable estimate of the parameter, when the more accurate and precise method cannot be used.

APPENDIX B

Relevant Emission Factors

All values interpreted from volume 1 of the technical report: A National Inventory of Greenhouse Gas (GHG), Criteria Air Contaminant (CAC) and Hydrogen Sulphide (H2S) Emissions by the Upstream Oil and Gas Industry dated September 2004 completed by Clearstone Engineering Ltd. on behalf of the Canadian Association of Petroleum Producers (CAPP).

Table A1: Emission Intensity of Fuel Extraction and Production (Diesel, Natural Gas, and Gasoline)

Diesel		
Production		
Emissions Factor (CO_2)	0.138	kg CO_2 per Litre
Emissions Factor (CH_4)	0.0109	kg CH_4 per Litre
Emissions Factor (N_2O)	0.000004	kg N_2O per Litre
Natural Gas		
Extraction		
Emissions Factor (CO_2)	0.043	kg CO_2 per m^3
Emissions Factor (CH_4)	0.0023	kg CH_4 per m^3
Emissions Factor (N_2O)	0.000004	kg N_2O per m^3
Processing		
Emissions Factor (CO_2)	0.090	kg CO_2 per m^3
Emissions Factor (CH_4)	0.0003	kg CH_4 per m^3
Emissions Factor (N_2O)	0.000003	kg N_2O per m^3
Gasoline		
Production		
Emissions Factor (CO_2)	0.138	kg CO_2 per Litre
Emissions Factor (CH_4)	0.0109	kg CH_4 per Litre
Emissions Factor (N_2O)	0.000004	kg N_2O per Litre

Table A2: Emission Intensity of Combustion (Diesel, Natural Gas and Gasoline)

Diesel		
Emissions Factor (CO_2)	2.730	kg CO_2 per Litre
Emissions Factor (CH_4)	0.000133	kg CH_4 per Litre
Emissions Factor (N_2O)	0.0004	kg N_2O per Litre
Natural Gas		
Electric Utilities		
Emissions Factor (CO_2)	1.891	kg CO_2 per m^3
Emissions Factor (CH_4)	0.00049	kg CH_4 per m^3
Emissions Factor (N_2O)	0.000049	kg N_2O per m^3
Gasoline		
Heavy-Duty Gasoline Vehicles (3-way catalyst)		
Emissions Factor (CO_2)	2.360	kg CO_2 per Litre
Emissions Factor (CH_4)	0.000068	kg CH_4 per Litre
Emissions Factor (N_2O)	0.0002	kg N_2O per Litre