

QUANTIFICATION PROTOCOL FOR INCLUDING EDIBLE OILS IN CATTLE FEEDING REGIMES

Version 3.0

July 2011

Specified Gas Emitters Regulation

**Government
of Alberta** ■

Alberta ■

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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Alberta Environment Related Publications

Climate Change and Emissions Management Act
Specified Gas Emitters Regulation
Specified Gas Reporting Regulation

Alberta's 2008 Climate Change Strategy

Technical Guidance for Completing Annual Compliance Reports
Technical Guidance for Completing Baseline Emissions Intensity Applications
Additional Guidance for Cogeneration Facilities
Technical Guidance for Landfill Operators

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 2.0 to version 3.0 of this protocol. All changes apply as of the date of release of version 3.0.

- This protocol has been adapted to the new Alberta Environment quantification protocol format.
- Ownership of offset credits generated under this protocol is assigned to the project developer (e.g.: feedlot operator).
- Manure must be managed according to the *Agricultural Operation Practices Act* requirements for confined feeding operations.
- Additional details on quantification methodology and records required to support the project condition are provided in section 4.0 and section 5.0.
- Flexibility to apply this protocol using either live weight or carcass weight has been added to this protocol.
- The flexibility mechanism that allows the project developer 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.
- The project developer must disclose the legal land location of the feedlot, or lots where the cattle are 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 (CH₄) - a potent greenhouse gas - as a result of the digestion of feed materials in the rumen. These emissions are called enteric fermentation emissions. Reducing the amount of methane released by cattle results in greater conversion of feed into animal weight gain and increases the overall efficiency of the operation.

One of the strategies to reduce enteric methane emissions is to include edible oils in concentrations ranging from 4 to 6 per cent in the finishing diet of beef cattle. Including edible oils in beef cattle diets suppresses methanogenesis in the rumen leading to reduced enteric methane emissions. This can result in reduction in enteric fermentation emissions of up to 20 per cent from these animals. The Alberta Quantification Protocol for Including Edible Oils in Cattle Feeding Regimes was developed to provide a standard quantification methodology for calculating these greenhouse gas reductions

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 methane emissions generated by different cattle classes in Canada. This science forms the basis for the quantification methodologies used in this protocol.

The scope of this protocol is limited to enteric fermentation emissions associated with beef cattle using a functionally equivalent metric of emissions per kilogram of live cattle weight. The protocol allows users to quantify reductions in these emissions using established scientific estimates. Cattle operations that are incorporating edible oils at a concentration of 4 to 6 per cent on a dry matter basis¹ in the finishing diets of beef cattle sometime after Jan 1, 2002, and where sufficient records exist to quantify the baseline and project condition are eligible to claim offsets under Alberta's offset system if greenhouse gas reductions (enteric emission reductions) are quantified in accordance with this protocol and the claim is verified by an qualified third party.

For the purposes of this protocol, the project activity must occur during the finishing stages of beef cattle that occur primarily in feedlots. The feedlot operator will be required to collect and maintain data and records to support the offset project implementation and is assumed to be the project developer for this activity.

The baseline condition defines what was happening before the change in the feeding practices of the animals was implemented and must represent business as usual operations for the feedlot. The project condition defines the project activities and must meet the requirements of this protocol.

¹ Feeding of edible oils at concentrations greater than 6 per cent will not yield any incremental greenhouse gas reductions and may result in compromising the health of the animal.

Baseline Condition for Feeding Edible Oils:

The baseline condition for the edible oils protocol is the feeding regime, dry matter intake of the cattle and time period required to complete a finishing diet regimen before edible oils or fats are added to the diets of cattle in the feedlot.

The baseline is calculated using 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.

The baseline quantification approach is explained further in section 2.0.

Project Condition for Feeding Edible Oils:

The project condition requires the project developer to implement a revised feeding regime that includes 4 to 6 per cent edible oils or fats in the animals' finishing diet, on a dry matter basis, thereby reducing enteric fermentation emissions when compared to the project baseline.

The quantification approach and requirements are explained further in section 4.0.

Specified Gas	Formula	100-year GWP	Applicable to Project
Carbon Dioxide	CO ₂	1	No
Methane	CH ₄	21	Yes
Nitrous Oxide	N ₂ O	310	Yes
Sulphur Hexafluoride	SF ₆	23,900	No
Perfluorocarbons*	PFCs	Variable	No
Hydrofluorocarbons*	HFCs	Variable	No

- 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

To apply this protocol, the project developer must meet the following requirements:

1. Diets fed to animals in the baseline and project have sufficient documentation to quantify a reduction in enteric emission through the inclusion of edible oils or fats in the project condition. Specifically, the project developer must be able to demonstrate the content and quantity of feed in order to quantify enteric emissions in the baseline and project condition.
2. Animals must be grouped into categories with similar feeding regimes. Animal grouping criteria must be similar between the baseline and project conditions to be able to demonstrate a change in practice in the project condition. Emission

reductions must represent a reduction in emissions based on a common metric of emissions per kilogram live cattle weight to ensure emissions reductions being quantified represent real reductions when compared against the project baseline.

3. Manure must be managed according to the *Agricultural Operation Practices Act* requirements for confined feeding operations.
4. Sampling of baseline and project is allowed under this protocol and must be done using the statistical sampling methodology outlined in Appendix B.
5. The quantification of reductions achieved by the project is based on actual measurement and monitoring as indicated by the proper application of this protocol; and,
6. The project meets the eligibility criteria stated in section 7.0 of the *Specified Gas Emitters Regulation*. In order to qualify, emissions reductions must:
 - Occur in Alberta;
 - Result from actions not otherwise required by law;
 - Result from actions taken on or after January 1, 2002;
 - Be real, demonstrable, and quantifiable;
 - Have clearly established ownership including, if applicable, appropriate, documented transfers of ownership from the land owner to land lessee;
 - Be counted once for compliance; and
 - Be implemented according to ministerial guidelines.

The general data requirements for this protocol are shown in Table 2 below. Additional details are provided in sections 4 and 5.

Table 2: General Overview of Data Requirements to Justify the Baseline and Project Condition		
Data Requirements:	What is needed?	Why do you need it?
Animal identifier tag	CCIA or unique tag identifier	To track animals as they move through the feedlot.
Characterization of the animal grouping methods in the pre-project and baseline condition including similar grouping methodology across all project years; and Average number of animals/pen.	Documented feedlot records of animal pen entry and exit records that show: <ul style="list-style-type: none"> • Average weights of the group in and out, • Date of entry (by production system, quality grid program, sex, breed or custom feeding lots records) for both the baseline and project condition; and • Average number of animals in 	The methods used to define an animal grouping (ie: sex, age, weight, breed, etc...) should be similar between project and baseline to ensure like groupings are compared for the offset calculation.

	each pen.	
Documented proof of what was being fed to the cattle per animal grouping/pen in the feedlot including the days on feed for each diet and the diet composition	<ul style="list-style-type: none"> • Feed purchase receipts or scale tickets, weights, etc; • Delivery records for a pen; • Diet formulations signed off by a Doctor of Veterinarian Medicine or Professional Agrologist indicating the diet includes 4 to 6 percent edible oils on a dry matter basis; • Proof the diet was fed to the animals as indicated from internal record keeping systems or third party files (such as Feedlot Health Management or ComputerAid or others). This must include the dry matter content of the feed, kilograms of feed per day delivered to each pen (or monthly totals), the number of days on the diet, edible oil content, and any additives and levels of concentrates in the diets. 	To support calculations of the offset claim and for third party verification. Note, a verifier will need evidence of diets and total mixed diets fed to cattle groupings for the baseline and project condition.
Incoming and outgoing average weight of each grouping of animals being included in the baseline and project	Documented feedlot records of animal pen entry and exit records that show: <ul style="list-style-type: none"> • Average weights of the group in and out, • Date of entry (by production system, quality grid program, sex, breed or custom feeding lots records) for both the baseline and project condition; and • Average number of animals in each pen. 	To determine average daily gain as a check for the verifier to determine if the diet is stated correctly.
Legal land location of the feedlot operation and feeding agreements for the animals in the project	<ul style="list-style-type: none"> • Legal land description for the registration of the project; • Proof that the animals fed in the project were under control of the feedlot operator (see section 5.5) 	Registration of the project on the Alberta Emissions Offset Registry.

This protocol is only applicable to emission reductions generated through the inclusion of edible oils in feeding regimes to reduce enteric methane emissions. Other emission reduction opportunities may be applicable to feedlot operations in Alberta and where sufficient records exist, one or more reduction projects may be implemented at a single site. These opportunities are summarized in Table 3 below.

Activity:	Protocol:
Reducing the number of days cattle are on a finishing diet regimen.	Quantification Protocol for Reducing Days on Feed of Cattle
Reducing the number of days it takes to take cattle through the beef production chain (cow-calf to market).	Quantification Protocol for Reduced Days to Harvest in Beef Cattle
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 data varies across groups of animals (e.g.: weight class, age, sex, breed), these animals can be grouped in discreet units and tracked individually rather than in groupings of similar animals as discussed in the protocol. Exercising this flexibility option will require tracking each individual head of cattle through its specific feeding regimes as it moves through the feedlot.
2. Greenhouse gas reductions are calculated on a ‘kilogram of live weight’ unit of production. Emission reductions may be calculated based on dressing percentages (kilograms of carcass weight) as long as the same unit is applied to the baseline and project conditions and the data can be substantiated (i.e. packing plant receipts).
3. Corn dried distillers and grains and solubles have been identified as an acceptable source of dietary fat that will suppress methanogenesis in the rumen. If these distillers and grains are being included in the project condition, the diet, signed off by a qualified animal nutritionist (see Glossary below) must ensure the diets continue to meet the dietary fat content of 4 to 6 per cent on a dry matter basis as required by this protocol and that diets are adjusted to account for the higher protein content to prevent excessive nitrogen excretion by the animals.

1.4 Glossary of New Terms

Animal groupings	Specific groupings of cattle in the feedlot, as they move through to the finishing stage. They are typically based on production system (calf-fed, yearling-fed, gender - heifer, steers, bulls - weight and marketing program (e.g., Lean's Lean, natural, grass finished). Note – there can be many pens within a feedlot containing the same animal grouping ² .
Animal head days	A basic unit used to account for the number of days animals were on feed in a specific animal grouping and is the sum of the number of days each individual animal spends on a specific feeding diet. The reason for the unit is for tracking animals as they move in and out of feedlot pens for that animal grouping.
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 per cent 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	Is feed ingredients or mixture of ingredients, including water, which is 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.

² The range of incoming weight should be no more than 45.4 kg (100 lb) within each grouping. As an 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 for part of a specific project. However, another part of the project or even a different project site 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 called *feeding periods* in this protocol.

Edible oils ³	Are oils derived from plants that are composed primarily of triglycerides. Although many different parts of plants may yield oil, in commercial practice oil is extracted primarily from the seeds of oilseed plants. Whole seeds can be applied as a feed ingredient so long as the oil content is calculated on a dry matter basis to achieve the 4 to 6 per cent content in the diet.
Enteric emissions	Emissions of methane (CH ₄) from the cattle as part of the digestion of the feed materials.
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.
Feeding periods	Groupings of cattle will typically have a series of diets for a specified number of days on feed; this is termed <i>feeding periods</i> in this protocol.
Feeding regimes	The whole system of diets or diets fed to animals over the baseline/project period.
Licensed nutritionist	Is a Doctor of Veterinary Medicine or Professional Agrologist.
Quality grid program	A set of quality attributes (carcass weight, marbling, back fat thickness) for which a cattle processor can either charge a premium or discount the meat.
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 labour, and operator labour.

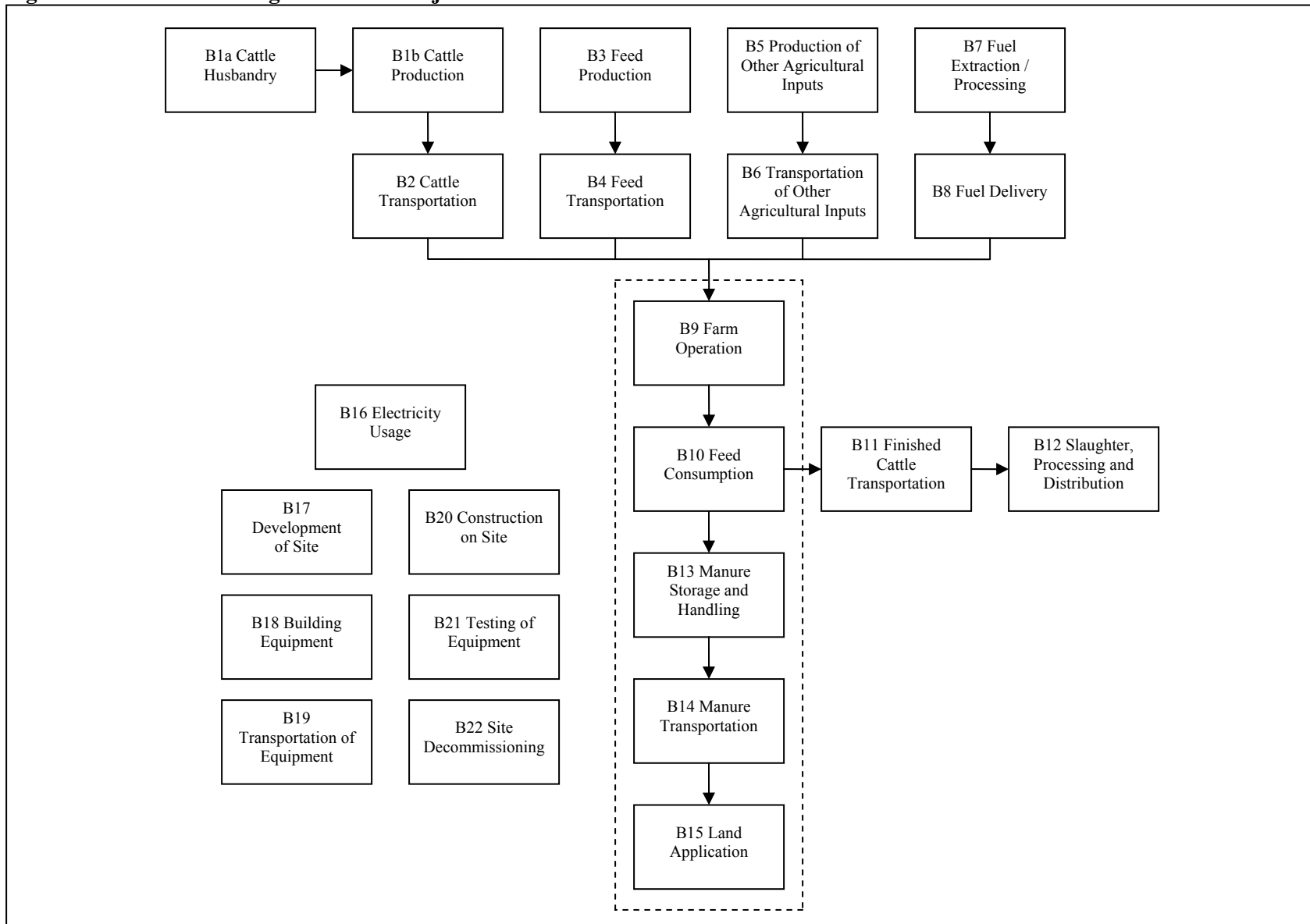
³ Note - there are other edible oil-containing products such as unstabilized rice bran, or walnut oils, extracted oil form Dried Distillers Grains, or even beef tallow where available. The onus is on the project developer to work with their nutritional specialist to ensure the ration formulation fits the requirements of this protocol.

2.0 Baseline Condition

The protocol uses a **static historic benchmark** baseline condition. Under this scenario, an average baseline greenhouse gas emissions intensity per kg of live weight (kg CO₂e per kg live weight) is quantified for each animal grouping and averaged over a period of 3 years prior to incorporating edible oils into the diet. This protocol allows the project developer to maintain a static baseline over the project life that is representative of the baseline practices for their operations recognizing that baseline emissions will vary as a function of the number of animals included under the project condition. Information on establishing a statistically representative baseline is included in Appendix B.

Sources and sinks were identified for the project by reviewing the seed documents and relevant process flow diagram developed by the Beef Technical Working Group under the federal-provincial territorial initiative called the National Offset Quantification Team (NOQT) and work completed during 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).

Figure 1: Process Flow Diagram for the Project Baseline



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/or sink is under the direction and influence of a project developer through financial, policy, management, or other instruments.

Related: A related source and/or 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/or 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/or 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/or 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/or sinks 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 Including Edible Oils

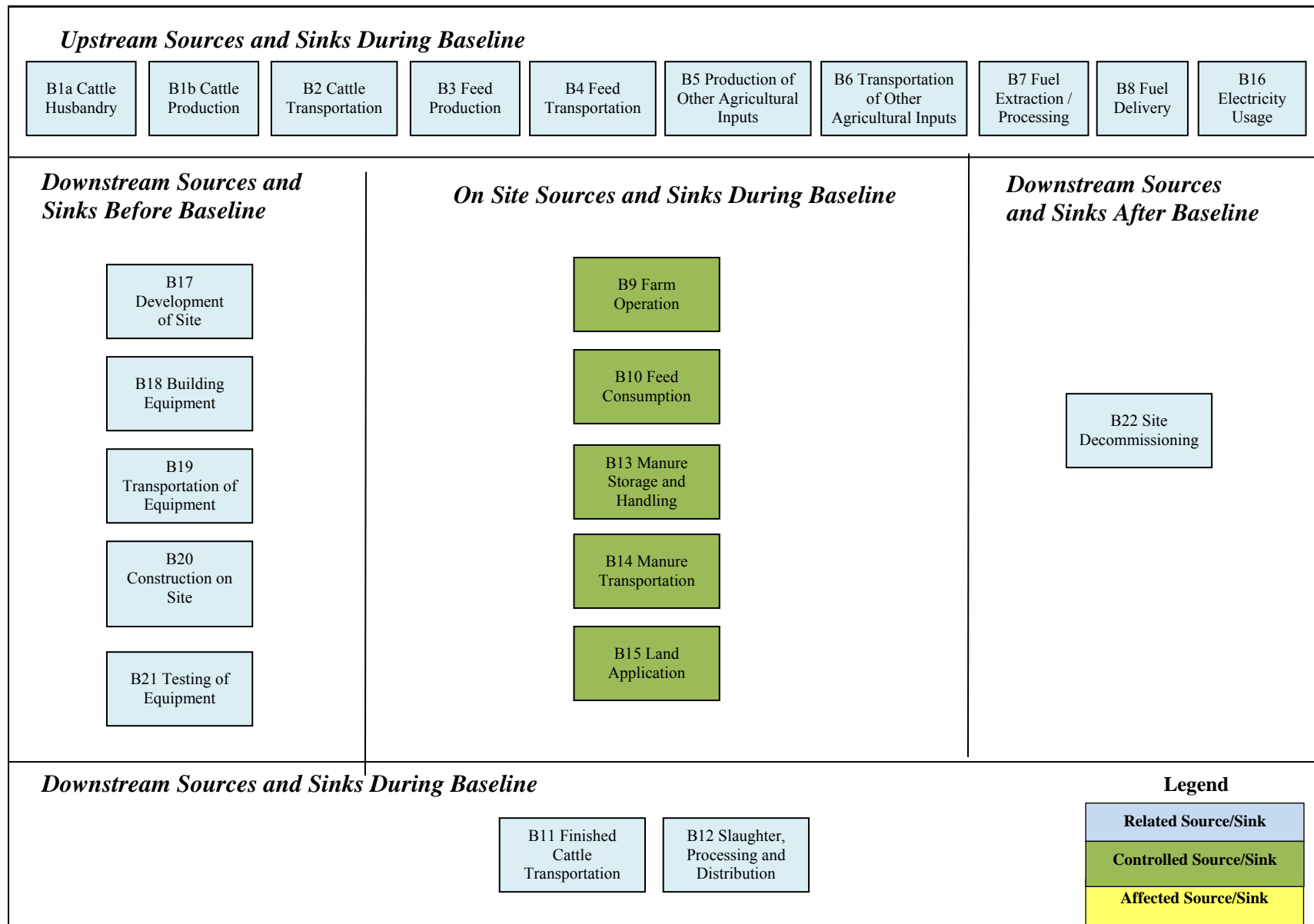


Table 4: Baseline Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
Upstream Sources and Sinks During Baseline Operation		
B1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities and types for each of the energy inputs would be contemplated to evaluate functional equivalence with the 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 be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site source/sink are considered under this source/sink. Volumes and types of fuels are the important characteristics to be tracked.	Related

Table 4: Baseline Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
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 sources/sinks 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 Operation		
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 as would the length of each type of feeding cycle.	Controlled
B13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This could include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Operational aspects of the manure storage and handling systems may 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 could include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Operational aspects of the manure land application systems may need to be tracked..	Controlled
Downstream Sources and Sinks During Baseline Operation		
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 souce/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	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	Related

Table 4: Baseline Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
Distribution	running vehicles and facilities at other sites. Quantities and types for each of the energy inputs would be tracked.	
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, 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

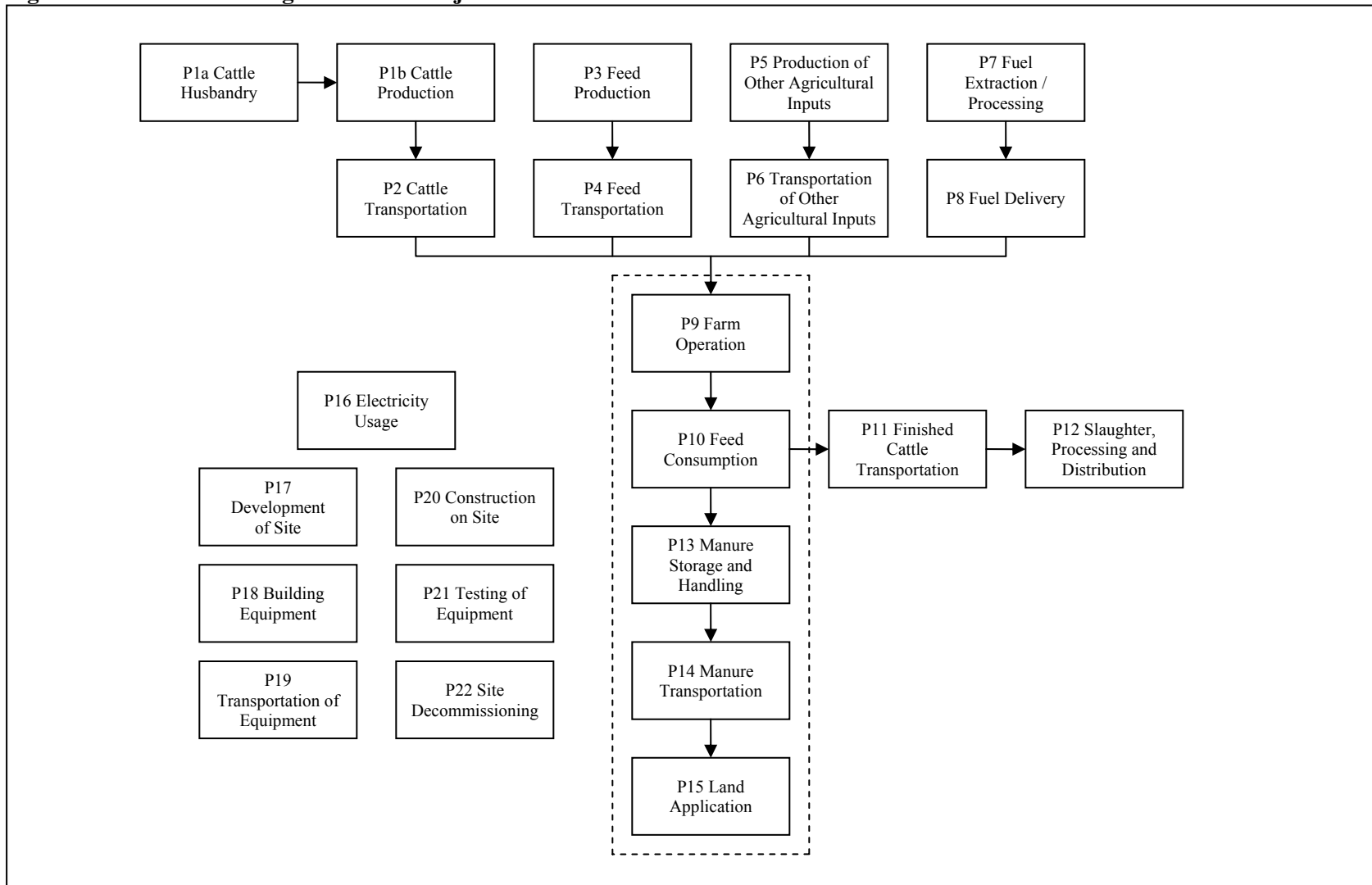
3.0 Project Condition

The project condition is defined by including edible oils in the finishing diets of beef cattle. Specifically, edible oils should be incorporated at concentrations ranging from 4 to a maximum of 6 per cent of dry matter content.

Enteric emissions are produced from cattle during the project condition; however, the incorporation of edible oils in cattle finishing diets can result in up to a 20 per cent reduction in the average enteric emissions from these animals. The difference in emissions between the project and baseline condition will result in the total number of emission reductions generated from the project.

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

Figure 3: Process Flow Diagram for the Project Condition



3.1 Identification of Project Sources and Sinks

Sources and sinks for the inclusion of edible oils in cattle feeding regimes were identified based on 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 feedlot(s) where the cattle are finished, the facility where manure is stored and the land where the manure is spread.

These sources and sinks have been further refined according to the life cycle categories identified in Figure 4. The approach to quantifying emissions in the project does not differ from the baseline. That is, animal diets, animal grouping characteristics, and days on feed are all factors that must be documented in order to justify the project condition.

These sources and sinks were further classified as controlled, related, or affected as described in Table 5below.

Figure 4: Project Conditions Sources and Sinks for Including Edible Oils in Cattle Feeding Regimes

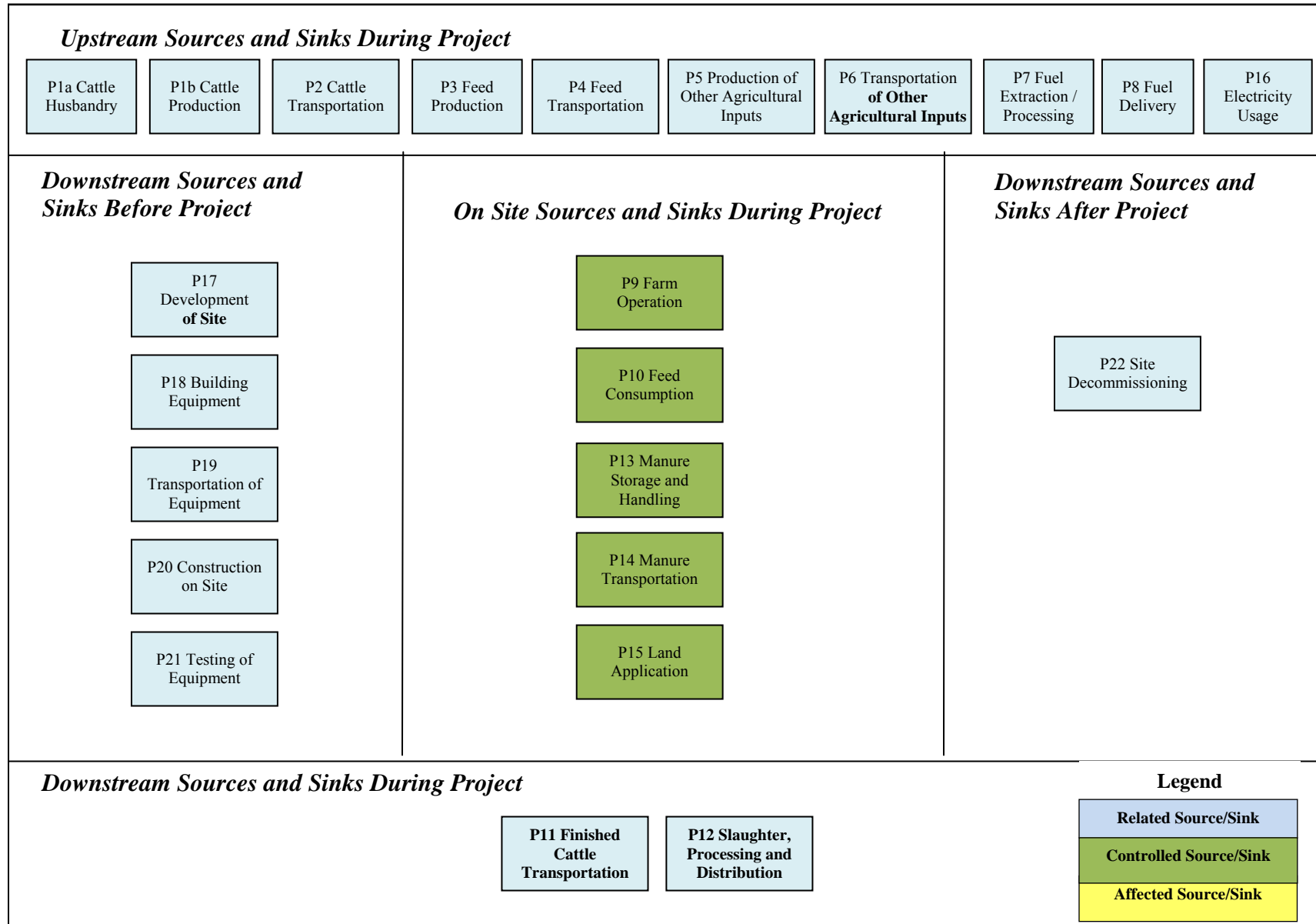


Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
Upstream Sources and Sinks During Project Operation		
P1a Cattle Husbandry	Cattle husbandry may include insemination and all other practices prior to the birth of the calf. Quantities 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 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
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
P7 Fuel Extraction and Processing	Each of the fuels used throughout the on-site component of the project will need to be sourced and processed. This will allow for the calculation of the greenhouse gas emissions from the various processes involved in the production, refinement and storage of the fuels. The total volumes of fuel for each of the on-site sources/sinks are considered under this source/sink. Volumes and types of fuels are the important characteristics to be tracked.	Related

Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
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 Sources and Sinks 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 as would the length of each type of feeding cycle.	Controlled
P13 Manure Storage and Handling	Greenhouse gas emissions can result from the operation of manure storage and handling facilities. This could include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Operational aspects of the manure storage and handling systems may 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
P15 Land Application	Manure may then be land applied. This may require the use of heavy equipment and mechanical systems. This could include emissions from energy use, and from the emissions of methane and nitrous oxide from the manure being stored and processed. Operational aspects of the manure land application systems may need to be tracked.	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

Table 5: Project Condition Sources and Sinks		
1. Sources and Sinks	2. Description	3. Controlled, Related or Affected
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 Sources and Sinks		
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
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 are 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 and Sinks				
1. Identified Sources and Sinks	2. Baseline (C, R, A)*	3. Project (C, R, A)*	4. Include or Exclude from Quantification	5. 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	Exclude	Excluded as cattle production upstream of the feedlot is functionally equivalent to the baseline scenario.
B1b Cattle Production	R	N/A	Exclude	
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	Rd	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	
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 farm operation for beef production is not materially impacted

Table 6: Comparison of Sources and Sinks				
1. Identified Sources and Sinks	2. Baseline (C, R, A)*	3. Project (C, R, A)*	4. Include or Exclude from Quantification	5. Justification
B9 Farm Operation	C	N/A	Exclude	by the implementation of the project as feed transportation and delivery is only modified to a negligible degree. As such the baseline and project conditions will be functionally equivalent.
P10 Feed Consumption	N/A	C	Include	
B10 Feed Consumption	C	N/A	Include	Included because emissions from the baseline to project are materially different.
P13 Manure Storage and Handling	N/A	C	Include	
B13 Manure Storage and Handling	C	N/A	Include	Included because emissions from the baseline to project are materially different.
P14 Manure Transportation	N/A	C	Exclude	
B14 Manure Transportation	C	N/A	Exclude	Excluded as the emissions from transportation are likely functionally equivalent to the baseline scenario.
P15 Land Application	N/A	C	Include	
B15 Land Application	C	N/A	Include	Included because emissions from the baseline to project are materially different.
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 Sources and Sinks				
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	Emissions from site development are not material for the baseline condition given the minimal site development typically required.
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	Emissions from building equipment are not material for the baseline condition given the minimal building equipment typically required.

Table 6: Comparison of Sources and Sinks				
1. Identified Sources and Sinks	2. Baseline (C, R, A)*	3. Project (C, R, A)*	4. Include or Exclude from Quantification	5. Justification
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	Emissions from transportation of equipment are not material for the baseline condition given the minimal transportation of equipment typically required.
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	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
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	Emissions from testing of equipment are not material for the baseline condition given the minimal testing of equipment typically required.
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	Emissions from decommissioning are not material for the baseline condition given the minimal decommissioning typically required.

*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 and sinks for each of the greenhouse gases will be completed using the methodologies outlined below. These calculation methodologies serve to complete the following 3 equations for calculating the emission reductions from the comparison of the baseline and project conditions.

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

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Cattle}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Cattle}}$$

Where,

Emissions_{Baseline} = sum of the emissions under the baseline condition.

Emissions_{Cattle} = emissions under B10 Feed Consumption

Emissions_{Project} = sum of the emissions under the project condition.

Emissions_{Cattle} = emissions under P10 Feed Consumption

4.2 Standardized Quantification Approach

Quantification of emission reductions of relevant sources and sinks for each of the greenhouse gases will be completed using methodologies outlined in Table 8. These calculation methodologies serve to complete the following equation for calculating the emission reductions from a comparison of the baseline and project conditions. Definitions for each of the variable used in the various equations are provided below.

Equation 1: Calculating Enteric Methane Emissions

$$\text{Cattle Enteric Methane (kg CH}_4\text{/feeding period)} = \sum [\text{Number Production}_i * \text{DOF} * \text{DMI}_i * \text{GE Diet} * (\text{EF Enteric } i / 100\%) / \text{EC Methane}]$$

Where

Number Production

This is the number of head in each animal grouping/pen and can be estimated using the animal head.days factor.

DOF (Days on Feed)

This is the number of days that the animal grouping is being a being fed a specific diet. This can be estimated using the animal head.days factor.

DMI (Dry Matter Intake)	The dry matter intake is calculated in CALC Step 1, by dividing the total kg DM delivered to the pen for the days on that diet, divided by the animal head.days for that diet.
GE Diet (Gross Energy Content of Diet)	This is a default factor, depending on the concentration of edible oil/fat content: <ul style="list-style-type: none"> • Use 19.10 MJ per kg of dry matter feed if the edible oil/fat concentration is between 4.0 and 6.0 per cent. • Use 18.5 MJ per kg of dry matter fed to each head if the edible oil/fat concentration is less than 4 per cent.
EF Enteric (Enteric Emissions Factor)	A default factor, depending on level of concentrates in the diet and edible oil/fat content: <ul style="list-style-type: none"> • Use 3.2 per cent for diets with \geq 85 per cent concentrates and edible oils/fats as per above; and, • Use 5.2 per cent for diets with less than 85 per cent concentrates and edible oils/fats as per above.
EC Methane (Methane Energy Content)	This is a default factor of 55.65 MJ per kg of methane.

4.3 Cattle Inventories and Data Collection

Cattle Inventories and Data Collection:

The protocol allows cattle inventories to be collected in 2 ways: tracking distinct groupings of animals daily based on the general animal/weight class they belong to or tracking each animal individually.

Transparent and accurate data is needed to support project implementation and facilitate a third party verification of the emission reductions. How animals are tracked is critical for to this protocol and must be consistent between the baseline and project conditions. If the project developer is using weight groupings or some other criteria, they must ensure that the groupings are clearly defined (e.g.: Class 1 = x kg to x kg) 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 should be accounted for in the animal head.day calculations explained below.

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

- The number of head of cattle within each animal grouping (or individually);

- The average weight in kilograms of cattle entering the grouping (or individually);
- The average weight in kilograms of cattle exiting the grouping (or individually);
- The average weight in kilograms of dry matter feed provided to each group per day (for the whole pen/animal grouping); and
- The number of days the group of cattle are fed a specific diet.

Cattle inventory data can be 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 where 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 7 below:

Pen		Days on Feed	No. of Head	Head.days	DMI (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 could be recorded in lbs or imperial measurements, so long as the calculation steps are consistent with the imperial metrics throughout, and converted to metric at the end.

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

- a) **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.

$$\text{Days on Feed (days)} = \text{animal head.days} / \text{average number of animals in production}$$

Referencing Table 7 above, days on feed would be extrapolated by taking the quotient of 1,736 animal head.days / 124 animals, with a result of 14 days on feed.

- b) **Number in Production** can be extrapolated from animal head.days if the days on feed or feeding period is known.

$$\text{Number in Production (head)} = \text{animal head.days} / \text{days on feed}$$

Referencing Table 7 above, number in production for diet 1 would be extrapolated by taking the quotient of 1,736 animal head.days / 14 days, with a result of 124 animals.

- c) **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 and 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.

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, or from a diet-balancing program used by the feedlot.

$$\text{Dry Matter Intake (kg / head / day)} = (\text{Total quantity of feed for a specific diet} \times \text{dry matter content of diet}) / \text{animal head.days}$$

Statistical Sampling Approach Allowed under this Protocol

Appendix B describes a statistical sampling method that can be used to support project development. Biological traits in beef cattle lend themselves well to sampling approaches because they typically follow a normal distribution curve. To sample the feedlot or feedlots for a statistically valid sample, the feedlot has to be sufficiently large to support the method and the sampling method within the animal groupings needs to follow random selection procedures to prevent bias. The sampling method used must be documented and will be reviewed by the third party verifier.

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 data when all the pens are combined are then representative of the larger population. The confidence interval becomes the range within which the actual greenhouse gas reductions will occur. This protocol requires a confidence interval of 95 per cent. If the interval is small, then the estimation is more precise.

Table 8: 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
Baseline Sources and Sinks						
B10 Feed Consumption	$Emissions_{Cattle} = \sum (Number_{Production\ i} * DOF * DMI_i * GE_{Diet} * (EF_{Enteric\ i} / 100\%) / EC_{Methane})$					
	Enteric Emissions from Cattle for each feeding regime within each animal grouping / $Emissions_{Cattle}$	kg CH ₄ / day / per animal grouping	N/A	N/A	N/A	Quantity being calculated.
	Number of Cattle in Grouping i / $Number_{Production\ i}$	Head	Measured	Direct measurement of number of head within each grouping of animals. This value can also be extrapolated from animal head.days if the days on feed (otherwise termed feeding period) are known. Number in Production (head) = animal head.days/days on feed	Continuous	Direct measurement is the highest level possible.
Days on Feed for Each Feeding Regime for Cattle in Grouping i / DOF_i	Days	Estimated	Average for cattle in specific animal grouping over the three years prior to the implementation of the project. This value 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.	Annual	Based on feedlot records.	

Table 8: 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
	Dry Matter Intake for Each Feeding Regime for Cattle in Grouping i / DMI_i	$kg_{\text{ dry matter / head / day}}$	Estimated	<p>Estimated based on average mass of feed provided to cattle during period on diet.</p> <p>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.</p> <p>Dry Matter Intake (kg/head/day) = (Total quantity of feed for a specific diet) x (dry matter content of diet) / animal head.days</p>	Continuous	Based on actual feed delivery records to each pen.
	Default value Gross energy content (GE) of the diet GE_{Diet}	$MJ / kg_{\text{ dry matter}}$	Estimated	18.45 MJ / $kg_{\text{ dry matter}}$	Annual	Default value taken from IPCC, 2006 guidance (Section 10.4.2).
	Emission Factor for Enteric Emissions for Each Feeding Regime in Grouping i / $EF_{\text{Enteric i}}$	%	Estimated	4 % for diets with greater than or equal to 85 % concentrates. 6.5 % for diets with less than 85 % concentrates.	Continuous	Set based on best available science and in reference to the IPCC, 2006 guidance.
	Energy Content of Methane / EC_{Methane}	$MJ / kg_{\text{ methane}}$	Estimated	55.65 MJ / $kg_{\text{ methane}}$	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.3.2).
Project Sources and Sinks						

Table 8: 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
P10 Feed Consumption	$Emissions_{Cattle} = \Sigma (Number_{Production\ i} * DOF_i * DMI_i * GE_{Diet} * (EF_{Enteric\ i} / 100\%) / EC_{Methane})$					
	Enteric Emissions from Cattle for each feeding regime within each animal grouping / $Emissions_{Cattle}$	kg CH ₄ / day / per animal grouping	N/A	N/A	N/A	Quantity being calculated.
	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. This value can also be extrapolated from animal head.days if the days on feed (otherwise termed feeding period) are known. Number in Production (head) = animal head.days/days on feed	Continuous	Based on feedlot records.
Days on Feed for Each Feed Regime for Cattle in Grouping i / DOF_i	Days	Measured	Average for cattle in specific animal grouping over the three years prior to the implementation of the project. This value 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.	Continuous	Based on feedlot records.	

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
	Dry Matter Intake for Each Feeding Regime for Cattle in Grouping i / DMI_i	$kg_{dry\ matter} / head / day$	Estimated	<p>Estimated based on average mass of feed provided to cattle during period on diet.</p> <p>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.</p> <p>Dry Matter Intake (kg/head/day) = (Total quantity of feed for a specific diet) x (dry matter content of diet) / animal head.days</p>	Continuous	Based on actual feed delivery records to each pen.
	Default value Gross energy content (GE) of the diet GE_{Diet}	$MJ / kg_{dry\ matter}$	Estimated	<p>19.10 MJ / $kg_{dry\ matter}$ for diets including edible oils/fats in the range of 4 to 6 per cent.</p> <p>18.45 MJ / $kg_{dry\ matter}$ for diets with edible oils/fats below the range of 4 to 6 per cent.</p>	Annual	Default value taken from IPCC, 2006 guidance (Section 10.4.2).
	Emission Factor for Enteric Emissions for Each Feeding Regime in Grouping i / $EF_{Enteric\ i}$	%	Estimated	<p>3.2 per cent for diets with greater than or equal to 85 per cent concentrates including edible oils/fats in the range of 4 to 6 per cent.</p> <p>5.2per cent for diets with less than 85% concentrates including edible oils/fats in the range of 4 to 6 per cent</p>	Continuous	Set based on best available science and in reference to the IPCC, 2006 guidance.
	Energy Content of Methane / $EC_{Methane}$	$MJ / kg_{methane}$	Estimated	55.65 MJ / $kg_{methane}$	Annual	Conversion factor taken from IPCC, 2006 guidance (Section 10.3.2).

4.4 Ensuring Functional Equivalence Between Baseline and Project

Emission related to the baseline and project conditions are calculated in a similar manner. In order to maintain functional equivalence both baseline and project emissions need to be adjusted for production equivalency of the cattle. For the purposes of quantifying greenhouse gas emissions reductions in Alberta, this is set as an intensity on a **per kilogram live weight basis** for both baseline and project once the emissions are summed for all animal groupings.

This is determined by dividing the total enteric methane emissions in baseline and project by the total number of animals in production and the average live weight of the animals as finishing is completed and they are determined ready for market (harvest).

Baseline CH₄ Emissions Intensity (kg CH₄ /kg live weight during the baseline condition)

$$= \frac{\Sigma [(CH_4 \text{ Emissions}_i) / (\text{Total Number in Production}_i * \text{Average Live Weight of Cattle}_i \text{ sent to market (kg)})]}{}$$

Project CH₄ Emissions Intensity (kg CH₄ /kg live weight during the project condition) =

$$\Sigma [(CH_4 \text{ Emissions}_i) / (\text{Total Number in Production}_i * \text{Average Live Weight of Cattle}_i \text{ sent to market (kg)})]$$

Note: the equations above must also take into account the global warming potential of methane which is 21 times more potent than carbon dioxide. Multiply the project and baseline methane emissions by 21 to determine emission reductions in terms of kg CO₂e/kg live weight. A sample calculation is provided in Appendix A.

5.0 Data Management

Data quality management must be of sufficient quality to support quantification requirements and must be substantiated by company records. Alberta Environment cannot accept offset credits for compliance purposes that are not supported by actual records.

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, the more robust the overall project will be. This can help reduce the potential for errors and facilitate third party verification.

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 enteric emission reduction projects through inclusion of edible oils on the Alberta Emissions Offsets Registry.

To facilitate quantification and verification of emission reductions, cattle inventory data must be tracked for each specific pen within a feedlot. Feedlots must track number of head days and the dry matter intake for each of the feeding periods and each pen/animal grouping in their close-out sheets, which can facilitate the calculations.

The following are minimum data and records requirements need to support the project quantification:

- Animal ID tag registered with the Canadian Cattle Identification Agency (CCIA) or a unique identifier with the ability to internally track the animal;
- Methods used to group cattle in the feedlot (note: the same method must be used for baseline and project calculations);
- Method applied for statistical sampling of animal groupings in the feedlot(s) valid for the baseline condition;
- Entry and exit records for cattle in groupings;
- Records of the amount of feed fed to each grouping on a dry matter basis;
- Diet composition of the diets/total mixed diet including any additives fed to the cattle groupings;
- Records of the days on feed for each ration;
- Legal land location of the feedlot operation(s); and,
- Copies of feeding agreements for cattle in the project, where applicable.

Note: Attestations from land owners or feedlot operators with regards to any factor related to the quantification of emission reductions will not be accepted by Alberta Environment as proof of an activity took place.

Table 9 below is a summary of sources of evidence that are acceptable for quantifying enteric emissions reductions associated with edible oils projects.

Table 9: Evidence Sources for Edible Oil Projects

Data Point	Evidence
Animal ID tag number	Registered with the Canadian Cattle Identification Agency (CICA) or a unique tag identifier.
Methods for grouping animals	Documented methods used in the feedlot to group like animals. The method used must be consistent between baseline and project conditions.
Statistical sampling method	Procedures used to identify the number of pens to be sampled within each animal grouping according to the method outlined in appendix B.
Pen entry and exit records	Feedlot records or third party managed data for average weights of the group in and out of the pens; date of entry; and average number of animals in each pen.
Average daily dry matter intake for each diet	Feedlot records or third party managed data for the amount of dry matter the animals in each pen/grouping take in, on average, on a daily basis. These should be supplemented with feed purchase receipts and kilograms of feed delivered to each pen, either daily or monthly.
Composition of each diet	Feedlot records or third party managed data for the composition of each diet on a dry matter basis. This should include kilograms of dry matter; level of concentrates in the diet, edible oil/fat content and any additives being mixed in. The diet must be signed off by a Doctor of Veterinarian Medicine or Professional Agrologist.
Number of days on feed for each diet	Feedlot records or third party managed data for the number of days animals or animal groupings spend on each diet
Legal land location for the feedlot operation(s)	Must cover the full extent of the feedlot operations.
Commercial agreements.	Feeding agreements showing the project developer was feeding the animals involved in the project.

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 (farmer and aggregator) must keep the information listed below and disclose all information to the verifier and/or government auditor upon request.

A list of minimum records required is provided in section 5.1 above.

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.

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.

Any changes or anomalies that occur during project implementation should be clearly documented in the offset project report completed annually or before third party verification.

5.4 Liability

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.

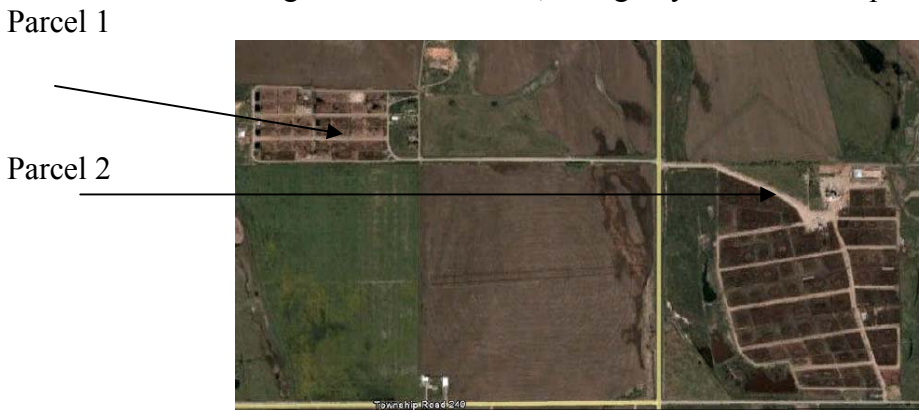
Notwithstanding any agreement between a project developer and the farmer, the project developer shall not and cannot pass on any regulatory liability for errors in design of the project developer's data management system.

5.5 Registration and Claim to Offsets

It is important to note that the emission reductions associated with adding edible oils in the diets of beef cattle occur specifically at feedlot operations where the activity takes place. There must be clear, legal claim of the greenhouse gas reductions achieved from the project in order to have the offsets verified and registered. Emission reductions are tracked through the Alberta Emissions Offset Registry. The registry relates the reduction to a specific land location.

Project developers 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 of land registered in the spatial locator template for the project. Emission reductions cannot be consolidated to the parcel where the business entity is legally located.

Figure 2: One Feedlot, 2 Registry Parcels Example



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). Ownership of offset credits generated under this protocol is assigned to the project developer. 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 and must be able to substantiate any claims with feeding agreements for animals being included in the project condition.

6.0 References

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7.0 Appendices

Appendix A: Alberta Case Study - Adding Edible Oils to Diets of Beef Cattle

The emission reduction potential of incorporating edible oils in the finishing diets of beef cattle was evaluated with data from 10,245 youthful cattle and three commercial feedlots. These data were used to calculate the enteric methane produced from common finishing programs (referred to as the baseline condition) and to calculate the enteric methane produced from incorporating edible oils at a concentration between 4 and 6 per cent, combined with concentrates at levels either equal to or greater than 85 percent or less than 85 per cent.

Records were obtained on a pen basis for number of cattle, gender, days on feed, average cattle weight in, average weight out, average daily feed intake, average daily gain, and diet ingredients and composition (percent dry matter, net energy for maintenance, net energy for gain, and crude protein) for each feeding period (e.g., starter (1), transition (2), backgrounding (3) and final finishing (4)). Equivalent diets containing 4 per cent edible oil were formulated using CowBytes⁴ for each feedlot and feeding period.

Step 1: Defining the Baseline and Project Conditions

As discussed in section 3 and 4, there are a number of factors and data sets which are required to complete a quantification of emissions reductions. The following is a description of the baseline and project conditions defining this particular case study.

Project Condition:

Yearling steers entered a pen averaging 392.4 kg in body weight. They were adjusted to a high concentrate diet over a 21 to 28 day diet, with edible oils introduced immediately. Steer were fed four diets during the finishing regime as follows:

Pen #1	Days on Diet (days)	Number of Cattle (head)	Animal. Head Days	In Weight (kgs)	Out Weight (kgs)	DMI (kgs / head/day)	Level of Concentrates (%)	Edible Oil Content (%)
1	14	124	1,736	392.4	410.9	10.00	Below 85	4
2	7	127	889	410.9	420.7	9.51	Below 85	4
3	7	122	854	420.7	431.0	9.49	Below 85	4
4	130	120	15,624	431.0	631.0	11.0	Above 85	4

Baseline Condition:

The same conditions apply as the project condition in defining the baseline with the exception of the feeding of edible oils under each diet. As such, number of cattle, level of concentrates and days on feed remain constant between the project and baseline conditions, while the diet constituents vary.

⁴ Cowbytes 2000. Cowbytes, a ration formulation program for beef cattle. Alberta Agriculture and Food, #204, 7000-113 Street, Edmonton, Alberta, Canada <http://www.agric.gov.ab.ca/ruraldev/homestdy/cowbytesdemo.html>

Calculating potential emission reductions per number of head processed during the project and baseline condition:

Table A1: Edible Oils – Base Study Emission Reduction Calculations	
Project Cattle Enteric Emissions = (Number Production_i * DOF * DMI_i * GE Diet * (EF Enteric_i / 100%) / EC Methane)	
Diet 1 – (392.4 to 410.9 kg)	
DOF (Days on Feed)	14 days
Number in Production	124 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	10.00 kg / head / day
GE Diet (Gross Energy Content of Diet)	19.10 MJ per kg of Dry Matter Feed as edible oil concentration is greater than 4% but less than 6%
EF Enteric (Enteric Emissions Factor)	5.2% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Project Enteric Emissions_{Diet 1} = (124 head) * (14 days) * (10.00 kg / head / day) * (19.10 MJ / kg of dry matter) * (0.052) / (55.65 MJ per kg methane) = 308.21 kg methane	
Diet 2 – (410.9 to 420.7 kg)	
DOF (Days on Feed)	7 days
Number in Production	127 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	9.51 kg / head / day
GE Diet (Gross Energy Content of Diet)	19.10 MJ per kg of Dry Matter Feed as edible oil concentration is greater than 4% but less than 6%
EF Enteric (Enteric Emissions Factor)	5.2% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Project Enteric Emissions_{Diet 2} = ((127 head) * (7 days) * (9.51 kg / head / day) * (19.10 MJ / kg of dry matter) * (0.052) / (55.65 MJ per kg methane) = 150.89 kg methane	
Diet 3 – (420.7 to 431.0 kg)	
DOF (Days on Feed)	7 days
Number in Production	122 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	9.49 kg / head / day
GE Diet (Gross Energy Content of Diet)	19.10 MJ per kg of Dry Matter Feed as edible oil concentration is greater than 4% but less than 6%
EF Enteric (Enteric Emissions Factor)	5.2% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Project Enteric Emissions_{Diet 3} = ((122 head) * (7 days) * (9.49 kg / head / day) * (19.10 MJ / kg of dry matter) * (0.052) / (55.65 MJ per kg methane) = 144.64 kg of methane	
Diet 4 – (431.0 to 631.0 kg)	
DOF (Days on Feed)	130 days
Number in Production	120 head
Concentrates	Above 85%
DMI (Dry Matter Intake)	11.0 kg / head / day
GE Diet (Gross Energy Content of Diet)	19.10 MJ per kg of Dry Matter Feed as edible oil concentration is greater than 4% but less than 6%
EF Enteric (Enteric Emissions Factor)	3.2% as the level of concentrates is greater than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Project Enteric Emissions_{Diet 4} = ((120 head) * (130 days) * (11.0 kg / head / day) * (19.10 MJ / kg of dry matter) * (0.032) / (55.65 MJ per kg methane) = 1,884.67 kg of methane	
Total Project Enteric Emissions = (308.21 + 150.89 + 144.64 + 1,884.67) = 2,488.41 kg of methane	

Baseline Cattle Enteric Emissions = (Number Production_i * DOF * DMI_i * GE Diet * (EF Enteric_i / 100%) / EC Methane)	
Diet 1 – (392.4 to 410.9 kg)	
DOF (Days on Feed)	14 days
Number in Production	124 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	10.00 kg / head / day
GE Diet (Gross Energy Content of Diet)	18.5 MJ per kg of Dry Matter Feed as edible oil concentration is less than 4%
EF Enteric (Enteric Emissions Factor)	6.5% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Baseline Enteric Emissions_{Diet 1} = ((124 head) * (14 days) * (10.00 kg / head / day) * (18.50 MJ / kg of dry matter) * (0.065)) / (55.65 MJ per kg methane) = 375.12 kg methane	
Diet 2 – (410.9 to 420.7 kg)	
DOF (Days on Feed)	7 days
Number in Production	127 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	9.51 kg / head / day
GE Diet (Gross Energy Content of Diet)	18.5 MJ per kg of Dry Matter Feed as edible oil concentration is less than 4%
EF Enteric (Enteric Emissions Factor)	6.5% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Baseline Enteric Emissions_{Diet 2} = ((127 head) * (7 days) * (9.51 kg / head / day) * (18.50 MJ / kg of dry matter) * (0.065)) / (55.65 MJ per kg methane) = 182.68 kg methane	
Diet 3 – (420.7 to 431.0 kg)	
DOF (Days on Feed)	7 days
Number in Production	122 head
Concentrates	Below 85%
DMI (Dry Matter Intake)	9.49 kg / head / day
GE Diet (Gross Energy Content of Diet)	18.5 MJ per kg of Dry Matter Feed as edible oil concentration is less than 4%
EF Enteric (Enteric Emissions Factor)	6.5% as the level of concentrates is less than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Baseline Enteric Emissions_{Diet 3} = ((122 head) * (7 days) * (9.49 kg / head / day) * (18.50 MJ / kg of dry matter) * (0.065)) / (55.65 MJ per kg methane) = 175.12 kg methane	
Diet 4 – (431.0 to 631.0 kg)	
DOF (Days on Feed)	130 days
Number in Production	120 head
Concentrates	Above 85%
DMI (Dry Matter Intake)	11.0 kg / head / day
GE Diet (Gross Energy Content of Diet)	18.5 MJ per kg of Dry Matter Feed as edible oil concentration is less than 4%
EF Enteric (Enteric Emissions Factor)	4.0% as the level of concentrates is equal to or greater than 85%
EC Methane (Methane Energy Content)	55.65 MJ per kg of methane
Baseline Enteric Emissions_{Diet 4} = ((120 head) * (130 days) * (11.0 kg / head / day) * (18.50 MJ / kg of dry matter) * (0.040)) / (55.65 MJ per kg methane) = 2,281.83 kg methane	
Total Project Enteric Emissions = 375.12 + 182.68 + 175.12 + 2,281.83 = 3014.75 kg CH₄	

Table A2: Final Example Calculations			
Factor	Calculated Value (kg CH ₄)	GWP	Total Emissions (kg CO ₂ e)
Enteric Emissions Project	1,884.67	21	39,578
Enteric Emissions Baseline	3,014.75	21	63,309
Total Emission Reductions = (Baseline) - (Project)			23,731

Appendix B: Statistical Sampling Method for Baseline Quantification for Edible Oils 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

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

- Standard deviation: a measure of dispersion, calculated by

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

- 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 per cent confidence limits are given by:

$$\bar{x} \pm 2s_x / \sqrt{n} .$$

- We let L be the allowable error (for GHG projects it is set at 5 per cent of the mean) and we put:

$$L = 2s_x / \sqrt{n} .$$

In other words, we are 95 per cent certain that the actual error will not exceed $\pm L$ or we are willing to take a 5 per cent 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 include⁵:

⁵ The above data can be calculated as an average for the pen using the cattle inventory approach outlined in Section 4 of this document.

- 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 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 per cent certain that the actual error will not exceed $\pm L$ or we are willing to take a 5 per cent 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 coefficient of variations 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 5per cent error. For all animal groupings, with the exception of the yearling heifers (this group 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)	Slaughter Weight (lbs)
	No. of Pens	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 the project developer may need to consult with a statistician to correctly implement this methodology.