QUANTIFICATION PROTOCOL FOR REDUCING THE AGE AT HARVEST OF BEEF CATTLE

Version 2.0 **July 2011**

Specified Gas Emitters Regulation

Government of Alberta

Alberta

Disclaimer:
The information provided in this document is intended as guidance only and is subject to revisions as learnings and new information comes forward as part of a commitment to continuous improvement. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the *Specified Gas Emitters Regulation* or legislation, the *Specified Gas Emitters Regulation* or the legislation prevail.

All Quantification Protocols approved under the *Specified Gas Emitters Regulation* are subject to periodic review as deemed necessary by the Department, and will be re-examined at a minimum of every 5 years from the original publication date to ensure methodologies and science continue to reflect best-available knowledge and best practices. This 5-year review will not impact the credit duration stream of projects that have been initiated under previous versions of the protocol. Any updates to protocols occurring as a result of the 5-year and/or other reviews will apply at the end of the first credit duration period for applicable project extensions.

Any comments, questions, or suggestions regarding the content of this document may be directed to:

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Technical Guidance for Offset Project Developers
Technical Guidance for Offset Protocol Developers
Quantification Protocols (http://environment.alberta.ca/02275.html)

SUMMARY OF CHANGES

Below is a summary of key changes from version 1.3 to version 2.0 of this protocol. All changes apply as of the release date of version 2.0 effective [insert date].

- This protocol has been adapted to the new Alberta Environment quantification protocol format.
- Ownership of offset credits developed under this protocol is assigned to the project developer (e.g.: feedlot operator); however, because cattle in this protocol can span several operations (cow-calf, backgrounding, and feedlot), historic ownership agreements and legal ability to include cattle in the project condition may need to be established through additional contractual obligations (see section 1.2 and section 5.5).
- Manure must be managed according to the *Agricultural Operation Practices Act* requirements for confined feeding operations.
- This protocol uses a full lifecycle for beef cattle to determine emissions reductions. Project developers can use two methods to determine the date of birth of the cattle. The first method is a default birth date assigned to the first cow born on a cow-calf operation. This method is discounted by 28 days to represent the average age of the cattle born on that farm. The other method uses exact birth dates for each calf. More information establishing a date of birth for the calves is provided in section 4.2.
- Additional details on quantification methodology and records required to support the project condition are provided in section 4.0 and section 5.0.
- The flexibility mechanism allowing project developers to establish a baseline with less than 3-years of data has been removed. Where a project developer wishes to proceed with a project, but is not able to establish a 3-year baseline, they must contact Alberta Environment to discuss options.
- Project developers must disclose the legal land location of the feedlot, or lots where the cattle were finished. This information is collected by the Alberta Emissions Offset Registry in a spatial locator template and is used to track aggregated projects on the registry (see section 5.5).
- Liability clauses for aggregated projects stipulate the project developer cannot pass on liability for errors resulting from errors in the project developer's data management system (see section 5.4).

1.0 Offset Project Description

Agricultural activities, including the production of livestock, result in greenhouse gas emissions to the atmosphere. Beef cattle, in particular, release methane (CH_4) as a result of the digestion of feed materials in the rumen. These emissions are called "enteric emissions." Methane and nitrous oxide (N_20) emissions are also generated from manure storage and handling within beef cattle operations.

This protocol quantifies decreases in greenhouse gas emissions associated with the raising of beef cattle by reducing the number of days required to get a feeder calf from birth to harvest. This applies to youthful cattle, or those cattle under 24 months of age, which includes calf-fed or yearling-fed heifers, steers or bulls. In this context, feeder cattle that spend less time in backgrounding lots, on pasture and in the feedlot result in decreased greenhouse gas emissions from the following areas:

- **Enteric Fermentation:** less methane is produced from the cattle as a result of fewer days to market and fewer days on lower quality diets;
- **Manure Production:** less manure is produced, stored and handled as a result of fewer days to market and fewer days on lower quality diets.

1.1 Protocol Scope

Industry experts and agricultural scientists have developed, through the Intergovernmental Panel on Climate Change (IPCC 2006) and Canada's National Emissions Inventory (NIR 2009), Tier 2 accounting procedures for enteric and manure emissions generated by different cattle classes in Canada. This research has been adapted to Alberta in a standardized quantification approach provided in this protocol.

The reducing age to harvest protocol quantifies emissions reductions on the basis of the mass of beef produced. That is, emission reductions are measured on a common metric of emissions per kilogram of carcass weight for both the baseline and project condition. The starting point for all quantification is the birth date, number of cattle, dry matter intake and diets for the mass of cattle produced in the baseline and project conditions. This protocol does not prescribe the harvest age or production practices for raising beef cattle. Rather, this protocol serves as a guide for project developers to follow in order to meet the measurement, monitoring and greenhouse gas quantification requirements for offset credits being generated for use in the Alberta offset system.

The boundary of the reducing age at harvest protocol encompasses the pasture, backgrounding and feedlot operation where the cattle are raised and fed as well as the facility/sites where manure is stored and handled. The project may include a number of sites, and a variety of enterprises, but all project farms will address the activities within the boundary of the project as outlined in this protocol. Credits are generated by demonstrating a decrease in the average age to harvest of beef cattle, which results in a reduction in enteric emissions and manure emissions.

Baseline Condition for Reducing Age at Harvest:
The baseline condition for reducing age at harvest for beef cattle is the average emissions for 3 years prior to project implementation on a per head basis adjusted for carcass weight. The baseline is established before changes in cattle production resulting in a reduction in the age at which cattle are harvested are implemented.

This protocol uses a **static historic approach** to determine the baseline. This means that the 3 year average baseline emissions, once determined, are held constant and compared to the annual project emissions. More information on establishing and quantifying a baseline is provided in section 2.0 and 4.0.

Project Condition for Reducing Age at Harvest:
The project condition is defined as a change in beef cattle rearing practices that result in reduced age to harvest of the animals when compared to the baseline condition.

Approximately 55 per cent of the youthful feeder cattle in Alberta currently spend intermediary time in backgrounding operations before entering a finishing program in the feedlot, eventually being ready for market at between 18 to 22+ months of age. This segment of the beef cattle sector has the greatest potential for achieving greenhouse gas reductions by reducing the age to harvest of these cattle, thereby avoiding months of enteric fermentation and manure-based emissions when compared to baseline conditions.

More information on establishing and quantifying the project condition is provided in section 3.0 and 4.0.

Table 1: Relevant Greenhouse Gases Applicable for Reducing Age to Harvest of Beef Cattle

Specified Gas	Formula	100-year GWP	Applicable to Project
Carbon Dioxide	CO_2	1	N
Methane	CH_4	21	Y
Nitrous Oxide	N_2O	310	Y
Sulphur Hexafluoride	SF_6	23,900	N
Perfluorocarbons*	PFCs	Variable	N
Hydrofluorocarbons*	HFCs	Variable	N

* A complete list of perfluorocarbons and hydrofluorocarbons regulated under the *Specified Gas Emitters Regulation* is available in Technical Guidance for Offset Project Developers.

1.2 Protocol Applicability

The project developer for this protocol is designated as the operation where the animal spends the final stage prior to harvest (e.g. a feedlot operator).

Note: *The project developer is required to meet all contractual obligations relating to the beef cattle being included in the project, which may need to obtain additional contractual agreements to confirm the right to the offset credits being generated.*

Projects implemented under this protocol must demonstrate a change in practice in terms of the age of harvest of their cattle confirmed by operational records according to the following requirements:

1. All cattle in the baseline and project condition must be registered with the Canadian Cattle Identification Agency (CCIA) and have a Birth Certificate issued by the agency;
2. Cattle must have an established birth date. This can be done in two ways – either through a **default approach**, which assumes that the date registered with the CCIA is the date of first calf born (this method is discounted to reflect the variation in calf age) or the **documented approach**, where the actual birth date is backed up with calving records from the ranching operations (see Section 4.0 for more detail).

   Note: The project developer **must** use the same approach in both the baseline and project condition;
3. A legal land location of the feedlot where the animal is finished prior to harvest;
4. Animal grouping criteria used by the feedlot. These criteria must be the same in the baseline and project condition as these grouping comparisons are used to prove that the number of days it takes animals to finish their feeding cycle (from calf to harvest) is reduced in the project;
5. The project developer must demonstrate the method of establishing the average age at harvest and extrapolating this to the feedlot level such that it does not result in bias in emission reduction calculations from selecting the most favourable pens/groupings. Sampling of the baseline and project must be done as outlined in Appendix B;
6. The quantification of reductions achieved by the project is based on actual measurement, monitoring and estimations are applied according to the methodology outlined in this protocol;
7. The quantification of emissions related to the baseline and project condition must be functionally equivalent. That is, the metric for comparison must have the same production level and/or quality of products and/or services. The common unit for comparison of emission levels for this protocol is **kg CO_2e/hd/yr** normalized for the carcass weight of animals in both the baseline and project conditions. Further guidance on this calculation is provided in Section 4.0
8. Manure must be managed according to the *Agricultural Operation Practices Act* requirements for confined feeding operations.

9. The project must meet the eligibility criteria stated in section 7.0 of the *Specified Gas Emitters Regulation* as outlined below:
    a. Result from actions occurring in Alberta;
    b. Result from actions not otherwise required by law;
    c. Result from actions taken on or after January 1, 2002;
    d. Be real, demonstrable, and quantifiable;
    e. Have clearly established ownership including, if applicable, appropriate, documented transfers of ownership from the land owner to land lessee;
    f. Be counted once for compliance; and
    g. Be implemented according to ministerial guidelines.

The general data requirements for this protocol are shown in table 2 below. Additional details are provided in section 4.0 and 5.0.

Table 2: General Overview of Data Requirements to Justify the Baseline and Project Condition

Data Requirements	What type of data is required	Why is this needed
Established birth date for registered cattle	**Default birth date:** registration with and a birth certificate from the Canadian Cattle Identification Agency or Alberta Registry; **Documented birth date:** birth certificates corroborated with cow-calf birthing records	To prove and verify harvest age of the animal
Legal land location for the feedlot where cattle are fed prior to harvest	Legal land location of the feedlot location where the feeding activities occur	Registration and verification of the offsets created by the project;
Arrival dates and ages of cattle as they enter the feedlot	Feedlot records	Needed to infer days on feeding regimes prior to entering the feedlot
Characterization of the animal grouping methods in the pre-project or baseline condition; and similar grouping methodology in the project including the total number of animals produced under baseline and project;	Documented feedlot records including: • animal pen entry and exit records that show average weights in and out, • date of entry (by production system, quality grid program, sex, breed or custom feeding lots records); • total number of animals produced under baseline and project.	The methods used to define an animal grouping (i.e. sex, age, weight, breed, etc) must be similar between the project and baseline to ensure like groupings are compared in the offset calculations.
Outgoing weights and age of animals sent to market	Average weights and age for animal groupings at harvest	Needed for calculations
Proof of harvest of youthful animals	Shipping manifest of cattle to packing plant with each animal CCIA tag listed on board.	Needed for proof that animals were harvested.

	For cattle exports out of Alberta shipping manifests need to be on board as described above. All exported cattle will have an additional 0.25 months added to their harvest date.*	
Commercial Agreements for right to claim the offset	See Section 5	Supports ownership of the offset credits.

*0.25 months added to exported cattle harvest dates due to uncertainty of harvest date and to ensure conservatism.

Below is a list of other related approved quantification protocols available for use in Alberta. Where sufficient records exist, one or more of these protocols may be applied to a single project.

Table 3: Stackable Emission Project Opportunities for Cattle Producers

Activity:	**Alberta Offset System Protocol:**
Incorporation of Edible Oils in Beef Cattle Finishing Diets	Quantification Protocol for Including Edible Oils in Cattle Feeding Regimes
Use of anaerobic digesters in handling cattle manure waste at feedlots.	Quantification Protocol for the Anaerobic Decomposition of Agricultural Materials
Selecting for Low Residual Feed Intake in Beef Cattle	Quantification Protocol for Residual Feed Intake Markers In Beef Cattle

1.3 Protocol Flexibility

1. For feedlots where the age to harvest varies across groups of animals, these animals can be grouped in discreet units and tracked individually. In this case, the baseline condition may need to be calculated relative to the group that historically, had the longest time to harvest;
2. Operations using feeding cycles materially different from those outlined in the protocol may calculate custom emissions factors based on their particular feeding cycles using a relevant method, such as the IPCC (tier 2); or CowBytes$^{TM.}$. Justification and rational for the method chosen must be provided in the offset project plan.

1.4 Glossary of New Terms

Animal groupings: Refers to specific groupings of cattle in the feedlot as they move through to the finishing stage. They are typically based on production system and may be classified according to calf-fed, yearling-fed, gender - heifer, steers, bulls - weight and marketing programs (e.g., Lean's Lean, natural, grass finished). Note, a feedlot may contain more than one pen with the same animal

	grouping[1].
Animal head.days	A basic unit used to account for the number of days animals were on feed in a specific animal grouping calculated as the sum of the number of days each animal spends on a specific diet as they move through the feedlot pens.
Carcass Weight	Weight of the carcass of an animal following slaughter as it hangs on the rail expressed as warm (hot) carcass weight or weight of the dead animal after removal of hide, head, tail, forelegs, internal organs, digestive complex and kidney knob and channel fat.
Concentrates	A broad classification of feedstuffs which are high in energy and low in crude fibre (<18% Crude Fibre). This can include grains and protein supplements, but excludes feedstuffs like hay or silage or other roughage.
Custom feeding lot records	The records kept on a group of cattle by the feedlot. These cattle are owned by someone other than the feedlot.
Diet:	Feed ingredients or mixture of ingredients including water consumed by animals (Ensminger and Olentine (1980). It includes the amount of and composition for feed supplied to an animal for a defined period of time.
Edible oils[2]:	Are oils derived from plants that are composed primarily of triglycerides. These oils are typical extracted from seed of oilseed plants, but may be extracted from different parts of a variety of plants. Whole seeds may also be applied as a feed ingredient as long as the oil content is calculated on a dry matter basis to achieve the 4 to 6% content in the diet.
Feeding cycle	The combination of diets fed to animals over a set period of time. This is then repeated for a similar grouping of animals.

[1] The range of incoming weight should be no more than 45.4 kg (100 lb) within each grouping. For example, calf-fed steers on a quality grid program coming on feed between 272.2 kg (600 lb) and 317.5 kg (700 lb) and leaving the feedlot for slaughter between 601.0 (1325 lb) and 635.0 kg (1400 lb) may be an animal grouping while another part of the project may use yearling-fed heifers on a quality grid program coming on feed between 340.2 kg (750 lb) and 385.6 kg (850 lb) and leaving the feedlot for slaughter between 657.7 kg (1450 lb) and 703.1 kg (1550 lb). Groupings of cattle will typically have a series of rations for a specified number of days on feed; this is termed *feeding periods* in this protocol.

[2] Note there are other edible oil-containing products such as unstabilized rice bran or walnut oils extracted oil form dried distillers grains and beef tallow where available. The onus is on the project developer to work with their nutritional specialist to ensure the ration formulation fits the requirements of this protocol.

Feeding periods	Groupings of cattle will typically have a series of diets for a specified number of days on feed; this is termed *feeding periods* in this protocol.
Feeding regimes	The whole system of diets or diets fed to animals over the baseline/project period
Enteric emissions	Emissions of methane (CH_4) from the cattle as part of the digestion of the feed materials.
Yardage:	Yardage is overhead, or the cost of depreciation on original capital investment and interest, upkeep of pens, water, electricity, fuel, manure handling, equipment repairs, hired labor and operator labor.

2.0 Baseline Condition

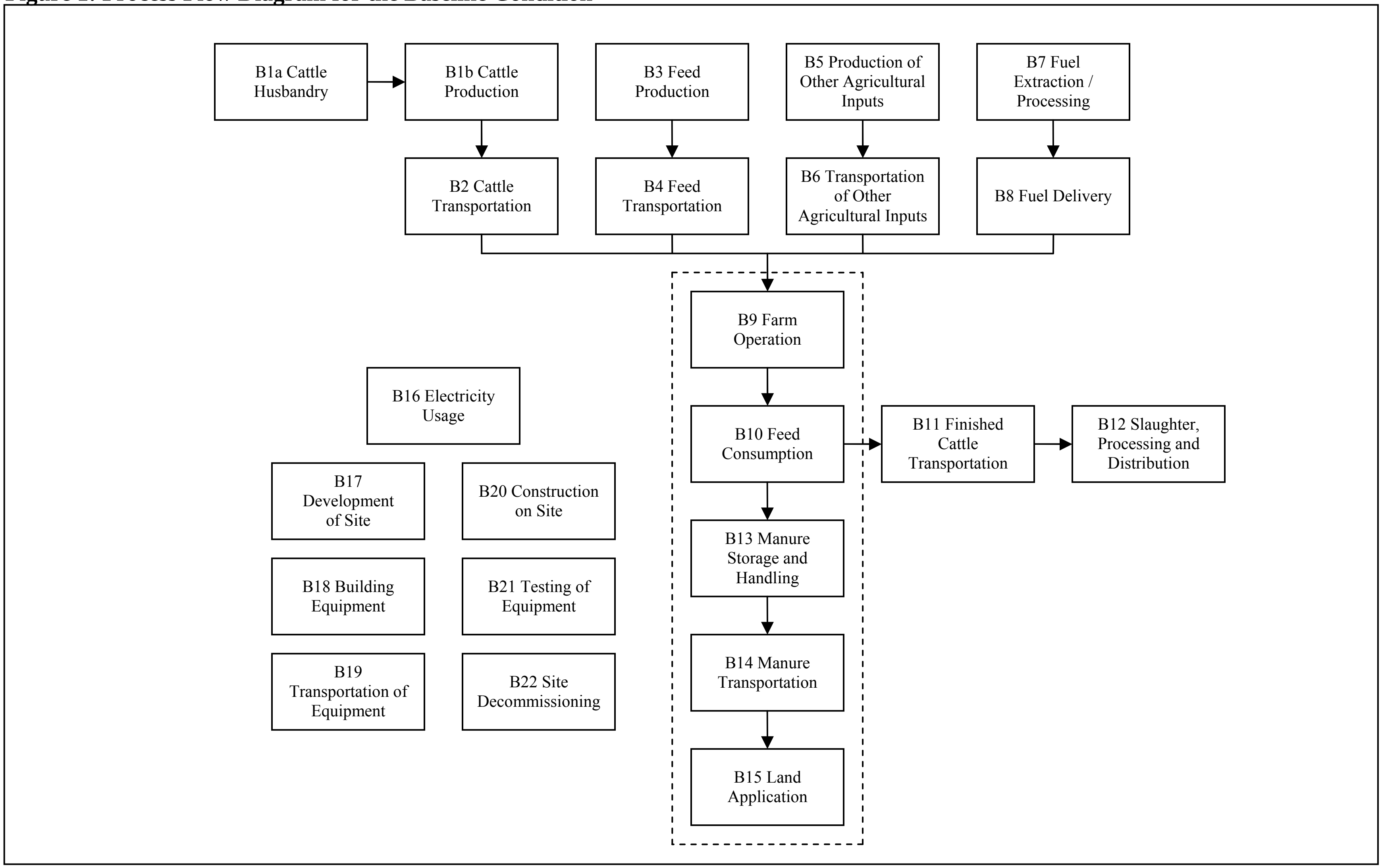
The protocol uses a **static historic benchmark** baseline condition. Under this scenario, a baseline greenhouse gas emissions intensity per kg of carcass weight (kg CO_2e per kg carcass weight) is quantified for each animal grouping averaged over a period of 3 years. A statistically relevant sample size must be used to establish this baseline. This allows the project developer to maintain a static baseline over the project life that is representative of the baseline practices for their specific operations. Information on establishing a statistically representative baseline is included in Appendix B.

The reducing age at harvest protocol differs from other Alberta beef quantification protocols in that it utilizes a **standardized quantification approach**. Regression curves for a range of typical feeding regimes over the life of cattle in Alberta were constructed to derive emissions intensity factors for each greenhouse gas based on age of cattle at harvest normalized to a s**tandard carcass weight of 345 kg**[3]**.** The final numbers are adjusted for the beef production differences between the baseline and project emissions to ensure consistency or functional equivalence.

Sources and sinks were identified for the project by reviewing the background documents and relevant process flow diagrams developed by the beef technical working group under the federal-provincial territorial initiative called the National Offset Quantification Team (NOQT), and the Alberta protocol review process. This process confirmed that the sources and sinks in the process flow diagrams covered the full scope of eligible project activities under the protocol (Figure 1).

[3] 345 kg is used as a standard weight for the calculations. It must be corrected with the actual carcass weights in the calculations (see Section 4.0).

Figure 1: Process Flow Diagram for the Baseline Condition



2.1 Identification of Baseline Sources and Sinks

Sources and sinks for an activity are assessed based on guidance provided by Environment Canada and are classified as follows:

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

Baseline sources and sinks were identified by reviewing the relevant process flow diagrams, consulting with technical experts, national greenhouse gas inventory scientists and reviewing good practice guidance. This iterative process confirmed that the sources and sinks in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process flow diagram provided above, the baseline sources and sink were organized into life cycle categories in Figure 2. Descriptions of each of the sources and/or sink and their classification as controlled, related or affected are provided in Table 4..

Figure 2: Baseline Sources and Sinks for Reducing the Age at Harvest of Beef Cattle

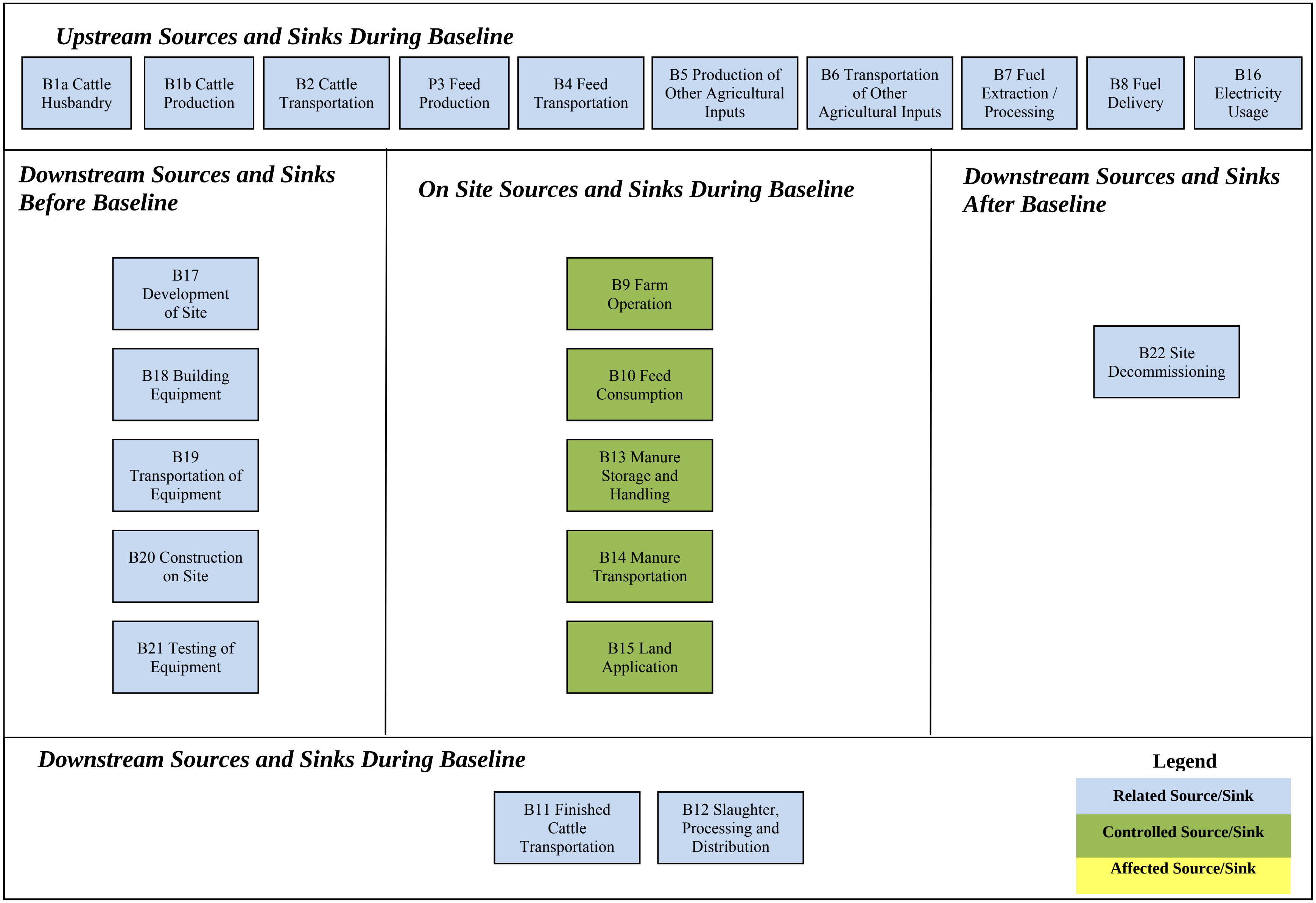


Table 4: Baseline Sources and Sinks		
1. Source and Sink	**2. Description**	**3. Controlled, Related or Affected**
Upstream Sources and Sinks During Baseline Operation		
B1a Cattle Production	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B1b Cattle Production	Cattle production may include raising calves, including time in pasture, that are input to the enterprise. Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the project condition. Length of each type of feeding cycle would need to be tracked.	Related
B2 Cattle Transportation	Cattle may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B3 Feed Production	Feed may be produced from agricultural materials and amendments. The processing of the feed may include a number of chemical, mechanical and amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B4 Feed Transportation	Feed may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B5 Production of Other Agricultural Inputs	Other agricultural inputs such as feed supplements, bedding, etc., may be produced from agricultural materials and amendments. The processing of the feed may include a number of chemical, mechanical and amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the project condition.	Related
B6 Transportation of Other Agricultural Inputs	Feed may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the project condition.	Related
B7 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to 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 source/sink are considered under this source/sink. Volumes and types of fuels are the important	Related

Table 4: Baseline Sources and Sinks		
1. Source and Sink	**2. Description**	**3. Controlled, Related or Affected**
	characteristics to be tracked.	
B8 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. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other source/sink and there is no other delivery.	Related
B16 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
Onsite Sources and Sinks During Baseline Operations		
B9 Farm Operation	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the beef production facility operations. This may include running vehicles and facilities at the project site for the distribution of the various inputs. Quantities and types for each of the energy inputs would be tracked.	Controlled
B10 Feed Consumption	Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the project condition. Length of feeding cycle would need to be tracked.	Controlled
B13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This will include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Quantities and types for each of the energy inputs would be tracked. Quantities, duration and conditions would also need to be tracked.	Controlled
B14 Manure Transportation	Manure may need to be transported to the field for land application from storage. Transportation equipment would be fuelled by diesel, gas or natural gas. Quantities for each of the energy inputs would be tracked to evaluate functional equivalence with the project condition.	Controlled
B15 Land Application	Manure may then be land applied. This may require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, or natural gas resulting in greenhouse gas emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be tracked to evaluate functional equivalence with the project condition.	Controlled
Downstream Sources and Sinks During Baseline Operations		

Table 4: Baseline Sources and Sinks		
1. Source and Sink	**2. Description**	**3. Controlled, Related or Affected**
B11 Finished Cattle Transportation	Finished cattle may be transported from the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
B12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility operations. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other Sources and Sinks		
B17 Development of Site	The site of the facility may need to be developed. 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, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. 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
B18 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. 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
B19 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 train, truck, by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B20 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
B21 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
B22 Site Decommissioning	Once the 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,	Related

Table 4: Baseline Sources and Sinks		
1. Source and Sink	**2. Description**	**3. Controlled, Related or Affected**
	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.	

3.0 Project Condition

The project condition is defined as the reduction in the age of beef cattle at harvest relative to the baseline condition. This protocol does not prescribe a method producers must follow to progress animals through the typical stages in beef production. Rather, it provides a standardized quantification approach based on beef sector production standards to calculate methane and manure emissions in both the project and baseline conditions.

The reduction in the days to harvest results in a lower (avoided) quantity of greenhouse gas emissions emitted over the lifespan of the cattle. The shortened cattle lifespan also mean a reduction in manure produced and volatile solids and nitrogen excreted by the animals. This can be quantified to obtain reduced greenhouse gas emissions under the project condition. The difference in emissions between the project and baseline condition represents the total number of emission reductions generated.

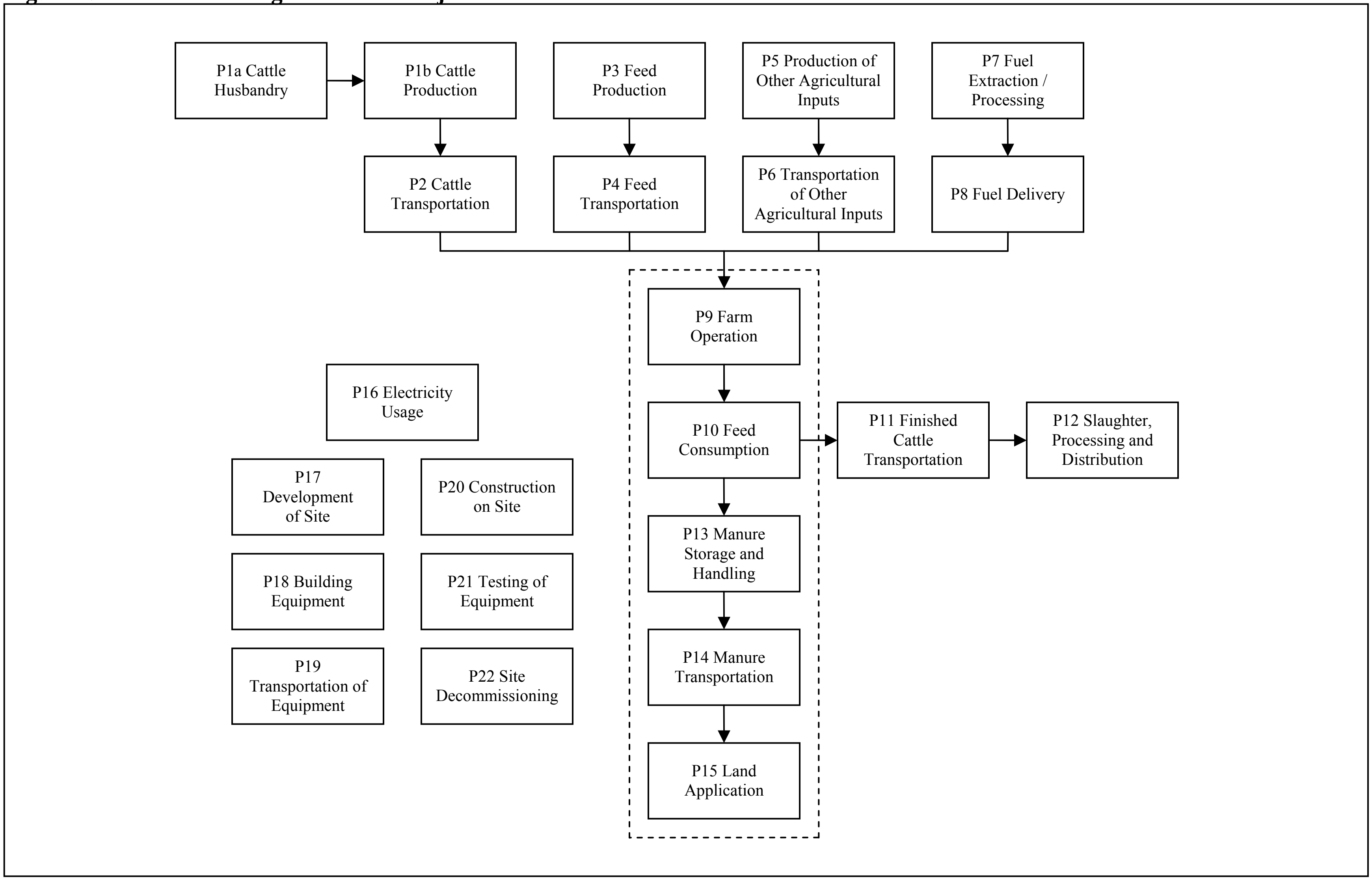
As with the baseline calculations, regression curves for a range of typical feeding regimes over the life of cattle in various production stages typical to Alberta were constructed to derive emission factors for each greenhouse gas based on age of cattle at harvest, normalized to a standard carcass weight of 345 kg[4].

Project developers must use these regression equations to calculate an annual emissions intensity per kilogram of cattle produced (kg CO_2e/kg carcass weight) for each animal grouping. The total number of animals in production for each grouping is used to calculate the total annual project emissions.

Project sources and sinks were identified by reviewing the relevant process flow diagrams, consulting with technical experts and national greenhouse gas inventory scientists, and reviewing good practice guidance. The process flow diagram for the project condition is provided in Figure 3.

[4] 345 kg is used as a standard weight for the calculations. It must be corrected with the actual carcass weights in the calculations (see Section 4.0).

Figure 3: Process Flow Diagram for the Project Condition



3.1 Identification of Project Sources and Sinks

Sources and sinks for reducing days on feed of beef cattle were identified through scientific review. This process confirmed that sources and sinks in the process flow diagram covered the full scope of eligible project activities under this protocol. The boundary for the project condition includes the pastures, backgrounding and feedlots where the cattle are finished and the facility/sites where manure is stored and handled.

These sources and sinks have been further refined according to the life cycle categories identified in Figure 4. These sources and sinks were further classified as controlled, related, or affected as described in Table 5 below.

Note: The same quantification approach must be used in the baseline and project condition. Specifically, the methods used to establish birth date and application of the standardized quantification equations must be documented and applied in order to justify the project condition.

Figure 4: Project Conditions Sources and Sinks for Reducing the Age at Harvest for Beef Cattle

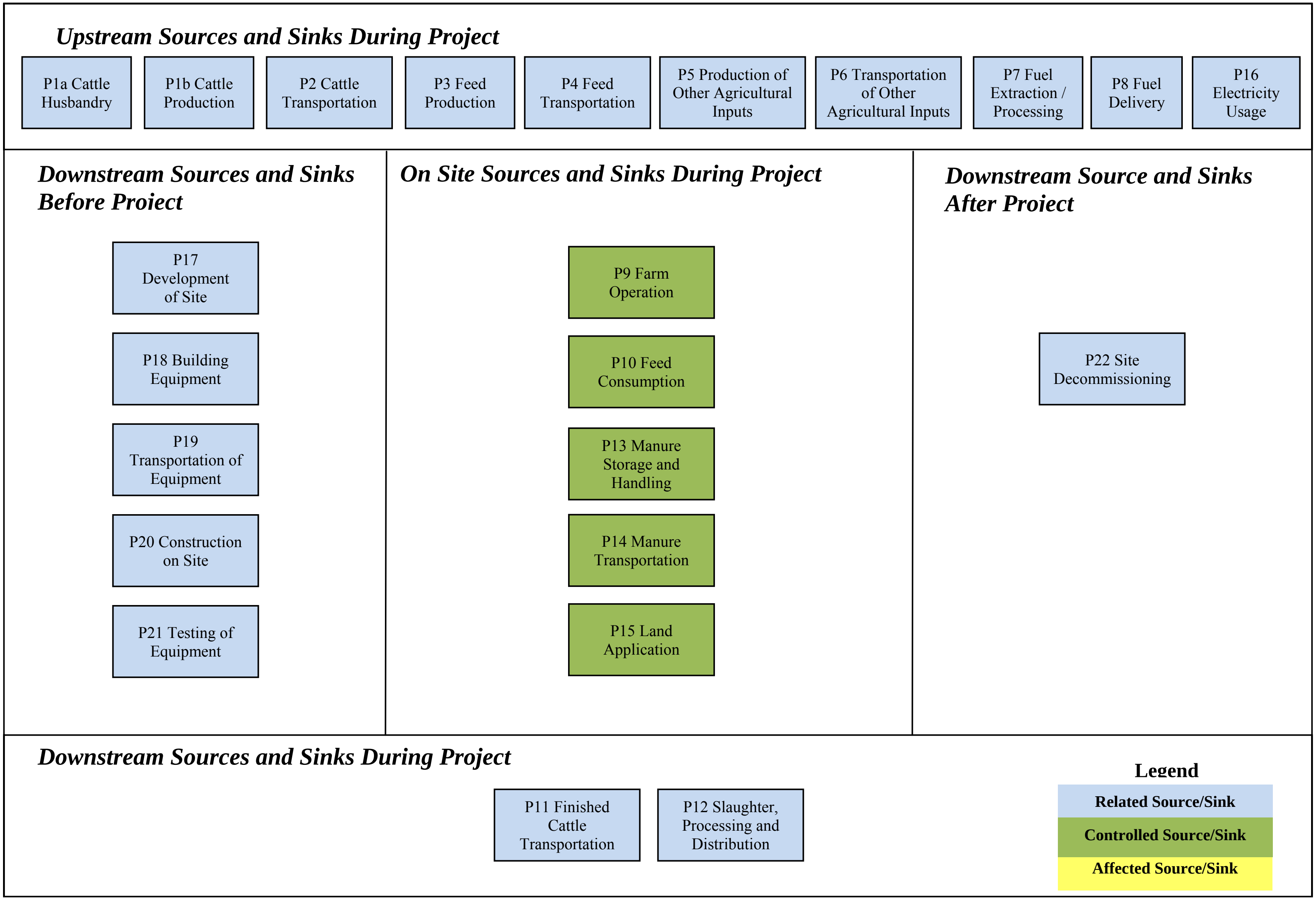


Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
Upstream Sources and Sinks During Project Operation		
P1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Related
P1b Cattle Production	Cattle production may include raising calves, including time in pasture, that are input to the enterprise. Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the baseline condition. Length of each type of feeding cycle would need to be tracked.	Related
P2 Cattle Transportation	Cattle may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this sources/sinks, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P3 Feed Production	Feed may be produced from agricultural materials and amendments. The processing of the feed may include a number of chemical and mechanical amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be tracked to evaluate functional equivalence with the baseline condition.	Related
P4 Feed Transportation	Feed may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related
P5 Production of Other Agricultural Inputs	Other agricultural inputs, such as feed supplements, bedding, etc., may be produced from agricultural materials and amendments. The processing of these inputs may include a number of chemical, mechanical and amendment processes. This requires several energy inputs such as natural gas, diesel and electricity. Quantities and types for each of the energy inputs would be tracked to evaluate functional equivalence with the baseline condition.	Related
P6 Transportation of Other Agricultural Inputs	Feed may be transported to the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would be used to evaluate functional equivalence with the baseline condition.	Related

Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
P7 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to 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 sources/sinks are considered under this source/sink. Volumes and types of fuels are the important characteristics to be tracked.	Related
P8 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. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other sources/sinks and there is no other delivery.	Related
P16 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
Onsite SS's during Project Operation		
P9 Farm Operation	Greenhouse gas emissions may occur that are associated with the operation and maintenance of the cattle feeding facility operations. This may include running vehicles and facilities at the project site for the distribution of the various inputs. Quantities and types for each of the energy inputs would be tracked.	Controlled
P10 Feed Consumption	Feed consumption includes the enteric emissions from the cattle and related manure production. The feed composition would need to be tracked to ensure functional equivalence with the baseline condition. Length of each type of feeding cycle would need to be tracked.	Controlled
P13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This will include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Quantities and types for each of the energy inputs would be tracked. Quantities, duration and conditions would also need to be tracked.	Controlled
P14 Manure Transportation	Manure may need to be transported to the field for land application from storage. Transportation equipment would be fuelled by diesel, gas or natural gas. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Controlled

Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
P15 Land Application	Manure may then be land applied. This may require the use of heavy equipment and mechanical systems. This equipment would be fuelled by diesel, gas, or natural gas resulting in GHG emissions. Other fuels may also be used in some rare cases. Quantities for each of the energy inputs would be contemplated to evaluate functional equivalence with the baseline condition.	Controlled
Downstream Sources and Sinks During Project Operation		
P11 Finished Cattle Transportation	Finished cattle may be transported from the project site by truck, barge and/or train. The related energy inputs for fuelling this equipment are captured under this source/sink, for the purposes of calculating the resulting greenhouse gas emissions. Type of equipment, number of loads and distance travelled would need to be tracked.	Related
P12 Slaughter, Processing and Distribution	Greenhouse gas emissions may occur that are associated with the slaughter, processing and distribution components downstream of the cattle finishing facility operations. This may include running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	Related
Other		
P17 Development of Site	The site of the facility may need to be developed. 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, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. 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
P18 Building Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control and safety systems. 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
P19 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

Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	**2. Description**	**3. Controlled, Related or Affected**
P20 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
P21 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity.	Related
P22 Site Decommissioning	Once the 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

4.0 Quantification

Baseline and project conditions were assessed against each other to determine the scope for reductions quantified under this protocol. Sources and sinks were either included or excluded depending how they were impacted by the project condition. Sources that are not expected to change between baseline and project condition are excluded from the project quantification. It is assumed that excluded activities will occur at the same magnitude and emission rate during the baseline and project and so will not be impacted by the project.

Emissions that increase or decrease as a result of the project must be included and associated greenhouse gas emissions must be quantified as part of the project condition.

All sources and sinks identified in Table 4 and Table 5 above are listed in Table 6 below. Each source and sink is listed as included or excluded. Justification for these choices is provided.

Table 6: Comparison of Sources/Sinks

Identified Sources and Sinks	Baseline (C, R, A)**	Project (C, R, A)**	Include or Exclude from Quantification	Justification
Upstream Sources and Sinks				
P1a Cattle Husbandry	N/A	R	Exclude	Excluded as animal husbandry is functionally equivalent to the baseline scenario.
B1a Cattle Husbandry	R	N/A	Exclude	
P1b Cattle Production	N/A	R	**Include**	Included because emissions from baseline to project are materially different.
B1b Cattle Production	R	N/A	**Include**	
P2 Cattle Transportation	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B2 Cattle Transportation	R	N/A	Exclude	
P3 Feed Production	N/A	R	Exclude	Excluded as upstream production of other agricultural inputs are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B3 Feed Production	R	N/A	Exclude	
P4 Feed Transportation	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B4 Feed Transportation	R	N/A	Exclude	
P5 Production of Other Agricultural Inputs	N/A	R	Exclude	Excluded as upstream production of other agricultural inputs are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B5 Production of Other Agricultural Inputs	R	N/A	Exclude	
P6 Transportation of Other Agricultural Inputs	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B6 Transportation of Other Agricultural Inputs	R	N/A	Exclude	
P7 Fuel Extraction and Processing	N/A	R	Exclude	Excluded as these sources/sinks are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B7 Fuel Extraction and Processing	R	N/A	Exclude	
P8 Fuel Delivery	N/A	R	Exclude	Excluded as these sources/sinks are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B8 Fuel Delivery	R	N/A	Exclude	

Table 6: Comparison of Sources/Sinks				
Identified Sources and Sinks	**Baseline (C, R, A)****	**Project (C, R, A)****	**Include or Exclude from Quantification**	**Justification**
P16 Electricity Usage	N/A	R	Exclude	Excluded as these sources/sinks are not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B16 Electricity Usage	R	N/A	Exclude	
Onsite Sources and Sinks				
P9 Farm Operation	N/A	C	Exclude	Excluded as beef production is not impacted by the implementation of the project and as such the baseline and project conditions will be functionally equivalent.
B9 Farm Operation	C	N/A	Exclude	
P10 Feed Consumption	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B10 Feed Consumption	C	N/A	**Include**	
P13 Manure Storage and Handling	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B13 Manure Storage and Handling	C	N/A	**Include**	
P14 Manure Transportation	N/A	C	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B14 Manure Transportation	C	N/A	Exclude	
P15 Land Application	N/A	C	**Include**	Included because emissions from baseline to project are materially different.
B15 Land Application	C	N/A	**Include**	
Downstream Sources and Sinks				
P11 Finished Cattle Transportation	N/A	R	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
B11 Finished Cattle Transportation	R	N/A	Exclude	
P12 Slaughter, Processing and Distribution	N/A	R	Exclude	Excluded as the emissions from slaughter, processing and distribution are likely functionally equivalent to the baseline scenario.
B12 Slaughter, Processing and Distribution	R	N/A	Exclude	
Other				

Table 6: Comparison of Sources/Sinks				
Identified Sources and Sinks	**Baseline (C, R, A)****	**Project (C, R, A)****	**Include or Exclude from Quantification**	**Justification**
P17 Development of Site	N/A	R	Exclude	Emissions from site development are not material given the long project life, and the minimal site development typically required.
B17 Development of Site	R	N/A	Exclude	
P18 Building Equipment	N/A	R	Exclude	Emissions from building equipment are not material given the long project life, and the minimal building equipment typically required.
B18 Building Equipment	R	N/A	Exclude	
P19 Transportation of Equipment	N/A	R	Exclude	Emissions from transportation of equipment are not material given the long project life, and the minimal transportation of equipment typically required.
B19 Transportation of Equipment	R	N/A	Exclude	
P20 Construction on Site	N/A	R	Exclude	Emissions from construction on site are not material given the long project life, and the minimal construction on site typically required.
B20 Construction on Site	R	N/A	Exclude	
P21 Testing of Equipment	N/A	R	Exclude	Emissions from testing of equipment are not material given the long project life, and the minimal testing of equipment typically required.
B21 Testing of Equipment	R	N/A	Exclude	
P22 Site Decommissioning	N/A	R	Exclude	Emissions from decommissioning are not material given the long project life, and the minimal decommissioning typically required.
B22 Site Decommissioning	R	N/A	Exclude	

**Where C is Controlled, R is Related, and A is Affected.

4.1 Quantification Methodology

Quantification of the reductions, removals and reversals of relevant sources/sinks for each of the greenhouse gases will be completed using the methodologies outlined in Table 7, below. A listing of relevant emission factors is presented 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.

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

$$\textbf{Emissions}_{\textbf{Baseline}} = \text{Emissions}_{\text{Cattle}} + \text{Emissions}_{\text{Manure}}$$

$$\textbf{Emissions}_{\textbf{Project}} = \text{Emissions}_{\text{Cattle}} + \text{Emissions}_{\text{Manure}}$$

Where:

Emissions $_{\textbf{Baseline}}$ = sum of the emissions under the baseline condition.
Emissions $_{\textbf{Cattle}}$ = emissions under B1b Cattle Production and B10 Feed Consumption
Emissions $_{\textbf{Manure}}$ = emissions under B13 Manure Storage and Handling and B15 Land Application

Emissions $_{\textbf{Project}}$ = sum of the emissions under the project condition.
Emissions $_{\textbf{Cattle}}$ = emissions under P1b Cattle Production and P10 Feed Consumption
Emissions $_{\textbf{Manure}}$ = emissions under P13 Manure Storage and Handling and P15 Land Application

4.2 The Standardized Quantification Approach

Regression curves for a range of typical feeding regimes over the life of cattle in Alberta were constructed to calculate an emissions intensity factor for each greenhouse gas based on age of cattle at harvest normalized to a standard carcass weight of 345 kg[5].

The enteric methane emissions that form the regression equation emission factors shown in Table 7 below are calculated for each animal grouping based on the number of days on feed based on the range in typical feeding regimes, the dry matter intake predicted from CowBytes, the gross energy content of the diet set as a constant of 18.45 MJ/kg dry matter in the diet, default methane emission factors for the diet based on 4.0 per cent methane lost for diets containing 85 per cent or more concentrates excluding edible oil, and 6.5 per cent for diets containing less than 85 per cent concentrates excluding edible oil.

[5] 345 kg is used as a standard weight for the calculations. It must be corrected with the actual carcass weights in the calculations as shown in this document.

Methane and nitrous oxide emission factor regression equations are based on Intergovernmental Panel on Climate Change (IPCC) Tier 2 equations (IPCC 2006) for the following sources:

- direct emissions of nitrous oxide from manure created by the cattle.
- nitrous oxide created from manure storage
- indirect volatilization of nitrous oxide from re-deposited ammonia
- indirect emissions of nitrous oxide from runoff and from nitrogen leached in the soil profile.

The reduced lifespan of the cattle in the project condition results in less manure being produced on an annual basis and less greenhouse gases being emitted on a per animal basis.

Data requirements for each animal must be tracked according to protocol requirements. The average age at slaughter in months for youthful cattle is substituted for 'x' for the natural log power in the regression equations shown in table 7 to derive enteric and manure methane and nitrous oxide emissions for baseline and project:

Table 7: Standardized Quantification Approach Emissions Intensity Factors
(kg CO_2e/kg carcass beef/yr) Based on Age at harvest in youthful cattle
(normalized to a standard carcass weight of 345 kg).

Emissions Factor (EF)	Age at Harvest (months)				Equation[2,3]	R^2
	12[1]	14[1]	18[1]	21[1]		
EF $Enteric_{CH4}$	0.418	0.490	0.672	0.851	$y=0.162\ e^{0.079\ x}$	0.9931
EF Manure $_{N2o}$	0.0064	0.0085	0.0153	0.0238	$y=0.0011\ e^{0.1464\ x}$	0.9791
EF $Manure_{CH4}$	0.0037	0.0051	0.0099	0.0163	$y=0.0005\ e^{0.1659\ x}$	0.9935

[1] Emissions factors developed for each age at harvest scenario was part of the work completed by the Beef Technical Working Group under the National Offset Quantification Team (NOQT). The calculation of these emission factors follows the guidance from IPCC (Tier2) and is based on the feeding regimes provided in Table below.
[2]Equations represent best fits with the data from analysis of a range of typical beef diets, ensuring that the interpolation by the use of equations represent a conservative approach and reflect the likely variances around the data points.
[3]for the natural log, "x" represents the average age of youthful cattle sent to harvest, in months.

Where: x equals the average age of animals in months in each distinct animal grouping for both the baseline and project conditions. The averaging period for the baseline condition is 3 years while the project condition is calculated annually for a maximum 8-year crediting period with a possible 5-year extension.

Table 8 below shows general diet classes based on a typical range of diets fed to cattle based on the majority of the beef operations in Alberta. They have been aggregated from the typical diet components modeled with the regression curves above and are shown here to help the project developer to infer the number of days spent on each feeding regime. There will be slight variations across beef cattle operations across Alberta; however, most these numbers considered representative of the stages of feeding during a beef animal's lifespan.

Note: It is not necessary to gather feed documentation for feeding regimes 1, 2, 3 and 4 as these are common to most beef operations. It is, however, important to track the age of the animal as it enters the feedlot. Groupings and feeding regimes for 1, 2, 3 and 4 can be inferred from the age of the animal entering the feedlot/backgrounder using the example given in Table 8.

Table 8: Typical Feeding Regimes for Beef Cattle in Alberta

Feeding Regime [1]	Age at Harvest (months)			
	12	**14**	**18**	**21**
	Typical Duration of Days on Feed for Animals			
1. 100 per cent Milk- baby calf suckling cow, days	91	91	91	91
2. Forage:milk – suckling calf on pasture with cow, days	31	92	92	92
3. Backgrounding on pasture and/or drylot - high roughage diet (e.g., 100 per cent barley silage on a dry matter basis), days	0	0	212	212
4. Backgrounding on tame and/or native pasture, days	0	0	0	153
5. Step-up diet[2] to final finishing diet, days	31	31	0	0
6. Finishing in a feedlot (≥85 per cent concentrate diet on a dry matter basis), days	212	212	153	92

[2] Step-up diets - typically start at a high roughage level and moves to the finishing diets over a 30-60 day period (dry matter basis), – where a high grain level is finally incorporated (≥85 per cent concentrate)

4.3 Cattle Inventories and Data Collection

The protocol allows cattle inventories to be collected in two ways: tracking distinct groupings of animals daily based on the general animal/weight class they belong to, or by tracking each animal individually.

Transparent and accurate data is needed to facilitate a third party verification of the emission reductions. Animals must be tracked consistently between baseline and project conditions. If animals are tracked based on weight groupings or some other criteria, the project developer must ensure that the groupings are clearly defined (ie: Class 1 = x kgs to x kgs) in both the baseline and project and must ensure these groups are similar in both the baseline and project. Any deaths that occur as cattle progress or if animals are removed from a weight grouping due to sickness must be accounted for in the animal head.day calculations (see below).

The data points to be collected for cattle inventory under the project and baseline conditions include:

- The number of head of cattle within a particular classified animal grouping (or individually)
- The average weight of cattle entering the grouping (or individually)
- The average weight of cattle exiting the grouping (or individually)

- The average kg of dry matter feed provided to each group per day (for the entire grouping)[6]
- The number of days the group of cattle are fed a specific diet.

Cattle inventory data are derived using a matrix commonly applied by feedlot operators and referred to as animal head.days. Many feedlots use this approach to calculate their 'yardage'. Again, animal head.days is the sum of the product of the number of days an individual animal is on a particular feeding regime. This is demonstrated in table 9 below:

Table 9: Using Animal Head.Days to Track Cattle Inventory Data

Pen		**Days on Feed**	**No. of Head**	**Head. days**	**Dry matter intake (kg)***
A	**Diet 1**	1	119	119	1190
A		2	126	126	1260
A		3	126	126	1260
A		4	125	125	1250
A		5	125	125	1250
A		6	124	124	1250
A		7	124	124	1240
A		8	124	124	1240
A		9	124	124	1240
A		10	124	124	1240
A		11	124	124	1240
A		12	124	124	1240
A		13	124	124	1240
A		14	124	124	1240
Total		**14**	**124**	**1,736**	**17,380**

*Note-this table can be recorded in imperial measurements if other calculations are consistent with the imperial metrics. Final results must be in metric units.

An animal head.days factor can be used to extrapolate a number of cattle inventory data points including:

- **Days on Feed** - can be extrapolated from animal head.days if the average number of animals in a pen under a specific diet and the animal head.days is known.

Days on Feed (days) = animal head.days / average number of animals in production

Referencing table 9 above, days on feed is extrapolated by taking the quotient of 1,736 animal head.days / 124 animals, with a result of 14 days on feed.

- **Number in Production** – can be extrapolated from animal head.days if the days on feed (otherwise termed feeding period) is known.

[6] Note: this protocol standardizes dry matter intake in the regression equations. This data point is not included in the calculations, but is included here for completeness.

Number in Production (head) = animal head.days / days on feed

Referencing table 9 above, Number in Production for Diet 1 is extrapolated by taking the quotient of 1,736 animal head.days / 14 days, with a result of 124 animals.

- **Dry Matter Intake** – the amount of feed provided to a pen of animals under a particular diet regimen expressed as kilograms of feed per animal per day can be extrapolated from animal head.days if the total quantity of feed diets provided to a grouping of animals over the feeding period is known.

Note: this protocol standardizes dry matter intake in the regression equations. This data point is not included in the calculations, but is included here for completeness.

Feed is provided to cattle on an as fed basis and must be converted to a dry matter basis. This is accomplished by multiplying the feed intake by the dry matter content of the total mixed diet. The dry matter content of the diet can be obtained from a feed analysis of the total mixed diet, from a feed analysis of the total mixed diet, or from a diet-balancing program used by the feedlot.

Dry Matter Intake (kg / head / day) = (Total quantity of feed for a specific diet x dry matter content of diet) / animal head.days

Statistical Sampling Approach Allowed under this Protocol

Appendix B describes a statistical sampling method that can be used to support baseline and project quantification. Biological traits in beef cattle follow a normal distribution. Larger feedlots can support this type of analysis to classify cattle. The sampling method within the animal groupings needs to follow random selection procedures and be unbiased. The project developer will need to demonstrate to the third party verifier that the approach was applied appropriately as required by this protocol.

Sampling a subset of pens must be done to achieved a 95% confidence interval. That is, 95 times out of 100, the true greenhouse gas emissions for the project will lie within the interval calculated using the sample population. If the interval is small, the estimation is more precise.

4.4 Establishing Birth Dates

Two options for establishing birth dates of cattle are allowed under this protocol:

1. **Default approach**: this method is based on the CCIA Birth Certificate. It applies an average birth date for calves born on a farm discounted to maintain conservativeness in the age estimates; and
2. **Documented approach**: this method is based on documented methods of tracking birth dates for each calf born on a farm.

Default Birth Date Approach:
In the default approach, it is assumed that the birth certificate issued by the CCIA is the date of the first calf born. This assumption applies here due to the various methods used by cow-calf producers to establish their birth dates on the CCIA. If a default birth date is used, 28 days must be added to the birth certificate date to estimate the average calving date and address the average known variance for calving patterns in Alberta. This is a conservative approach to quantifying the age of cattle at harvest.

Documented Birth Date Approach:
Alternatively, project developers can record actual birth dates for calves in both the project and baseline. This method requires that animals be registered with the CCIA with actual birth dates supported by evidence from calving record books from cow-calf operations. If actual birth dates are used, the 28-day adjustment factor is not applied to calculations. This method requires more detailed records and is more accurate that default birth dates.

Note: *The method of establishing birth date must be the same between baseline and project regardless of approach used.*

4.5 Quantification Approach

The first step is to calculate the months of age the animals are at harvest. To do this, determine the number of days on feed for each animal grouping for each general feeding regime (according to Table 8 and 9 above) by tracking the number of days on feed from calf to market for each animal grouping for both the project and baseline conditions. Sum up the days in each to get the total number of days and then months on feed before harvest. Divide by 30 to get the average months to harvest.

Note: there may be some feeding regimes that disappear completely from the project calculations (notably regime 3 and 4 in Table 8). Refer to Appendix A for a more detailed sample calculation.

Next, determine the average live weight after finishing is complete for each animal grouping for both the baseline (3 year average) and project conditions (see Appendix A for an example). Determine the number of animals in production for each animal grouping for each year of the project condition (see Table 9 above). Sum up the number of animals for the project condition.

Once the data requirements in months for each animal grouping have been tracked and the average age at harvest for both baseline and project for youthful cattle is determined, emissions related to the baseline and project conditions are calculated in a similar manner, that is, they are calculated in two parts and summed. The first part being enteric emissions and the second related to manure (see equations 1 below).

Again, both sources of emissions (enteric and manure) must be expressed on the basis of carbon equivalence and must be functionally equivalent. See final steps below for adjusting for production equivalency for baseline and project conditions.

Equation 1: Calculating Enteric Emissions Intensity in the Project and Baseline Conditions:

$$\text{kg enteric } CH_4 \text{ Produced/kg carcass beef/yr} = 0.162\ e^{0.079\ x}$$

Using the equation above, substitute the 3 year average lifespan (in months) for the baseline as 'x' , multiply by 0.79 and use the product of these to take the natural log power for deriving enteric methane emissions/kg carcass beef for the baseline condition - the functional unit.

Repeat the step above, substituting the average number of months to harvest during the project condition, the time until the animals are sent to market to derive the enteric methane emissions/kg of carcass weight for the project. This unit provides the common reference point for baseline and project conditions to ensure functional equivalence.

Account for the global warming potential (GWP) of methane which is 21 times more potent than carbon dioxide. Multiply the project and baseline enteric emissions by 21 to determine emission reductions in terms of kg CO_2e/kg carcass weight.

Calculate the average carcass weight of the cattle produced under Baseline and Project conditions (average live weight * shrunk weight * dressing percentage). Shrunk weight is assumed to be 96 per cent of live weight and dressing percentage is assumed to be 58 per cent of shrunk weight (see equation 4 below).

These equations are based on a percentage dressing of 58 per cent. If animals in the project differ from this percentage, the emissions can be adjusted according to the project percentage. Project developers using a different dressing percentage must include justification in the offset project plan and offset project report.

Equation 2: Calculating Manure Methane (CH_4) Enteric Emissions Intensity in the Project & Baseline Conditions

$$\text{kg manure } CH_4 \text{ Produced/ kg carcass beef/yr} = 0.0005\ e^{0.1659\ x}$$

Using the equation above, substitute the 3-year average lifespan (in months) for the baseline as 'x' , multiply by 0.79 and use the product of these to take the natural log power for deriving manure methane emissions/kg carcass beef for the baseline condition -the functional unit.

Repeat the step above, substituting the average number of months to harvest during the project condition, until animals are sent to market to derive the manure methane emissions/kg of carcass weight for the project.

Account for the global warming potential of methane which is 21 times more potent than carbon dioxide. Multiply the project and baseline manure methane emissions by 21 to determine emission reductions in terms of kg CO_2e/kg carcass weight.

Equation 3: Calculating Indirect and Direct Manure Nitrous Oxide (N_20) Emissions Intensity in the Project & Baseline Conditions

kg manure N_20 Produced/ kg carcass beef/yr $= 0.0011\, e^{0.1464\, x}$

Using the equation above, substitute the 3 year average lifespan (in months) for the baseline as 'x' , multiply by 0.79 and use the product of these to take the natural log power for deriving direct and indirect manure N_20 emissions/kg carcass beef for the baseline condition -the functional unit.

Repeat the step above, substituting the average number of months to harvest during the project condition, until animals are sent to market to derive the manure nitrous oxide emissions/kg of carcass weight for the project.

Account for the global warming potential of nitrous oxide which is 310 times more potent than carbon dioxide. Multiply the project and baseline manure nitrous oxide emissions by 310 to determine emission reductions in terms of kg CO_2e/kg carcass weight.

To correct for animal carcass weight, calculate the average carcass weight of the cattle produced under the baseline and project conditions for each animal grouping (average live weight * shrunk weight * dressing percentage). Shrunk weight is assumed to be 96 per cent of live weight and dressing percentage is assumed to be 58 per cent of shrunk weight and correct for actual carcass weight since the emission factor regression curve references a standardized carcass weight of 345 kg /animal.

Equation 4: Correcting for Average Carcass Weight in Determining Emission Reduction Intensities

kg CO_2e/hd/yr =

[(baseline emissions kg CO_2e) * (345 kg carcass weight/head) / (average baseline carcass weight kg/head)]

[(project emissions kg CO_2e) * (345 kg/carcass weight/head) / (average project carcass weight kg/head)]

Refer to Appendix A for a sample calculation.

To determine total emissions reduced in the project, sum the enteric and manure CO_2e emissions/corrected carcass weight for all animal groupings then, take the sum in baseline and project and apply the following equation to arrive at the total GHG emissions reduced in the project.

Equation 5: Calculating Emissions Reduced in the Project

kg CO_2e reduced in the project = (baseline emissions kg CO_2e per head per year – project emissions kg CO_2e per head per year) * number of head in the project

Further information on how to apply the reduced age to harvest protocol is available from Alberta Agriculture and Rural Development.

Table 10: Quantification Methodology

1.0 Project/ Baseline Sources and Sinks	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justify measurement or estimation and frequency**
Project Sources and Sinks						
P1b Cattle Production and P10 Feed Consumption	$Emissions_{Cattle} = \Sigma (EIF_{Enteric\ i} * Mass_{Production\ i} * Number_{Production\ i})$ **(For Each Animal Grouping$_i$)**					
	Enteric Emissions from Cattle / $Emissions_{Cattle}$	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Mass of Cattle Produced / $Mass_{Production\ i}$	kg beef	Measured	Direct measurement of kg of beef produced within each grouping of animals.	Monthly	Direct measurement is the highest level possible.
	Enteric Emissions Intensity Factor / $EF_{Enteric\ i}$	kg CH_4 / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source for each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data.
	Number of Cattle in Grouping i / $Number_{Production\ i}$	Head	Measured	Direct measurement of number of head sent to harvest within each grouping of animals.	Continuous	Direct measurement is the highest level possible.
P13 Manure Storage and Handling and P15 Land Application	$Emissions_{Manure} = \Sigma (EIF\ Manure_{N2Oi} * Mass_{Production\ i}); (EIF\ Manure_{CH4i} * Mass_{Production\ i}) *(Number_{Production\ i})$					
	Emissions from Manure Handling, Storage and Land Application / $Emissions_{Manure}$	kg N_2O; kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Mass of Cattle Produced / $Mass_{Production\ i}$	kg beef	Measured	Direct measurement of kg of beef produced within each grouping of animals.	Monthly	Direct measurement is the highest level possible.

1.0 Project/ Baseline Sources and Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Emissions Intensity Factor for Manure Handling, Storage and Land Application / EF Manure $_{CH4\ i}$	kg CH_4 / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source or each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data.
	Emissions Intensity Factor for Manure Handling, Storage and Land Application / EF Manure $_{N2O\ i}$	kg N_2O / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source or each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data.
	Number of Cattle in Grouping i / Number $_{Production\ i}$	Head	Measured	Direct measurement of number of head sent to slaughter within each grouping of animals.	Continuous	Direct measurement is the highest level possible.
Baseline Sources and Sinks						
B1b Cattle Production and B10 Feed Consumption	Emissions $_{Cattle}$ = Σ (EIF $_{Enteric\ i}$ * Mass $_{Production\ i}$ * Number $_{Production\ i}$) **(For Each Animal Grouping$_i$)**					
	Enteric Emissions from Cattle / Emissions $_{Cattle}$	kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Mass of Cattle Produced / Mass $_{Production\ i}$	kg beef	Measured	Direct measurement of kg of beef produced within each grouping of animals.	Monthly	Direct measurement is the highest level possible.
	Enteric Emissions Intensity Factor / EF $_{Enteric\ i}$	kg CH_4 / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source or each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data

1.0 Project/ Baseline Sources and Sinks	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
	Number of Cattle in Grouping i / Number $_{Production\ i}$	Head	Measured	Direct measurement of number of head sent to slaughter within each grouping of animals.	Continuous	Direct measurement is the highest level possible.
B13 Manure Storage and Handling and B15 Land Application	Emissions $_{Manure}$ = Σ (EIF Manure $_{N2Oi}$ * Mass $_{Production\ i}$); (EIF Manure $_{CH4}$ * Mass $_{Production\ i}$) *(Number $_{Production\ i}$)					
	Emissions from Manure Handling, Storage and Land Application / Emissions $_{Manure}$	kg N_2O; kg CH_4	N/A	N/A	N/A	Quantity being calculated.
	Mass of Cattle Produced / Mass $_{Production\ i}$	kg beef	Measured	Direct measurement of kg of beef produced within each grouping of animals.	Monthly	Direct measurement is the highest level possible.
	Emissions Intensity Factor for Manure Handling, Storage and Land Application / EF Manure $_{CH4\ i}$	kg CH_4 / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source or each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data
	Emissions Intensity Factor for Manure Handling, Storage and Land Application / EF Manure $_{N2O\ i}$	kg N_2O / kg beef	Estimated	Calculated using equation in Table 7 or other applicable source or each grouping of animals; based on average age (months) of animals in the group	N/A	Reference values in table 7 may be adjusted periodically based on availability of updated data
	Number of Cattle in Grouping i / Number $_{Production\ i}$	Head	Measured	Direct measurement of number of head sent to slaughter within each grouping of animals.	Continuous	Direct measurement is the highest level possible.

5.0 Data Management

Data quality management must be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project developer shall establish and apply quality management procedures to manage data and information. Written procedures must be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigor of the management system for the data, the more easily verification will be to conduct for the project.

5.1 Project Documentation

A number of records and data points are required to justify a greenhouse gas emissions assertion for the purposes of verification and registration of a reduced age at harvest offset projects on the Alberta Emissions Offsets Registry.

Cattle inventory data must be tracked for each specific pen/animal grouping in baseline and project to support quantification and verification of emission reductions being claimed. Some feedlots will track number of head.days and the dry matter intake for each feeding period and each pen/animal grouping in their close-out sheets. This level of detail facilitates the calculations and verification of an assertion of emission reductions. Guidance for determining the standardized feeding regimes and days on each regime is given in table 8.

Minimum records required to support project implementation are outlined below:

- Legal land location of the feedlot where the animal spends the final stage prior to harvest (see section 5.5);
- Documented method for establishing birth dates of cattle for baseline and project;
- If using the documented approach, birth certificates, birth dates and calving records and Radio Frequency Identification (RFID) tag numbers for each calf based upon birth records that **are registered** with the **Canadian Cattle Identification Agency (CCIA)** or an **Alberta registry**. Paperwork must accompany the animal or be accessible via the CCIA or appropriate registry;
- If using the default birth month, appropriate supporting records (i.e. CCIA registration, CCIA issued birth certificate) must be provided;
- Incoming or arrival age and weight of animals entering the feedlot;
- The number and weight of animals being fed in the designated animal groupings according to the feeding regimes in table 8 (e.g. calf-fed, yearling-fed, steers, in animal groupings);
- The type of feeding regime for the animal groupings and the number of days on feed for each regime (as per table 8);
- Methods used to group cattle in the baseline and project;
- Method applied for statistical sampling of animal groupings in the feedlot(s);
- Records of entry and exit records for cattle in groupings;
- Outgoing weights of animals and age at harvest for youthful animals;
- Proof of harvest of youthful animals;
- Records of the days on feed for feeding regime. This can include inferred feeding regimes 1-4 in table 8, and site specific feedlot records for feeding regimes 5 and 6;

- Copies of commercial agreements for offset ownership claims.

Justification for the greenhouse gas assertions must be supported by evidence. Records used to support the baseline and project condition must be sufficiently robust to support a reasonable (audit) level review of the greenhouse gas assertion. Credits that cannot be supported by records will not be accepted in the Alberta offset system.

Table 11 **below is a summary of sources of evidence in providing adequate justification for emission reduction assertions associated with reduced age at harvest beef projects.**

Table 11: Evidence Source for Reduced Days at Harvest of Beef Cattle Projects

Data Point	Evidence
Animal ID tag number	Registered with the Canadian Cattle Identification Agency or similar Alberta Registry.
Established birth date for registered cattle	Birth certificates, birth dates and calving records (if using the documented approach) and RFID tag numbers for each calf (paperwork to accompany the animal or accessed via the CCIA); based upon birth records that are registered with the Canadian Cattle Identification Agency (CCIA) or an Alberta registry
Methods for establishing birth date	Documented methods used for establishing the birth date for cattle in the baseline and project. Must be consistent for animals in both conditions.
Statistical sampling method	Documented procedures used to identify the number of pens to be sampled within each animal grouping according to the method outlined in appendix B. Demonstration of an unbiased, randomized selection of initial and finalized sampling of pens to determine required precision level.
Animal grouping methods	Documented procedures used to group animals in the baseline and project condition; inferred from table 8 for feeding regimes 1 to 4; actual procedures in the feedlot for feeding regimes 5 and 6.
Pen entry and exit records (feedlot or third party managed)	Number and weight of animals being fed in animal groupings -inferred from Table 8 and based on actual feeding records from the feedlot (e.g. calf-fed, yearling-fed, steers, in animal groupings applying Table 9 methods); average weights of the group in and out of the pens; date of entry; average number of animals in each pen;
Type of and number of days on feed for each feeding regime to arrive at months in age of cattle at harvest	Records of the days on feed for each feeding regime; and type of feeding regime for each animal grouping - inferred for feeding regimes 1-4 in Table 8; documented from feedlot records for feeding regimes 5 and 6 in the feedlot, based on diets and days on each

Data Point	Evidence
	diet;
Proof of harvest of cattle	Shipping manifests of cattle to packing plant with each animal CCIA tag listed on board. For cattle exports out of Alberta shipping manifests need to be on board as described above. All exported cattle will have an additional 0.25 months added to their harvest date.*
Legal land location for the feedlot operation(s)	See end of this section for guidance
Commercial arrangements/agreements	Agreements outlining the sharing/or apportioning of offsets between those that may have a claim to the offsets.

*0.25 months is added to exported cattle harvest dates to address uncertainty in the harvest date and to ensure conservatism.

5.2 Record Keeping

Alberta Environment requires that project developers maintain appropriate supporting information for the project, including all raw data for the project for a period of 7 years **after** the end of the project credit period. Where the project developer is different from the person implementing the activity, as in the case of an aggregated project, the individual farmer and the aggregator, must both maintain sufficient records to support the offset project. The project developer must keep the information listed below and disclose all information to the verifier and/or government auditor upon request.

Record Keeping Requirements:

- Raw baseline period , feed, and livestock production,, and\, independent variable data, and static factors within the measurement boundary
- A record of all adjustments made to raw baseline data with justifications
- All data and analysis used to support estimates and factors used for quantification
- Common practices relating to possible greenhouse gas reduction scenarios discussed in this protocol (such as manure management practices)
- A record of changes in static factors along with all calculations for non-routine adjustments
- All calculations of greenhouse gas emissions/reductions and emission factors
- Measurement equipment maintenance activity logs
- Initial and annual verification records and audit results
- Third party record keeping systems (such has Feedlot Health Management or CompuaidPro).

In order to support the third party verification and the potential supplemental government audit, the project developer must put in place a system that meets the following criteria:

- All records must be kept in areas that are easily located;
- All records must be legible, dated and revised as needed;
- All records must be maintained in an orderly manner;
- All documents must be retained for 7 years after the project crediting period;
- Electronic and paper documentation are both satisfactory; and
- Copies of records should be stored in two locations to prevent loss of data.

Note: Attestations will not be considered sufficient proof that an activity took place and will not to meet verification requirements.

5.3 Quality Assurance/Quality Control Considerations

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

- Ensuring that the changes to operational procedures (including feed intake, manure management, etc.) continue to function as planned and achieve greenhouse gas reductions
- Ensuring that the measurement and calculation system and greenhouse gas reduction reporting remains in place and accurate
- Checking the validity of all data before it is processed, including emission factors, static factors, and acquired data
- Performing recalculations of quantification procedures to reduce the possibility of mathematical errors
- Storing the data in its raw form so it can be retrieved for verification
- Protecting records of data and documentation by keeping both a hard and soft copy of all documents
- Recording and explaining any adjustment made to raw data in the associated report and files.
- A contingency plan for potential data loss.

5.4 Liability and Risk

Offset projects must be implemented according to the approved protocol and in accordance with government regulations. Alberta Environment reserves the right to audit offset credits and associated projects submitted to Alberta Environment for compliance under the *Specified Gas Emitters Regulation* and may request corrections based on audit findings.

Notwithstanding any agreement between a third party carbon data management system provider, and the project developer and/or the buyer of the offset credits, the third party data management system provider shall not and cannot pass on any regulatory liability for errors in design of their carbon data management system.

5.5 Registration and Claim to Offsets

It is important to note that the emission reductions associated with reducing age at harvest in beef cattle occur specifically at feedlot operations. This is where the activity takes place. As such, the project developer is designated in this protocol as the operation where the animal spends the final stage prior to harvest (e.g. a feedlot operator). The project developer/feedlot operator will need to ensure that they can justify the claim to the offsets to the satisfaction of the third party verifier. This will include contractual arrangements regarding the acknowledgement of who owns the carbon offset, or a portion thereof.

Emission reductions are tracked through the Alberta Emissions Offset Registry. The Registry relates the reduction to a specific land location. Projects will ensure the parcel used to create the reduction (i.e. where the animal is finished or achieves an acceptable marketable weight prior to harvest) is the actual parcel registered with the registry. Emission reductions will not be consolidated to the parcel where the business entity is legally located.

Figure 2: One Feedlot, 2 Registry Parcels Example

Parcel 1

Parcel 2

6.0 References

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7.0 Appendices

Appendix A: Alberta Case Study - Reducing Age at Harvest

This case study involves a baseline condition where the average age of yearling-fed steers harvested prior to implementation of the project was 18.2 months of age. The project condition involved shortening the time to harvest of steers to an average of 14.2 months of age. A total of 5000 head were produced in the project year for this case study.

The dietary composition for each category of beef cattle (animal grouping) for both the baseline and project conditions for specific feeding periods were gathered from feeding strategies developed at the Lacombe Research Centre, Lacombe, Alberta, Canada (Basarab et al. 2003; McCartney et al. 2004) and are generally representative of the feeding regimes in this protocol (Basarab et al. 2005).

Animal groupings in defining the baseline condition are:

1) Calf: 0-3 months on pasture with dams;
2) Calf: 3-6 months on pasture with dams;
3) Weaned calf: 6-9 months on stockpiled pasture;
4) Feeder: 9-12.6 months in feedlot on backgrounding diet;
5) Feeder: 13-16 months on pasture and
6) Feeder: 16-18.2 months on a finishing diet.

The animal groupings for the project are the same as 1 and 2 above, but move into feeders (6-7 months) in feedlot on a step-up diet and then feeders (7-14 months) on a finishing diet.

Diet composition for each category of beef cattle for baseline and project are given in Table A1. The diets were formulated using CowBytes (CowBytes 2000) based on thermal neutral environment conditions, average mid-point weight, days on each diet and desired average daily gain (ADG). Dry matter intake (DMI) for a given body weight and average daily gain was then predicted from CowBytes which is based on NRC (1996). They fit within the feeding regimes in table 8 above.

Table A1: Diets and diet ingredient composition of Baseline and Project Conditions

Animal Category, age and feeding location	Feeding period	Days on feed	Diet Ingredients, (% DM basis)						
			Milk	Alfalfa-meadow brome grass	Barley Silage	Barley Grain	Hay	Molasses	Beef Supp. Min/Vit
Baseline diets (steers harvested at 18.2 months of age)									
1. Calf, 0-3 months, pasture	May-Jul	91	100.0	----	----	----	----	----	----
2. Calf, 3-6 months, pasture	Aug-Oct	92	43.0	57.0	----	----	----	----	----
3. Wean calf, 6-9 months, pasture	Nov-Jan	92	----	100	----	----	----	----	----
4. Feeder, 9-12.6 months, feedlot	Feb-May 15	104	----	----	35.0	40.0	23.0	1.0	1.0
5.Feeder, 13 –16 months, pasture	May 16-Aug 15	92	----	100.0	----	----	----	----	----
6. Feeder, 16-18 months, feedlot	Aug 16-Nov 14	75	----	----	10.5	84.2	----	1.6	3.6
	Total (18.2 mo)	546							
Project diets (steers harvested at 14.2 months of age)									
1. Calf, 0-3 months, pasture	May-Jul	91	100.0	----	----	----	----	----	----
2. Calf, 3-6 months, pasture	Aug-Oct	92	43.0	57.0	----	----	----	----	----
5. Calf, 6-7 months, feedlot	Nov	31	----	----	40.0	58.0	----	1.0	1.0
7. Feeder, 7-14 months, feedlot	Dec-Jun	212	----	----	10.5	84.2	----	1.6	3.6
	Total (14.2 mo)	426							

Calculating Greenhouse Gas Emissions from Enteric Fermentation

Calculations for enteric methane emissions are done on a per kg of carcass beef basis or functional unit used for comparison (table A2) using the emission factor regression curves in table 7 of this document. The total number of cattle produced in the project for the example below was 5000 head.

Table A2: Enteric Fermentation Example Calculations

Calculation Input	Baseline – 18.2 months	Project – 14.2 months
Average Beef Production at Harvest (carcass weight) (shrink 4%, dressing 58%)	345.7	344.2
Relative Methane Intensity kg CH_4/kg carcass beef/yr[a], carcass weight based on 345 kg	0.682	0.497
Relative GHG Intensity kg CO_2e /kg carcass beef/yr[b]	14.33	10.45

a – using equation for EF $Enteric_{CH4}$: $y = 0.162\ e^{0.079\ x,}$ where x = age at harvest in months
b – multiplying by 21 times to convert methane to carbon dioxide equivalents

Functional units - corrected for actual baseline and project average carcass weight:

Baseline:

kg CO_2e/hd/yr = (14.33 * 345)/345.7) kg carcass
= 14.30*345 carcass weight
= 4,933.5 kg CO2e/hd/yr

Project:

kg CO_2e/hd/yr = (10.45 * 345)/344.4) kg carcass
= 10.47*345 carcass weight
=3,612 kg CO2e/hd/yr

Calculate enteric methane emissions reduction from the project:

kg CO_2e reduced = (4933.5 – 3612) * 5000 head in the project
= 6,607,500 kg CO2e

or 6,607.5 tonnes of CO2e.

Calculating Greenhouse Gas Emissions from Manure

The calculations using the emission factor regression curves are shown in table A3.

Table A3 Manure Emissions Example Calculations		
Calculation Input	**Baseline – 18.2 months**	**Project – 14.2 months**
Average Beef Production at Harvest (carcass weight (shrink 4%, dressing 58%)	345.7	344.2
Manure Methane		
Relative Methane Intensity kg CH_4/kg carcass beef/yr[a]	0.010	0.005
Relative GHG Intensity kg CO_2e /kg carcass beef/yr[b]	0.215	0.110
Manure Nitrous Oxide		
Relative Nitrous Oxide Intensity kg N_20/kg carcass beef/yr[c]	0.0157	0.008
Relative GHG Intensity kg CO_2e /kg carcass beef/yr[d]	4.89	2.72
Total Manure Carbon Dioxide Equivalents		
Total CO2e/kg carcass beef/yr	**5.112**	**2.837**

a – using equation for EF Manure $_{N20}$ in Table 7; $y = 0.0011\ e^{0.1464\ x,}$ where x = age at harvest in months
b – multiplying by 21 times to convert methane to carbon dioxide equivalents
c – using equation for EF Manure $_{CH4}$ in Table 7 above $y = 0.0005\ e^{0.1659,\ x}$ where x = age at harvest in months
d – multiplying by 310 times to convert nitrous oxide to carbon dioxide equivalents

Functional units for manure emissions - corrected for actual carcass weight:

Baseline:

kg CO_2e/hd/yr = ((5.112 * 345)/345.7) kg carcass
= 5.102*345 carcass weight
= 1,760.19

Project:

kg CO_2e/hd/yr = (2.837 * 345)/344.4) kg carcass
= 2.842*345 carcass weight
= 980.49

Calculate manure greenhouse gas reduction from the project:

kg CO_2e reduced = (1760.19 – 980.49) * 5000 head in the project
= 3,898,500 kg CO2e

or 3,898.5 tonnes of CO2e.

Total emission reduction = 6,607.5 t CO_2e enteric methane +
3,898.5 CO_2e t CO_2e from manure
= 10, 506 tonnes CO_2e reduced

Appendix B: Statistical Sampling Method Baseline Calculations for Reducing Age at Harvest Projects

Sampling is the process by which a subset of a population is analyzed in order to make generalizations about the whole population. The values attained from measuring a sampling of pens in a feedlot, for example, is intended to be an estimation of the true value (known as the parameter) for the entire population of cattle in the yard or of a specific animal grouping (e.g. 650-750 lb fall-placed steers). We need to have some idea of how close the estimation is to the parameter and this is provided by statistics.

Sampling a subset of pens in the feedlot for greenhouse gas estimation involves taking measurements of the desired data in a number of pens. The average values of the desired data when all the pens are combined represents the larger population and we can tell how representative it is by looking at the confidence interval. A 95 per cent confidence interval is a common and appropriate measure telling us that, 95 times out of 100, the true greenhouse gas emissions lie within the interval. If the interval is small, then the estimation is more precise.

To facilitate beef project development and increase the accuracy and precision of estimating carbon reductions, it is useful to divide the cattle in the feedlot by their animal groupings or “strata” (typically they are organized in feedlot pens according to specific groupings) to form relatively homogenous sampling units. In general, stratified sampling also decreases the costs of monitoring because it typically lessens the sampling efforts necessary, while maintaining the same level of confidence due to decreased variability in the data that drive the greenhouse gas reductions in each animal grouping. The more variable the data, the more pens are needed to attain targeted precision levels.

To apply the above method then, we will need an indication of the variability of the data within the sampled strata. This is calculated quite simply using the Coefficient of Variation (CV) of the data in the sampled animal grouping. The following key statistics need to be calculated for each set of measured data in each animal grouping:

- Mean or Average: a measure of central tendency, calculated by

$$\bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n}$$

- Standard deviation: a measure of dispersion, calculated by

$$s_x = \frac{\sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2}{n-1}$$

- Coefficient of variation (CV), calculated by:

$$CV = \frac{s_x}{\bar{x}} \times 100$$

In order to determine an appropriate size of a sample with the required precision, we need to avoid taking a sample that is too small or too large with under- or over-accuracy, respectively. Thus, we want to strike a balance by expressing the allowable error in terms of confidence limits.

- The 95% confidence limits are given by:
  $\bar{x} \pm 2s_x / \sqrt{n}$.
- We let *L* be the allowable error (for GHG projects it's set at 5% of the mean) and we put:
  $L = 2s_x / \sqrt{n}$.

In other words, we are 95% certain that the actual error will not exceed ±*L* or we are willing to take a 5% risk that the actual error will be below –*L* or above +*L*.

Applying the Sampling Approach

Biological traits in beef cattle lend themselves well to sampling approaches because they typically follow a normal distribution. To sample the feedlot or feedlots for a statistically valid sample, the feedlot has to be sufficiently large enough to support the method. Further, the sampling method within the animal groupings described below needs to follow random selection procedures and be unbiased. This method will need to be demonstrated to the verifier.

The biostatisticians and scientists at the Department of Agriculture and Rural Development (ARD) have tested this method with robust feedlot datasets (over 80,000 head in Alberta). The method is outlined below.

1. Determine Animal Groupings

Data are to be collected from the following pens/animal groupings if they are present in the feedlot:

- Cows
- Fall Heifer Calves
- Fall Steer Calves
- Mixed Steers and Heifers
- Winter Heifer Calves
- Winter Steer Calves
- Yearling Heifers
- Yearling Steers

2. Determine the Sampling Plan of the Data

Based on the analysis done in ARD and explained below in the example, the initial sample should contain 30 to 40 pens (i.e. n = 30 or 40 initially) in each of the above animal groupings. The data to be collected include[7]:

- Number of animals per pens
- Average arrival age (days) per pen
- Average arrival weight per pen (lb or kg)
- Average daily dry matter intake per animal per pen
- Average slaughter age per pen (days)
- Average slaughter weight per pen
- Average Daily Gain per pen

Note: The sampling plan will need to be presented to the verifier of the project and demonstrate that the animal grouping/pen selection was not biased.

3. **Calculate the mean, standard deviation and coefficient of variation (CVs) of the above data, by grouping.**

4. **Calculate the appropriate size of the sample for each strata/animal grouping**: Since the precision level we are setting for the sampling method dictates that we are 95% certain that the actual error will not exceed ±*L* or we are willing to take a 5% risk that the actual error will be below –*L* or above +*L*, the desired sample size is calculated as:

$$n = 4s_x^2 / L^2 = 4CV^2 / (L')^2,$$

Where: *L'* is the allowable error expressed as the percentage of the mean (in this case 5%).

Once the number of pens needed to reach the desired precision level is determined, these then become the sample for which the required data for the project and baseline can now be collected. See below for an example of the method being applied.

This procedure will need to be documented concisely in order to justify the method to the verifier.

Example Application:

After obtaining actual pen data for nearly 90,000 animals over a 3 year period (2006-2009), the animals were stratified according to the groupings in Step 1 above, and mean, standard deviations and CV's analyzed for the data outlined in Step 2 above.

The analysis shows that for the key trait of daily dry matter intake the CVs ranged from 4 to 32 per cent.

Next, the required sample size was calculated to find out how many pens would be required to produce a mean or an average that is repeatable 95 times out of 100 or have a 5% error. For all animal groupings, with the exception of the yearling heifers (this group

[7] The above data can be calculated as an average for the pen using the cattle inventory approach outlined in Section 4 of this document.

tends to be less homogenous than the others), the number of pens, required or ‘n’ is shown in Table B1.

Table B1 – Required sample ‘n’ within the Allowable Error (+/- 5 per cent) with a 5 per cent risk that the error will fall outside of the desired range (derived from Table 1 analysis) based on the example shown here.

Animal Grouping	**Daily Dry Matter Intake (lbs/head/day)** **No. of Pens**	**Slaughter Weight (lbs)** **No. of Pens**
Cows	34	4
Fall Heifer Calves	66	41
Fall Steer Calves	31	28
Mixed Steers/Heifers	2	0
Winter Heifer Calves	13	9
Winter Steer Calves	34	18
Yearling Heifers	167	26
Yearling Steers	48	8

A conservative starting point to recommend for initial sampling falls within 30 to 40 pens for the critical trait that drives greenhouse gas emissions from cattle operations (i.e. daily dry matter intake). Although the yearling heifers tend to be more variable in the data, the method takes care of that by requiring an increased sample size until the project developer can obtain a 5 per cent error in the estimated mean. Once this iterative process is finished, the project developer may find that less pens are required for some animal groupings as shown in the example above.

Note: This method may require consulting a statistician.